ABSTRACT OF THE DISCLOSURE

METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES

Measurements of a mobile object and particularly a living being are made using two techniques, normally radiation attenuation and radiation emission, in synchronisation to provide images of the object state. Movement displacement fields from one phase to the next are estimated for both techniques, but the final images obtained by the emission technique are improved by the knowledge of the displacement field obtained by the other technique that is more precise.

PATENT APPLICATION SERIAL NO. _____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

10/05/2004 EHAILE1 00000068 503218 10955037
01 FC:1001 770.00 DA

PTO-1556
(5/87)

*U.S. Government Printing Office: 2002 — 489-267/69033

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2003

Application or Docket Number: 10955032

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	8	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	8 minus 20=	* —
INDEPENDENT CLAIMS	1 minus 3 =	*
MULTIPLE DEPENDENT CLAIM PRESENT	☐	

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐			OR	OTHER THAN SMALL ENTITY	
RATE	FEE			RATE	FEE
BASIC FEE	385.00		OR	BASIC FEE	770.00
XS 9=			OR	XS18=	
X43=			OR	X86=	
+145=			OR	+290=	
TOTAL			OR	TOTAL	770

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM	☐			

SMALL ENTITY			OR	OTHER THAN SMALL ENTITY	
RATE	ADDITIONAL FEE			RATE	ADDITIONAL FEE
X$ 9=			OR	X$18=	
X43=			OR	X86=	
+145=			OR	+290=	
TOTAL ADDIT. FEE			OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM	☐			

			OR		
RATE	ADDITIONAL FEE			RATE	ADDITIONAL FEE
X$ 9=			OR	X$18=	
X43=			OR	X86=	
+145=			OR	+290=	
TOTAL ADDIT. FEE			OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM	☐			

			OR		
RATE	ADDITIONAL FEE			RATE	ADDITIONAL FEE
X$ 9=			OR	X$18=	
X43=			OR	X86=	
+145=			OR	+290=	
TOTAL ADDIT. FEE			OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
***If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Patent
Attorney Docket No. BRV.10002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Stéphane BONNET et al.

Application No.: Unassigned

Group Art Unit: Unassigned

Filing Date: September 30, 2004

Examiner: Unassigned

Title: Method of Reconstructing an Image With Data Acquisition According to Several Imagery Modes and Synchronisation of Image Series

Confirmation No.: Unassigned

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Prior to examination, please amend this application as follows:

Amendments to the Claims begin on page 2 of this paper; and

Remarks being on page 4 of this paper.

REMARKS

The claims have been amended to place the application in better form for examination. Entry of the amendment and favorable consideration are requested.

If any questions arise, the Examiner is invited to phone the undersigned at the below listed number.

Respectfully submitted,

HUTCHISON & MASON PLLC

Date: September 30, 2004

By: Joshua T. Elliott

Joshua T. Elliott
Registration No. 43,603

P.O. Box 31686
Raleigh, NC 27612
+1.919.829.9600

I hereby certify that the application/correspondence attached hereto is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Express Mail Label No. EV 613 035 543 US

Date of Deposit: September 30, 2004

Jennie Snead
(Typed Name of Person Signing Certificate)

Jennie Snead
(Signature of Person Signing Certificate)

Date of Signing: 9/30/04

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2003

Application or Docket Number: 10955032

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	(Column 1)	(Column 2)
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FOR	NUMBER FILED	NUMBER EXTRA
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INDEPENDENT CLAIMS	1 minus 3 =	*
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
RATE	FEE		RATE	FEE
BASIC FEE	385.00	OR	BASIC FEE	770.00
XS 9=		OR	XS18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL		OR	TOTAL	720

9/30/2004

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 8	Minus	** 20	= X
Independent	* 1	Minus	*** 3	= X
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	X
X43=		OR	X86=	X
+145=		OR	+290=	X
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	0

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

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*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

PTO/SB/05 (09-04)
Approved for use through 07/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office. U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

22764 U.S.P.O. 093004

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	BRV.10002
First Inventor	Stéphane BONNET et al.
Title	Method of Reconstructing an Image With Data Acquisition According to Several Imagery Modes...
Express Mail Label No.	EV 613 035 543 US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. [✓] **Fee Transmittal Form** (e.g., PTO/SB/17) *(Submit an original and a duplicate for fee processing)*
2. [ ] **Applicant claims small entity status.** See 37 CFR 1.27.
3. [✓] **Specification** [*Total Pages* 22] Both the claims and abstract must start on a new page *(For information on the preferred arrangement, see MPEP 608.01(a))*
4. [✓] **Drawing(s)** (*35 U.S.C. 113*) [*Total Sheets* 2]
5. **Oath or Declaration** [*Total Sheets*]
   a. [ ] Newly executed (original or copy)
   b. [ ] A copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional with Box 18 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) name in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. [ ] **Application Data Sheet.** See 37 CFR 1.76
7. [ ] **CD-ROM or CD-R** in duplicate, large table or Computer Program *(Appendix)* [ ] Landscape Table on CD
8. **Nucleotide and/or Amino Acid Sequence Submission** *(if applicable, items a. – c. are required)*
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] Paper
   c. [ ] Statements verifying identity of above copies

ADDRESS TO:

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

17858 U.S. PTO 10/955037 093004

ACCOMPANYING APPLICATION PARTS

9. [ ] **Assignment Papers** (cover sheet & document(s))
   Name of Assignee
10. [ ] **37 CFR 3.73(b) Statement** *(when there is an assignee)* [ ] **Power of Attorney**
11. [ ] **English Translation Document** *(if applicable)*
12. [ ] **Information Disclosure Statement** (PTO/SB/08 or PTO-1449) [ ] Copies of citations attached
13. [✓] **Preliminary Amendment**
14. [✓] **Return Receipt Postcard** (MPEP 503) *(Should be specifically itemized)*
15. [✓] **Certified Copy of Priority Document(s)** *(if foreign priority is claimed)*
16. [ ] **Nonpublication Request** under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
17. [✓] Other: Unexecuted Combined Declaration/Power of Attorney (2 pages)

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No.: .....

Prior application information: *Examiner* _____ *Art Unit:* _____

19. CORRESPONDENCE ADDRESS

[✓] The address associated with Customer Number: 45473 ***OR*** [ ] Correspondence address below

Name	Hutchison & Mason PLLC				
Address	P.O. Box 31686				
City	Raleigh	State	NC	Zip Code	27612
Country	US	Telephone	+1.919.829.9600	Fax	919-829-4332

Signature	Joshua T. Elliott	Date	September 30, 2004
Name (Print/Type)	Joshua T. Elliott	Registration No. (Attorney/Agent)	43,603

I hereby certify that the application/correspondence attached hereto is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Express Mail Label No. EV613 035 543 US Date of Deposit: 9/30/04

(Jennie Snead)

PTO/SB/17 (10-03)
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FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 770.00

Complete if Known	
Application Number	Unassigned
Filing Date	September 30, 2004
First Named Inventor	Stéphane BONNET et.al
Examiner Name	Unknown
Art Unit	Unknown
Attorney Docket No.	BRV.10002

METHOD OF PAYMENT *(check all that apply)*

☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☑ Deposit Account:

Deposit Account Number: 50-3218

Deposit Account Name:

The Director is authorized to: *(check all that apply)*

☑ Charge fee(s) indicated below ☐ Credit any overpayments

☑ Charge any additional fee(s) or any underpayment of fee(s)

☐ Charge fee(s) indicated below, **except for the filing fee** to the above-identified deposit account.

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	770	2001	385	Utility filing fee	770.00
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	

SUBTOTAL (1) ($) 770.00

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below	Fee Paid
Total Claims	8.00	-20** =	0.00	X	18.00	0.00
Independent Claims	1.00	- 3** =	0.00	X	86.00	0.00
Multiple Dependent					0.00	0.00

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0.00

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) 0.00%

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0.00

SUBMITTED BY				(Complete *(if applicable)*)	
Name *(Print/Type)*	Joshua T. Elliott	Registration No. *(Attorney/Agent)*	43,603	Telephone	+1.919.829.9600
Signature	Joshua T. Elliott			Date	September 30, 2004

I hereby certify that the application/correspondence attached hereto is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Express Mail Label No. EV 613 035 543 US Date of Deposit: 9/30/04

(Jennie Snead)

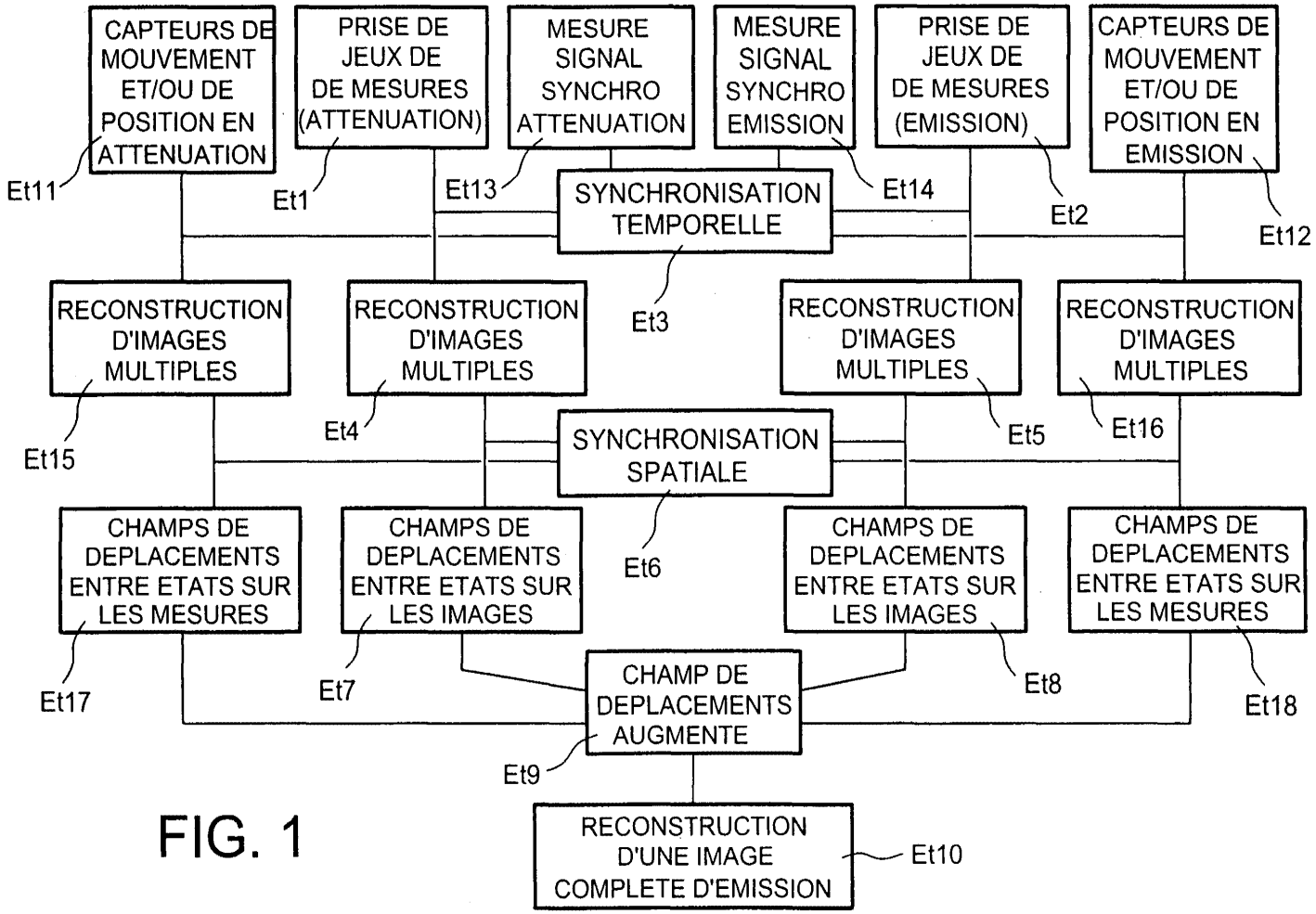

CAPTEURS DE MOUVEMENT ET/OU DE POSITION EN ATTENUATION
PRISE DE JEUX DE DE MESURES (ATTENUATION)
MESURE SIGNAL SYNCHRO ATTENUATION
MESURE SIGNAL SYNCHRO EMISSION
PRISE DE JEUX DE DE MESURES (EMISSION)
CAPTEURS DE MOUVEMENT ET/OU DE POSITION EN EMISSION
Et11
Et1
Et13
Et14
Et2
Et12
SYNCHRONISATION TEMPORELLE
Et3
RECONSTRUCTION D'IMAGES MULTIPLES
RECONSTRUCTION D'IMAGES MULTIPLES
RECONSTRUCTION D'IMAGES MULTIPLES
RECONSTRUCTION D'IMAGES MULTIPLES
Et15
Et4
Et5
Et16
SYNCHRONISATION SPATIALE
Et6
CHAMPS DE DEPLACEMENTS ENTRE ETATS SUR LES MESURES
CHAMPS DE DEPLACEMENTS ENTRE ETATS SUR LES IMAGES
CHAMPS DE DEPLACEMENTS ENTRE ETATS SUR LES IMAGES
CHAMPS DE DEPLACEMENTS ENTRE ETATS SUR LES MESURES
Et17
Et7
Et8
Et18
CHAMP DE DEPLACEMENTS AUGMENTE
Et9
RECONSTRUCTION D'UNE IMAGE COMPLETE D'EMISSION
Et10

FIG. 1

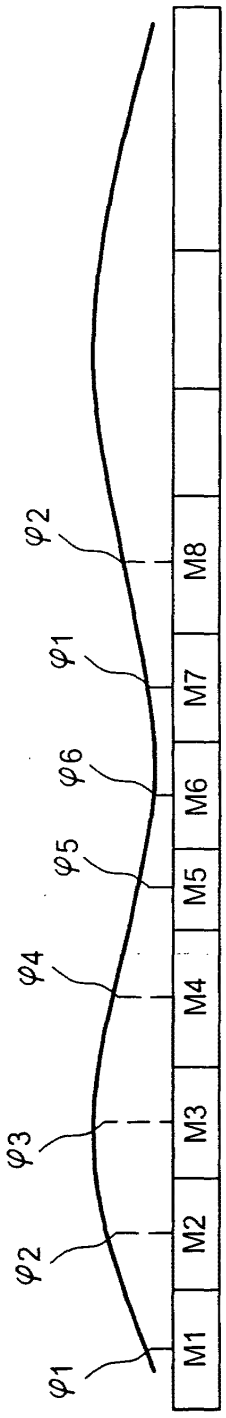


FIG. 2

Attorney Docket No. BRV.10002

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY OR DESIGN PATENT APPLICATION

I hereby declare that:

Each inventor's residence, mailing address, and citizenship are as stated below next to their name.

I believe the inventor(s) named below to be the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES

the specification of which

☒ is attached hereto

OR

☐ was filed on_____as United States Application Number or PCT International Application Number _____ and was amended on (mm/dd/yyyy) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (mm/dd/yyyy)	Priority Claimed?
03 50631	FR	10/01/2003	☒ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
☐ Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.			

I hereby appoint the attorneys and agents associated with the following PTO Customer Number of Hutchison & Mason PLLC to prosecute the application identified above and to transact all business in the United States Patent and Trademark Office connected therewith:

Address all correspondence to:

Customer Number: 45473
Hutchison & Mason PLLC
P.O. Box 31686
Raleigh, North Carolina 27612
(919) 829-9600

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.	
FULL NAME OF SOLE OR FIRST INVENTOR	Stéphane BONNET
Signature	
Date	
Residence (City, State, Country)	Grenoble, France
Citizenship	France
Mailing Address	42 rue Claude Genin
City, State, ZIP, Country	38100 Grenoble, France
FULL NAME OF SECOND INVENTOR	Pierre GRANGEAT
Signature	
Date	
Residence (City, State, Country)	Saint Ismier, France
Citizenship	France
Mailing Address	136 Allée Vignes du Persan
City, State, ZIP, Country	38330 Saint Ismier, France
FULL NAME OF THIRD INVENTOR	
Signature	
Date	
Residence (City, State, Country)	
Citizenship	
Mailing Address	

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (Original): Method of reconstruction of an image of a mobile object by a first measurement acquisition technique, comprising at least partial reconstruction of images of the object at corresponding movement states of the object, an estimate of the object movement between the states and a combination of state images by making compensations of the object movement according to the estimate, characterised in that object movement estimate at least uses partially other images of the object, obtained for the said states using a second measurement acquisition technique.

Claim 2 (Original): Method of reconstruction of an image according to claim 1, characterised in that the at least partial image reconstruction of the object at corresponding states of the object movement comprises a time synchronisation step applied to measurements originating from the second acquisition technique.

Claim 3 (Original): Method of reconstruction of an image according to claim 2, characterised in that the estimate of the object movement between the states comprises a spatial synchronisation step applied to at least partial images of the object at corresponding states of the object movement.

Claim 4 (Currently amended): Method of reconstruction of an image according to claim 1, ~~2 or 3,~~ characterised in that the first measurement acquisition technique is a functional radiation emission imagery technique and the second measurement acquisition technique is an anatomic radiation attenuation imagery technique.

Claim 5 (Currently amended): Method of reconstruction of an image according to ~~claims 1 to 4~~ claim 1, characterised in that it comprises a measurement of a cyclic element of the object movement to synchronise the states on periodic states of the cyclic element.

Claim 6 (Original): Method of reconstruction of an image according to claim 5, characterised in that the periodic states group measurements made on several phases associated with different periods of the movement cyclic element, at least for measurements acquired by the first technique.

Claim 7 (Currently amended): Method of reconstruction of an image according to ~~any one of the previous claims~~ claim 1, characterised in that it comprises the use of independent movement or position sensors to evaluate the movement of the object and / or to place the measurements by the two acquisition techniques and the states of the object on a common time scale.

Claim 8 (Currently amended): Method of reconstruction of an image according to claim 7, characterised in that the object movement is also compensated with the movement estimated by the independent sensors.

PTO/SB/05 (09-04)
Approved for use through 07/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office. U.S. DEPARTMENT OF COMMERCE
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	BRV.10002
First Inventor	Stéphane BONNET et al.
Title	Method of Reconstructing an Image With Data Acquisition According to Several Imagery Modes...
Express Mail Label No.	EV 613 035 543 US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☑ **Fee Transmittal Form** (e.g., PTO/SB/17)
   (Submit an original and a duplicate for fee processing)
2. ☐ **Applicant claims small entity status.**
   See 37 CFR 1.27.
3. ☑ **Specification** [*Total Pages* 22]
   Both the claims and abstract must start on a new page
   (For information on the preferred arrangement, see MPEP 608.01(a))
4. ☑ **Drawing(s)** (*35 U.S.C. 113*) [*Total Sheets* 2]
5. **Oath or Declaration** [*Total Sheets*]
   a. ☐ Newly executed (original or copy)
   b. ☐ A copy from a prior application (37 CFR 1.63(d))
   (for continuation/divisional with Box 18 completed)
   i. ☐ DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) name in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☐ **Application Data Sheet.** See 37 CFR 1.76
7. ☐ **CD-ROM or CD-R** in duplicate, large table or Computer Program *(Appendix)*
   ☐ Landscape Table on CD
8. **Nucleotide and/or Amino Acid Sequence Submission**
   (if applicable, items a. – c. are required)
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper
   c. ☐ Statements verifying identity of above copies

ADDRESS TO:

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P.O. Box 1450
Alexandria VA 22313-1450

ACCOMPANYING APPLICATION PARTS

9. ☐ **Assignment Papers** (cover sheet & document(s))
   Name of Assignee
10. ☐ **37 CFR 3.73(b) Statement** *(when there is an assignee)* ☐ **Power of Attorney**
11. ☐ **English Translation Document** *(if applicable)*
12. ☐ **Information Disclosure Statement** (PTO/SB/08 or PTO-1449)
    ☐ Copies of citations attached
13. ☑ **Preliminary Amendment**
14. ☑ **Return Receipt Postcard** (MPEP 503)
    (Should be specifically itemized)
15. ☑ **Certified Copy of Priority Document(s)**
    (if foreign priority is claimed)
16. ☐ **Nonpublication Request** under 35 U.S.C. 122(b)(2)(B)(i).
    Applicant must attach form PTO/SB/35 or equivalent.
17. ☑ Other: Unexecuted Combined Declaration/Power of Attorney (2 pages)

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: .....

Prior application information: *Examiner* _____ *Art Unit:* _____

19. CORRESPONDENCE ADDRESS

☑ The address associated with Customer Number: 45473 *OR* ☐ Correspondence address below

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Signature	Joshua T. Elliott	Date	September 30, 2004
Name (Print/Type)	Joshua T. Elliott	Registration No. (Attorney/Agent)	43,603

I hereby certify that the application/correspondence attached hereto is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Express Mail Label No. EV613 035 543 US Date of Deposit: 9/30/04

(Jennie Snead)

Volkswagen Exhibit 1002, Page 15 of 885

PTO/SB/17 (10-03)
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FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 770.00

Complete if Known	
Application Number	Unassigned
Filing Date	September 30, 2004
First Named Inventor	Stéphane BONNET et.al
Examiner Name	Unknown
Art Unit	Unknown
Attorney Docket No.	BRV.10002

METHOD OF PAYMENT *(check all that apply)*

☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☑ Deposit Account:

Deposit Account Number: 50-3218

Deposit Account Name:

The Director is authorized to: *(check all that apply)*

☑ Charge fee(s) indicated below ☐ Credit any overpayments

☑ Charge any additional fee(s) or any underpayment of fee(s)

☐ Charge fee(s) indicated below, **except for the filing fee** to the above-identified deposit account.

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	770	2001	385	Utility filing fee	770.00
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	

SUBTOTAL (1) ($) 770.00

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below	Fee Paid
Total Claims	8.00	-20** =	0.00	X	18.00	0.00
Independent Claims	1.00	- 3** =	0.00	X	86.00	0.00
Multiple Dependent					0.00	0.00

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0.00

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) 0.00%

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0.00

SUBMITTED BY				(Complete *(if applicable)*)	
Name *(Print/Type)*	Joshua T. Elliott	Registration No. *(Attorney/Agent)*	43,603	Telephone	+1.919.829.9600
Signature	Joshua T. Elliott			Date	September 30, 2004

I hereby certify that the application/correspondence attached hereto is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Express Mail Label No. EV 613 035 543 US Date of Deposit: 9/30/04

(Jennie Snead)

CLAIMS

1. Method of reconstruction of an image of a mobile object by a first measurement acquisition technique, comprising at least partial reconstruction of images of the object at corresponding movement states of the object, an estimate of the object movement between the states and a combination of state images by making compensations of the object movement according to the estimate, characterised in that object movement estimate at least uses partially other images of the object, obtained for the said states using a second measurement acquisition technique.

2 Method of reconstruction of an image according to claim 1, characterised in that the at least partial image reconstruction of the object at corresponding states of the object movement comprises a time synchronisation step applied to measurements originating from the second acquisition technique.

3. Method of reconstruction of an image according to claim 2, characterised in that the estimate of the object movement between the states comprises a spatial synchronisation step applied to at least partial images of the object at corresponding states of the object movement.

4. Method of reconstruction of an image according to claim 1, 2 or 3, characterised in that the first measurement acquisition technique is a functional radiation emission imagery technique and the second measurement acquisition technique is an anatomic radiation attenuation imagery technique.

5. Method of reconstruction of an image according to claims 1 to 4, characterised in that it comprises a measurement of a cyclic element of the object movement to synchronise the states on periodic states of the cyclic element.

6. Method of reconstruction of an image according to claim 5, characterised in that the periodic states group measurements made on several phases associated with different periods of the movement cyclic element, at least for measurements acquired by the first technique.

7. Method of reconstruction of an image according to any one of the previous claims, characterised in that it comprises the use of independent movement or position sensors to evaluate the movement of the object and / or to place the measurements by the two acquisition techniques and the states of the object on a common time scale.

8. Method of reconstruction of an image according to claim 7, characterised in that the object movement is

also compensated with the movement estimated by the independent sensors.

METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES

This invention relates to a method in which an image of an object is estimated using two series of data that are combined by synchronisation.

Images may be taken inside objects, and particularly living beings, using several types of methods. Some are attenuative, in other words the attenuation of radiation passing through the object is measured, and others are emissive, in other words ionising particles originating from a radioactive liquid previously swallowed by the organism to be studied, are collected. In both cases, detector networks rotating around the object or covering the periphery of the object collect radiation, and images of the object are obtained by combining measurements of detectors taken at different angles using well-known computed tomography methods (see "Tomography", directed by P. Grangeat Paris: Hermès Science Publications 2002 ibsn 2.7462-0356-1).

Some methods are better than others for obtaining specific result types. Typically, images obtained by attenuation can indicate the composition of the object at each location and thus enable an accurate drawing of the organs of a living being and their contours. This is not usually possible with images obtained by emission, but they can be used to distinguish healthy tissues that are only slightly emissive, from diseased tissues, for

example cancers tissues that are strongly emissive. The first images can be qualified as anatomic and the second images as functional. They are complementary and superposition of the two images can be very helpful in the diagnostic. Prior art also includes devices for simultaneously acquiring both types of images (as in the article "Attenuation correction for a combined 3D PET/CT scanner" by Kinahan et al., Med. Phys. 25(10), October 1998, p. 2046-2053).

One purpose that should be considered applies to movements of living beings during the measurements. Obviously, the mix of measurements made while the object is moving can only produce blurred images, if no precautions are taken. Many studies have been carried out on this problem for several years, and several types of solutions have been suggested. Some consist of taking the measurements as quickly as possible, for example making use of a network of a large number of detectors that completely surround the object to be studied, instead of moving around the object. Another method consists of making the measurements only at an approximately invariable state of the object, for example for the same state of the heart or breathing cycle, or another periodic biological cycle. The first of these methods is obviously expensive in equipment and the second method is difficult to apply, and will not work for non-periodic movements (for example a moving animal). Another type of method involves digital correction of the measurements and images, taking account of displacements of the object

between each series of measurements. Object movements are then estimated by displacement fields of their points. These displacement fields can be determined by making estimates on the first images, possibly including assumptions about the movements. The latter method is most likely to give good results. French patent 2 826 157 describes an example.

Image correction methods by estimating the displacement field have been applied primarily to attenuation images that can be taken quickly and for which the more distinct contents provide more details about object movements. Emission images have less abundant contents due to the fact that the measurements are more dispersed in time and they are not as easily recognisable since different categories of tissues are not as clearly distinguished. Therefore, it is difficult to establish a displacement field so that it can be used to compensate for object movements and regularise its image.

However, this document proposes to apply such an image reconstruction method to emission techniques, with compensation of object movements, using the methods described below

Images of the object are taken using an emission technique and an attenuation technique. Ordinary movement estimating methods are applied to the images obtained by attenuation, by reconstituting a series of images of the object studied using measurement sets taken at different times and therefore providing blurred images if no

movement compensation is made, due to the small movement of the object, but clearly representative of the state of the object at different times. The result is displacement fields of points on the object to obtain these first images.

These displacement fields are then applied to measurements taken using the emission technique in general after having been modified or adapted by processes that will be described in detail in the remainder of this document. Thus, these emission measurements may be corrected to compensate for the movement and obtain an improved final functional image. All that is necessary is to synchronise measurements made using the two techniques on a common time base.

Known installations in which both types of images were obtained do not use any analogue combination of measurement sets, and make use of a simple juxtaposition of two types of images obtained independently by superposition, or at the most use the attenuation image for a correction of another type of emission measurements, compensating for attenuations through the object being studied, which also affect these measurements.

Although the invention is useful at the moment in the special context of acquisition pairs by attenuation and emission, it could be easily be generalised to include any pair of measurement acquisitions and is not limited to the embodiments described below.

We will now describe the invention in more detail with reference to the attached figures, in which Figure 1 is a general flowchart and Figure 2 is a time diagram.

This invention is particularly applicable to medical imagery, therefore it will be assumed that a patient is being examined. He is instructed to breathe normally and regularly during the examination. In methods in which no movement compensation is made, he is asked to hold his breath or to stop breathing in the same state before each measurement. He has also ingested a radio-pharmaceutical substance such as FDG (fluoro-deoxy-glucose) by intravenous injection. This substance is used to monitor the cellular metabolism of glucose using an emission technique. Other emissive substances are used for other applications.

Attenuation and emission measurements are made in steps Et1 and Et2 in Figure 1. For each measurement category, measurement sets are taken at successive instants, which are usually not simultaneous for the two measurement categories. However, a time synchronisation of measurement sets is usually necessary, within the two series and between the two series after step Et3. One useful method for achieving this may be to measure a patient movement using an independent sensor such as a breathing sensor, a pressure sensor or an electrocardiogram. Each measurement set is then associated with a determined state of the patient during which a measurement of his movement was made. If this measurement relates to a cyclic phenomenon such as

breathing, the measurement sets may be associated with time phases of this movement as suggested in the diagram in Figure 2, in which six measurement sets M1 to M6 taken over a breathing cycle are associated with average phases $\varphi 1$ to $\varphi 6$.

Steps Et11 and Et12 in Figure 1 illustrate such uses of sensors. Movement or position sensors are usually suitable for this method. There may be an arbitrary number of these sensors. Some may be associated with the attenuation measurements and others with emission measurements. When a measurement set is taken, the associated sensors record the movement signal, etc., that they receive. When all measurement sets have been taken, comparisons between signals recorded by the different sensors may be used to place the two measurement sets at determined locations on a common time scale. Times at which measurements are made may be determined if some sensors also measure the time, or if an independent time measurement signal is taken and measured. In the method illustrated, two time measurement signals are taken at preliminary steps Et13 and Et14, and are used to determine times at which measurements are made with the two techniques, and times at which measurements are made by sensors, respectively.

Finally, the time may be synchronised by correlation processes between image projections. The article entitled "Kymogram detection and Kymogram-correlated image reconstruction from subsecond spiral computed tomography

scans of the heart", by Kachelriess et al., Med. Phys. 29 (7), July 2002, p. 1489 to 1503, gives an example.

After these measurement set collection and time synchronisation steps Et1, Et2 and Et3, at least a partial image reconstruction is carried out for the patient by multiple states in steps Et4 and Et5 for each measurement technique. This means that each measurement set such as M1 is used to give a particular image assuming that the patient is motionless throughout the time that the measurement sets are being taken. Conventional digital means such as filtering and back projection are applied. The partial images thus obtained are usually based on data that are too incomplete to be precise, but in any case they are sufficiently detailed so that they can be compared with each other to determine the patient's movements between two phases. For further information, refer to the previous state of the art described by P. Grangeat, A. Koenig, T. Rodet and S. Bonnet in "Theoretical framework for a dynamic cone-beam reconstruction algorithm based on a dynamic particle model", Phys. Med. Biol., vol. 47, No. 15, pp. 2611-2625, August 2002 for an attenuation technique, and D. R Gilland, B.A. Mair, J.E. Bowsher and R.J. Jaszczak, "Simultaneous reconstruction and motion estimation for gated cardiac ECT", IEEE Trans. Nucl. Sci., vol. 49, No. 5, pp. 2344-2349, October 2002, for an emission technique.

Steps Et15 and Et16 show that patient states can also be defined at these same states using information output by the sensors.

Time synchronisation could then have been applied to these state images rather than to measurement sets.

Spatial synchronization is undertaken in step Et6. It is an adjustment of at least partial image categories and information from sensors in which corresponding points (in other words points corresponding to the same point on the patient) must appear at the same position on the two image categories. The two image categories are compared with each other in this step that is not innovative, and the invention is not applicable to it.

It consists of determining a deformation operator D defined by parameters to change from a coordinate system associated with the attenuation images to the coordinate system associated with the emission images.

This operator is assumed to be invariable throughout the examination period. It is also assumed that the time synchronisation is sufficiently precise and that the patient's movements (physiological) are reproducible.

The result is that at time t, there is an attenuation image f_t and an emission image g_t. The next step is to identify the deformation operator D assuming consistency between the two images f_t and g_t on the measurement points.

$$D = \arg\min [E_{ima}(f_t, g_t, D)]$$

where

$$E_{ima}\ (f_t, g_t, D) = \Sigma\ \phi\ (f_t(r) - g_t[D(r)])$$

where ϕ is a convex function and i denotes the position of the pixel in the image.

To be general, measurements obtained by micro-systems that provide information about the position of the patient at the sensors (or checkpoints) can also be introduced. Consider the case in which images of the position of these checkpoints are available for each acquisition type (attenuation and emission). These measurement sets output by position sensors are denoted h^{att} and $h^{émi}$. These sensors use optical systems, unlike movement sensors that are based on accelerometer based systems.

It would also be possible to consider using imagery systems to position these sensors by varying their attenuation and incorporating radioactive sources into them for the emission part.

If this additional information h_t^{att} and $h_t^{émi}$ is available at time t, then the complete set can be minimised into a single function.

$$D = \arg\min\ [E_{ima}(f_t, g_t, D) + \alpha\ E_{capt}(h_t^{att},\ h_t^{émi},\ D)]$$

where α is a weighting factor.

Since D is assumed to be constant throughout the examination period, its determination is not limited to a set of images at time t, but it covers all available times.

D may be a solid movement (translation if the patient is not at exactly the same height, rotation if the patient has turned slightly) or for example an affine movement. The deformation D may also be interpreted by analogy to deformation grids of checkpoints using free form deformation techniques.

The simple case is then the case in which the patient does not move between the attenuation and emission techniques and therefore in which D = identity.

The next steps Et7 and Et8 relate to an estimate of the patient's movement between two phases for each of the two measurement categories. Once again, known methods are used, particularly as described in French patent 2 736 454 or the article by Gilland mentioned above. The result is displacement fields of points of the object from one phase to the next. Dense displacement fields may be obtained for attenuation measurements that reproduce details of images very well. In general, they cannot be reproduced with emission measurements; they can be completed using other information (for example from movement sensors located on the patient) or by making assumptions about object movements, such as lack of deformation (movements are reduced to translations and rotations), or a deformation without a volume variation,

or a deformation obeying determined parameters. Heart muscle and thorax cage movements can thus be easily used.

Another method of completing displacement fields is more particular to the invention and is particularly important. It relates to cyclic movements such as breathing or heart beats. Attenuation measurements are usually made quickly, in a few breathing cycles or even a single cycle, while emission measurements are made much more slowly, ten minutes often being necessary. The invention then includes grouping of measurement sets, particularly emission measurements, using the phases φ considered in a single movement cycle, even if these measurements actually concern different cycles. This is illustrated in Figure 2, in which measurement sets subsequent to the measurements in the previous breathing cycle (M7, M8, etc.) will be associated with phases $\varphi 1$ and $\varphi 2$, etc. already mentioned rather than with phases $\varphi 7$ and $\varphi 8$, etc., that are deduced by an angle of 2π or a multiple of an angle of 2π. A small number of partial images are richer in contents.

Although this synchronisation method using a small number of phases is very practical, it is not essential for use of this invention that can be applied to a patient subjected to an arbitrary movement or a cyclic movement.

Steps E17 and E18 illustrate that displacement fields can also be calculated using sensor measurements.

The next step Et9 is one of the most important steps in the invention. It consists of obtaining a displacement field, said to be enhanced, by a combination of two movement estimates Et7 and Et8 obtained previously and possibly using other contributions originating from different measurements or assumptions.

We will now describe the calculation of the enhanced displacement field, this time attempting to be as general as possible.

To be more general, it is also possible to introduce micro-system measurements that would both be obtained either by attenuation or by emission or both, and a deformation operator D configured to make the conversion from the attenuation coordinate system to the emission coordinate system and for movements m_{att} in the attenuation coordinate system and $m_{émi}$ in the PET emission coordinate system, such that

$$m_{att}(i) = m_{émi}(D(i)) = m_{émi} \circ D^{-}(i)$$

The formula to minimize information obtained no longer only by imagery systems, but also by micro-systems providing information about the position and / or movement of the patient at the sensors (or also at checkpoints) is explicitly added.

As explained above, we will consider the case in which a measurement set output by these sensors is available for each attenuation or emission acquisition. However, a distinction is made between the case in which

position images output by the sensor are available (used for adjustment).

$$\begin{cases} h_1^{att}, & h_2^{att} \\ h_1^{émi}, & h_2^{émi} \end{cases} \text{ at times } t_1 \text{ and } t_2$$

and the case in which displacement fields are directly available at some points in space (such as checkpoints)

$$\begin{cases} m_{att} \\ m_{émi} \end{cases} \text{ between times } t_1 \text{ and } t_2,$$

the two fields being related by the previously determined relation

$$m_{att} = m_{émi} \circ D$$

Finally, an attempt is made to make the following consistency:

$$\text{On medical images } \begin{vmatrix} (f_1,f_2,moD)(g_1,g_2,m) \\ (mf,moD)\ (mg,m) \end{vmatrix};$$

E1 is a function expressing consistency between two at least partial emission images g1 and g2 obtained in step Et5, and the displacement field m that must relate them, and that can be expressed by $E1(g1, g2, m)=\Sigma\phi1[g1(r)-g2(r+m(r))]$ where $\phi1$ is a convex function and r denotes the position of the pixel

considered on the image; E9 is the a priori knowledge about the regularity of the displacement field, for example with $E9(m) = \Sigma\phi g(m(r))$; and E3 and E4 reflect the consistency of the displacement field m with respect to estimated displacement fields for the two techniques, using the formulas $E3(mg,m) = \Sigma\phi 3(m(r)-mg(r))$ and $E4(mF,moD) = \Sigma\Phi 4(moD(r)-mf(r))$. Functions $\phi 1$, $\phi 2$, $\phi 3$ and $\phi 4$ are chosen fairly freely and may consist of convex positive polynomials, the essential requirement being that it is easy to use digital analysis procedures to find a displacement field m that satisfactorily reconciles existing results and that can thus be applied to at least partial emission images.

In particular, consistency between two attenuation images f_1 and f_2 obtained in step Et4 and the displacement field m defining a relation between them, is explicitly introduced.

Considering data for micro-systems

$$\begin{vmatrix} (h_1^{att}, h_2^{att}, moD) & (h_1^{émi}, h_2^{émi}, m) \\ (m_{att}, moD) & (m_{émi}, m) \end{vmatrix}$$

with some regularity on m.

The set can be minimized in a single function $(m,D) = \arg\min$.

$$\left\{\begin{array}{l} a\ E_1(g_1, g_2, m_{émi}) + b\ E_2\ (f_1, f_2, moD) + c\ E_3(mg, m) + d\ E_4(mf, moD) \\ + e\ E_5(h_1^{émi}, h_2^{émi}, m) + f\ E_6(h_1^{att}, h_2^{att}, moD) + g\ E_7(m_{émi}, m) + h\ E_8(m_{att}, moD) \\ + i\ E_9(m) \end{array}\right\}$$

where m, is the enhanced displacement field.

The unknowns are m and the parameters of the deformation D.

This deformation is precisely the deformation required during the spatial synchronisation step.

Therefore, it will be possible to separate the problem firstly by identifying D to ensure that (h_1^{att}, $h_1^{émi}$, D), (h_2^{att}, $h_2^{émi}$, D), etc., are consistent.

This partial minimisation has been described above.

As a result, the function then becomes applicable only to the unknown m.

Microsystems can perform two roles:

- make the two acquisition techniques correspond to each other;

- remove some ambiguities on the calculation of the displacement and trajectory field for at least one of the two acquisition techniques.

In any case, the use of another reference imagery method remains necessary to compensate for the poor spatial resolution and the mediocre image quality (noisy and defined only in regions in which the radioactive product is fixed) which characterise emission images and would result in poor quality displacement fields for areas of interest.

Failure to use sensors imposes e = f = g = h = 0 and the result is a function based only on information obtained using imagery systems.

In the particular case in which there are no position and / or movement sensors, this enhanced displacement field is denoted m, and the displacement fields obtained in steps Et7 and Et8 are denoted mf and mg, and the formula can be simplified and becomes:

$M=\arg\min\{aE1(g1,g2,m) + bE2(f1,f2,moD) + cE3(mg,m) + dE4(mF,moD)+iEg(m)\}$; where a, b, c and d are weighting factors.

One important case corresponds to a = b = d = 0: displacement fields estimated by the attenuation technique would then be applied unchanged to partial images estimated by the emission technique; since as mentioned, the displacement field obtained by the attenuation technique is usually much more precise and accurate.

The displacement field calculated in steps Et17 and Et18 can also contribute to the calculation of the displacement field enhanced by the use of other weighting factors. However, it must be emphasized that the use of independent sensors is not essential if the measurement sets can be placed otherwise (in steps Et13 and Et14) in a same time scale; steps Et11 and Et12, Et15, Et16, Et17 and Et18 can then be eliminated from the method.

The method is completed by use of this enhanced displacement field to reconstruct at least a final image of the patient according to step Et10. To achieve this,

the partial images are combined by addition, taking account of displacements of their points from one phase to the next so as to make additions only on successive states of the same points. Weighting factors expressing the confidence assigned to each point or to each partial image may be applied. The final image obtained is sharper than the partial images (and composed of entire complete acquisitions of the patient). The improvement achieved with the invention is expressed primarily on the image obtained by emission techniques. However, if the acquisition was long (in other words made over several cycles), a single image is not necessarily reconstructed, instead a series of images is created each corresponding to a state in the breathing cycle (for example), and the estimate of the enhanced displacement fields and movement compensation are applied to these state images. This method reduces the influence of an overall cyclic movement of the patient and can give better quality results than a single image obtained with all measurement sets accumulated during the cycle and that could better reduce the measurements noise compared with the useful signal, but would cause blur due to this overall movement.

Images using the emission technique may be also corrected in a known manner by correction of emission data with or without movement corrections, as a function of the attenuation made to them and that can be deduced from attenuation images.

Attenuation and emission techniques that could be used with the invention include CT (X-ray tomography) and MRI (nuclear magnetic resonance imagery) for attenuation, and SPECT (Single Photon Emission Computed Tomography) or TEP (position emission tomography) for emission.

The use of position and movement micro-sensors may be used with one of the techniques, or it may replace one of them in order to provide a reference on the displacement field to be applied finally on the images obtained by emission techniques.

The advantage of the invention is obvious for pairs of measurements including an attenuation technique and a radiation emission technique, but it can also be applied to other double measurement situations.

Patent
Attorney Docket No. BRV.10002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Stéphane BONNET et al.

Application No.: Unassigned

Group Art Unit: Unassigned

Filing Date: September 30, 2004

Examiner: Unassigned

Title: Method of Reconstructing an Image With Data Acquisition According to Several Imagery Modes and Synchronisation of Image Series

Confirmation No.: Unassigned

SUBMISSION OF CERTIFIED COPY OF PRIORITY DOCUMENTS

Commissioner for Patents
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Sir:

The benefit of the filing date of the following priority foreign application in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed.

Country: France

Patent Application No.: 03 50631

Filed: October 1, 2003

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In support of this claim, enclosed is a certified copy of the foreign application. Said prior foreign application is referred to in the oath or declaration. Acknowledgement of receipt of the certified copy is requested.

Respectfully submitted,

HUTCHISON & MASON PLLC

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I hereby certify that the application/correspondence attached hereto is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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Vos références pour ce dossier: B14387JCI-DD2548	

1 NATURE DE LA DEMANDE			
Demande de brevet			
2 TITRE DE L'INVENTION			
	PROCEDE DE RECONSTRUCTION D'IMAGE AVEC ACQUISITION DE DONNEES SELON PLUSIEURS MODES D'IMAGERIE ET SYNCHRONISATION DES SERIES D'IMAGES.		
3 DECLARATION DE PRIORITE OU REQUETE DU BENEFICE DE LA DATE DE DEPOT D'UNE DEMANDE ANTERIEURE FRANCAISE	Pays ou organisation	Date	N°
4-1 DEMANDEUR			
Nom	COMMISSARIAT A L'ENERGIE ATOMIQUE		
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Code postal et ville	75752 PARIS 15ème		
Pays	France		
Nationalité	France		
Forme juridique	Etablissement Public de Caractère Scientifique, technique et Ind		
5A MANDATAIRE			
Nom	LEHU		
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Qualité	Liste spéciale: 422-5 S/002, Pouvoir général: 7068		
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Courrier électronique	brevets.patents@brevalex.com		
6 DOCUMENTS ET FICHIERS JOINTS	Fichier électronique	Pages	Détails
Texte du brevet	textebrevet.pdf	20	D 17, R 2, AB 1
Dessins	dessins.pdf	2	page 2, figures 2, Abrégé: page 1, Fig.1
Pouvoir général			

7 MODE DE PAIEMENT				
Mode de paiement	Prélèvement du compte courant			
Numéro du compte client	024			
8 RAPPORT DE RECHERCHE				
Etablissement immédiat				
9 REDEVANCES JOINTES	Devise	Taux	Quantité	Montant à payer
062 Dépôt	EURO	0.00	1.00	0.00
063 Rapport de recherche (R.R.)	EURO	320.00	1.00	320.00
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Nom ou dénomination sociale	COMMISSARIAT A L'ENERGIE ATOMIQUE
Nombre de demandeur(s)	1
Pays	FR

TITRE DE L'INVENTION

PROCEDE DE RECONSTRUCTION D'IMAGE AVEC ACQUISITION DE DONNEES SELON PLUSIEURS MODES D'IMAGERIE ET SYNCHRONISATION DES SERIES D'IMAGES.

DOCUMENTS ENVOYES

package-data.xml	Requetefr.PDF	fee-sheet.xml
Design.PDF	ValidLog.PDF	textebrevet.pdf
FR-office-specific-info.xml	application-body.xml	request.xml
dessins.pdf	indication-bio-deposit.xml	

EFFECTUE PAR

Effectué par:	J.Lehu
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Empreinte officielle du dépôt	81:81:EC:47:39:9A:7E:AB:95:B4:BE:37:30:F4:0E:63:8C:21:CD:32

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ETABLISSEMENT PUBLIC NATIONAL CREE PAR LA LOI No 51-444 DU 19 AVRIL 1951

PROCEDE DE RECONSTRUCTION D'IMAGE AVEC ACQUISITION DE DONNEES SELON PLUSIEURS MODES D'IMAGERIE ET SYNCHRONISATION DES SERIES D'IMAGES

DESCRIPTION

Cette invention ressortit à un procédé dans lequel une image d'un objet est estimée au moyen de deux séries de données, qu'on combine en faisant une synchronisation.

La prise d'images de l'intérieur d'objets et notamment d'êtres vivants peut se faire par plusieurs genres de procédés. Certains sont de nature atténuative, c'est-à-dire qu'on mesure l'atténuation d'un rayonnement traversant l'objet, et d'autres sont de nature émissive, c'est-à-dire qu'on recueille des particules ionisantes provenant d'un liquide radioactif ingéré préalablement par l'organisme à étudier. Dans les deux cas, des réseaux de détecteurs tournant autour de l'objet ou couvrant le tour de l'objet recueillent le rayonnement, et des images de l'objet sont obtenues en combinant les mesures des détecteurs prises à des angles différents selon des méthodes bien connues de reconstruction tomographique "La tomographie" sous la direction de P.Grangeat Paris : Hermès Science Publications 2002 ibsn 2.7462-0356-1).

Certaines méthodes conviennent mieux pour obtenir certains genres de résultats. De façon typique, des images obtenues par atténuation peuvent indiquer la composition de l'objet à chaque endroit et permettre ainsi de bien dessiner les organes d'un être vivant et leurs contours. Les images obtenues par émission n'ont

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généralement pas cette possibilité mais permettent de distinguer les tissus sains, qui sont faiblement émissifs, des tissus malades, cancéreux par exemple, qui sont fortement émissifs. On peut qualifier les premières images d'anatomiques et les secondes de fonctionnelles. Elles sont complémentaires et leur superposition peut aider grandement au diagnostic. L'art antérieur comprend ainsi des dispositifs pour acquérir simultanément les deux genres d'images (comme dans l'article « Attenuation correction for a combined 3D PET/CT scanner » de Kinahan et autres, Med. Phys. 25(10), octobre 1998, p.2046 - 2053).

Un aspect qu'il convient de considérer concerne le mouvement des êtres animés au cours des mesures. Il est évident que le mélange de mesures prises pendant que l'objet bouge ne peut produire que des images brouillées si aucune précaution n'est prise. On s'est beaucoup intéressé à ce problème depuis plusieurs années, et plusieurs genres de solutions ont été proposés. Les unes consistent à prendre les mesures aussi vite que possible, en recourant par exemple à un réseau de détecteurs particulièrement nombreux qui entoure complètement l'objet à étudier, au lieu de se déplacer autour de lui. Un autre procédé consiste à s'arranger pour ne prendre des mesures qu'à un état à peu près invariable de l'objet, par exemple pour un même état du cycle cardiaque ou respiratoire ou d'un autre cycle biologique périodique. La première de ces méthodes est évidemment coûteuse en matériel et la deuxième est difficile à bien appliquer, et inopérante pour des mouvements non périodiques (animal bougeant,

par exemple). Un autre genre de méthodes implique une correction numérique des mesures et des images en tenant compte du déplacement de l'objet entre chaque série de mesures. Les mouvements de l'objet sont estimés alors par des champs de déplacements de leurs points. Ces champs de déplacements peuvent être obtenus par des estimations sur des premières images en incluant éventuellement des hypothèses sur les mouvements. Cette dernière méthode est la plus susceptible de donner de bons résultats. Le brevet français 2 826 157 décrit un exemple.

Les méthodes de correction des images par estimation du champ de déplacements ont été appliquées avant tout aux images d'atténuation qui peuvent être prises rapidement et dont le contenu plus distinct donne plus de détails sur les mouvements de l'objet. Les images d'émission ont un contenu moins abondant du fait que les mesures sont plus dispersées dans le temps, et elles sont moins reconnaissables puisque les différentes catégories de tissus sont moins distinguées. Il est donc difficile de bien établir un champ de déplacements afin de s'en servir pour compenser les mouvements de l'objet et régulariser son image.

Il est pourtant proposé ici d'appliquer aux techniques d'émission une telle méthode de reconstruction d'images avec une compensation du mouvement de l'objet, grâce aux modalités ci-dessous.

Des images de l'objet sont prises à la fois par une technique d'émission et une technique d'atténuation. Les procédés ordinaires d'estimation du

mouvement sont appliqués aux images obtenues par atténuation, en reconstituant une série d'images de l'objet étudié au moyen de jeux de mesures pris à des instants respectifs et fournissant donc des images floues, si elles ne sont pas compensées en mouvement, à cause du faible mouvement de l'objet, mais bien représentatives de l'état de l'objet à des instants respectifs. Les champs de déplacements des points de l'objet pour arriver à ces premières images sont obtenus.

Ces champs de déplacements sont ensuite appliqués aux mesures prises par la technique d'émission en général après avoir été modifiés ou adaptés par des procédés qui seront détaillés dans la suite de ce document. Ainsi, ces mesures d'émission peuvent aussi être corrigées pour compenser le mouvement et obtenir une image fonctionnelle finale améliorée. Il est simplement nécessaire de synchroniser les prises des mesures par les deux techniques sur une base de temps commune.

Les installations connues dans lesquelles les deux genres d'images ont été obtenus n'utilisent aucune combinaison analogue des jeux de mesures, et recourent à une simple juxtaposition des deux genres d'images obtenues indépendamment par superposition, ou utilisent tout au plus l'image d'atténuation pour une correction d'un autre genre des mesures d'émission, en compensant les atténuations à travers l'objet étudié, qui affectent aussi ces mesures.

Quoique l'invention soit aujourd'hui utile surtout dans le contexte particulier des couples

d'acquisitions par atténuation et émission, elle peut être généralisée sans difficulté à n'importe quel couple d'acquisitions de mesures et ne saurait donc être limitée par les réalisations décrites ici.

On va maintenant décrire l'invention plus dans le détail en recourant aux figures jointes, dont la figure 1 est un organigramme général et la figure 2 un diagramme temporel.

Cette invention concernant surtout l'imagerie médicale, l'hypothèse de l'examen d'un patient sera retenue ici. Il reçoit la consigne de respirer normalement et régulièrement pendant l'examen. Dans les procédés où aucune compensation de mouvement n'est faite, on lui demande au contraire de retenir sa respiration ou de l'arrêter à même état avant chaque mesure. Il a aussi ingéré un corps radio-pharmaceutique comme le FDG (fluoro-deoxy-glucose) par injection intraveineuse. Ce corps permet de suivre le métabolisme cellulaire du glucose en technique d'émission. D'autres corps émissifs sont utilisés pour d'autres applications.

Les mesures d'atténuation et d'émission sont entreprises aux étapes Et1 et Et2 de la figure 1. Pour chacune des catégories de mesures, des jeux de mesures sont pris à des instants successifs, qui ne sont pas généralement simultanés pour les deux catégories de mesures. Il est cependant nécessaire d'accomplir une synchronisation temporelle des jeux de mesures, au sein des deux séries et entre les deux séries d'après l'étape Et3. Un procédé utile pour cela peut consister en la mesure d'un mouvement du patient

par un capteur indépendant tel qu'un capteur de respiration, un capteur de pression ou un electro-cardiogramme. Chacun des jeux de mesures est alors associé à un état déterminé du patient pendant lequel une mesure de son mouvement a été entreprise. Si cette mesure concerne un phénomène cyclique comme la respiration, les jeux de mesures peuvent être associés à des phases temporelles de ce mouvement comme le suggère le diagramme de la figure 2, dans laquelle six jeux de mesures M1 à M6 pris sur un cycle respiratoire sont associés à des phases moyennes $\varphi 1$ à $\varphi 6$.

Les étapes Et11 et Et12 de la figure 1 illustrent de telles utilisations de capteurs. Les capteurs de mouvements ou de position en général conviennent à ce procédé. Ils peuvent être en nombre quelconque. Certains peuvent être associés aux mesures d'atténuation et les autres aux mesures d'émission. Quand un jeu de mesures est pris, les capteurs associés enregistrent le signal de mouvement, etc. qu'ils reçoivent. Quand tous les jeux de mesures sont pris, des comparaisons entre les signaux enregistrés des différents capteurs permettent de placer les deux jeux de mesures à des emplacements déterminés sur une échelle de temps commune. Les instants des prises des mesures peuvent être déterminés si certains des capteurs mesurent aussi le temps, ou si un signal de mesure de temps autonome est pris et mesuré. Dans le procédé illustré, deux signaux de mesure de temps sont pris aux étapes préliminaires Et13 et Et14, et servent respectivement à déterminer les instants de prises de

mesures avec les deux techniques et les instants de prises de mesures par les capteurs.

Enfin, la synchronisation temporelle peut être assurée par des procédés de corrélation entre les projections de l'image. L'article "Kymogram detection and Kymogram-correlated image recontruction from subsecond spiral computed tomography scans of the heart", par Kachelriess et autres, Med. Phys. 29 (7), juillet 2002, p.1489 à 1503, donne un exemple.

Après ces étapes Et1, Et2 et Et3 de prise de jeux de mesures et de synchronisation temporelle, on procède à une reconstruction d'images au moins partielles du patient par états multiples selon les étapes Et4 et Et5 pour chacune des techniques de mesures. Cela signifie que chacun des jeux de mesures, tel M1, est utilisé pour donner une image particulière en supposant le patient immobile pendant toute la durée de prise du jeu de mesures. Des moyens numériques classiques comme le filtrage et la rétroprojection sont appliqués. Les images partielles ainsi obtenues sont généralement fondées sur des données trop incomplètes pour être exactes, mais elles sont tout de même assez détaillées pour être comparées entres elles et permettre de déterminer les mouvements du patient d'une phase à la suivante. On pourra plus précisément appliquer les travaux de l'art antérieur donnés ci-dessous : P. Grangeat, A. Koenig, T. Rodet and S. Bonnet, « Theoretical framework for a dynamic cone-beam reconstruction algorithm based on a dynamic particle model », Phys. Med. Biol., vol. 47, n°15, pp. 2611-2625, August 2002, pour une technique d'atténuation et

D. R Gilland, B. A. Mair, J. E. Bowsher and R.J Jaszczak, « Simultaneous reconstruction and motion estimation for gated cardiac ECT », IEEE Trans. Nucl. Sci., vol. 49, n°5, pp. 2344-2349, October 2002, pour une technique d'émission.

Les étapes Et15 et Et16 montrent que des états du patient peuvent aussi être définis à ces mêmes états d'après les renseignements fournis par les capteurs.

La synchronisation temporelle aurait pu être appliquée maintenant à ces images d'état plutôt qu'aux jeux de mesures.

Une synchronisation spatiale est entreprise à l'étape Et6. Il s'agit d'un recalage des catégories d'images au moins partielles et des renseignements des capteurs d'après lequel des points homologues, (c'est-à-dire correspondant à un même point du patient) doivent apparaître à la même position sur les deux catégories d'images. Cette étape qui permet de comparer les deux catégories d'images entre elles n'est pas originale et l'invention ne porte par sur elle.

Elle consiste à déterminer un opérateur de déformation D paramétré pour passer d'un référentiel associé aux images d'atténuation vers le référentiel associé aux images d'émission.

Cet opérateur est supposé invariant pour la durée de l'examen. On suppose également que la synchronisation temporelle est suffisamment précise et que les mouvements du patient (physiologiques) sont reproductibles.

Ainsi, on dispose à l'instant t d'une image d'atténuation f_t et d'une image d'émission g_t. On cherche ensuite à identifier l'opérateur de déformation D en assurant la cohérence entre les deux images f_t et g_t sur les points de mesure.

$$D = \arg\min \left[E_{ima}(f_t, g_t, D)\right]$$

avec

$$E_{ima}(f_t, g_t, D) = \sum \phi \left(f_t(r) - g_t[D(r)]\right)$$

ou ϕ est une fonction convexe et i désigne la position du pixel dans l'image.

Pour être général, on peut aussi introduire des mesures obtenues par des micro-systèmes qui renseignent sur la position du patient au niveau des capteurs (ou points de contrôle). On se place dans le cas où on dispose pour chaque type d'acquisition (à la fois d'atténuation et d'émission) d'images de la position de ces points de contrôle. On note h^{att} et $h^{émi}$ de tels jeux de mesure délivrés par les capteurs de position. De tels capteurs utilisent des systèmes optiques par opposition aux capteurs de mouvement qui eux se basent sur des systèmes à base d'accéléromètres.

On peut aussi envisager d'utiliser des systèmes d'imagerie pour localiser ces capteurs en jouant sur leur atténuation ou en leur incorporant des sources radioactives pour la partie émission.

Si on dispose à l'instant t de ces informations supplémentaires h_t^{att} et $h_t^{émi}$, alors on peut minimiser l'ensemble d'une seule fonctionnelle.

$$D = \arg\min \left[E_{ima}(f_t, g_t, D) + \alpha\, E_{capt}(h_t^{att}, h_t^{émi}, D)\right]$$

où α est un coefficient de pondération.

Puisque D est supposé constant pour la durée de l'examen, sa détermination n'est pas limitée à un jeu d'images à l'instant t mais bien sur l'ensemble des instants à disposition.

D peut être un mouvement solide (de translation si le patient n'est pas replacé exactement à la même hauteur, rotation si le patient s'est légèrement tourné), ou un mouvement affine par exemple. La déformation D peut être aussi interprétée par analogie aux grilles de déformation des points de contrôle des techniques de déformation de forme libre.

Le cas simple est ensuite le cas où le patient ne bouge pas entre les techniques d'atténuation et d'émission et donc où D = identité.

Les étapes suivantes Et7 et Et8 concernent l'estimation du mouvement du patient d'une phase à l'autre pour chacune des deux catégories de mesures. Ici aussi on applique des procédés connus, notamment ceux du brevet français 2 736 454 ou l'article de Gilland indiqué plus haut. On obtient des champs de déplacements de points de l'objet d'une phase à une autre. Les champs de déplacements peuvent être obtenus de façon dense pour les mesures d'atténuation qui restituent bien les détails des images. Ils ne le peuvent en général pas être avec les mesures d'émission ; on peut les compléter en utilisant d'autres informations (provenant par exemple de capteurs de mouvement situés sur le patient) ou des hypothèses sur les mouvements de l'objet, comme l'absence de déformation (les mouvements sont réduits à

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des translations et des rotations), ou une déformation sans variation de volume, ou encore une déformation obéissant à des paramètres déterminés. Les mouvements du muscle cardiaque et de la cage thoracique peuvent ainsi être utilisés simplement.

Une autre façon de compléter les champs de déplacements est plus particulière à l'invention et revêt une importance spéciale. Elle concerne les mouvements cycliques comme la respiration ou le rythme cardiaque. Les mesures d'atténuation sont en général faites rapidement, en quelques cycles respiratoire ou même un seul, alors que les mesures d'émission sont faites beaucoup plus lentement, dix minutes étant souvent nécessaires. L'invention comprend alors un regroupement des jeux de mesures, surtout des mesures d'émission, d'après les phases φ considérées dans un seul cycle du mouvement, même si ces mesures concernent en réalité des cycles différents. C'est ce qu'on a encore illustré à la figure 2, où les jeux de mesures postérieurs à ceux du premier cycle respiratoire : M7, M8, etc. seront associés aux phases $\varphi 1$ et $\varphi 2$, etc. déjà mentionnées plutôt qu'aux phases $\varphi 7$ et $\varphi 8$, etc. qui s'en déduisent par un angle de 2π ou un de ses multiples. Les images partielles réduites à un petit nombre sont plus riches en contenu.

Si ce procédé de synchronisation sur un petit nombre de phases a une grande importance pratique, elle n'est cependant pas indispensable à la mise en œuvre de cette invention, qu'on pourra appliquer à un patient subissant un mouvement quelconque, ou un mouvement cyclique.

Les étapes E17 et E18 illustrent que des champs de déplacements peuvent aussi être calculés d'après les mesures des capteurs.

L'étape suivante Et9 est une des plus importantes de l'invention. Elle consiste à obtenir un champ de déplacements dit augmenté par une synthèse des deux estimations de mouvements Et7 et Et8 obtenues précédemment et en utilisant éventuellement d'autres contributions provenant de mesures différentes ou d'hypothèses.

On expose ici le calcul du champ de déplacements augmenté en essayant cette fois d'être le plus général possible.

Pour être plus général, on peut aussi introduire des mesures de microsystèmes qui seraient en les deux obtenues soit en atténuation soit en émission soit en les deux ainsi qu'un opérateur de déformation D paramétré pour passer du référentiel en atténuation vers le référentiel en émission et pour des mouvements m_{att} dans le référentiel en atténuation et $m_{émi}$ dans le référentiel en émission PET, de telle façon que

$$m_{att}(i) = m_{emi}(D(i)) = m_{émi} \circ D^{-}(i)$$

On ajoute explicitement la formule de minimisation des informations obtenues non plus seulement par des systèmes d'imagerie mais aussi par des micro systèmes enseignant sur la position et/ou le mouvement du patient au niveau des capteurs (ou aussi à des points de contrôle).

Comme expliqué précédemment, on se place dans le cas où on dispose pour chaque acquisition en atténuation ou émission d'un jeu de mesures délivré par

ces capteurs. On distingue toutefois le cas où on dispose d'images de position délivrées par le capteur (celles utilisées pour le recalage).

$\begin{cases} h_1^{att} \\ h_1^{émi} \end{cases}$, $\begin{matrix} h_2^{att} \\ h_2^{émi} \end{matrix}$ aux instants t_1 et t_2

de celui où on dispose directement du champs de déplacement en certains points de l'espace (comme les points de contrôle)

$\begin{cases} m_{att} \\ m_{émi} \end{cases}$ entre les instants t_1 et t_2,

les deux champs étant reliés par la relation précédemment établie

$m_{att} = m_{émi} \circ D$

Finalement, on cherche à assurer la cohérence entre :

Sur les images médicales $\begin{vmatrix} (f_1, f_2, moD) & (g_1, g_2, m) \\ (mf, m_oD) & (mg, m) \end{vmatrix}$;

E1 est une fonction exprimant la cohérence entre deux images au moins partielles d'émission g1 et g2 obtenues à l'étape Et5, et le champ de déplacements m qui doit les relier, et qui peut s'exprimer par $E1(g1, g2, m)=\Sigma\phi1[g1(r)-g2(r+m(r))]$ où $\phi1$ est une fonction convexe et r désigne la position du pixel considéré sur l'image ; E9 est la connaissance a priori sur la régularité du champ de déplacements, avec par exemple $E9(m)=\Sigma\ \phi g(m(r))$; et E3 et E4 reflètent la cohérence du champ de déplacements m par rapport aux champs de déplacements estimés pour les deux techniques, selon les formules $E3(mg,m)=\Sigma\phi3(m(r)-mg(r))$ et $E4(mF,moD)=\Sigma\Phi4(moD(r)-mf(r))$. Les fonctions $\phi1$, $\phi2$, $\phi3$ et $\phi4$ sont choisies assez librement et peuvent consister en des polynômes positifs convexes,

Volkswagen Exhibit 1002, Page 59 of 885

l'essentiel étant de pouvoir trouver facilement par des procédés d'analyse numérique un champ de déplacements m qui concilie bien les résultats existants et qu'on puisse ainsi appliquer aux images au moins partielles d'émission.

En particulier, on ajoute explicitement une cohérence entre deux images d'atténuation f_1 et f_2 obtenues à l'étape Et4 et le champ de déplacements m qui doit les relier.

Sur les données des microsystèmes $\begin{vmatrix} (h_1^{att}, h_2^{att}, moD) & (h_1^{émi}, h_2^{émi}, m) \\ (m_{att}, moD) & (m_{émi}, m) \end{vmatrix}$

avec une certaine régularité sur m.

On peut minimiser l'ensemble dans une seule fonctionnelle qui serait (m, D) = arg min

$$\left\{\begin{array}{l} a\ E_1(g_1, g_2, m_{émi} + b\ E_2\ (f_1, f_2, moD) + c\ E_3(mg, m) + d\ E_4(mf, moD) \\ + e\ E_5(h_1^{émi}, h_2^{émi}, m) + f\ E_6(h_1^{att}, h_2^{att}, moD) + g\ E_7(m_{émi}, m) + h\ E_8(m_{att}, moD) \\ + i\ E_9(m) \end{array}\right\}$$

avec m, qui est le champ de déplacements augmenté.

Les inconnues sont m et les paramètres de la déformation D.

Cette déformation est justement celle qu'on recherche lors de l'étape de synchronisation spatiale.

On peut donc imaginer séparer le problème en identifiant d'abord D en assurant la cohérence entre $(h_1^{att}, h_1^{émi}, D)$, $(h_2^{att}, h_2^{émi}, D)$, etc.

Cette minimisation partielle a été décrite plus haut.

Du coup, la fonctionnelle ne porte plus que sur l'inconnue m.

Les microsystèmes peuvent jouer deux rôles :

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- mettre en correspondance les deux techniques d'acquisition ;

- lever certaines ambiguïtés sur le calcul du champ de déplacement et de trajectoire pour au moins l'une des deux techniques d'acquisition.

En tout état de cause, l'utilisation d'une autre modalité d'imagerie de référence reste nécessaire pour pallier la mauvaise résolution spatiale et la qualité d'image médiocre (bruitée et définie seulement au niveau des régions de fixation du produit radioactif) qui caractérisent les images d'émission et qui conduiraient à des champs de déplacements de mauvaise qualité pour les zones d'intérêt.

L'inutilisation de capteurs impose e=f=g=h=o et conduit à une fonctionnelle se basant uniquement sur les informations obtenues par les systèmes d'imagerie.

Dans le cas particulier où il n'y a pas de capteurs de position et/ou de mouvements, ce champ de déplacements augmenté est noté m, et les champs de déplacements obtenus aux étapes Et7 et Et8 par mf et mg, la formule peut être simplifiée et devient :

$m=\arg\min \{aE1(g1, g2,m)+bE2(f1, f2, moD)+cE3(mg,m)+dE4(mF, moD)+iEg(m)\}$;

a, b, c et d sont des coefficients de pondération.

Un cas important correspondrait à a=b=d=0 : les champs de déplacements estimés par la technique d'atténuation seraient alors appliqués tels quels aux images partielles estimées par la technique d'émission ; puisque ainsi qu'on l'a mentionné, le champ de déplacements obtenu par la technique d'atténuation est généralement beaucoup plus précis et exact.

Les champs de déplacements calculés aux étapes Et17 et Et18 peuvent aussi contribuer au calcul du champ de déplacements augmenté par le moyen d'autres coefficients de pondération. Toutefois, on doit souligner que l'utilisation de capteurs autonomes n'est pas indispensable si les jeux de mesures peuvent être placés autrement (par les étapes Et13 et Et14) dans une même échelle de temps ; les étapes Et11 et Et12, Et 15, Et16, Et 17 et Et 18 peuvent alors être supprimées du procédé.

Le procédé est complété par une exploitation de ce champ de déplacements augmenté pour reconstruire au moins une image définitive du patient d'après l'étape Et10. Pour cela, les images partielles sont combinées par addition en tenant compte des déplacements que leurs points ont subi d'une phase à l'autre afin de ne procéder à des additions que sur des états successifs des mêmes points. Des coefficients de pondération exprimant la confiance accordée à chaque point ou chaque image partielle peuvent être appliqués. L'image définitive plus nette que les images partielles (et composée d'acquisitions complètes entières du patient) est finalement obtenue. L'amélioration offerte par l'invention s'exprime avant tout sur l'image obtenue par les techniques d'émission. Si toutefois l'acquisition a été longue (c'est-à-dire effectuée sur plusieurs cycles), on ne reconstruit pas nécessairement une image unique mais une série d'images correspondant chacune à un état du cycle respiratoire (par exemple), et on applique l'estimation des champs de déplacements augmenté et la compensation du mouvement à ces images

d'état. Une telle façon de procéder réduit l'influence d'un mouvement cyclique d'ensemble du patient et peut donner des résultats de meilleure qualité qu'une image unique obtenue avec tous les jeux de mesures cumulés sur le cycle et qui permettrait de mieux réduire le bruit des mesures par rapport au signal utile, mais produirait du flou dû à ce mouvement d'ensemble.

Les images de la technique d'émission peuvent encore être corrigées, de façon connue, par une correction des données d'émission corrigées ou non en mouvement, d'après l'atténuation qu'elles ont subie et qu'on peut déduire des images d'atténuation.

Des techniques d'atténuation et d'émission qui pourraient recevoir l'invention sont le CT (Tomographie à rayon x) ou l'IRM (Imagerie par résonance magnétique nucléaire) pour l'atténuation, et le SPECT (Single Photon Emission Computed Tomography) ou le TEP (tomographie à émission de positions). Pour l'émission.

L'utilisation de micro-capteurs de position et de mouvement peut venir compléter une des technique ou se substituer à elle afin de fournir une référence sur le champ de déplacements à appliquer à la fin sur les images obtenues par les techniques d'émission.

L'intérêt de l'invention est évident pour les couples de mesures comprenant une technique d'atténuation et une technique d'émission de rayonnement, mais celle-là peut aussi être appliquée à d'autres situations de double mesure.

REVENDICATIONS

1. Procédé de reconstruction d'images d'un objet mobile par une première technique d'acquisition de mesures, comprenant une reconstruction d'images au moins partielles de l'objet à des états respectifs de mouvement de l'objet, une estimation du mouvement de l'objet entre les états et une combinaison des images d'états en faisant des compensations du mouvement de l'objet d'après l'estimation, caractérisé en ce que l'estimation du mouvement de l'objet utilise au moins partiellement d'autres images de l'objet, obtenues pour lesdits états, par une deuxième technique d'acquisition de mesures.

2. Procédé de reconstruction d'images selon la revendication 1, caractérisé en ce que la reconstruction d'images au moins partielles de l'objet à des états respectifs de mouvement de l'objet comporte une étape de synchronisation temporelle appliquée aux mesures issus de la première technique d'acquisition et aux mesures issues de la deuxième technique d'acquisition.

3. Procédé de reconstruction d'images selon la revendication 2, caractérisé en ce que l'estimation du mouvement de l'objet entre les états comporte une étape de synchronisation spatiale appliquée aux images au moins partielles de l'objet à des états respectifs de mouvement de l'objet.

4. Procédé de reconstruction d'images selon la revendication 1, 2 ou 3, caractérisé en ce que la première technique d'acquisition de mesures est une technique d'imagerie fonctionnelle d'émission de

rayonnement et la deuxième technique d'acquisition des mesures est une technique d'imagerie anatomique d'atténuation de rayonnement.

5. Procédé de reconstruction d'images selon la revendication 1 à 4, caractérisé en ce qu'il comprend une mesure d'un élément cyclique du mouvement de l'objet pour synchroniser les états sur des états périodiques de l'élément cyclique.

6. Procédé de reconstruction d'images selon la revendication 5, caractérisé en ce que les états périodiques regroupent des mesures faites sur plusieurs phases associées à différentes périodes de l'élément cyclique du mouvement, au moins pour les mesures acquises par la première technique.

7. Procédé de reconstruction d'images selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il comporte l'emploi de capteurs autonomes de mouvement ou de position pour évaluer le mouvement de l'objet et/ou placer les mesures par les deux techniques d'acquisition et les états de l'objet sur une échelle de temps commune.

8. Procédé de reconstruction d'images selon la revendication 7, caractérisé en ce que le mouvement de l'objet est compensé aussi avec le mouvement évalué par les capteurs autonomes.

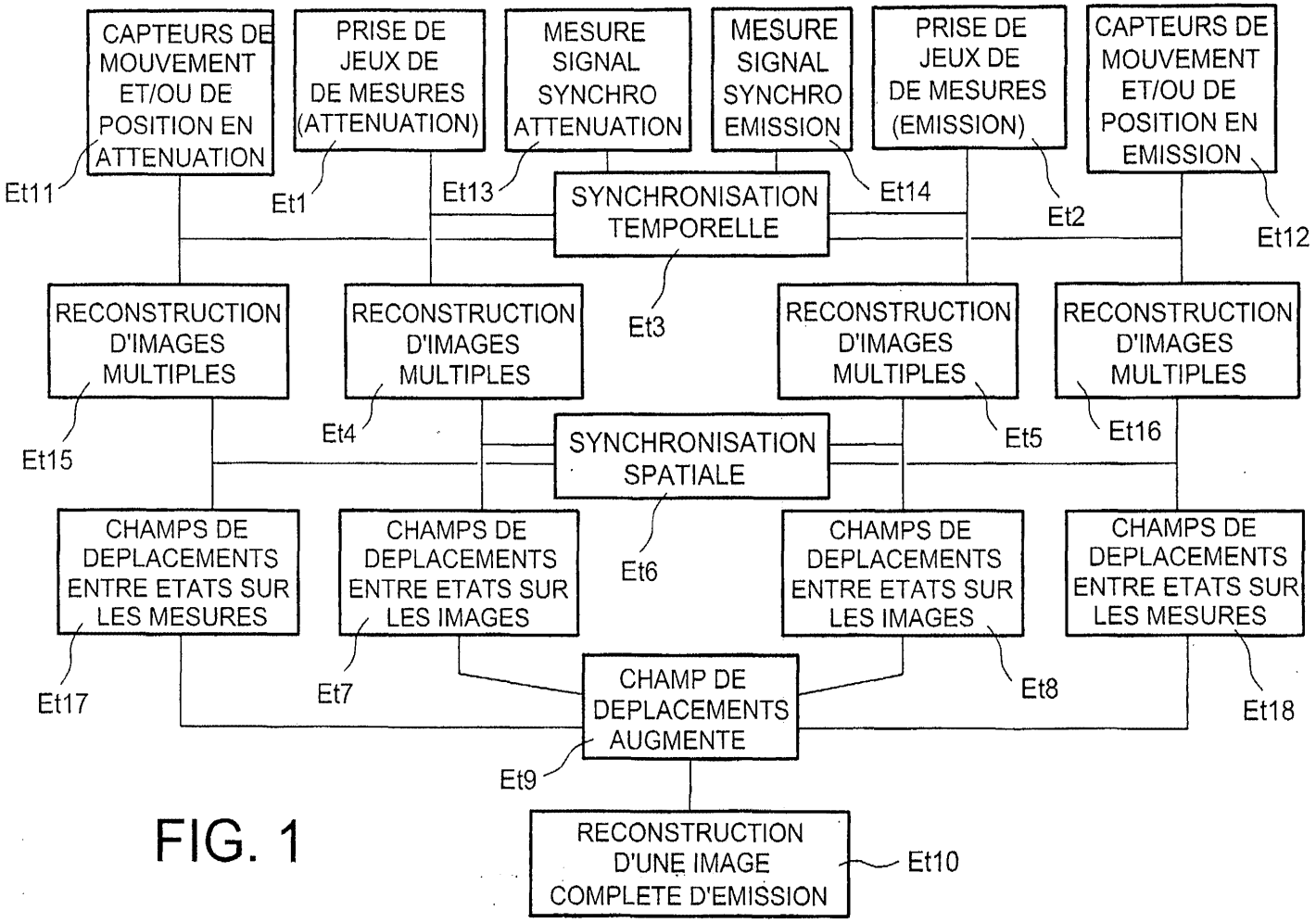


FIG. 1

B.14387

1 / 2

1er dépôt

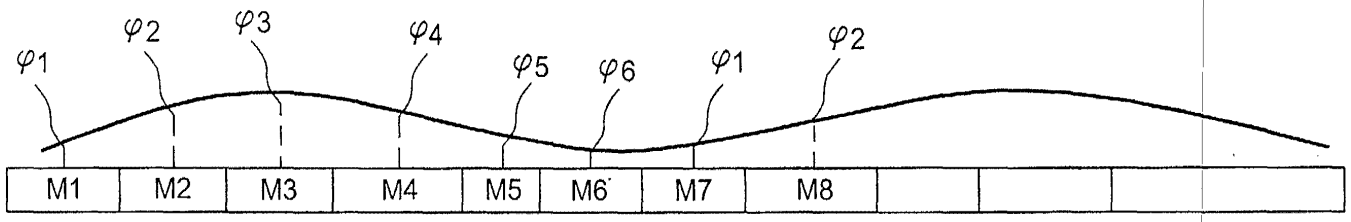


FIG. 2

1er dépôt

reçue le 17/10/03

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DÉPARTEMENT DES BREVETS

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Téléphone : 33 (1) 53 04 53 04 Télécopie : 33 (1) 42 94 86 54

BREVET D'INVENTION
CERTIFICAT D'UTILITÉ

Code de la propriété intellectuelle - Livre VI

cerfa N° 11235*03

DÉSIGNATION D'INVENTEUR(S) Page N° 1../1..

INV

(À fournir dans le cas où les demandeurs et les inventeurs ne sont pas les mêmes personnes)

Cet imprimé est à remplir lisiblement à l'encre noire

DB 113 @ W / 270601

Vos références pour ce dossier *(facultatif)*	B 14387.3/JCI DD2548VR
N° D'ENREGISTREMENT NATIONAL	03.50631 DU 01.10.2003

TITRE DE L'INVENTION (200 caractères ou espaces maximum)

PROCEDE DE RECONSTRUCTION D'IMAGE AVEC ACQUISITION DE DONNEES SELON PLUSIEURS MODES D'IMAGERIE ET SYNCHRONISATION DES SERIES D'IMAGES

LE(S) DEMANDEUR(S) :

COMMISSARIAT A L'ENERGIE ATOMIQUE
31-33 rue de la Fédération
75752 PARIS 15 ème.

DESIGNE(NT) EN TANT QU'INVENTEUR(S) :

1 Nom		BONNET
Prénoms		Stéphane
Adresse	Rue	42 rue Claude Genin
	Code postal et ville	38100 GRENOBLE
Société d'appartenance *(facultatif)*		
2 Nom		GRANGEAT
Prénoms		Pierre
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Société d'appartenance *(facultatif)*		
3 Nom		
Prénoms		
Adresse	Rue	
	Code postal et ville	
Société d'appartenance *(facultatif)*		

S'il y a plus de trois inventeurs, utilisez plusieurs formulaires. Indiquez en haut à droite le N° de la page suivi du nombre de pages.

DATE ET SIGNATURE(S)
DU (DES) DEMANDEUR(S)
OU DU MANDATAIRE
(Nom et qualité du signataire)

PARIS LE 13 OCTOBRE 2003

J. LEHU
422-5/S002

La loi n°78-17 du 6 janvier 1978 relative à l'informatique, aux fichiers et aux libertés s'applique aux réponses faites à ce formulaire. Elle garantit un droit d'accès et de rectification pour les données vous concernant auprès de l'INPI.

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/955,037	09/30/2004	Stephane Bonnet	BRV.10002

CONFIRMATION NO. 4535

45473
HUTCHISON & MASON PLLC
PO BOX 31686
RALEIGH, NC 27612

FORMALITIES LETTER

Date Mailed: 08/19/2005

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is unsigned.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.16(f) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$130** for a Large Entity

- **$130** Surcharge.

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

Office of Initial Patent Examination (703) 308-1202

PART 3 - OFFICE COPY

B 14387.3 JCI



Attorney Docket No. _____

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY OR DESIGN PATENT APPLICATION

I [illegible] declare that:

Each inventor's residence, mailing address, and citizenship are as stated below next to their name.

I believe the inventor(s) named below to be the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES

the specification of which

☐ is attached hereto

OR

☒ was filed on September 30, 2004 as United States Application Number or PCT International Application Number 10/955,037 and was amended on (mm/dd/yyyy) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (mm/dd/yyyy)	Priority Claimed?
03 50631	FRANCE	01 OCTOBER 2004	☒ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
☐ Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.			

I hereby appoint the attorneys and agents associated with the following PTO Customer Number of Hutchison & Mason PLLC to prosecute the application identified above and to transact all business in the United States Patent and Trademark Office connected therewith:

Address all correspondence to:

Customer Number: 45473
Hutchison & Mason PLLC
P.O. Box 31686
Raleigh, North Carolina 27612
(919) 829-9600

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.	
FULL NAME OF SOLE OR FIRST INVENTOR	BONNET Stéphane
Signature	March 16, 2005
Date	
Residence (City, State, Country)	SEYSSINET-PARISET - FRANCE
Citizenship	française
Mailing Address	20, rue de Pacalaire
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FULL NAME OF SECOND INVENTOR	GRANGEAT Pierre
Signature	March 16, 2005
Date	
Residence (City, State, Country)	SAINT ISMIER - FRANCE
Citizenship	française
Mailing Address	136, allée des Vignes du Persan
City, State, ZIP, Country	38330 SAINT ISMIER - FRANCE
FULL NAME OF THIRD INVENTOR	
Signature	
Date	
Residence (City, State, Country)	
Citizenship	
Mailing Address	same as residence
City, State, ZIP, Country	same as residence

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CONFIRMATION NO. 4535

45473
HUTCHISON & MASON PLLC
PO BOX 31686
RALEIGH, NC 27612

FORMALITIES LETTER

Date Mailed: 08/19/2005

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

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- The oath or declaration is unsigned.

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SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$130** for a Large Entity

- **$130** Surcharge.

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09/13/2005 NNGUYEN1 00000021 503218 10955037

01 FC:1051 130.00 DA

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PART 2 - COPY TO BE RETURNED WITH RESPONSE

OIPE IAP88
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PATENT & TRADEMARK OFFICE

Patent
Attorney Docket No. BRV.10002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Stephane BONNET et al.	Mail Stop: Missing Parts
Application No.: 10/955,037	Group Art Unit: 2882
Filing Date: September 30, 2004	Examiner: Unassigned
Title: Method of Reconstructing an Image With Data Acquisition According to Several Imagery Modes and Synchronisation of Image Series	Confirmation No.: 4535

TRANSMITTAL LETTER FOR MISSING PARTS OF APPLICATION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In complete response to the Notice to File Missing Parts of Application filed under 37 C.F.R. § 1.53(b) dated August 19, 2005 (a copy of which is enclosed), the following items are enclosed:

☒ Combined Declaration/Power of Attorney signed by the inventor(s);

☒ The surcharge of $130.00 as set forth in 37 C.F.R. § 1.16(e);

☒ Information Disclosure Statement and PTO- 1449;

☒ Please charge $130.00 to Deposit Account No. 50-3218 for the fee due for missing parts.

The Director is hereby authorized to charge any appropriate fees that may be required by this paper, and to credit any overpayment, to Deposit Account No. 50-3218. This paper is submitted in duplicate.

Respectfully submitted,

HUTCHISON & MASON PLLC

Date: 9/6/05

By: Mary B. Grant
Mary B. Grant
Registration No. 32,176

P.O. Box 31686
Raleigh, NC 27612
+1.919.829.9600

I hereby certify that this correspondence is being facsimile transmitted to the United States Patent and Trademark Office or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on 09/07/2005

Jennie Snead
(Typed Name of Person Signing Certificate)

Snead
(Signature of Person Signing Certificate)

Date of Signing: 09/07/2005

OIPE IAP88
SEP 12 2005
PATENT & TRADEMARK OFFICE

Patent
Attorney Docket No. BRV.10002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Stephane BONNET et al.

Application No.: 10/955,037 | Group Art Unit: 2882

Filing Date: September 30, 2004 | Examiner: Unknown

Title: Method of Reconstructing an Image With Data Acquisition According to Several Imagery Modes and Synchronisation of Image Series | Confirmation No.: 4535

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In accordance with the duty of disclosure as set forth in 37 C.F.R. § 1.56, Applicants hereby submit the following information in conformance with 37 C.F.R. §§ 1.97 and 1.98. A copy of each of the documents cited and required by 37 C.F.R. § 1.98 is enclosed.

Some of the listed documents were cited in a Search Report from the French Patent Office in a corresponding prior application, a copy of which is enclosed

This Information Disclosure Statement contains information which is not in the English language. In accordance with MPEP § 609 IIIA(3), English language equivalent applications have been provided, where applicable.

To assist the Examiner, the documents are listed on the attached form PTO/SB/08. It is respectfully requested that an Examiner initialed copy of this form be returned to the undersigned.

The cited documents are being submitted within three (3) months of the filing or entry of the national stage of this application or before the first Office Action on the merits, whichever is later. Since these documents are being filed within the time period set forth in 37 C.F.R. § 1.97(b), no fee or statement is required.

The Director is hereby authorized to charge any appropriate fees that may be required by this paper, and to credit any overpayment, to Deposit Account No. 50-3218.

Respectfully submitted,

HUTCHISON & MASON PLLC

Date: 9/6/05

By: Mary B. Grant
Mary B. Grant
Registration No. 32,176

P.O. Box 31686
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S Snead
(Printed Name of Person Signing Certificate)

S Snead
(Signature of Person Signing Certificate)

Date of Signing: 09/07/2005

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

SEP 12 2005
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Sheet 1 of 1

Complete if Known	
Application Number	10/955,037
Filing Date	September 30, 2004
First Named Inventor	BONNET, Stephane
Group Art Unit	2882
Examiner Name	Unknown
Attorney Docket No: BRV.10002	

US PATENT DOCUMENTS			
Examiner Initial *	**USP Document Number**	**Publication Date**	**Name of Patentee or Applicant of cited Document**
	US-2003-0004405-A1	01/02/2003	TOWNSEND, David W., et al.
	US-2004-170246-A1	09/02/2004	KOENIG, Anne , et al.
	US-5,889,525	03/30/1999	DE MURCIA, Jérôme , et al.

FOREIGN PATENT DOCUMENTS				
Examiner Initials*	**Foreign Document No**	**Publication Date**	**Pages,Columns,Lines,Where Relevant Passages or Relevant Figures Appear**	**Abstract, Translation, English Language Equivalent or Search Report**
	EP-1 087 337	03/28/2001		
	FR-2736454	01/10/1997		X
	FR-2826157	12/20/2002		X
	WO-01/80184	10/25/2001		

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS		
Examiner Initials*	**Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.**	**Abstract, Translation, English Language Equivalent or Search Report**
	GILLAND, DAVID R.,et al.,"Simultaneous Reconstruction and Motion Estimation for Gated Cardiac ECT", IEEE Trans. on Nuclear Science 49(5):2344-2349 (Oct. 2002)	
	GRANGEAT, PIERRE ,et al.,"Theoretical framework for a dynamic cone-beam reconstruction algorithm based on a dynamic particle model", Phys. Med. Biol. 47:2611-2625 (2002)	
	KACHELRIESS, MARC ,et al.,"Kymogram detection and kymogram-correlated image reconstruction from subsecond spiral computed tomography scans of the heart", Med. Phys. 29(7):1489-1503 (July 2002)	
	KINAHAN, P. E.,et al.,"Attenuation correction for a combined 3D PET/CT scanner", Med. Phys. 25(10):2046-2053 (Oct. 1998)	

EXAMINER **DATE CONSIDERED**

Substitute Disclosure Statement Form (PTO-1449)

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional) 2 Applicant is to place a check mark here if English language Translation is attached

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(54) Process for reconstructing a tri-dimensional image of a moving object

(57) A process for reconstructing a tri-dimensional image of an object moving with a substantially cyclic motion, for example the vessels of the human heart, in which, for an acquisition duration extending over several cycles of the movement of the object, an acquisition of a plurality of initial digital radiographic images is performed using a snapshot apparatus rotating around the object. Initial images having the same temporal occurrence in the course of each cycle are selected respectively in successive cycles so as to form a group of images which is associated with this same temporal occurrence. Several different groups of initial images corresponding respectively to several different temporal occurrences are formed. An intermediate tri-dimensional representation of the object is reconstructed on the basis of each group of initial images and of an iterative image reconstruction algorithm. A law of spatial deformation between two intermediate tri-dimensional representations is formulated on the basis of the two intermediate tri-dimensional representations corresponding to two successive temporal occurrences, and a final tri-dimensional representation of the object is reconstructed on the basis of the initial images successively acquired, of the spatial deformation laws successively formulated and of an iterative image reconstruction algorithm.

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Description

[0001] The invention relates to the reconstruction of a tri-dimensional image of a moving object, in particular moving with a substantially cyclic motion.

[0002] The invention finds a particularly interesting application in the medical field, in which the reconstruction of the internal structures of patients under examination, in particular the reconstruction of images of vessels of the heart, is undertaken.

[0003] The invention can however find applications in other fields, especially in industrial non-destructive testing in which examinations of the same type as medical examinations are carried out.

[0004] The tri-dimensional reconstruction of images is generally performed on the basis of bi-dimensional projected images of the object. However, difficulties arise in this image reconstruction when the object is moving, as is the case for the heart.

[0005] Another difficulty encountered in the reconstruction of tri-dimensional images on the basis of bi-dimensional images resides in the difficulty of matching between the images, that is to say of being able to tag with minimum error the same elements of the object, for example certain vessels, from one image to another. The difficulty is further increased here owing to the movement of the object, for example the heart.

[0006] Certain reconstruction techniques require the intervention of the user, in this instance the doctor, to solve the matching problems more easily.

[0007] he invention proposes a fully automatic reconstruction of images of a moving object, and which requires minimum, or even zero interaction with the doctor.

[0008] In an embodiment of the invention, there is proposed a process for reconstructing a tri-dimensional image of an object moving with a substantially cyclic motion, for example the vessels of the human heart, in which, for an acquisition duration extending over several cycles of the movement of the object, an acquisition of a plurality of initial digital radiographic images is performed using a snapshot apparatus rotating around the object. Initial images having the same temporal occurrence in the course of each cycle are selected respectively in successive cycles in such a way as to form a group of images which is associated with this same temporal occurrence. Several different groups of initial images corresponding respectively to several different temporal occurrences are formed. An intermediate tri-dimensional representation of the object is reconstructed on the basis of each group of initial images and of an iterative image reconstruction algorithm. A law of spatial deformation between two intermediate tri-dimensional representations is formulated on the basis of the two intermediate tri-dimensional representations corresponding to two successive temporal occurrences, and a final tri-dimensional representation of the object is reconstructed on the basis of the initial images successively acquired, of the spatial deformation laws successively formulated and of an iterative image reconstruction algorithm.

[0009] An embodiment of the invention makes it possible ultimately to obtain a tri-dimensional representation of the object which takes its movement into account. The user, in this instance the doctor, can then easily be provided, on his screen, with a projected bi-dimensional image of this object on the basis of the final tri-dimensional representation obtained. Moreover, given that successive laws or models of spatial deformation corresponding to different temporal occurrences have moreover been formulated, it is also possible to provide the user, for example the doctor, with projected bi-dimensional images of the object, and especially of certain vessels, at successive time instants.

[0010] Stated otherwise, the process according to the invention allows the reconstruction of an image in "four" dimensions, namely a tri-dimensional image furthermore assigned a time parameter.

[0011] The selection, in the successive cycles, of the images having the same temporal occurrence can be performed by using an auxiliary control signal representative of the cyclic motion of the object. Thus, it will be possible to use a physiological signal such as for example an electrocardiogram representative of the movement of the heart and making it possible to determine accurately the cycles of the cardiac movement.

[0012] The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:-

Figure 1 illustrates an acquisition of digital radiographic images in a cardiac application, and

Figures 2 to 4 very schematically illustrate the various steps making it possible to obtain the final tri-dimensional representation of the object.

[0013] Although the invention is not limited thereto, the application of the process according to the invention to the reconstruction of an image of vessels VS of the heart OBJ of a patient will now be described.

[0014] In Figure 1, the references PVi designate various snapshots acquired by rotating Rot an X-ray source (not represented here for the sake of simplification) around the chest of the patient.

[0015] Each initial image acquired IMi is obtained on the basis of a bi-dimensional radiation detector, for example of the luminance amplifier type used in radiology, disposed opposite the X-ray tube in a projection plane.

[0016] In the case of an X-ray imaging system composed of an X-ray source and a bi-dimensional detector, the geometrical operation involved in producing the image acquired is a conical projection of an analysed object deployed in a three-dimensional space, onto a two-dimensional space which is that of the projection

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plane corresponding to the detection plane. The calibration of an imaging system, that is to say the operation which culminates in accurate indirect knowledge of the geometrical parameters which are involved in producing an image is conventional and well known to the person skilled in the art.

[0017] As illustrated in Figure 1, a continuous acquisition is performed for a predetermined duration, for example 5 seconds, corresponding to 5 cycles CYC1-CYC5 of the movement of the heart. With an acquisition rate of 10 images per second, substantially 10 acquired initial images are therefore obtained per cycle of the cardiac movement.

[0018] The cycles of the cardiac movement are tagged by using an auxiliary control signal ECG, which can be in this instance an electrocardiogram. The systolic and diastolic phases of the movement of the heart are thus determined in particular.

[0019] Once the acquisition of the initial images has been performed, an initial image, whose temporal occurrence is the same for all the cycles, is selected in each cycle. For example, the first initial image IM1 after the start of the cycle of the cardiac movement is selected. 5 initial images IM1 (Figure 2) are then obtained on the basis of which a reconstruction of an intermediate tri-dimensional representation of the vessels VS of the heart is performed using an iterative image reconstruction algorithm. The principle of such an iterative image reconstruction algorithm is fully known to the person skilled in the art and has already formed the subject of numerous publications. Mention will be made in particular of the article by Gordon, Bender, and Herman entitled "Algebraic reconstruction technique for tri-dimensional electron microscopy and X-ray photography", Journal of Theol. Biol. 29, pages 9471 to 781 (1970) or else French patent applications no. 89 03606 or 89 16906.

[0020] The process for reconstructing a tri-dimensional image of an object as described in French patent application no. 2 752 975 can also be implemented.

[0021] The person skilled in the art will be able to refer to these prior art documents for further details regarding a mode of implementation of the image reconstruction algorithm and/or the phase for calibrating the snapshot apparatus.

[0022] At the conclusion of this intermediate reconstruction step, a first intermediate tri-dimensional representation of the blood vessels of the heart RT1 is obtained. The same operations are performed with the images IM2, each initial image IM2 of the cycle being the second initial image acquired after the start of the cycle. A second intermediate tri-dimensional representation RT2 is then obtained.

[0023] The same operations are preferably performed for each image of the cycle so as finally to obtain in the present case 10 tri-dimensional intermediate representations.

[0024] The next step consists, as illustrated in Figure 3, in formulating for two successive intermediate tri-dimensional representations RT1 and RT2 for example, a law of spatial deformation making it possible to formulate a model of deformation between the two tri-dimensional representations RT1 and RT2. The same operations are performed in a general manner so as to obtain between two successive intermediate representations RTi and RTj a model of geometrical deformation LDij.

[0025] By way of example, one manner of obtaining such a law of spatial deformation, representative of the movement of the heart between two successive temporal occurrences, can be performed by a conventional technique for tracking elements of interest (for example a specific vessel) between the various successive tridimensional representations.

[0026] Such matching techniques are for example described in the article by Singh A. and Allen P.K. entitled "Image flow computation: an estimation theoretic Framework and a unified perspective", Computer Vision Graphics and Image Processing, Vol. 56, number 2, September 1992, pages 152-177. The person skilled in the art may optionally refer thereto.

[0027] Once all the spatial deformation laws have been obtained, a final tri-dimensional representation RTF of the vessels of the heart is reconstructed by applying the iterative image reconstruction algorithm and this time using all the initial images acquired IMi in the course of the total duration of acquisition. Moreover, the iterative image reconstruction algorithm will successively take into account, from one initial image to another, the corresponding spatial deformation law previously formulated in such a way as ultimately to obtain a correct representation of the vessels of the heart, given the latter's movement.

[0028] From a hardware point of view, in addition to the conventional snapshot apparatus, the device allowing the implementation of the process includes a computer implementing the various software means such as the iterative image reconstruction algorithm and equipped with a screen for displaying the final projected images obtained on the basis of the final tri-dimensional representation.

[0029] Moreover, although all the initial images of the cycle have been taken into account so as to formulate as many intermediate tri-dimensional representations, it would have been possible to take just one out of two, or one out of three into account so as to formulate fewer intermediate representations. This would however have led to less accurate spatial deformation laws.

Claims

1. A process for reconstructing a tri-dimensional image of an object moving with a substantially cyclic motion, in which, for an acquisition duration extending over several cycles of the movement of the object, an acquisition of a plurality of initial dig-

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ital radiographic images (IMi) is performed using a snapshot apparatus rotating around the object, initial images having the same temporal occurrence in the course of each cycle are selected respectively in successive cycles in such a way as to form a group of images which is associated with this same temporal occurrence, several different groups of initial images corresponding respectively to several different temporal occurrences are formed, an intermediate tri-dimensional representation of the object (RTi) is reconstructed on the basis of each group of initial images and of an iterative image reconstruction algorithm, a law of spatial deformation (LDIj) between two intermediate tri-dimensional representations is formulated on the basis of the two intermediate tri-dimensional representations corresponding to two successive temporal occurrences, and a final tri-dimensional representation of the object is reconstructed on the basis of the initial images successively acquired, of the spatial deformation laws successively formulated and of an iterative image reconstruction algorithm.

2. The process according to claim 1 wherein the images having the same temporal occurrence are selected in successive cycles by using an auxiliary control signal (ECG) representative of the cyclic motion of the object.

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FIG.1

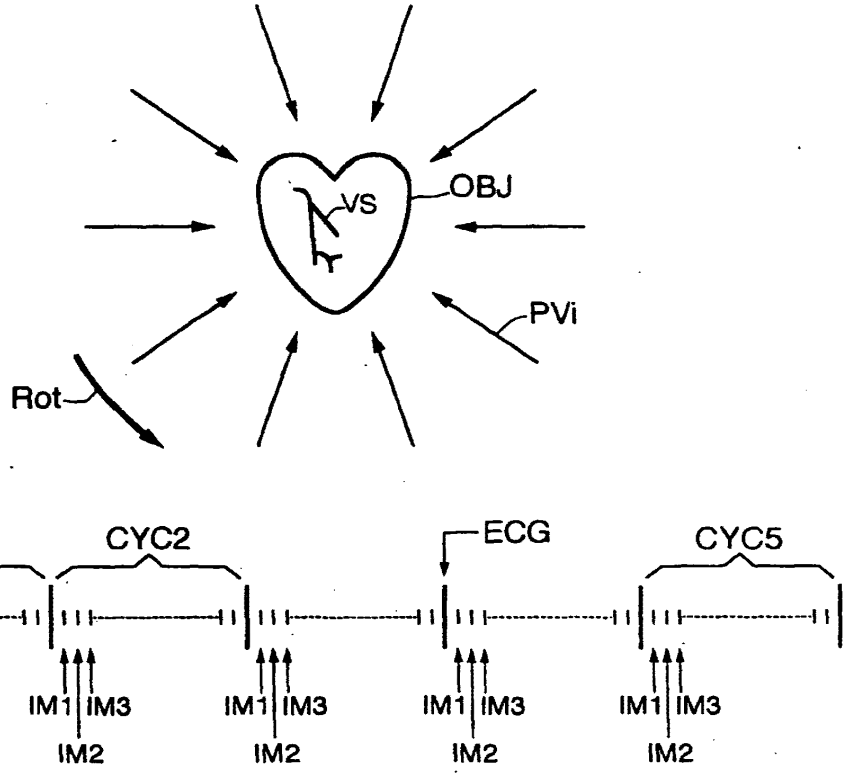
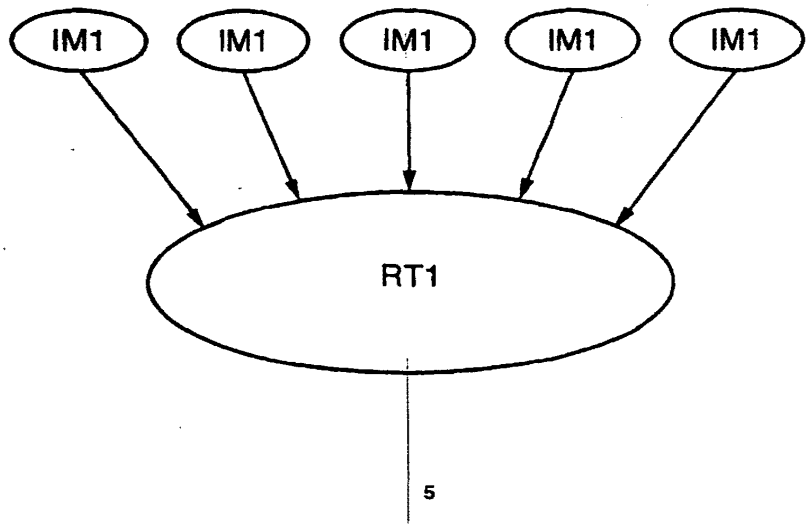


FIG.2



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FIG.3

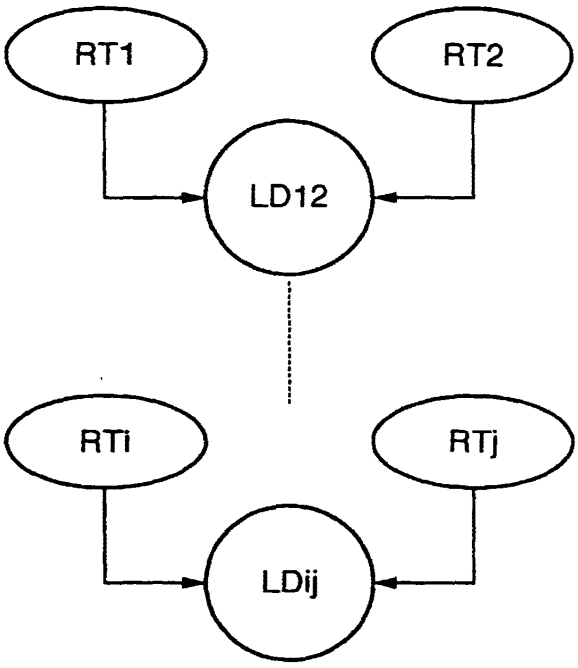
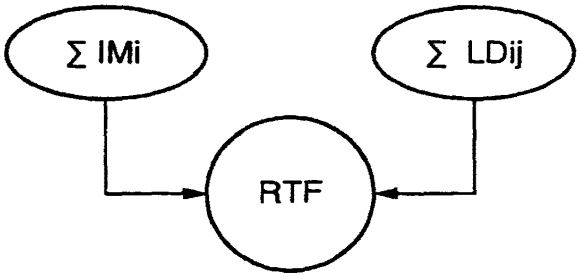


FIG.4



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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 30 7918

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 406 478 A (DELAGENIERE SOLANGE ET AL) 11 April 1995 (1995-04-11) * claims 1,2; figure 2 *	1	G06T11/00
Y	WO 99 07283 A (ELSCINT LTD ;NAHALIEL EHUD (IL); RUIMI DAVID (IL)) 18 February 1999 (1999-02-18) * claims 1,27,28 *	2	
X Y	US 5 889 525 A (GRANGEAT PIERRE ET AL) 30 March 1999 (1999-03-30) * claim 4; figure 2 *	1 2	
Y	US 5 383 231 A (YAMAGISHI ICHIRO) 17 January 1995 (1995-01-17) * claims 1,2 *	2	
A	DE MURCIA J ET AL: "Spatio-temporally regularized reconstruction of gated SPECT myocardial image sequences" PROCEEDINGS. INTERNATIONAL CONFERENCE ON IMAGE PROCESSING (CAT. NO.96CH35919), PROCEEDINGS OF 3RD IEEE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING, LAUSANNE, SWITZERLAND, 16-19 SEPT. 1996, pages 721-724 vol.2, XP002139670 1996, New York, NY, USA, IEEE, USA ISBN: 0-7803-3259-8 * page 721, left-hand column, paragraph 1 - right-hand column, paragraph 2 *	1,2	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
G06T

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 November 2000	Perez Molina, E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 7918

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02-11-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5406478 A	11-04-1995	FR 2701135 A	05-08-1994
		DE 69421303 D	02-12-1999
		DE 69421303 T	18-05-2000
		EP 0611181 A	17-08-1994
		IL 108425 A	31-10-1996
		JP 6274627 A	30-09-1994
WO 9907283 A	18-02-1999	NONE	
US 5889525 A	30-03-1999	FR 2736454 A	10-01-1997
		EP 0752684 A	08-01-1997
		IL 118786 A	17-08-1999
		JP 9043354 A	14-02-1997
US 5383231 A	17-01-1995	JP 5003867 A	14-01-1993

EPO FORM P0459

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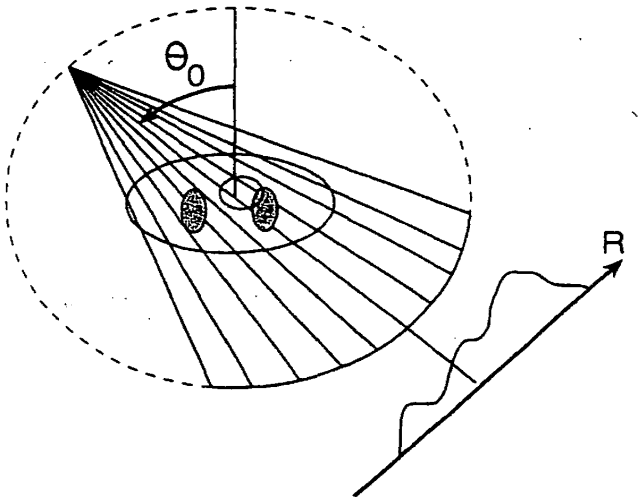
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Published:
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: RECONSTRUCTION OF COMPUTED TOMOGRAPHIC IMAGES USING INTERPOLATION BETWEEN PROJECTION VIEWS



(57) Abstract: An approach to image reconstruction provides enhanced image quality from limited projection data, particularly when the imaging object (or a portion of interest) is in motion during the tomographic projection data collection process. An interpolated projection view is generated from existing projection views between which an additional relationship exists by virtue of being respectively based on data collected in different data acquisition cycles. The existing projection views may represent an imaging object in consecutive data acquisition cycles or in separated data acquisition cycles or in both. The present invention provides a technique for combining the existing projection views into an interpolated projection view by interpolation in time. A further aspect of the invention provides an approach for selecting a reconstruction range for projection data representing the imaged object and covering a plurality of projection ranges. The disclosed approach allows a separation measure to be determined for the projection data for each reconstruction range. The selected reconstruction range is chosen based on the separation measures. Particular advantages are thereby obtained for cardiac imaging.

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RECONSTRUCTION OF COMPUTED TOMOGRAPHIC IMAGES USING INTERPOLATION BETWEEN PROJECTION VIEWS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is related to Provisional Application U.S. Serial No. 60/166,499, filed November 19, 1999 and Provisional Application U.S. Serial No. 60/197,208, filed April 19, 2000 in the U.S. Patent and Trademark Office, the contents of which are incorporated herein by reference, and the benefit of priority to which is claimed under 35 U.S.C. §119(e).

BACKGROUND OF THE INVENTION

This invention relates to generation of computed tomographic images. More particularly, the invention relates to reconstruction of such images through use of interpolated projection views generated by interpolating between existing projection views.

Computed tomography (CT) is an imaging technology in which an array of detectors generates data from energetic rays transmitted through or emitted from an imaged subject. For example, a transmission-type medical CT imaging system uses an array of x-ray detectors to detect an x-ray beam that has passed through the body of a human or animal subject. The attenuation of the beam by the subject causes the collected data, including the effects of the attenuation, to contain information about the interior structure of the subject. The detector data are processed by a computer system to generate image data representing a recognizable view of that interior structure.

CT techniques are valuable in a wide range of application areas where noninvasive and nondestructive examination of internal structures is needed. Medical applications include imaging of emissions from radioactive substances introduced into the subject (single photon emission CT, positron emission CT, etc.), as well as x-

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ray transmission CT. Non-medical applications include, for example, non-destructive testing and inspection, mineral deposit mapping (microseismic CT imaging), and three-dimensional image generation in electron microscopy.

A CT system generates a display image from data representing measurements of energetic signals transmitted through or emitted from a subject in a range of directions. This process is "tomographic" in that structural details of a subject are represented as a cross-sectional view along a given plane through the subject. The process is "computerized" because the raw detector data indirectly represent a view of the subject. Intensive data processing is required to convert the raw data into a recognizable view of the internal features of the subject.

Computer processing of the collected data is performed because the data correspond to mere projections of the subject structure along various different paths. The term "projection data" will be used herein for such CT data, irrespective of the application area in which the CT imaging procedure is used. The differences between the projection data for different paths through the imaged subject, in relation to the spatial separation of the paths, indirectly contain information about the interior structure of the object.

A CT reconstruction algorithm is applied to the projection data to generate image data that specify the image to be displayed. The image data are generated from the structure information indirectly represented by the projections. This is possible in view of the Fourier Slice Theorem, which states generally that a projection view of an imaged subject is related by Fourier transformation to the spatial structure of the subject. More specifically, and with reference to the canonical form of the Fourier Slice Theorem for parallel beam projection data, the Fourier transform of a parallel projection at a given view angle θ is equivalent to a one-dimensional "slice" of the two-dimensional Fourier transform of the imaged subject, taken at the same angle θ in the frequency domain.

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The Fourier Slice Theorem allows the image to be reconstructed by Fourier transforming the projection views, assembling the transforms into a two-dimensional Fourier transform, and applying inverse Fourier transformation to the result. Of course, in practical applications this process may be implemented by some form of filtered back-projection or (for diffracting sources) filtered back-propagation. The salient point is that the reconstruction process relies upon the projection views that are available. It is a commonplace fact that the resolution of the generated image will depend on the spacing of the projection views in θ: the more projection views that are taken, the greater the resolution of the resulting image.

This dependence in CT imaging on data resolution in θ (angular direction) is the source of a persistent problem that will be termed here the "missing projection views" problem. An insufficient number of projection views for a desired level of image resolution can arise in many situations. For example, the data for some projection views may be corrupted, or the level of desired resolution may exceed the maximum resolution possible with the given discretization in θ.

A typical solution for data corruption is to repeat the entire data acquisition process, i.e., to throw out the entire set of projection data. Further, where θ discretization has been too coarse, the simplest solution has been to collect more projection views. More data, to provide a finer level of resolution in θ, requires more intensive computation and also entails longer data acquisition cycles. In some situations, constraints imposed by the subject to be imaged, the imaging environment, or the computational resources of the reconstruction engine make denser data collection in θ (i.e., finer resolution in θ) an unattractive solution at best and frequently one that is unfeasible in practice.

The problem of missing projection views is particularly acute when the subject being imaged, or a relevant part thereof, is in motion. For example, CT x-ray imaging is currently being used for cardiac imaging to detect arterial calcification, which can be an indicator for coronary artery disease. X-ray CT is one alternative among various non-invasive techniques for generating images of a patient's beating

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heart. Other modalities include Doppler ultrasound, fluoroscopy, magnetic resonance imaging (MRI), and electron beam tomography (EBT). Each modality has its own advantages and disadvantages for a given application context.

For cardiac imaging, x-ray CT has the potential to provide finer spatial resolution in three dimensions, as compared with MRI (especially with multi-row spiral CT). However, current third and fourth generation CT scanners suffer from coarse temporal resolution because of limited gantry speed. This limitation on temporal resolution directly affects the available spatial resolution of the resulting images of the heart. More specifically, in a data acquisition session of practicable length, each phase or distinct configuration of the beating heart will correspond to a few projection views. For any given phase, therefore, the θ discretization will be unduly coarse and will limit the resolution of the resulting image to an unacceptably coarse level.

Recent developments in image reconstruction algorithms have improved this situation somewhat by enabling CT techniques to achieve much better time resolution than with the standard operation mode. The basic approach of these improved techniques has been to use consistent projection data, collected from multiple heart cycles, and to perform retrospective data rebinning. Such data rebinning methods have been shown to improve significantly the time resolution of the collected data. In practice, however, existing rebinning methods have been found to introduce some image artifacts due to inconsistencies in the data.

It is therefore apparent that the problem of missing projection views, in cardiac imaging and in other applications of CT imaging techniques, has remained as a persistent obstacle to wider use of CT imaging. In the particular context of cardiac imaging, physicians desire a "freeze frame" capability for medical imaging systems. Such a capability would permit an image to be accurately reconstructed to represent the patient's heart at a selected part of the cardiac pumping cycle.

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More generally, what has been needed is a method and system for processing CT projection data to overcome or minimize the effects of missing projection views. Such a method desirably would provide acceptable spatial resolution in the resulting images, without requiring extensive additional data acquisition. In imaging contexts where the imaged object is in motion, such as in cardiac imaging, the method would desirably overcome the artifact problems that have existed with current data rebinning methods. Preferably, the technique would be flexibly applicable in a broad range of CT imaging contexts.

BRIEF SUMMARY OF THE INVENTION

The present invention provides methods, apparatus, software, and systems for generating additional projection views based on existing projection data and indirect relationships between the existing data. For example, such indirect relationships may exist in timing relationships between an imaged subject in a desired state and projection data representing the imaged subject in nearby states.

In a first particular aspect, the present invention provides a tomographic image generation method, and a corresponding apparatus, system and software. An exemplary implementation of this aspect of the invention is a method comprising determining a plurality of working projection views of an object at a selected view angle based on initial projection data collected in respective different data acquisition cycles. The exemplary method further comprises interpolating between the working projection views to generate an interpolated projection view of the object at the selected view angle.

In a second aspect, the present invention may be directed toward methods, apparatus, systems, and software for generating a tomographic image of an object in cyclical motion. An exemplary method of this second aspect comprises determining a plurality of working projection views of an object in cyclical motion based on initial projection data collected from the object. The working projection views are based on selected initial projection data collected in respective different

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data acquisition cycles. The exemplary method further comprises interpolating between the working projection views to generate an interpolated projection view representing the object at the selected view angle and at a specified phase of the cyclical motion.

In a third aspect, the present invention provides a method, apparatus, and software for tomographic image generation. An exemplary method of this third aspect of the invention may comprise determining separation measures for projection data covering corresponding reconstruction ranges and representing an imaged object over plural data acquisition cycles. Such an exemplary method further comprises reconstructing a tomographic image of the object based on a portion of the projection data covering a reconstruction range selected responsive to a determination that the corresponding separation measure satisfies a predetermined selection criterion.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following detailed description of the preferred embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a block diagram of a general x-ray CT scanning system in which the present invention may be implemented;

FIG. 2 is a diagram of a third generation source detector assembly for a CT scanning system as shown in FIG. 1;

FIG. 3 is a diagram of a fourth generation source detector assembly for such a CT scanning system;

FIG. 4 is a diagram illustrating the correspondence between a particular view angle and generation of a row of projection data;

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FIG. 5 is an illustration of a sinogram of projection data including the row of projection data of FIG. 4;

FIG. 6 is a diagram illustrating a time dependent feature of sinogram data;

FIG. 7 is a schematic diagram illustrating a sector approach for rebinning data in cardiac imaging applications;

FIG. 8 is a diagram depicting a different perspective of the time dependent characteristics of sinogram data as provided by the invention;

FIG. 9 illustrates contrasting features of the sector approach of FIG. 7 and the perspective provided by FIG. 8;

FIG. 10 is a flow diagram illustrating a procedure of the invention;

FIG. 11 is a timing diagram illustrating a tagging function for correlation of projection data with corresponding phases of an imaged subject's cardiac cycle;

FIGS. 12-13 are diagrams illustrating an application of the present invention in cardiac imaging;

FIGS. 14-16 are flow diagrams illustrating procedures for carrying out operations as illustrated in FIGS. 12-13;

FIGS. 17-19 are diagrams illustrating an application of the present invention in a case of irregular heartbeat;

FIG. 20 is a trajectory diagram illustrating another embodiment of the invention for phase interpolation between several projection views;

FIG. 21 is a diagram of a source-detector assembly for a helical x-ray CT scanning system using a multi-row detector array;

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FIG. 22 is a schematic diagram of a multi-row detector array;

FIG. 23 is a time evolution diagram of detector row positions of a multi-row detector in helical scanning;

FIG. 24 is a graph illustrating tagging for rows of a multiple-row detector array;

FIG. 25 is a flow diagram illustrating a procedure of an embodiment of the present invention as applied in multi-row helical scanning for cardiac imaging;

FIG. 26 is a flow diagram illustrating details of an operation for selecting neighboring scanning rotations as shown in FIG. 25;

FIGS. 27-28 are diagrams illustrating operations of the procedure shown in FIG. 26;

FIG. 29 is a flow diagram illustration details of an operation for determining working projection views as shown in FIG. 25;

FIG. 30 is a diagram illustrating application of the procedure of FIG. 29;

FIG. 31 is a flow diagram illustrating a procedure of another aspect of the present invention as applied to the particular context of multiple-row helical scanning for cardiac imaging;

FIG. 32 is a flow diagram illustrating a procedure for determining a set of projection views for a selected axial position;

FIG. 33 is a trajectory diagram illustrating multiple reconstruction ranges in a set of projection views for a selected axial position;

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FIG. 34 is a flow diagram illustrating a procedure for selection of a particular reconstruction range in which to perform phase interpolation between projection views;

FIG. 35 is a flow diagram illustrating phase interpolation between projection views for view angles in a selected reconstruction range; and

FIG. 36 is a flow diagram illustrating a procedure for generating a set of tomographic slice images using phase interpolation between projection views.

DETAILED DESCRIPTION OF THE INVENTION

The present invention implements a different perspective on CT projection data, whereby a broader range of information contained in the data is recognized and used. Previous approaches to processing projection data, such as the aforementioned data rebinning techniques, have used data substitution to overcome partially the problems caused by missing projection views. In other contexts, interpolation methods have been applied to projection data to accommodate changes in the sampling grid.

However, previous methods for processing projection data have failed to recognize that distinct projection views from the same data acquisition session may contain additional information that can enhance image resolution. Such additional information may be contained in the differences between the corresponding projection data values of the respective projection views. The present invention embodies the realization that selective combination of different projection views can extract this additional information for use in improving the resolution of the generated images.

In a preferred embodiment, the present invention provides an improved processing method that achieves the objectives of previous data rebinning approaches for CT projection data collected from multiple cardiac cycles, while avoiding many of the image artifacts that have accompanied such previous approaches. The result of

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the invention is improved image quality and reduced artifacts for reconstructed images at arbitrary heart phases.

FIG. 1 is a schematic illustration showing the major components of an x-ray CT imaging system 100 in which the present invention may be embodied or incorporated. A subject 102 for imaging is typically a human patient who may be undergoing diagnostic assessment for coronary artery disease or other disease processes. Alternatively, the subject 102 may be a veterinary patient (i.e., a non-human animal) or even a non-animal subject such as an inanimate object (machine part, material sample, etc.) undergoing nondestructive testing or evaluation.

As is well known, x-ray tomographic imaging with such an imaging system 100 is typically carried out by illuminating the subject 102 with an x-ray beam 104 substantially transverse to an axis (shown by cross-hairs) through the subject 102. Typically the axis is centered on an object 106 of interest, such as an organ or other tissue structure. The subject 102 may be disposed on a table 108 that translates along the direction of the axis, thereby enabling illumination of a volumetric portion of the subject 102 by the x-ray beam 104. In the typical case the illuminated volumetric portion comprises all or a relevant portion of the object 106 of interest within the subject 102.

The CT system 100 desirably comprises a source-detector assembly 110, which in an exemplary embodiment may comprise a gantry 112 rotatable about the axis. An X-ray source 114, such as a typical X-ray tube, may be mounted on the gantry 112 and may rotate with rotation of the gantry 112. Source 114, which may comprise a collimating element (not shown), projects the beam 104 of x-rays toward a detector array 116 disposed opposite the source 114 relative to the gantry 112.

The detector array 116 is typically comprised of numerous individual detector elements 118. An alternative term in the art for an array such as detector array 118 is "a multi-channel detector." It will be understood that either term is

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intended to mean a multiple-channel detection device usable in a computed tomography system.

Detector elements 118 together provide information regarding the internal structures of the subject 102, such as the object 106. As noted above, the subject 102 may be a human patient or an animal patient. In either of these cases, the object 106 may be an organ or body part of the subject 102 and thus is the "object" for purposes of the tomographic image. In a still further alternative application, the subject 102 may itself be the object 106 being subjected to, for example, nondestructive testing or examination.

In the typical case, each detector element 118 generates an electrical signal indicating the intensity of a portion of the x-ray beam 104 impinging thereupon. Various alternatives for the specific arrangement of the source-detector assembly 110 will be described with reference to FIGS. 2-3 and 21.

The signals from detector elements 118 may indicate a degree of attenuation of the beam 104 as the x-rays traverse the material or substance of the subject 102. Typically the source 114 is rotated around the subject 102 to execute a so-called "scan" operation whereby the system 100 acquires x-ray data. The gantry 112, with source 114 attached to a side portion thereof, typically rotates about the axis of the subject 102 to acquire x-ray data from numerous different illumination angles or "view angles."

The rotation operation for the source 114 is controlled by a control/interface system 120. A controls section 122 of the control/interface system 120 provides control for positioning of the gantry 112 relative to the subject 102, such as controlling speed of rotation about the axis and control of relative positions of the table 108 and the gantry 112. The controls section 122 also typically provides control over x-ray generation (power and timing) of the source 114. The control/interface system 120 also includes a data acquisition system (DAS) 124 that samples the

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detector signals generated from the detector elements 120 and converts the sampled signals into digital data for further processing.

A reconstruction engine 130 receives the sampled and digitized data (now termed "projection data") from the DAS 1124 and performs high-speed image reconstruction. The reconstruction engine 130 may comprise a separate processor 132 and memory 134. Various algorithms are known in the art for reconstructing a slice image from projection data comprising a plurality of projection views.

The reconstruction engine 130 sends the reconstructed image to, for example, a system management computer 140 for storage, display, or further processing. The computer 140 typically comprises a CPU (a processor) 142 and a memory 144. The memory 144 may store a program 146 comprising instructions for executing a process of the present invention. Alternatively, such a program 146 may be executed (in whole or in part) by the reconstruction engine 130 or by another computer system (not shown) comprised in or coupled to the imaging system 100.

The computer 140 may display the reconstructed image on a display 152 in response to instructions from an operator console 154. Computer 140 may also convey commands and scanning parameters from the operator console 154 to the control/interface section 120. Alternatively, the image may be output to a recording device 156, such as a film recorder, or stored in a mass storage device 158. Alternatively, the image may be transmitted as image data over a network (not shown) for disposition at another location. If the computer 140 stores the image in the storage 158, the image data may be stored as a data array, a linked list, or any other known data storage configurations as are well known in the art.

An aspect of the present invention provides a tomographic imaging system with the capability to generate accurate tomographic images of an object in motion. Such an imaging system may therefore comprise a system or apparatus for acquiring timing data by which the projection data collected by the system may be correlated in time with the motion of the imaged object. For example, the system 100

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may be used to generate tomographic images of a patient's heart while the heart is beating. A timing data acquisition system for the imaging system 100 may therefore comprise an electrocardiogram such as an EKG unit 160 shown in FIG. 1. The EKG unit 160 detects electrical activity of the patient's heart and provides to the computer 140 timing information based on the detected electrical activity. For example, the timing information may be digital electrocardiographic data. The construction and use of electrocardiograms is well known to those of skill in the art and will not be presented in detail here.

The different functions of control/interface system 120, reconstruction engine 130, and computer 140 are desirably implemented on dedicated modular platforms, as described. However, the division of functions described herein is for purposes of example and is not intended to be limiting. Such functions may alternatively be implemented in software, on a single computational platform, or in a different arrangement on multiple hardware platforms.

FIG. 2 illustrates a source-detector assembly 200 as a specific embodiment of the source-detector assembly 110 shown schematically in FIG. 1. An imaging subject 202 corresponds to the subject 102 in FIG. 1. Assembly 200 illustrates the particular case of a so-called third generation "fan beam" CT system in which the subject 202 is illuminated by a beam 204 while positioned on a motorized table 208. The beam 204 may be a "fan beam," as described below.

A gantry assembly 212 corresponds to the gantry 112 of FIG. 1. An x-ray source 214 generates the fan beam 204 of x-rays directed toward a detector array 216, which is also affixed to the gantry assembly 212. Array 216 comprises individual detector elements 218 that detect x-rays emitted by source 214. The array 216, source 214, gantry 212, and table 208 of the fan beam assembly 200 are respective instances of the array 116, source 114, gantry 114, and table 108 as shown in FIG. 1.

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In operation, assembly 212 rotates around the axis Z, which typically passes through subject 202 and is perpendicular to the plane XY. Source 214 can thereby be transported completely around subject 202 along a circular path. Detector array 216, being fixed with respect to source 214, is also transported around subject 202 and thus remains opposite source 214.

Rotation of the gantry assembly 212 around the subject 202 results in x-ray data being generated by detector elements 218 for a range of view angles θ. A typical detector array 212 may comprise several hundred, such as 888, individual detector elements 218. The array 216 may be positioned on the gantry 212 at a distance of, for example, 0.949 meter (m) from the source 214. The circular path of source 214 has a radius of, for example, 0.541 m. Particular values of these parameters are not critical to the present invention and may be varied according to well-known principles of CT system design.

One complete gantry rotation for the gantry 212 may comprise, for example, 984 increments. Source 214 is thereby positioned to illuminate the subject 202 successively from 984 different directions θ. Detector array 216 generates x-ray data at each incremental position θ, from which projection data for 984 projection views may be generated.

FIG. 3 illustrates a source-detector assembly 300 for a so-called fourth generation CT system. A subject 308 is again illuminated by a fan beam 304 while positioned on a motorized table 308. An x-ray source 314, like source 214 and as a further example of source 114, generates the fan beam 304 of x-rays directed toward a detector array 316. The array 316 comprises detector elements 318 that generate x-ray data indicating internal structural information about the subject 302.

The fourth generation case of FIG. 3 differs from the third generation case, in that the detector array 316 is fixed with respect to rotation. The source 314 is supported by a suitable guide mechanism (not shown) and typically traverses a circular path around the subject 302. The detector array 316 may translate axially (in

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the Z direction) to provide x-ray data for a particular axial position. Alternatively, the array 316 may be fixed axially as well as rotationally, and positioning of the subject 302 with respect to the detector array 316 and source 314 may be achieved entirely by axial translation of the table 308.

As FIG. 2 shows, a typical third generation CT scanning system performs an axial CT scan by rotation of the gantry around the subject to be imaged. The detector data are collected as the gantry rotates the source and the detector array together. The projection data are thereby generated for different angular positions (i.e., view angles) of the gantry. A fourth generation system comprising an arrangement such as the assembly 300, shown in FIG. 3, differs in that the detector array is usually stationary (at least rotationally) with respect to the subject. The source then traverses a path around the subject and thereby projects imaging rays at different angles for detection by different portions of the fixed array.

On the other hand, both the assembly 300 and the assembly 200 may use a fan beam (204 or 304). A "fan beam" is a fan shaped beam of radiation, i.e., a beam subtending a finite angular sector in a given plane. Usually the fan is thin, where "thin" refers to the direction transverse to the fan plane, e.g., a direction generally parallel to the axis Z. X-rays in the angular sector actually subtended by the fan beam may not all be used for generation of detector data. Thus, an effective portion of the fan beam may subtend a smaller angular sector whose angular extent is called the "fan angle" of the fan beam. In the arrangements of FIGS. 2 and 3, the plane of the fan beam is transverse (typically perpendicular) to the axis Z at a fixed axial position.

A rotational scanning operation performed at a fixed axial position is sometimes called an "axial scan." The axial scan is carried out with rotation of the source (or the source and detector together) about the subject at a fixed axial position z0. Therefore, the projection data from an axial scan all represent the imaged subject at the same axial position z_0.

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The present invention provides an approach for enhancing resolution and image quality of a CT image without requiring additional detectors or additional data acquisition and generally may be applied to axial CT systems (e.g., third generation and fourth generation systems). The invention may also be used with less advanced (e.g., first or second generation) source-detector arrangements. Moreover, as will be explained below, the invention may be embodied in or implemented with spiral (i.e., helical) CT imaging systems. The basic features of the invention will be explained first in the axial CT context and then extended, with appropriate enhancements, to the helical case.

It is noted that similar operations of rotation apply in both third generation and fourth generation systems for the acquisition of detector data during a complete cycle of the source-detector assembly. In the axial scanning case, the data acquisition cycle is called an axial scan. More generally, the principle of a rotational cycle of data acquisition is generally applicable in all such x-ray CT scanning systems. The term "scanning rotation" will therefore be used here to mean the rotational operation for positioning the x-ray source (e.g., source 214 or source 314) at each angular position θ around an axis of rotation and collecting corresponding data. "Scanning rotation set" will mean the set of projection data generated from a scanning rotation. Where no confusion will arise, the term "scanning rotation" will be used variously to mean either the data acquisition operation or the projection data set generated as a result of the data acquisition operation.

Typical x-ray CT systems (e.g., third generation systems and fourth generation systems) are an exemplary class of tomographic imaging systems. For example, magnetic resonance imaging (MRI) systems also are used to generate tomographic images by a data collection and image reconstruction process that may be termed (in a generalized sense) computed tomography.

Cardiac imaging can be performed with some MRI systems by processing a series of magnetic echo data sequences with various types of gating techniques. In prospective spin echo gating, for example, the system acquires

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imaging data over a series of cardiac cycles. An additional sequence of spin echo data is acquired at each cycle. Each spin echo data sequence represents the heart at different spatial locations but is acquired during the same cardiac cycle and with the same k-space encoding value. Thus, the data collection operation for acquiring such a spin echo data sequence is analogous to the scanning rotation operation in x-ray tomographic imaging. In each case, the operation is a data sampling cycle for acquiring a consecutive sequence of data samples over a cycle interval.

Also, retrospective gating of gradient echo pulse sequences is used in MR systems to acquire "cine" images at multiple time frames of the cardiac cycle. Data acquisition again occurs over several cardiac cycles, and in each acquisition cycle the data samples have the same phase (i.e., k-space) encoding value. The phase encoding value is thus stepped to a next value at each successive R-wave trigger. The excitation pulses run asynchronously with the cardiac cycle, so that the echo pulse data acquired in each sampling cycle is resorted and interpolated into evenly distributed time frames within the cardiac cycle. Nevertheless, like rotational scanning in x-ray systems, the sample data are again acquired in a series of sequences of data samples acquired consecutively over a sampling cycle interval.

These examples illustrate a general principle of data acquisition in tomographic imaging systems: the imaging data are acquired in one or more sequences of data samples. Here, the term "data acquisition cycle" will mean a data acquisition operation for obtaining such a sequence of data samples at a sequence of consecutive sampling times. Thus, in existing approaches to x-ray tomography the data acquisition cycle is the scanning rotation (which may be carried out by gantry rotation or source rotation, for example). For MRI systems, the data acquisition cycle may be the sequence of measurement operations in which the magnetic field gradients are varied according to the particular localization method being used. As will be explained in detail, the present invention adopts a different perspective on combining data from different data acquisition cycles.

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Data from an axial scan may be stored in a two dimensional array called a "sinogram." One dimension of the sinogram corresponds to angular position of the fan beam (e.g., scanning rotation angle or "view angle"), relative to the initial rotational orientation of the beam at the start of the data acquisition cycle. The other dimension corresponds to positions of the detector elements (218 or 318) of the detector array. The detector array in a fan beam CT system (such as array 216 or array 316) typically comprises a single row of detector elements. In such a case, therefore, each row of the sinogram will correspond to a discrete view angle θ and a single axial position z0.

In the fan beam case, the sinogram may be considered as a collection of projection views of the subject at the position z_0. Here the term "projection view" means such a row of projection data corresponding to a given view angle θ and representing the imaged subject at a single axial position z_0. Well known reconstruction procedures utilize as their principal inputs a complete set of such projection views (discretized in θ, but all consisting of data values for the same axial position z_0). The projection views are processed to generate a slice image depicting the internal features of the subject at the position z_0. Usually the complete set of projection views comprises projection views at view angles covering at least radians (i.e., 180 degrees) plus the fan angle.

FIG. 4 illustrates the correspondence between a particular view angle θ_0 for the source and the generation of a well-defined row R of projection data. In the fan beam case, as noted above, the detector data from the detector array may convert directly into a single row of projection data for a projection view at view angle θ_0. This correspondence results because the detector array provides a single row of detector data representing intensities of the x-rays impinging upon the detector elements. These intensity values indicate attenuation information for the subject at the axial position z_0.

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FIG. 5 shows how the projection data for the particular view angle θ_0 is stored in a corresponding row of the sinogram. Each row of the sinogram thus constitutes a projection view that indicates attenuation information for a distinct view angle θ, but the same axial position z_0. Once the sinogram is filled with projection views (rows) for all the discrete view angles θ around the subject, then a suitable CT image reconstruction algorithm is applied to reconstruct a cross-sectional image of the subject.

FIG. 6 illustrates a time dependent feature of the projection data stored in the sinogram. The view angle θ of the source relative to a fixed direction can be written as

$$\theta(t) = \omega t,$$

where ω represents the angular speed of the gantry in radians per second and t denotes time. Each row R of the sinogram therefore represents information about the subject (at the axial position z_0) at a different time t.

Usually the fact that the rows of the sinogram are time dependent is inconsequential, because the subject is immobile during the scanning process. The assumption of stasis may be reasonable even for a living patient, because the patient can be well constrained during the time it takes to collect all the projection views (0.5 – 0.8 seconds). For example, when the area of interest is the patient's head, abdomen, etc., the body part of interest can be assumed to be stationary during the scan.

However, in cardiac imaging the assumption of stasis clearly does not apply, at least for a living subject. The beating of the patient's heart persists and cannot be suspended. Moreover, a heart rate of 72 beats per minute (bpm), for example, corresponds to 0.83 seconds (s) per beat. The heart thus completes a full cardiac cycle in a time span comparable to the time required for collecting projection views at all the view angles θ. The beating heart thus undergoes a substantial portion

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of a complete cardiac cycle while the projection data for a slice image are being obtained.

The particular motion that affects cardiac CT imaging is largely the cyclical change in the shape of the heart throughout the cardiac cycle. However, the same imaging problem appears in various situations where the object of interest is in motion during the CT scan process (the data acquisition cycle). The scanner is unable to generate a clear image of the object being imaged at a particular position (e.g., a particular phase of the cardiac cycle) because the object moves too rapidly for a complete set of projection data to be collected while the subject is in the desired position or configuration.

The problem may be analogized to the problem in conventional photography of freezing a subject in motion. If the camera shutter speed is too slow, the subject will undergo a significant amount of motion while the shutter is open (i.e., collecting image data). The resulting image of the subject is blurred. In a like manner, the CT scanning system may be unable to generate a clear slice image, if the subject is in motion while the scan data are being collected. In effect, the CT scanner has a slow shutter speed relative to most rates of motion of the subject.

FIG. 6 thus emphasizes that the collection of projection data proceeds as a function of time while the gantry or source is rotating. A projection data set should be complete (covering as much as 360°, but at least 180° plus the fan angle) to provide a useable tomographic image upon reconstruction. However, if the projection data set consists of projection views from a single scanning rotation, the projection views will respectively represent the heart at many different phases of the cardiac cycle. Each projection view corresponds to a particular row in the sinogram, but is collected at a different moment in time. Strictly speaking, reconstruction of an image at any particular phase of the heart requires collecting all the projection views (all rows of the sinogram) at that particular instant in time. This would require a very fast data acquisition cycle (i.e., a very fast shutter speed for the CT scanning system).

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A feasible solution to this problem can be achieved by making use of the cyclical nature of the cardiac cycle (more generally, any repeating feature of the motion of the object of interest). As the cycle repeats, the beating heart moves through the same cycle of shapes and assumes successive shapes in an ordered sequence in time. Multiple scanning rotations, together with data gating, can be used to collect several projection views corresponding to the same phase from multiple heart cycles. The CT scanning system can thereby generate the projection views to be used in reconstructing an image of the beating heart at a particular heart phase.

Unfortunately, obtaining all the desired projection data directly through respective data acquisition cycles would entail an inordinately large number of scanning rotations for the corresponding projection views. The "shutter speed" problem arises here in a different form: although the heart regularly repeats the cardiac cycle, the subject being imaged otherwise desirably remains stationary throughout the data collection process. A reasonable number of scanning rotations, during which the subject can be expected to remain generally stationary, will provide just a few projection views of the heart at a given phase.

FIG. 7 illustrates this problem through a simplified example in which three projection views are collected at the desired heart phase, $t=\phi_0$. It is noted that phase ϕ is measured in units equivalent to time t. Here a distinct symbol (ϕ) is used for phase to emphasize the periodicity of the heart motion, because periodicity is a dynamical feature not present in dynamic phenomena generally. The three views correspond sequentially to heart cycles 3, 1, and 2 as shown and may be collected in, for example, three scanning rotations. At 0.5 s per scanning rotation, even this level of data collection requires the patient (the imaged subject) to remain stationary for at least 1.5 s.

The following scheme has been partially successful in overcoming the persistent problem of missing projection views in the context of cardiac imaging. An assumption is made that, at least for some phases to of the cardiac cycle, the heart motion may be relatively slight in the neighborhood of $t= \phi_0$. As FIG. 7 shows, the

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heart cycle is divided into a few phase sectors, in each (or at least some) of which the heart is assumed to be close to stationary.

For each scanning rotation of the CT system, the phase sectors of the cardiac cycle can be associated with angular sectors of the rotation. Data for projection views at many different view angles are collected in each scanning rotation. If the foregoing assumptions are valid, then from all the scanning rotations the data corresponding to the phase sector of the desired phase can be used for reconstruction of an image of the heart at the desired to phase.

The approach described above has been termed data "sectoring" or "data segmentation" and has been implemented successfully in various contexts. For example, U.S. Patent No. 5,997,883, issued December 7, 1999, to Epstein et al. and assigned to the assignee of the present application, discloses a cardiac imaging technique using segmented MRI cardiac data. Data segmentation has been shown to yield x-ray CT images with image quality satisfactory for many purposes. On the other hand, such CT images suffer from certain noticeable artifacts, such as streaks. The artifacts in these images are believed to be due to inconsistency of the projection data, particularly in the regions of transition between the different sectors, because the different projection views actually represent the heart at somewhat different cardiac phases..

FIGS. 8-9 illustrate analysis of sinogram data through a different perspective that constitutes an aspect of the present invention. The diagonal trajectories 1, 2, and 3 in FIG. 8 illustrate the time dependence of the sinogram data, as shown previously in FIG. 6. Thus, each trajectory (1, 2, or 3) represents a sequence of sinogram rows as θ evolves in time. FIGS. 8-9 depict the trajectories as continuous diagonal lines, for purposes of illustration. However, like the sinograms they represent, these trajectories actually represent the sinogram data as comprising projection views corresponding to a discrete sequence of view angles θ.

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If the period of the cardiac cycle and the period of the data acquisition cycle are different, projection views can be collected corresponding to different phases of the heart during each rotation. Here T_{gantry} and T_{heart} correspond to scanning rotation period and cardiac cycle period, respectively. For description purposes, the particular example of FIG. 8 illustrates the case where T_{gantry} is less than T_{heart}. However, and the present invention readily applies also to the case T_{gantry} greater than T_{heart}.

The data trajectories are indicated in FIG. 8 by diagonal lines with arrows and represent the projection data in the θ-t domain. It is noted that θ=0° and θ=360° actually represent the same angular position. Hence each trajectory in FIG. 8 wraps around to 0° whenever θ reaches 360°. Further, because $T_{gantry} < T_{heart}$ in the case illustrated, the ordinal extent of the domain is [0, T_{heart}), and each trajectory wraps back to t=0 whenever the trajectory reaches t=T_{heart}. Each recurrence of t=0 corresponds to a next cardiac cycle, which is represented in FIG. 8 by another trajectory.

The scheme described above assigns projection data for a given view angle θ from the trajectory nearest to the vertical line at $t=\phi_0$. As noted above, this approach is commonly known as data sectoring or data segmentation. However, in view of the perspective provided by FIG. 8, a more descriptive term may be "nearest neighborhood substitution." The idea is to substitute data from the desired view, but from a nearby phase, in place of the missing projection view for the desired phase.

FIG. 9 illustrates the relationship between the data sectoring approach and the perspective illustrated in FIG. 8. The range of cardiac phases is "segmented," or divided into segments (or "sectors") denoted I, II, and III. The sectors correspond to predetermined portions of the cardiac cycle. In each of the trajectories 1, 2, and 3, the phase sectors correspond to respective angular regions in θ. Hence each of the trajectories 1, 2, and 3 is divided into angular segments corresponding to the phase sectors I, II, and III. FIG. 9 also shows that the phase sector (sector I) of the phase to coincides with different angular segments for the different trajectories. As noted

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above, the sectoring approach assigns substitute projection data for missing projection views according to the phase sector of the phase to at the desired view angle θ_m.

For example, the view angle θ_m in FIG. 9 corresponds to a missing projection view 900 for the phase ϕ_0, because none of the trajectories 1, 2, and 3 pass through the point (in θ and t) at which the view 900 is desired. The sector approach determines the trajectories within the phase sector of the target phase at the desired view angle and identifies an available projection view at that view angle and on the trajectory nearest in time to the phase to.

In FIG. 9, the projection view 910 is the projection view nearest to the desired phase. The projection data for this nearest neighbor projection view are then substituted for the missing projection view. It is noted that the information associated with other projection views, such as the next nearest projection view 920 in FIG. 9, is completely ignored in the sector approach.

The present invention uses a different perspective of the projection data and of the problem of missing projection views. For a scan where the gantry is continuously rotated, the trajectories in FIG. 8 represent the data collected in the two dimensional domain of view angle versus time (θ vs. t). This perspective enables the invention to take a different approach for processing the projection data. Instead of block assignment of the data to different phase sectors, the present invention makes use of additional information revealed by representing the projection data as trajectories. In fact, the trajectories allow quantitative relationships between the available data and the desired data to be discovered and utilized.

The perspective adopted by the invention enables the additional information contained in an additional projection view, such as the second projection view 920 in FIG. 9, to be incorporated into projection data for the missing projection view. This incorporation of multiple working projection views into projection data for a missing projection view is achieved through interpolation in the sinogram phase domain, i.e., along the t axis. For a set of (two or more) existing projection views at a

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given view angle, corresponding data values of the projection views are interpolated to generate a corresponding data value for an interpolated projection view at the given view angle and the desired phase. Here, therefore, interpolation between projection views means to carry out the same relative combination of data values for all the row positions of the set of projection views being interpolated.

FIG. 10 shows a flow diagram illustrating an interpolation procedure 1000 of the invention. An operation 1010 determines the initial projection data available. This initial data may comprise, for example, sinograms of projection data providing plural trajectories of projection views accumulated over time, as illustrated in FIG. 8. Such initial projection data may be generated directly by a DAS such as DAS 124 in FIG. 1. Alternatively, as explained below, the initial projection data may be determined from the digitized detector data by rebinning or other preprocessing operations, as are well known in the art.

An operation 1020 selects a view angle for which a projection view is to be synthesized through interpolation. From existing projection views of the initial projection data at the selected view angle, working projection views are determined in an operation 1030. The working projection views will represent the imaged object at the selected view angle, but in different data acquisition cycles. For example, in a particular embodiment of the invention, the interpolation may be performed between two projection views such as views 910 and 920 shown in FIG. 9. In such a particular instance, then, the working projection views are determined as the two projection views that are nearest in time to the desired phase ϕ_0, among projection views at the desired view angle in the initial projection data.

Interpolation is performed between the corresponding data values of the working projection views in an operation 1040. Any of various different interpolation techniques may be employed for this purpose, as are well known to those of skill in the art. For example, weighted linear interpolation between neighboring data trajectories is a particular interpolation method that has been used effectively. The weights may be computed based on respective timing differences

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between timings of the selected working projection views and a corresponding timing of the desired projection view. For example, in an implementation of the invention for cardiac imaging, the timings of the working projection views and the desired projection views may be embodied in corresponding phases of the cardiac cycle.

Where the initial projection data comprise data sinograms for cardiac imaging, the sinograms are preferably correlated with simultaneously collected timing data such as electrocardiogram (EKG) data generated by the EKG unit 160 of FIG. 1. The correlation provides a time stamp for each row of detector data. The time stamp of a row of projection data provides an explicit cross reference between the row of data and the shape configuration of the heart (as determined by the EKG data) at the time the row of data was collected.

FIG. 11 illustrates an approach for using such time stamps to correlate the projection data with contemporaneous electrocardiographic data. The EKG data represent an electrocardiograph 1110 of the patient's heart during the tomographic scanning procedure. The projection data represent the heart at various phases of the cardiac cycle and are collected at a known sampling frequency (e.g., 984 projection views in each period of the gantry rotation) that allows the projection views to be time stamped with respective temporal locations.

On the other hand, the projection data do not contain explicit phase information. The contemporaneously collected EKG waveform 1110 can be used to determine such phase information, provided the collection of the EKG data is synchronized with collection of the projection data. The projection data also do not explicitly comprise axial position (Z-location) information, but such position data may be recorded sequentially as each axial scan is performed.

In a particular implementation, for example, the EKG data for the waveform 1110 may be collected during the scanning procedure by the EKG unit 160 and may be digitized at a specified sampling frequency (e.g., 240 samples per second). The particular sampling frequency is not critical to the present invention.

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The criteria for selecting a suitable sampling frequency are well known to those of skill in the art, and such criteria will not be described here.

The temporal locations of the R-wave peaks of the waveform 1110 may be identified using any of various well-known waveform analysis techniques. Using the identified peak locations, a linear phase function 1120 may be defined to increase from 0.0 to 1.0 between each consecutive pair of R-wave peaks.

The function 1120 may be used to map (i.e., to correlate) the phases of the cardiac cycle to the time-stamped temporal locations of the projection views. Each projection view is thereby assigned a cardiac phase $_{ij}\Phi$, where the indexes i and j respectively identify the cardiac cycle and gantry rotation of the scanning procedure. It is noted that the cardiac phase assignment $_{ij}$ may further be associated with specific axial positions, as will be explained below with reference to FIG. 24. The phase function 1120 (defined between all consecutive R-wave peaks of the waveform 1110) thereby allows all the projection views of the projection data to be correlated (tagged) with an associated cardiac phase $_{ij}$.

In the simplest case, it may be assumed that the heart rate is constant while the scan data are collected. The desired phase (in the case of cardiac imaging, corresponding to a shape configuration of the patient's heart) then occurs in each cardiac cycle at a fixed fraction of the heart period T_h following the preceding R-wave. This assumption of regular heartbeat simplifies the process of cross-referencing the projection data and the EKG data. In particular, for each R-R heart cycle the desired phase of the heart occurs on the vertical line ϕ_0 in FIG. 8.

An advantage of the foregoing implementation is that a phase function, such as the linear phase function 1120, allows correlation between heart phases and row data to be carried out even when the subject's heart rate is irregular. In either case, the time correlation between the EKG data and the collected scan data may be performed off-line, i.e., after the projection data is initially collected, binned, and time stamped.

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The linear phase function 1120 shown in FIG. 11 is only one example of a feasible phase mapping function for EKG data. Other, possibly non-linear phase mapping functions are also feasible for use with the present invention. Such alternative mappings may permit the electrocardiographic behavior of the R-R cycle to be modeled more accurately and in more detail. In turn, more accurate and detailed modeling of the electrical cycle of the heart may permit more accurate time correlation of the heart phases.

Adaptive Projection Data Processing

In a particular embodiment of the procedure illustrated in FIG. 10, the initial projection data may represent a patient's beating heart, and the two nearest projection views may be identified based on the time correlation between the collected projection data and the EKG data. The time stamps of the projection data allow the working projection views to be determined in operation 1030 based on the correlation between the gantry rotation and cardiac cycle. For example, the projection view 910 on trajectory 1 in FIG. 9 may be identified from the timing at which the gantry rotation coincides with the missing view angle θ_m and the assigned phases $_{ij}$. The phases $_{ij}$ of the projection views may be used with the EKG data to determine the phase differences, as will now be explained.

FIGS. 12-13 illustrate the data relationships that may be utilized in a particular embodiment of the invention. In FIG. 12, the initial trajectories 1 and 2 respectively include projection views 1210 and 1220 at the desired phase ϕ_0 and corresponding view angles. The point 900 again represents a missing projection view for the heart phase ϕ_0, because neither of the available trajectories includes a projection view at the view angle θ_m. Two nearest neighbor projection views 910 and 920 may be identified from the trajectories 1 and 2, respectively, using the time stamp correlations.

FIG. 13 shows phase differences d_1 and d_2 (represented as timing differences) respectively associated with the projection views 910 and 920. Using

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such timing differences, the data values of 910 and 920 may be combined through a predetermined interpolation process (operation 1040 of FIG. 10) such as a weighted linear interpolation process. A data value for view 900 may be determined in such a process from corresponding data values for the views 910 and 920 using an interpolation formula such as

$$P = \frac{1}{\Delta T}[d_2 P' + d_1 P''] \qquad (1)$$

$$= \left(\frac{\phi_0 - T_2}{T_1 - T_2}\right)P' + \left(\frac{T_1 - \phi_0}{T_1 - T_2}\right)P''$$

where $\Delta T = T_1 - T_2$, $d_1 = T_1 - \phi_0$, and $d_2 = \phi_0 - T_2$. Here P′ and P″ are the data values of the views 910 and 920 at respective detector positions in the projection views.

In the foregoing example the differences d_1 and d_2 may be determined directly from the time stamp data of the projection views 910 and 920, if the heart rate is assumed to be constant. Such an assumption ensures that the difference in the heart configuration at ϕ_0 and T_1, for example, directly corresponds to the time difference d_1. On the other hand, as noted above, the present invention also accommodates an irregular heart rate for which the heartbeat period T_h may vary with each trajectory.

FIG. 14 shows a flow diagram illustrating the main operations of a procedure to implement the invention for generating a projection data set comprising a complete set of projection views for reconstructing a slice image. As in the operation 1010 of FIG. 8, an operation 1410 determines the initial projection data (i.e., the sinogram data for a plurality of scanning rotations). A particular phase of the cardiac cycle, such as $t = \phi_0$, is selected in an operation 1420.

An initial view angle is selected in an operation 1430. Both the initial view angle and the angular interval between projection views typically will depend on the θ discretization (the sampling frequency, such as 240 Hz) of the sinogram data.

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An initial testing operation 1440 may determine whether the initial projection data includes a projection view for the selected view angle and the selected phase.

If the selected view angle corresponds to a missing projection view at operation 1440, then the procedure determines working projection views at operation 1450. An interpolated projection view is generated at an operation 1460. These operations will be described in detail with reference to FIGS. 15-16. If the sinogram data includes a projection view for the selected phase and view angle, then the desired view angle is not a missing view angle. The procedure of FIG. 14 then skips operations 1450-1460 and advances to an operation 1470, where a determination is made as to whether the selected view angle is the last view angle needed for the desired reconstruction. If not, then a next view angle is selected at operation 1480, and the procedure returns to the testing operation 1440.

FIG. 15 shows a flow diagram illustrating a version of the determination operation 1450. In an operation 1510, a projection view for the selected view angle is selected from the initial projection data. The particular projection view may be selected based on both the selected view angle and the initial projection data corresponding to phases prior to the selected phase ϕ_0 in the cardiac R-R cycle.

As has been noted with respect to FIGS. 12-13, the selected view angle occurs in each of the data trajectories of the initial projection data at a specific timing. A preferred embodiment of the invention in this aspect selects the projection view 920 at the selected view angle and occurring in the trajectory 2 closest in time before the timing of the desired cardiac phase ϕ_0. The term "configuration phase" will be used to mean the phase of the physical configuration of the heart at an associated moment in each beat of the heart.

An operation 1520 produces a similar selection result, but the projection view 910 is selected from projection data subsequent to the selected phase (time). These two operations (1510 and 1520) determine two projection views that

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may be used as the working projection views in the remainder of the procedure illustrated in FIG. 14.

FIG. 15 illustrates a particular embodiment for selecting working projection views in pairs. It will be apparent to those of skill in the art that the present invention also encompasses other arrangements for selecting the working projection views. Indeed, a significant aspect of the present invention is the discovery that substantive relationships can exist between disparate initial projection views. Such relationships can provide additional information for improving the quality of reconstructed images. Thus, as will be seen, the present invention encompasses a variety of different approaches for identifying initial projection views between which such substantive relationships exist. Various embodiments of the invention are possible for combining the initial projection views to utilize the additional information that may be provided by relationships.

FIG. 16 is a flow diagram illustrating a particular embodiment of the interpolation operation 1460 of FIG. 14. As FIGS. 4-5 indicate, each projection view may comprise, for example, 888 data values each corresponding to an output of a detector element of the detector array (such as array 216 or 316). An operation 1610 selects respective initial data elements from the working projection views. This selection may be based on the position of the detector element from which the data elements are generated. Alternatively, any other commensurate numbering system for identifying the respective data elements in the sinogram rows may be used.

An operation 1620 performs a computational procedure to interpolate between the selected data element values of the working projection views. Any of various interpolation procedures may be used, as discussed below. The result is an interpolated data value corresponding to the selected data element position, the selected phase, and the selected view angle. An operation 1630 determines whether further sets of data elements remain to be interpolated between the working projection views. If so, then the next data element values are selected at an operation 1640 (such

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as by selecting a next detector element position). The procedure of FIG. 16 then returns to the operation 1620 for another iteration of the interpolation computation.

The approach of the present invention makes the resulting projection data (any initial projection data for the desired phase, in combination with interpolated projection data) more consistent, particularly at view angles near angles at which the sector approach would join different sectors. The results provided by the invention are further improved by the fact that the general profile of motion during the cardiac cycle is known as a function of time. This profile can be used to compute weights to be used in the interpolation operation 1460. In particular, it has been found that careful selection of the interpolation weights based on the motion profile can result in even better image quality.

In a particular implementation of the invention, the weights may be selected to minimize image distortion arising from motion of the heart at the working projection views. In this approach the interpolation method weights the data from a particular working projection view (and trajectory) based on the amount of heart motion at the phase of the cardiac cycle to which the working projection view corresponds. The weighting applied to the other trajectory (or trajectories) used in the interpolation may be changed similarly, based on the relative heart position (or configuration) at the respective phases.

The relative heart position at a given projection view may be determined through off-line analysis of the contemporaneous EKG data. The amounts of heart motion at different configuration phases are well known to those of skill in the art of cardiac physiology and may be correlated to the projection views P′ and P″ through the EKG data.

Alternatively, any of various other interpolation methods may be used. In another particular implementation, a weighted inverse quadratic interpolation is performed. Here each weight may be computed to be proportional to the square of the time difference between the interpolated time and the time of the weighted

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projection data value. For example, a data value for the projection view 900 may be computed according to the formula

$$P = \frac{1}{d_1^2+d_2^2}[d_2^2 P' + d_1^2 P''] \quad (2)$$

$$P = \frac{(\phi_0 - T_2)^2}{d_1^2+d_2^2} P' + \frac{(T_1 - \phi_0)^2}{d_1^2+d_2^2} P''$$

$$P = \frac{(\phi_0 - T_2)^2}{(T_1 - \phi_0)^2 + (\phi_0 - T_2)^2} P' + \frac{(T_1 - \phi_0)^2}{(T_1 - \phi_0)^2 + (\phi_0 - T_2)^2} P''$$

It is noted that the equations (1) and (2) illustrate this feature of the present embodiment in the simple case where $|T_1-\phi_0|$ and $|\phi_0 T_2|$ are less than $T_h/2$. In many cases this condition may be satisfied automatically by using existing projection views 910 and 920 from consecutive gantry rotations (consecutive data acquisition cycles). However, the present aspect of the invention also applies in many other contexts where one or more of these simplifying assumptions fails to hold. The principles of the present aspect of the invention may also be applied where a direct phase difference (such as $T_1-\phi_0$) actually is greater than $T_h/2$. Such a case may be addressed as described with reference to equation (5) below.

Among its numerous advantages, the present invention enables the times at which to collect the projection data (for reconstructing an image of the heart at a particular configuration phase) to be determined prospectively. A method of the present invention therefore does not require the X-ray tube to be on all the time. Instead, a method of the invention operates with data collected at or near a particular phase of the heart. The time correlation by which such a method is employed can be achieved by prospective gating.

Usually in medical imaging procedures the heart rate is not uniform during the data acquisition process. As in the discussion above with respect to FIG. 10, the preferred procedure here is to collect an electrocardiographic data set along

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with the projection data. The EKG data set can then be correlated off-line with CT scan data, using the time stamps as noted previously. Thereafter, using the time stamps and the correlations to the EKG data, the particular projection data corresponding to a selected cardiac configuration phase can be identified.

Such an adaptation to heart rate variations is well known in the art and has been used, for example, in the sector approach described above with respect to FIG. 7. Persons skilled in the art will readily appreciate the appropriate measures to be used with the present invention to compensate for the presence of heart rate variability. For example, a compensation model is employed in the technique of U.S. Patent No. 5,997,883 to Epstein et al. noted previously.

On the other hand, a further embodiment of the present invention is particularly useful in cases where heart rate variability exists. The basic approach described above is employed again, but variations in the heart rate are accommodated in the interpolation process.

FIG. 17 illustrates a typical effect on a trajectory when the heart rate varies. Trajectories 1 and 2 again represent successive portions of CT projection data. The scanning rotation also continues to have a fixed period T_g. However, unlike in FIGS. 12-13, the heart rate is now variable with a period varying around some nominal period T_h. The rightmost extent of the graph in FIG. 17 does not represent successive completions of the R-R cycle of the heart. However, like FIGS. 12-13, the trajectories in FIG. 17 wrap around to t=0 when they reach $t=T_h$.

Unlike FIG. 12, for example, in FIG. 17 the R-waves of different heart cycles occur at different time positions on the graph. An R-wave R_1 that begins the R-R cycle of trajectory 1 is illustrated as occurring at temporal position t=0 on the graph. However, an R-wave R_2 occurs at a later temporal position $t=\Delta t$. The R-wave peak at R_2 occurs at a time $T_h+\Delta t$ following R_1, while the temporal positions on the graph reflect the fact that the graph wraps around to t=0 at intervals of T_h. The time

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difference Δt can thus be viewed as a phase delay between the cycle beginning with R_1 and the cycle beginning with R_2.

FIG. 18 illustrates the effect of heart rate variability on the time correlations between the CT projection data and the configuration phases of the heart as indicated by contemporaneously collected EKG data. Trajectories 1 and 2 with respective R-waves R_2 and R_1 are shown as in FIG. 17. Again, a set of projection views is desired for reconstructing a useful image of the heart at a specified configuration phase. In the cardiac cycle of trajectory 1, the specified configuration phase is assumed to occur at temporal position t_1. The trajectory 1 again includes the projection view 910 having a time stamp correlated to the temporal position t_1. A fixed time delay TD is defined to be numerically equal to the temporal position t_1.

The fixed time delay TD will serve a function similar to the fixed heart cycle ratio mentioned above (represented by ϕ_0 in FIG. 12), but for the case of varying heart rate. In each successive heart cycle, the timing of the specified configuration phase will occur at the time delay TD after the R-wave of the cycle. FIG. 18 shows that the specified phase therefore occurs in trajectory 2 at a temporal position t_2 on the graph.

The trajectory 2 includes a projection view 1820 that is time stamped to correspond to the temporal position t_2. The temporal position t_2 of view 1820 is commensurately offset (by the phase delay Δt) from the time position t_2 corresponding to the projection view 910 from trajectory 1. The view 1820 nevertheless represents the heart at the specified phase, because the cycle of trajectory 2 begins at the R-wave R_2. An image reconstruction of the heart in that specified configuration will therefore utilize both the projection view 910 and the projection view 1820.

The embodiment of the invention described with reference to FIGS. 12-13 can provide data for such a missing projection view through gated reconstruction that bins the data into phases. If the heart rate is uniform, as illustrated

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in FIG. 12, then these phases occur at regular intervals T_{heart} in time. The horizontal axis in FIG. 12 consistently represents both time t and cardiac phase $_{ij}$. This correspondence allows differences in the phases of the heart at the projection views 900, 910, and 920 to be determined directly from the temporal positions of those views on the graph.

However, heart rate irregularity is particularly common among patients undergoing cardiac care, and this creates a problem for using EKG data for gated reconstruction. As in FIGS. 12-13, this embodiment of the invention provides an additional, synthesized projection view 900 to be combined with the views 910 and 1820 in reconstructing the image. But when the cardiac cycle is irregular, the direct correspondence between temporal position and cardiac phase is destroyed.

FIG. 18 illustrates that the temporal position t_2 of the projection view 1820 is delayed relative to the temporal position of 910. This delay is induced by, and is numerically equal to, the phase delay Δt: $t_2 - t_1 = \Delta t$. It follows that when the heart rate is irregular, a given configuration phase will not occur at a regularly repeating temporal position, such as at ϕ_0. Instead, the desired phase will occur in each cardiac cycle at a time position determined by the R-wave of the cycle and the fixed time delay TD.

FIG. 19 illustrates an approach to account for the phase delay Δt in the determination of the differences between the cardiac phases. This approach enables the present invention to provide consistent projection view interpolation, in the presence of heart rate irregularity. The basic approach is the same as illustrated in FIG. 13: combine the working projection views 910 and 920 by interpolation to generate an interpolated projection view 900. Moreover, as in the case of constant heart rate, the interpolation formula will generally blend corresponding data values from initial projection views 910 and 920 based on differences between the different phases.

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The timing differences δ_1 and δ_2 in FIG. 19 correspond to d_1 and d_2 as in FIG. 13 and are again associated with the projection views 910 and 920. However, because the desired phase occurs in trajectory 2 at temporal position t_2, d_2 includes the difference between t_1 and t_2, i.e., t_2-t_1=Δt. Thus, for an irregular heart rate, the interpolation formula desirably blends the initial projection views 910 and 920 based on

$$\delta_1 = T_1 - t_1, \tag{3}$$

$$\delta_2 = t_2 - T_2 = t_1 - T_2 + (t_2 - t_1) = t_1 - T_2 + \Delta t.$$

Any of the various interpolation methods known in the art may be used for interpolation between 910 and 920 in FIG. 19, using appropriate measures of phase differences such as δ_1 and δ_2. For example, either of the formulas (1) and (2) above may be used directly by substituting δ_1 and δ_2 for d_1 and d_2, respectively. The use of a fixed delay TD ensures that the working projection views will correspond to a same phase of the cardiac cycle following the trigger phase. The procedure illustrated in FIGS. 14-16 may then be employed to generate the interpolated projection view 900.

The same delay time TD can be used to generate projection views for image reconstruction at a succession of slice positions z_0. A number of slice images can be generated to provide a reconstructed three dimensional image of the heart at the configuration phase specified by the selected delay TD. It is desirable to use a delay time TD corresponding to a cardiac phase at which the heart is nearly still. Alternatively, the approach of the invention may be further extended by performing the aforementioned three dimensional image reconstruction for each of a series of delay times TD. This alternative allows the creation of a time succession of such three dimensional images to provide a dynamic (four-dimensional) model of the heart.

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The aspect of the present invention described with reference to FIG. 10 may be implemented in various different embodiments, several of which may have particular application in dynamic imaging contexts such as cardiac imaging. An embodiment suitable for a given imaging context may be selected according to the particular imaging system hardware to be used, characteristics of the object to be imaged, image parameters to be emphasized, and so forth. Two particular embodiments of the invention will now be described in more detail. Those of skill in the art will appreciate details and desirable features of other alternative embodiments, upon considering the foregoing general description together with the particular descriptions to be presented below.

Interpolation Between Several Projection Views

FIG. 20 is a trajectory graph, similar to the graphs of FIGS. 12-13, but illustrating an alternative aspect of the invention. The embodiment illustrated in FIGS. 12-13 provided phase interpolation between two projection views selected from consecutive different data acquisition cycles, and thus falling on neighboring trajectories in the graphs. Here, for added clarity of illustration, the trajectories are labeled to indicate both their respective gantry rotations and heart cycles. Thus the label "M_N" indicates the trajectory represents a sequence of projection views from the M-th heart cycle and the N-th gantry rotation.

The alternative embodiment of FIG. 20 provides for generating an interpolated projection view 2000 by phase interpolation between several working projection views 2010, 2020, 2030, and 2040. While four working projection views 2010-2040 are shown, it will be apparent that this aspect of the invention encompasses other numbers of projection views, both more than four and less than four. Moreover, it may be seen that assignment of zero interpolation weights may effectively exclude some working projection views from the phase interpolation of a particular embodiment. For example, assignment of zero weights to the projection views 2030 and 2040 effectively reduces this alternate aspect of the invention to the

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previous aspect, in which phase interpolation is applied to two neighboring projection views.

More generally, this alternative aspect may be embodied through phase interpolation between several (e.g., three or more) working projection views. The result is again to obtain an interpolated projection view, now based on the interpolation formula

$$P_{\phi}(\theta) = \sum_{i,j} w_{ij}(\theta, \phi) \cdot P_{ij}(\theta) \qquad (4)$$

Here *i* indexes cardiac cycle and *j* indexes gantry rotation (i.e., data acquisition cycle). The equation (4) applies fully to the case of axial scanning but is not limited to such contexts, as will be seen below.

The weights $w_{ij}(\theta, \phi)$ in equation (4), some of which may be zero, may be selected based on any of various suitable weighting schemes. For example, the weighting formulas

$$w_{ij}(\theta,\phi) = \frac{w'_{ij}(\theta,\phi)}{\sum w'_{ij}(\theta,\phi)}, \text{ where} \qquad (5)$$

$$w'_{ij}(\theta,\phi) = \left[\Delta(\Phi_{ij}(\theta) - \phi)\right]^{-p} \text{ and}$$

$$\Delta(\Phi_{ij}(\theta) - \phi) \equiv \begin{cases} \left|\Phi_{ij}(\theta) - \phi\right|, & \left|\Phi_{ij}(\theta) - \phi\right| \le \frac{T_h}{2} \\ T_h - \left|\Phi_{ij}(\theta) - \phi\right|, & \frac{T_h}{2} < \left|\Phi_{ij}(\theta) - \phi\right| \le T_h \end{cases}$$

define weights $w_{ij}(\theta, \phi)$ similar to the coefficients of P′ and P″ in (1) and (2) above.

The case where the exponent is p=2, for example, achieves rapid decay with increasing phase distance of the working projection view from the desired phase. A rapid decay condition reduces the influence of more distant working projection

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views, relative to the contribution to the interpolation result from views close to the desired phase.

It is noted that the above definition of $\Delta(\Phi_{ij}(\theta)-\phi)$ accounts for the case when the distance $|\Phi_{ij}(\theta)-\phi|$ is greater than $T_h/2$, one-half the heart cycle period. Such a difference function may be applied (with changes that will be apparent to those of skill in the art) in equations (1) and (2) above, in any case where the difference ϕ_0-T_2 or the difference $T_1-\phi_0$ exceeds one-half of the heart cycle period T_h.

Those of skill in the art will appreciate that the inverse-polynomial weighting $[\cdot]^{-p}$ set forth above is only one example of a weighting function that may be applied for phase interpolation as provided by the present invention. For example, the weights $w_{ij}(\theta, \phi)$ may be defined in terms of any nonnegative monotonically decreasing function of the distance $\Delta(\Phi_{ij}(\theta)-\phi)$ such that the sum of the weights for a given θ and ϕ is unity: $\Sigma\, w_{ij}(\theta, \phi)=1$. For example, the weighting function $w_{ij}(\theta, \phi)$ may be reduced to a unit step function having value 1 at the nearest-neighbor phase $\Phi_{ij}(\theta, \phi)$ and value 0 at more distant phases. The result of this weighting choice in equation (4) would be to reduce the interpolation approach of the present invention to the nearest-neighbor substitution approach described above.

Another implementation provided by the present invention assigns non-zero weights to working projection views in pairs, with each pair comprising one view before and one view after the desired phase (i.e., the phases of each pair "sandwich" the desired phase). In such an alternative implementation it may be particularly desirable to use sandwiching with working projection views from consecutive trajectories. That is, for each of the sandwich pairs, the projection views of the pair may be chosen from consecutive data acquisition cycles to sandwich the desired phase therebetween.

Helical Scanning

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In an implementation for cardiac imaging, as described above, the invention enables reconstruction of a single slice through the heart with high resolution in time. If reconstruction is desired for more than one slice, such as for a volumetric section (for example, a volumetric image of the entire heart), then further processing is performed.

One way to achieve this further goal is to perform the previously described method for each of several slices through the heart. However, collection of the scan data to be used for each slice involves multiple rotations of the gantry. For the example illustrated in FIG. 8, three complete scanning rotations would be needed for each slice.

Such an operation of multiple rotations for multiple slices would require an undesirably long data collection time. In particular, collection of data for all the slices through the heart would be difficult to achieve in one breath hold (20-60 seconds), at least with the current CT technology. Such an approach would also deliver to the patient an undesirably large X-ray dose. Thus, at least for dynamic contexts such as cardiac imaging, the axial scanning arrangements illustrated in FIGS. 2-3 may have disadvantages.

FIG. 21 illustrates a source-detector assembly 2100 for a desirable alternative to axial scanning, called helical scanning. The principal features of assembly 2100 are analogous to the components of assemblies 200 and 300 in FIGS. 2 and 3, respectively. A subject 2102 (here illustrated as a human patient) is illuminated by an x-ray beam 2104 while disposed on a (possibly movable) table 2108. A gantry 2112 supports an x-ray source 2114 that generates the imaging x-ray beam 2104. However, unlike the fan beams 204 and 304 described previously, beam 2104 is a so-called cone beam that spreads (or "fans") in two generally orthogonal directions as the beam is projected away from the source 2114.

The particular assembly 2100 of FIG. 21 corresponds to the third generation axial assembly 200 of FIG. 2. Specifically, the gantry 2112 also supports

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a detector array 2116 comprising multiple detector elements 2118, and both the source 2114 and the detector array 2116 are transported around the subject 2102 along respective circular paths as the gantry 2112 rotates. The detector array 2116 and the source 2114 are both fixed to the gantry 2112. The detector 2116 thereby remains opposite the source 2114, relative to the subject 2102, during the rotation.

Unlike detector array 216, however, the array 2116 is a so-called multi-row detector comprising several rows of detector elements. The array 2116 thereby provides a two dimensional detection area, which corresponds to the spread of the cone beam 2104 in two directions. Accordingly, at each (lateral) detector position of a single row detector array (such as array 216 in FIG. 2), the array 2116 comprises an entire set of detector elements arranged in a column generally parallel to the axial direction z.

FIG. 22 shows a schematic diagram of the detector elements of a multi-row detector such as detector array 2116. In the illustrated example, each column of the array 2116 comprises four detector rows. Each detector has a thickness of Δ_d.

Helical scanning relaxes the requirement of axial scanning systems that the axial position of the gantry is fixed at a single point throughout the data collection cycle. Instead, the entire gantry (source and detector array) translates axially (in the z direction) relative to the patient. This mode of operation allows a single scan to cover the entire organ or structure under study. Thus, the motion of the gantry, as well as the individual detector elements, traces a helix. The extent of translation in the z direction (as a fraction of detector thickness Δ_d) per gantry rotation is called "pitch" and is denoted by "p" in FIG. 21. Thus, the axial position of the *k*-th detector row can be written as

$$z_k(t) = p\Delta_d \frac{\omega t}{2\pi} + k\Delta_d .$$

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A helical/cone beam CT scanning system provides advantages for performing a volumetric reconstruction of the heart. For example, a multi-row detector such as detector array 2116 can collect several times more x-ray data from each scanning rotation. The axial position of the cone beam 2104 also advances continuously during the scanning operation, so that each detector element 2118 traces a helical path around the subject 2102. In this manner, the data collection proceeds continuously as the cone beam 2104 advances axially, rather than being repeatedly interrupted for a next translation maneuver.

FIG. 23 illustrates a complication that arises with helical scanning. The rotations 1, 2, and 3 represent successive loops of the helical advance of a four-row detector array such as array 2116 shown in FIGS. 21-22. As time t evolves, each scanning rotation progresses from a 0° view angle to a 360° view angle. Further, the angle 360° for a given rotation coincides with the view angle 0° of the succeeding rotation.

However, the helical advance of the gantry during the scanning process causes the detector elements of the multi-row detector to be displaced axially during each rotation. The locations of the detector rows of a three-row detector in the z direction are shown in FIG. 23 in the z-t domain. The axial position of each detector row therefore changes, both between rotations and within each rotation. Still, each of the detector rows in the multi-row detector defines data corresponding to a proper projection view, i.e., a projection view representing attenuation data for a single axial position.

The axial displacement of the detector positions in helical scanning entails additional processing (rebinning) of the collected projection data to assemble projection views conformable to the standard image reconstruction methods. One approach is initially to reformat the helically skewed data from the multi-row detector into a sequence of sinograms each corresponding to a single axial position z. This rebinning procedure typically entails an interpolation procedure between detector element values of neighboring detector rows. An additional, phase interpolation

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procedure of the present invention is also performed to obtain projection data for the missing projection views at each axial position.

FIG. 24 illustrates an alternative approach in which each data row of the three-dimensional helical projection data is tagged with corresponding phase information. Thus, following FIG. 11, the phase of the projection at view angle , cardiac cycle i, gantry rotation j, and detector row k is represented as Φ_{ijk}. The projection data may also be tagged with Z-axis position information $Z_{ijk}()$ based on the geometry of the detector rows, the relative speed of gantry and patient, and the gantry rotation rate. In FIG. 24 the diagonal line represents the common trajectory followed by each detector row in z as time evolves. The values $np^*\Delta_d$ on the vertical axis represent the accumulated number of data rows obtained after the corresponding number of gantry rotation periods (T_g, $2T_g$, $3T_g$, etc.). The slope of the diagonal line is determined by the table speed.

FIG. 25 shows a flow diagram illustrating a procedure to implement the present invention in the context of helical scanning. An operation 2510 cross-references the view angles of the helical projection data and the timing of the cardiac cycle. This may entail tagging the set of projection data for each view angle with timing information. The operation 2510 thereby correlates the projection data sets to the cardiac cycle phases to which the respective data sets correspond. In the case of a multi-row detector, each projection data set will comprise several rows of projection data for each view angle.

A particular cardiac phase is selected for reconstruction at an operation 2520. Because the helical scanning process collects scan data over a range of axial positions, an axial position z_0 of the slice to be reconstructed is also selected at an operation 2530. An initial view angle is selected at an operation 2540 for processing of the helical data.

An operation 2550 selects a set of neighboring scanning rotations for the selected cardiac phase and the selected view angle. This operation is described in

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more detail below with reference to FIGS. 26-28. Briefly, operation 2550 relates to the fact that the helical scan data are collected as the axial position of the gantry advances through multiple rotations. A first stage toward determining working projection views is to identify from the helical projection data the scanning rotations for which the projection data are most relevant to the missing projection view.

An operation 2560 determines working projection views for the scanning rotations selected in the operation 2550. This determining operation is described in greater detail below with reference to FIGS. 29-30. Operation 2560 relates to the fact that the helical scan data from a multi-row detector is desirably conformed into projection views for the selected slice position.

When the working projection views have been determined at operation 2560, the procedure of FIG. 25 advances to an operation 2570. In this operation, an interpolated projection view is generated from the working projection views determined in the operation 2560. The operation 2570 may be the same phase interpolation (i.e., interpolation in time) described above with respect to operation 1460 of FIGS. 14 and 16. An operation 2580 determines whether the current view angle is the last view angle for which a projection view is needed for reconstruction of the selected slice. If more view angles remain, the procedure advances to an operation 2590 where the next view angle is selected. The procedure then returns to operation 2550.

FIG. 26 shows a flow diagram illustrating an exemplary sequence of operations for performing the operation 2550 of FIG. 25. The context for this procedure is that the helical projection data comprise data for a succession of scanning rotations each including the selected view angle. However, because the cardiac cycle will not be synchronized with the scanning rotations, the data for the selected view angle from different scanning rotations generally will represent the heart at different cardiac phases.

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Operations 2610 and 2620 determine particular helical projection data (such as by selecting particular scanning rotations) for which the selected view angle corresponds to respective cardiac phases near the selected phase. The operation 2610 determines such data for a nearby phase timing prior to the timing of the selected phase, and the operation 2620 determines data for a nearby phase subsequent to the selected phase.

For example, with reference to the trajectories of FIG. 8, the trajectories 3 and 2 would be selected as neighbors for (i.e., before and after) the selected phase t_0, for all view angles θ between 0° and 60°. For θ between 60° and 180°, trajectories 1 and 3 would be selected; for θ between 180° and 300°, trajectories 2 and 1 would be selected; and for θ between 300° and 360°, trajectories 3 and 2 would be selected. It is desirable for the procedure to select those scanning rotations for which the selected view angle occurs at a cardiac phase closest to the selected cardiac phase.

FIGS. 27-28 illustrate the determinations of operations 2610 and 2620. In FIG. 27, each of scanning rotations 1, 2, and 4, the timing of the selected phase is denoted as ϕ_0. The scanning rotation 3 lacks an occurrence of the selected phase, reflecting the fact that in the illustrated example the cardiac cycle period T_h is longer that the scanning rotation period T_g. The selected view angle is denoted θ_v and occurs in every rotation, including rotation 3.

FIG. 28 illustrates determination of scanning rotation sets for operations 2610 and 2620. In a preferred embodiment, the rotations are ones in which the selected view angle occurs at a cardiac phase close to an occurrence of the selected phase. FIG. 28 shows that the phase differences between the phase at the selected view angle θ_v and the selected phase ϕ_0 are represented as phase differences $\Delta\phi$.

The designation of phase differences $\Delta\phi$ emphasizes that the present invention may determine a working projection view based on the difference between

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the phase of the heart at the working view and the desired phase. An interpolation rule used in the present invention may account for the relative phase differences of two working projection views and may give greater weight to a working view that is closer in phase than a working view that is farther away. As indicated above with reference to FIGS. 17-19, the actual phase difference may be better determined by a delay following a most recent trigger wave in the EKG (such as an R-wave), rather than a uniform phase timing such as timing ϕ_0 in FIG. 12.

Returning to FIG. 28, the view angle θ_v in rotation 1 occurs at a phase delay $\Delta\phi_1$ away from the occurrence of the phase ϕ_0. In rotation 2, view angle θ_v occurs $\Delta\phi_2$ away from ϕ_0 in rotation 1 and $\Delta\phi_3$ away from ϕ_0 in rotation 2. Similarly, in rotation 3 θ_v occurs $\Delta\phi_4$ away from ϕ_0 in rotation 2 and $\Delta\phi_5$ away from ϕ_0 in rotation 4. θ_v in rotation 4 occurs $\Delta\phi_6$ away from ϕ_0 in the same scanning rotation. Of course, additional scanning rotations will generally provide additional occurrences of θ_v at corresponding phase differences $\Delta\phi$ away from ϕ_0.

The selection of neighboring scanning rotations in operation 2550 (see FIG. 25), performed in operations 2610 and 2620 of FIG. 26, may select a pair of rotations for which the selected view angle θ_v occurs at a timing close in phase to the desired phase ϕ_0. In a particular case, θ_v may occur in the selected rotations at the closest phases before and after phase ϕ_0, respectively, among the collected projection data. Thus, rotation 4 will be selected because θ_v occurs closest in phase to ϕ_0, of the available rotations. The occurrence of θ_v in rotation 3 is the closest occurrence after an occurrence of ϕ_0, among the available rotations. It should be observed at this point that the selected rotations 3 and 4 are temporally consecutive data acquisition cycles, a natural consequence of selecting the closest trajectories before and after the desired phase.

It follows that the exemplary embodiment illustrated in FIG. 28 determines the helical projection data in operation 2610 as the data at θ_v in rotation 4. The data determined in operation 2620 are, in like manner, the data at θ_v in rotation 3.

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In summary, the illustrated embodiment of the procedure selects the nearest neighbor scanning rotations before and after the selected phase. The possibility exists to interpolate between view angles corresponding to other scanning rotations, as well, as noted above with reference to FIG. 20. Such alternatives will be described in more detail below with reference to FIGS. 31-36.

FIG. 29 shows a flow diagram illustrating an exemplary sequence of operations for performing the operation 2560 of FIG. 25. The result of these operations is to determine for each selected scanning rotation a projection view representing the subject at the selected axial position. As noted above, the helical scan data is usually collected with a multi-row detector and cone beam.

An operation 2910 selects an initial scanning rotation from the selected scanning rotations for which working projection views are to be determined. The selected axial position will generally fall between the axial positions for two detector rows of the selected scanning rotation at the selected view angle. FIG. 27 shows that the axial position of each detector row advances as the view angle of the rotation increments from 0° to 360°. For the selected view angle, operation 2920 determines from the selected scanning rotation the two rows closest to the selected position z_0.

FIG. 30 is a time evolution diagram, similar to FIGS. 27-28, showing the helical projection data determined in the procedure of FIG. 26. As seen in FIG. 30, the helical projection data will usually comprise several rows of data corresponding to the rows of detector elements arranged successively in the axial direction. In the typical case, as illustrated in FIG. 30, none of the selected data rows will provide a projection view at the selected axial position z_0. This is a common occurrence with helical scanning data and arises because of the axial translation of the detector array during the scanning rotation. A projection view for the selected position z_0 will therefore be constructed from the existing helical projection data.

FIG. 30 also illustrates the scanning rotations and data rows that may be selected in operations 2910 and 2920. For the purposes of this illustration, it is

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assumed that the scanning rotation 3 is the selected initial scanning rotation. The two data rows 3010 and 3020, respectively below and above z_0 in the axial direction Z, comprise the neighboring detector row data selected in the operation 2920.

Returning to FIG. 29, projection data for an interpolated projection view at the selected position z_0 are then computed at an operation 2930. Here the interpolated projection data are generated by interpolating in z (the axial direction) between the neighboring row data at each detector position along the selected rows. In some respects this computation resembles a grid transformation operation, whereby the available data are converted to projection data for a different grid. Such transformations are well known in the art, and the various available alternatives for carrying out the corresponding computations will not be detailed here. In a typical such alternative, the data values of the z-interpolated projection view are obtained according to a formula such as

$$P_{ij}(\theta, z_0) = \sum_{ijk \ni |Z_{ijk}(\theta)-z_0| \le \Delta_d} \omega_k(z_0) \cdot P_{ijk}(\theta), \text{ where} \qquad (6)$$

$$\omega_k(z_0) = G\left(\left|Z_{ijk}(\theta) - z_0\right|\right), \ \sum_k \omega_k(z_0) = 1.$$

Here k indexes the rows of the multi-row detector array, $Z_{ijk}(\theta)$ is the z-location of the projection view $P_{ijk}(\theta)$, and Δ_d is the collimation (which, as noted previously, is the inter-row distance). It is also noted that the projection views $P_{ijk}(\theta)$ for given θ, i and j have the same phase $\Phi_{ij}(\theta)$ for all rows k. This commonality arises because in such a case the projections of all the rows are collected at the same moment in time.

The weights $\omega_k(z_0)$ may be defined in terms of a function $G(\cdot)$ of the distance $\left|Z_{ijk}(\theta) - z_0\right|$, where G is a non-negative monotonically decreasing function of its argument. For example, G may be a linear function of the distance $\left|Z_{ijk}(\theta) - z_0\right|$. The idea behind this z-interpolation, like the phase interpolation described previously, is that the closer a projection view is to z_0 (or ϕ_0), the more that

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projection view contributes to the interpolated projection view. As with the previous discussion of weights for phase interpolation, those of skill in the art will appreciate that many weighting schemes may be employed to carry out z-interpolation with the present invention.

An operation 2940 determines whether working projection views are to be determined for more scanning rotations. If so, then the procedure advances to an operation 2950 where the next of the selected scanning rotations is selected for interpolation. For example, in FIG. 30 the next scanning rotation would be scanning rotation 4. The procedure of FIG. 29 then returns to operation 2920. The two data rows 3030 and 3040, respectively below and above z_0, comprise the neighboring detector row data selected in the operation 2920. The operation 2930 then interpolates between rows 3030 and 3040 to generate the second working projection view at the selected axial position z_0.

In the procedure of FIG. 26 the operations 2610 and 2620 will be performed twice. At the completion of the procedure illustrated in FIG. 29, there will have been determined two (or more) separate working projection views each computed by interpolation in z between neighboring detector rows of the respective scanning rotation data. At this point the procedure of FIG. 25 continues as described above.

Flexible Projection Data Processing

A further alternative embodiment of the invention will now be described with reference to FIGS. 31-35. A procedure of this alternative bears some similarities to the procedure of FIG. 14 above. The result to be obtained may be a 3-D image of the patient's heart at a desired cardiac phase ϕ_0. A three-dimensional image (a volumetric representation based on several slice images) of the subject's heart may be obtained through this alternative embodiment by reconstructing 2-D slices for a range of z-locations (z_0). For each two-dimensional slice, the system may

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obtain a slice image corresponding to the given phase ϕ_0, as well as the axial position of the slice.

FIG. 31 is a flow diagram illustrating a procedure 3100 of this alternative embodiment of the invention for the case of helical scan data. In an operation 3110 the three-dimensional projection data are tagged with phase and z-location information. Based on the temporal location of the identified R-wave peaks, as described above with reference to FIG. 11, each projection view is assigned a cardiac phase Φ_{ijk}. In this operation the gantry period T_g is also used to determine the gantry rotation of the projection view. Similarly, the z-locations of the projection views are determined based on the relationship between the gantry period T_g and the table speed, as indicated above with reference to FIG. 24. The phase and z-location tags are used in the subsequent operations of the procedure 3100.

An operation 3120 selects a cardiac phase at which a slice image of the patient's heart is to be reconstructed. A corresponding axial position z_0 for the slice image is selected in an operation 3130. These operations specify the slice image and enable the appropriate projection data to be identified by reference to the phase and location tags.

An operation 3140 determines, from among the helical projection data, the set of projection views from which an interpolated projection view for the slice image may be generated. Given the selected z-location z_0, the projection views that possibly could contribute to the interpolation result of equation (4). As noted above, for a given axial position either one or two data rows of the helical projection data correspond to row positions that are closest to the selected axial position z_0. The projection data were tagged with location information in the operation 3110, and therefore the data rows can be searched for the one or two nearest neighbors to z_0.

Operation 3150 determines a reconstruction range in which to obtain a complete set of projection views for the selected slice image. The operation 3170 determines working projection views for the selected view angle by interpolating in

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the z-direction between the neighboring projection views as determined by the location tags $Z_{ijk}(\theta)$. This operation determines a reconstruction range, i.e., a range of view angles (the range having extent 180°+fan angle) from among the full range [0°, 360°). Here a "reconstruction range" comprises a plurality of discrete view angles, because the projection data are sampled in discrete sampling intervals. A set of projection data is said to "cover" a given reconstruction range if the set of projection data comprises a projection view at each of the discrete view angles of the reconstruction range.

The reconstruction range is selected as a subset of the projection views covering the selected axial position (see operation 3140) for which the total phase distance from the selected phase ϕ_0 is a minimum. The operation 3150 will be described in more detail with reference to FIG. 33. An operation 3160 selects an initial view angle at which an interpolated projection view will be generated.

Operations 3170 and 3180 are repeated for each view angle in the selected reconstruction range. This interpolation may be carried out substantially as described above with reference to FIG. 29.

The operation 3180 performs phase interpolation between the z-interpolated projection views obtained from the operation 3170, using the selected interpolation rule of the form (4) above. Alternatively, the interpolations of operations 3170 and 3180 may be performed in an integrated computation, using an interpolation rule such as

$$P_\phi(\theta) = \sum_{i,j,k} w_{ij}\omega_k P_{ijk}(\theta). \qquad (7)$$

It is further noted that the separated weight $w_{ij}\omega_k$ may be replaced with an integrated weight Ω_{ijk}

The procedure 3100 advances from the operation 3170 to an operation 3180 that determines whether more view angles in the selected reconstruction range

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remain for interpolated projection views to be generated. If so, then an operation 3190 selects the next view angle and the procedure loops back to the operation 3150. If not, the procedure 3100 returns.

FIG. 32 is a flow diagram illustrating details of an exemplary procedure for carrying out the operation 3140 of FIG. 31. An operation 3210 selects an initial time stamp corresponding to an initial sampling interval of the (three-dimensional) helical projection data. This identifies the projection data rows generated first in time among the helical data.

From the operation 3210 the procedure of FIG. 32 enters an iterative loop in which rows of data are examined for possible inclusion in the set of selected projection views. An operation 3220 determines whether any data row corresponding to the current time stamp is tagged with a z-location within the collimation distance Δ_d from the selected axial position z_0. If such a row is identified, the row is selected for the set of projection views in an operation 3230.

The procedure of FIG. 32 advances from the selection operation 3230 to an operation 3240 in which it is determined whether the projection data comprise a second row within the collimation distance Δ_d from the z-position z_0. If so, the second row is selected for the set of projection views. As noted above, for any given data sampling interval (i.e., any given time stamp) will correspond to at most two data rows tagged with z-locations within the collimation distance from a selected axial position.

If the determination at either the operation 3220 or the operation 3240 is negative, then the procedure advances directly to an operation 3260. The operation 3260 determines whether all the time stamps for the collected projection data have been considered. If not, then the procedure advances to an operation 3270 where a next time stamp is selected. From the operation 3270 the procedure loops back to the determination at the operation 3220. If the determination at the operation 3260 is affirmative, then the procedure returns. Alternatively, instead of looping back based

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on the determination of operation 3260, the procedure of FIG. 32 may instead continue until a row of data has been selected at a time stamp and no row of data is selected at a subsequent time stamp, or until all of the time stamps have been considered, whichever occurs first. This alternative may be more efficient because a final block of rows that comprises no selectable rows will not be searched.

FIG. 33 is a trajectory graph, similar to the graph of FIG. 20, for illustrating the operation 3150 of FIG. 31. The filled circles 3310 each represent projection data corresponding to a respective data sampling interval. The data acquisition cycles of the imaging system 100 provide several trajectories 1, 2, 3 of projection data. Each trajectory, although discretized in time and hence also in view angle, nevertheless covers the full range [0°, 360°) of view angles. Moreover, for each discrete view angle in the range [0°, 360°), the projection data comprise several sets 3310 of projection data having time stamps corresponding to the given view angle. Thus, as in FIG. 20, an interpolated projection view could be generated for each discrete view angle from the existing sets of projection data at that view angle.

On the other hand, as noted above, current reconstruction algorithms generally can produce high quality image reconstructions with projection data covering less than the full range [0°, 360°). The projection views should cover an angular sector of at least 180° plus the fan angle. FIG. 33 illustrates that this condition may be satisfied by several different sets of projection views covering different sectors of view angles. The several trajectories 1, 2, 3, etc., therefore comprise more projection data than is necessary for the desired image reconstruction.

This surplus of projection data presents a potential opportunity for optimizing the image quality by carefully selecting the reconstruction range for the desired image. Here a reconstruction range Θ_r is simply the range of view angles of the projection views from which the slice image will be reconstructed. The perspective of the projection data afforded by the trajectory graph of FIG. 33 raises the possibility that different reconstruction ranges may provide reconstructed images with different features.

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Yet another aspect of the present invention provides an approach for determining a reconstruction range that will optimize some data parameter having an influence on image quality. In one implementation of this aspect of the invention, a reconstruction range is selected that has a minimum total phase distance from the desired phase. Here, "minimum total phase distance" means the smallest distance value defined by the following formula:

$$D(\theta_1,\theta_2)=\sum_{\theta\in R_r=[\theta_1,\theta_2]} d(\theta,\phi) \tag{8}$$

where the reconstruction range R_r extends between beginning and ending view angles θ_1 and θ_2, respectively. The total phase distance is a "separation measure" for the reconstruction range, because the total phase distance measures a separation (in phase) between the existing projection views of the reconstruction range and an ideal set of projection views (e.g., all at the desired phase). The value $d(\theta,\phi)$ is selected as the minimum phase distance between the phase of the current projection view and the desired phase, as follows:

$$d(\theta,\phi)=\arg\min_{i,j}\left|\Phi_{ij}(\theta)-\phi\right|. \tag{9}$$

Those of skill in the art will appreciate that the reconstruction range R_r may begin at an angle θ_1 that is actually larger than the ending angle θ_2, due to the periodicity of θ_1. In such a case the representation $[\theta_1, \theta_2]$ for the reconstruction range R_r in equation (2) above may be replaced by the corresponding representation $R_r=[\theta_1, 2\pi)\cup[0, \theta_2]$.

In the foregoing particular example the detector array has four rows of detectors. In this exemplary case it follows from simple geometry that the number of gantry rotations contributing projection views for a given z-location is determined by 4/p, where p is again the pitch of the helical scan. The pitch p may be selected to be small enough that multiple projection views are generated for the same view angle,

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although from different gantry rotations and cardiac cycles. Depending on the heart rate, these projection views will represent the heart in a distribution of cardiac phases.

Therefore, in a first procedure, the temporal (phase) distance d_{ij} of each projection to the reconstruction (target) phase ϕ_0 will be determined. Each of these phase distances indicates a separation (in phase) between the projection view and an ideal projection view (at the desired phase), and thus each is a "separation value" for the respective projection view. Then, for each view angle, the minimum temporal distance is found and used with equations (8) and (9) to determine the start angle θ_s and the end angle θ_e of the least-distance reconstruction range. The result is a reconstruction range with a subset of projection views that are closest in phase to the reconstruction phase ϕ_0.

FIG. 34 is a flow diagram illustrating a procedure of this further aspect of the invention for determining such a reconstruction range. An operation 3410 computes the phase difference d_{ij} for each projection view in the selected set of projection data. An operation 3420 then selects a projection view closest in phase to the desired phase ϕ_0, for each view angle. A total D_R of these minimum distances is computed at an operation 3430 for each potential reconstruction range in the full sector [0°, 360°). A particular reconstruction range whose total distance D_R is a minimum relative to the other reconstruction ranges is selected in an operation 3440, and the procedure of FIG. 34 returns.

FIG. 35 is a flow diagram illustrating an exemplary procedure of the invention for determining the interpolated projection views for a selected reconstruction range. An operation 3510 selects an initial view angle in the selected range. It is noted that the reconstruction range may be represented by an angular interval $[\theta_s, \theta_e]$, so that the initial view angle may be θ_s. An operation 3520 interpolates between the row data of the projection views selected for the view angle. An operation 3530 determines whether more view angles remain at which to generate

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interpolated projection views. If more view angles remain, an operation 3540 selects the next view angle, and the procedure loops back to the operation 3520.

FIG. 36 is a flow diagram outlining an overall procedure of the invention for generating a set of slice images for a corresponding range of axial positions z. Where the set of slice images comprises a plurality of images, this procedure effectively provides for generating a volumetric image of the object of interest. The direct result of the particular procedure as illustrated is a three-dimensional representation of the patient's heart at a selected phase of the cardiac cycle. Persons of skill in the art will appreciate that this basic procedure may be employed for a range of selected phases to generate a dynamic model of the patient's heart, for purposes such as dynamic functional assessment.

An operation 3610 selects the desired cardiac phase ϕ_0. An operation 3620 similarly selects a range of axial (z-axis) locations for the slice images to be generated. An operation 3630 tags the projection data with phase identification information and z-location information, as described previously with reference to FIGS. 11 and 24. An operation 3640 selects an initial slice location (z_0).

Operation 3650 generates interpolated projection views for the selected slice by phase interpolation, as provided by the various aspects of the present invention. A complete set of projection views is thereby generated for the selected slice, perhaps with supplementation from the existing views of the projection data. Operation 3660 performs reconstruction on the complete set of projection views, using any of various well-known methods for tomographic image reconstruction. An operation 3670 determines whether more slice images remain to be generated. If so, the procedure advances to operation 3680 where the next slice position is selected, and the procedure then returns to the operations 3650 and 3660.

A Technique for Re-ordering Data in the Phase Domain

The foregoing exemplary embodiments illustrate an aspect of the invention that provides advantages for tomographic imaging of objects in motion.

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This aspect of the invention provides for reconstruction of a tomographic image from projection views that have been processed to account for dynamic behavior of the imaged object during collection of the projection data [$\theta(n)$, $Z(m)$].

The examples described above further illustrate that such processing to account for dynamic behavior may be carried out in various alternative ways. For example, the adaptive processing approach of the first embodiment described above is oriented toward independent sets of projection data where each set corresponds to a single axial position z. In this sense, the first embodiment may be described as "position driven." When the raw data [$\theta(n)$, $Z(m)$] are obtained by helical/cone beam scanning, further processing (rebinning) may be carried out to assemble the helically skewed data into a sequence of such independent sets for successive axial positions. This rebinning procedure typically entails an interpolation procedure between detector element values of neighboring detector rows, such as z-interpolation as described above.

An additional technique for preprocessing the raw projection data will now be described. Such preprocessing may be used with the present invention and particularly with "position driven" embodiments as noted above.

This additional technique proceeds from the further observation that useful information potentially exists in relationships between helical scan data in both space and time. The rebinning procedure noted above illustrates that the spatial proximity of adjacent detector rows has been used to synthesize projection data corresponding to a particular axial position. The technique to be described uses the further discovery that the selection of appropriate subsets of the three-dimensional projection data can allow additional information to be extracted from relationships between the raw data collected in different gantry rotations.

One source of this additional information may be the potential for overlap between the helical scan paths of various detector elements in a multi-row detector array. However, it has been recognized also that other relationships may

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exist between the raw data of different gantry rotations. A particular instance of such relationships will now be described in conjunction with an exemplary embodiment of the present additional technique in the particular context of volumetric cardiac imaging.

FIG. 37 is a flow diagram illustrating a general procedure provided by the present additional technique. An operation 3710 is the basic data collection operation for obtaining three-dimensional projection data. If the projection data are generated with a helical scanning system comprising or having a source-detector assembly such as the assembly 2100, then the operation may comprise several rotations of the gantry 2112 to execute multiple data acquisition cycles. In any case, the operation 3710 obtains volumetric projection data representing the imaged object over a plurality of data acquisition cycles.

In an operation 3720, the three-dimensional projection data are analyzed to determine (for example, to select) a particular set of projection views at a selected view angle for each data acquisition cycle. It is desirable to select the view angles for this operation 3720 according to a time dependent feature (i.e., a "dynamic behavior") of the object being imaged. The particular sets of projection views may then be selected to satisfy a predetermined relationship for the time dependent feature between the different sets. A particular case of this determining operation will be described below with reference to FIGS. 40-42.

An operation 3730 provides a reconciliation between the axial positions at which the projection views of a given set represent the object and the axial positions at which the stacked slice images are to represent the object. This reconciliation is typically helpful because the helical projection data are axially skewed within each rotation data set. Thus, with reference to FIG. 23, it will be likely that none of the detector rows will coincide in axial position with a specified position, at least when the view angle θ is chosen according to some other criterion. Thus, to generate projection views representing the object at the specified axial position, a

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spatial interpolation (such as the z-interpolation described above) is typically carried out in the operation 3730.

An operation 3740 generally completes the procedure by reconstructing a number of slice images (usually several, but possibly only one or two) at the respective specified axial positions. For each slice image, this operation entails selecting projection views from respective ones of the sets of projection views (or from the reconciled sets of projection views). In this way, each slice image may be reconstructed from several projection views representing the object at different view angles but at the same specified axial position.

A particular embodiment of the present additional technique will now be described in the context of cardiac imaging. Persons of skill in the art will appreciate, however, that this technique can also be applied in other medical and non-medical imaging contexts where a time dependent feature of the three dimensional projection data implicitly carries additional information about the imaged object.

As noted above, in the simplest case of cardiac imaging, it may be assumed that the heart rate is constant while the scan data are collected. The desired phase of the heart's cycle of configurations then occurs in each cardiac cycle at a fixed fraction of the heart period T_h following the preceding R-wave. For a given cardiac cycle, a projection view corresponding to the desired heart phase may be identified by reference to the fixed fraction and the time stamps correlating to the cardiac R-wave that begins the cardiac cycle.

The assumption of regular heartbeat simplifies the process of cross-referencing the projection data and the EKG data. In particular, for each R-R heart cycle the desired phase of the heart occurs at the same time t_0 after the R-wave of the cycle. The simplifying assumption of regular heart rate thus creates an assumed correlation between the time stamps of the row data and the respective phases of the cardiac cycle.

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However, usually the heart rate is not uniform during the data acquisition process. The preferred procedure is then to collect an electrocardiogram (EKG) data set along with the helical scan data. The EKG data set can then be correlated off-line with CT scan data, using the time stamps associated with the raw volumetric projection data. Thereafter, using the time stamps and the correlations to the EKG data, the particular projection data corresponding to a selected cardiac configuration phase can be identified, as in the embodiments described above.

Such an adaptation to heart rate variations is well known in the art and has been used, for example, in the sector approach described above with respect to FIG. 6. Persons skilled in the art will readily appreciate the appropriate measures to be used with the present additional technique to compensate for the presence of heart rate variability. For example, a compensation model is employed in the technique of U.S. Patent No. 5,997,883 to Epstein et al. noted previously.

On the other hand, an embodiment of the present additional technique is particularly useful in cases where heart rate variability exists. It is known that in most cases where the heart cycle duration varies, the systole period of the cardiac cycle is relatively stable. In other words, the portion of the cardiac cycle that changes in duration most commonly is the diastole period, when the heart is in a relaxed state. This fact can be used to develop a selection criterion for selecting sets of projection views, as in the operation 3720 of FIG. 37.

FIG. 38 depicts timing diagrams that illustrate the determination of a trigger delay TD with which to select the projection data sets. In trace A of FIG. 38, the R waves of successive cardiac cycles occur at irregular times, due to the heart rate variability. Trace B of FIG. 38 shows the corresponding displacement of a coronary artery to be imaged.

During the systole period, the displacement is substantial and will tend to create motion inconsistencies in the projection data. However, if a fixed time TD is measured after each R wave, it can be seen that the heart has entered the quiescent

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diastole period. As trace B of FIG. 38 illustrates, the duration of the diastole period may vary substantially from cardiac cycle to cardiac cycle. However, the entering portion of the diastole occurs reliably at the delay time TD after the R wave.

Trace C of FIG. 38 illustrates the timing of trigger signals by which to select the sets of projection views from the three-dimensional projection data. By generating a trigger signal at a fixed trigger delay TD after each R wave, sets of projection views can be selected from the volumetric data to represent the heart in a same phase of the cardiac cycle. The trigger delay can be chosen so that the particular phase is a phase at which the heart is nearly still, thereby enhancing the consistency of the selected projection data sets.

Different trigger delays can be used to generate a four-dimensional model of the heart. The foregoing aspects of the present invention, such as the first embodiment described above, may be employed to generate interpolated projection views for this purpose. For a given phase of the desired four-dimensional model, a projection view at a selected view angle and a selected axial position may be synthesized by interpolating between projection views at nearby phases.

FIG. 39 is a flow diagram illustrating a procedure of the present technique as applied in the foregoing context of cardiac imaging. A trigger delay TD is set to a specific value in an operation 3910, thereby determining the particular phase of the heart for the three-dimensional image reconstruction.

As can be seen from FIG. 23, the trigger delay TD will typically correspond to a different view angle θ for each of the scanning rotations (data acquisition cycles ROTATION 1, ROTATION 2, etc.). An operation 3920 therefore identifies the trigger angles θ_i for the corresponding rotational data sets. An operation 3930 collects the raw data $[\theta(n), Z(m)]$ at the corresponding trigger angles θ_i, using the time stamp correlations between the EKG data and the projection data.

An operation 3940 selects the axial positions z_i at which the one or more slice images are to be reconstructed. The positions z_i may be chosen to coincide

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with the successive axial positions of one of the selected projection data sets, although the helical skew of the volumetric projection data will generally prevent such coincidence for the other sets. An operation 3950 then completes the reconciliation of the axial positions of the selected projection data sets with the specified axial positions for the slice images, by interpolating the collected projection data sets in z. The reconciled projection data sets can then be input to the reconstruction process to generate the desired slice images.

FIG. 40 shows a time evolution diagram similar to the diagram of FIG. 23, but with the trigger delay TD indicated after the R waves R_1, R_2, and R_3. In the illustrated example, the gantry rotation period T_{gantry} is less than the nominal period of the cardiac cycle. Therefore, triggers t_1 and t_2 occur in rotations 1 and 2, respectively, but trigger t_3 does not occur until rotation 4. A different choice for TD would result in different locations of the triggers t_i.

FIG. 41 shows that the triggers t_i determine trigger angles θ_i in the rotations 1, 2, and 4. Each selected trigger angle θ_i determines a corresponding set of projection views in the time stamped projection data. For example, θ_1 determines the projection views 4112, 4114, 4116, and 4118, which happen to correspond to the first through fourth detector rows of the multi-row detector array. The trigger angle θ_2 determines the projection views 4122, 4124, 4126, and 4128 from rotation 2. The trigger angle θ_3 determines the projection views 4132, 4134, 4136, and 4138 from rotation 4.

A notable point is that all of the projection views 4112 through 4138 represent the imaged heart in the same phase of the cardiac cycle. This is achieved by determining the sets of projection views from the raw data, rather than selecting a specified axial position for the desired image and then searching for suitable projection views in the raw data.

FIG. 42 shows the selected sets of projection views at their respective view angles relative to a single cycle of view angles θ. Due to the axial skewing of

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the raw projection data, the several projection views 4112 through 4138 correspond to different axial positions z. Reconstruction of a slice image at a specified axial position therefore will typically entail reconciliation of the selected projection view sets. A reconciled set of projection views is thereby selected to representing the heart at the same view angles θ_1 through θ_3, but at a single specified axial position z.

Various implementations of the invention described herein above have been tested with clinical cardiac data. These results demonstrate that the invention can noticeably reduce the streaks and other artifacts that occur when the sector approach is applied.

As this invention may be embodied in several forms without departing from the spirit or principal characteristics thereof, the present embodiments are therefore illustrative and not restrictive. Those skilled in the art will appreciate that changes may be made to these embodiments without departing from the principles and spirit of the invention. Accordingly, the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within the metes and bounds of the claims, or equivalents of such metes and bounds thereof, are therefore intended to be embraced by the claims.

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WHAT IS CLAIMED IS:

1. A tomographic image generation method, comprising:

determining a plurality of working projection views (910, 920) of an object (106) at a selected view angle based on initial projection data collected in respective different data acquisition cycles; and

interpolating between the working projection views (910, 920) to generate an interpolated projection view (900) of the object (106) at the selected view angle.

2. A method according to claim 1, wherein the plurality of working projection views comprises three projection views.

3. A method according to claim 2, wherein the three projection views are respectively based on initial projection data collected in consecutive data acquisition cycles.

4. A method according to claim 1, wherein the plurality of working projection views comprises four projection views.

5. A method according to claim 1, wherein the plurality of working projection views (910, 920) consists of two projection views.

6. A method according to claim 1, wherein the object (106) is in motion during collection of the initial projection data.

7. A method according to claim 6, wherein the motion of the object (106) is cyclical motion.

8. A method according to claim 7, wherein successive cycles of the cyclical motion have a same cycle period.

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9. A method according to claim 7, wherein successive cycles of the cyclical motion each has a cycle duration within a range of variation about a nominal cycle period.

10. A method according to claim 1, wherein:

the object (106) is in cyclical motion during collection of the initial projection data; and

the determining operation comprises selecting the working projection views (910, 920) from projection views of the initial projection data based on the selected view angle and a specified phase of the cyclical motion, whereby the interpolated projection view (900) represents the object at the selected view angle and in the specified phase of the cyclical motion.

11. A method according to claim 10, wherein:

the cyclical motion comprises successive cycles of at least one of translation, rotation, and elastic deformation of the object (106); and

the specified phase corresponds to a selected translation, rotation, or elastic deformation state assumed by the object (106) in each of the successive cycles.

12. A method according to claim 1, wherein the plurality of working projection views (910, 920) consists of two projection views (910, 920) respectively based on initial projection data collected in two consecutive data acquisition cycles.

13. A method according to claim 12, wherein the specified phase is determined by a selected shape configuration repeatedly assumed by the object (106) during the cyclical change in shape configuration.

14. A method according to claim 1, wherein the initial projection data represent intensities of energetic rays transmitted through the object (106) and detected by a detector array (116).

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15. A method according to claim 1134, wherein the energetic rays comprise x-rays (104).

16. A method according to claim 14, wherein:

the detector array (116) is a multi-row detector array (2116); and

a cone beam (1104) impinges on a side of the object opposite the detector array and the energetic rays comprise rays of the cone beam (1104) transmitted through the object (106) to the detector array (2116).

17. A method according to claim 14, wherein the energetic rays are attenuated by the object (106) and the initial projection data represent intensities of the energetic rays subsequent to the attenuation.

18. A method according to claim 1, wherein the working projection views (910, 920) comprise projection views selected from the initial projection data based on contemporaneously collected timing data.

19. A method according to claim 1, wherein:

the initial projection data are collected by the detector array (116) in a cyclical scan comprising a plurality of rotational data acquisition cycles; and

the initial projection data comprise initial projection views of the object (106) collected in plural successive rotational data acquisition cycles.

20. A method according to claim 19, wherein:

the object (106) is in cyclical motion during collection of the initial projection data; and

a rotation period of the plurality of rotational data acquisition cycles is different from a cycle duration of successive cycles of the cyclical motion.

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21. A method according to claim 1, wherein the object (106) is an organ of a subject (102).

22. A method according to claim 21, wherein the organ (106) is a heart.

23. A method according to claim 12, wherein the object (106) is a human heart.

24. A method according to claim 1, wherein the interpolating operation comprises performing weighted linear interpolation between respective projection data of first and second ones of the working projection views (910, 920).

25. A method according to claim 1, wherein the interpolating operation comprises performing weighted nonlinear interpolation between respective projection data of first and second ones of the working projection views (910, 920).

26. A method according to claim 25, wherein the weighted nonlinear interpolation is weighted quadratic interpolation.

27. A method according to claim 12, wherein:

the determining operation comprises selecting first and second projection views from the initial projection data as the working projection views (910, 920), the first projection view (710) comprising projection data collected in a first data acquisition cycle and the second projection view (720) comprising projection data collected in a second data acquisition cycle subsequent to the first data acquisition cycle; and

the interpolating operation comprises performing weighted quadratic interpolation between respective projection data of the first and second projection views (910, 920).

28. A computer readable medium encoded with a program for tomographic image generation, said program comprising instructions for:

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determining a plurality of working projection views (910, 920) of an object (106) at a selected view angle based on initial projection data collected in respective different data acquisition cycles; and

interpolating between the working projection views (910, 920) to generate an interpolated projection view (900) of the object at a selected view angle.

29. A computer readable medium according to claim 28, wherein:

the object (106) is in cyclical motion during collection of the initial projection data; and

the instructions for the determining procedure comprise instructions for selecting each working projection view (910, 920) from projection views of the initial projection data based on the selected view angle and a specified phase of the cyclical motion, whereby the interpolated projection view (900) represents the object (106) at the selected view angle and in the specified phase of the cyclical motion.

30. A computer readable medium according to claim 28, wherein the plurality of working projection views (910, 920) consists of two projection views respectively based on initial projection data collected in two consecutive data acquisition cycles.

31. A computer readable medium according to claim 28, wherein the initial projection data represent intensities of energetic rays transmitted through the object (106).

32. A computer readable medium according to claim 28, wherein the working projection views (910, 920) comprise projection views selected from the initial projection data based on contemporaneously collected timing data.

33. A tomographic image generation device (130, 140), comprising:

a storage (134, 144) storing initial projection data collected from an object by a detector array; and

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a processor (132, 142) determining a plurality of working projection views (910, 920) of an object (106) at a selected view angle based on initial projection data collected in respective different data acquisition cycles, and interpolating between the working projection views (910, 920) to generate an interpolated projection view (900) of the object (106) at the selected view angle.

34. A device (130, 140) according to claim 33, wherein:

the object (106) is in cyclical motion during collection of the initial projection data; and

said processor (132) determines the working projection views (910, 920) by selecting each working projection view from projection views of the initial projection data based on the selected view angle and a specified phase of the cyclical motion, whereby the interpolated projection view (900) represents the object (106) at the selected view angle and in the specified phase of the cyclical motion.

35. A device (130, 140) according to claim 33, wherein:

the object (106) is in cyclical motion during collection of the initial projection data; and

the plurality of working projection views (910, 920) consists of two projection views respectively based on initial projection data collected in two consecutive data acquisition cycles.

36. A device (130, 140) according to claim 33, wherein the projection data are collected from energetic rays transmitted through the object (106).

37. A device (130, 140) according to claim 33, wherein the working projection views (910, 920) comprise projection views selected from the initial projection data based on contemporaneously collected timing data.

38. A tomographic image generation system (100), comprising:

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a detector array (116) generating initial projection data for an object (106); and

a computer (130, 140) comprising a processor (132, 142) determining a plurality of working projection views (910, 920) of an object (106) at a selected view angle based on initial projection data collected in respective different data acquisition cycles, and interpolating between the working projection views (910, 920) to generate an interpolated projection view (900) of the object (106) at the selected view angle.

39. A system (100) according to claim 38, wherein:

the object (106) is in cyclical motion during collection of the initial projection data; and

the processor (132, 142) determines the working projection views (910, 920) by selecting each working projection view from projection views of the initial projection data based on the selected view angle and a specified phase of the cyclical motion, whereby the interpolated projection view (900) represents the object (106) at the selected view angle and in the specified phase of the cyclical motion.

40. A system (100) according to claim 38, wherein the plurality of working projection views (910, 920) consists of two projection views respectively based on initial projection data collected in two consecutive data acquisition cycles.

41. A system (100) according to claim 38, wherein the initial projection data represent intensities of energetic rays transmitted through the object (106).

42. A system (100) according to claim 38, wherein the working projection views comprise projection views selected from the initial projection data based on contemporaneously collected timing data.

43. A projection data processing method, comprising:

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tagging projection views (910, 920) representing an object (106) in motion with tags indicating respective phases of the motion and respective axial locations for the projection views (910, 920);

determining the tagged projection views (910, 920) representing the object at respective axial locations within a collimation distance from a selected axial location;

determining separation values representing phase separations between the phases of the determined projection views (910, 920) and a selected phase of the motion;

determining projection view subsets from the determined projection views, each projection view subset comprising plural projection views tagged with respective different phases of the motion at each of plural view angles covering a corresponding reconstruction range;

determining for each view angle of each projection view subset a minimum of the separation values of the projection views of the subset at the view angle;

computing a separation measure for each projection view subset by summing the minimum separation values of the projection view subset;

selecting from the determined projection view subsets a subset having a minimum separation measure of the computed separation measures;

successively selecting the view angles of the selected projection view subset; and

interpolating between the plural projection views of the selected projection view subset at each selected view angle to generate an interpolated projection view (900) of the object (106) at the selected axial position and the selected view angle.

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44. A method according to claim 43, wherein the motion of the object (106) is cyclical motion.

45. A method according to claim 43, wherein the selected projection view subset comprises for each view angle thereof at least three projection views at respective different phases of the motion.

46. A method according to claim 44, wherein:

the selected projection view subset comprises for each view angle thereof and each of a predetermined number of different phases of the motion a plurality of projection views representing the object at respective axial positions within the collimation distance from the selected axial position; and

the interpolating operation comprises, for each of the view angles and each of the predetermined number of different phases, interpolating between the plurality of projection views representing the object at respective axial locations.

47. A tomographic image generation method, comprising:

determining a plurality of working projection views (910, 920) of an object (106) in cyclical motion based on initial projection data collected from the object (106), the working projection views (910, 920) being based on selected initial projection data collected in respective different data acquisition cycles; and

interpolating between the working projection views (910, 920) to generate an interpolated projection view (900) representing the object (106) at the selected view angle and at a specified phase of the cyclical motion.

48. A method according to claim 47, wherein the plurality of working projection views (910, 920) consists of two projection views.

49. A method according to claim 47, wherein the cyclical motion comprises successive cycles of motion each having a cycle duration within a range of variation about a nominal cycle duration.

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50. A method according to claim 47, wherein the cyclical motion comprises successive cycles of periodic motion.

51. A method according to claim 47, wherein the object (106) is a heart within a living subject (102).

52. A method according to claim 51, wherein the cyclical motion consists of successive repetitions of a cardiac cycle of the heart (106) and the specified phase is a specified phase of the cardiac cycle.

53. A method according to claim 47, wherein the working projection views (910, 920) comprise projection views selected from the initial projection data based on contemporaneously collected timing data.

54. A method according to claim 47, wherein:

the cyclical motion comprises cyclical elastic deformation of the object (106); and

the specified phase corresponds to a selected shape repeatedly assumed by the object (106) during the cyclical elastic deformation.

55. A method according to claim 47, further comprising collecting quantitative data over plural successive cycles of the cyclical motion, the quantitative data representing a physical property of the object (106) varying synchronously in time with the cyclical motion of the object (106).

56. A method according to claim 55, wherein:

the object (106) is a heart within a living subject (102) and the cyclical motion comprises successive repetitions of a cardiac cycle of the heart (106); and

the quantitative data comprises electrocardiogram data representing an electrical cycle of the heart (106) and the specified phase of the cyclical motion coincides with a selected wave of the electrical cycle.

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57. A method according to claim 56, wherein the selected wave is an R-wave of the electrocardiogram data and the specified phase occurs at a selected time delay after the R-wave.

58. A method according to claim 47, wherein the initial projection data are determined from energetic rays (104) transmitted through the object (106).

59. A method according to claim 58, wherein the initial projection data represent attenuation of the energetic rays (104) by the object (106).

60. A method according to claim 47, wherein the determining operation comprises selecting the working projection views (910, 920) from a plurality of first projection views of the initial projection data.

61. A method according to claim 47, wherein:

the initial projection data are collected in a helical tomographic scan of the object (106) by a multi-row detector array (2116) and comprise plural rows of projection data for each of plural rotational data acquisition cycles of the helical tomographic scan; and

the determining operation comprises computing working projection data for each working projection view (910, 920) based on the initial projection data.

62. A method according to claim 61, further comprising selecting an axial position of the helical scan for the interpolated projection view 900, and wherein for each working projection view (910, 920), the determining operation comprises:

selecting a rotational data acquisition cycle of the helical tomographic scan corresponding to the specified phase of the cyclical motion,

selecting from the plural rows of projection data for the selected rotational data acquisition cycle first and second rows of data corresponding to first and second rows of the multi-row detector array (2116) nearest to the selected axial position during the selected rotational data acquisition cycle, and

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interpolating between the respective projection data of the first and second rows of data to generate the working projection data for the working projection view (900).

63. A method according to claim 47, wherein:

the initial projection data are collected for the object (106) over a plurality of rotational data acquisition cycles using a rotation period different from a cycle duration for a cycle of the cyclical motion; and

first and second ones of the working projection views (910, 920) represent the object (106) in two consecutive rotational data acquisition cycles.

64. A method according to claim 63, wherein the object (106) is an organ of a living subject (102).

65. A method according to claim 47, further comprising:

performing the determining operation successively to determine a succession of pluralities of working projection views (910, 920); and

performing the interpolating operation successively for the succession of pluralities of working projection views (910, 920) to generate a succession of interpolated projection views (900); and

generating a tomographic image of the object (106) by image reconstruction using the projection views of the succession of pluralities of working projection views (910, 920) and the projection views of the succession of interpolated projection views (900).

66. A tomographic image generation apparatus, comprising:

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a storage (134, 144) storing initial projection data for an object in cyclical motion, the initial projection data relating to a specified phase of the cyclical motion and a selected view angle; and

a processor (132, 142) determining a plurality of working projection views (910, 920) of an object (106) in cyclical motion based on initial projection data collected from the object (106), the working projection views (910, 920) being based on selected initial projection data collected in respective different data acquisition cycles, and interpolating between the working projection views (910, 920) to generate an interpolated projection view (900) representing the object (106) at the selected view angle and at a specified phase of the cyclical motion.

67. A tomographic image generation system (100), comprising:

an x-ray source (1114) generating a cone beam (1104) of x-rays to impinge upon a subject (1122);

a multi-row detector array (2116) receiving x-rays transmitted through the subject (1122) from said x-ray source (1114) and generating initial projection data from the received x-rays, at least a portion of the subject (1122) being in cyclical motion and the initial projection data corresponding to a specified phase of the cyclical motion and a selected view angle; and

a computer (130, 140) determining a plurality of working projection views of the at least a portion in cyclical motion based on initial projection data collected from the subject (1122), the working projection views (910; 920) being based on selected initial projection data collected in respective different data acquisition cycles, said computer (130, 140) interpolating between the working projection views (910, 920) to generate an interpolated projection view (900) representing the at least a portion of the subject (1122) at the selected view angle and at a specified phase of the cyclical motion.

68. A tomographic image generation method, comprising:

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determining separation measures for projection data covering corresponding reconstruction ranges and representing an imaged object over plural data acquisition cycles; and

reconstructing a tomographic image of the object based on a portion of the projection data covering a reconstruction range selected responsive to a determination that the corresponding separation measure satisfies a predetermined selection criterion.

69. A method according to claim 68, wherein determining the separation measures comprises:

calculating a separation value for each projection view comprised in the projection data; and

calculating each separation measure based on the separation values of the projection views having view angles in the corresponding reconstruction range.

70. A method according to claim 68, further comprising:

determining a minimum separation measure from the separation measures of the reconstruction ranges; and

selecting the reconstruction range corresponding to the minimum separation measure as the selected reconstruction range.

71. A method according to claim 68, further comprising:

collecting the projection data over the plural data acquisition cycles; and

collecting timing information contemporaneously with collecting the projection data, the timing information representing a time sequence of a dynamic behavior of the object during collection of the projection data;

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and wherein the separation measures are determined based on the contemporaneous timing information.

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SUBSTITUTE SHEET (RULE 26)

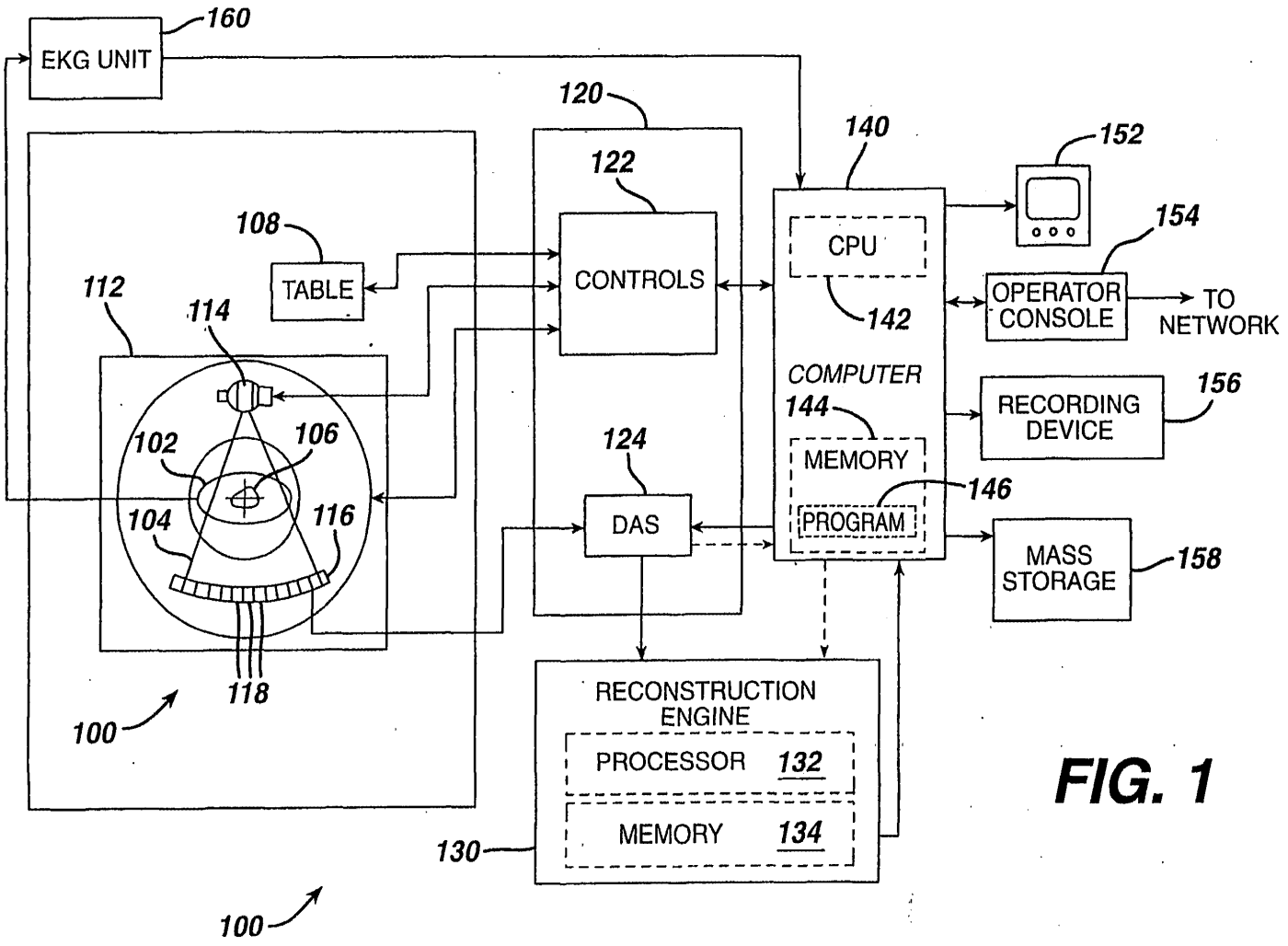
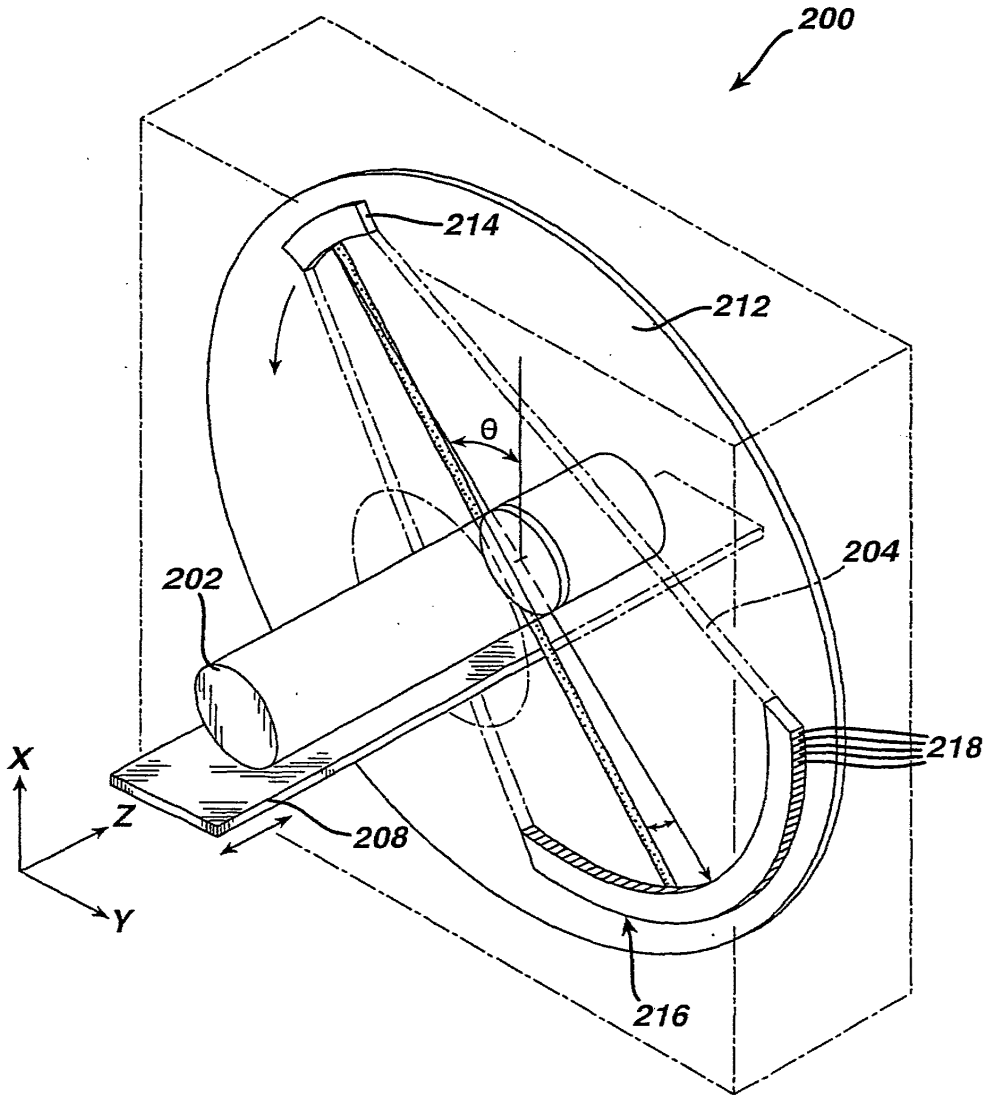


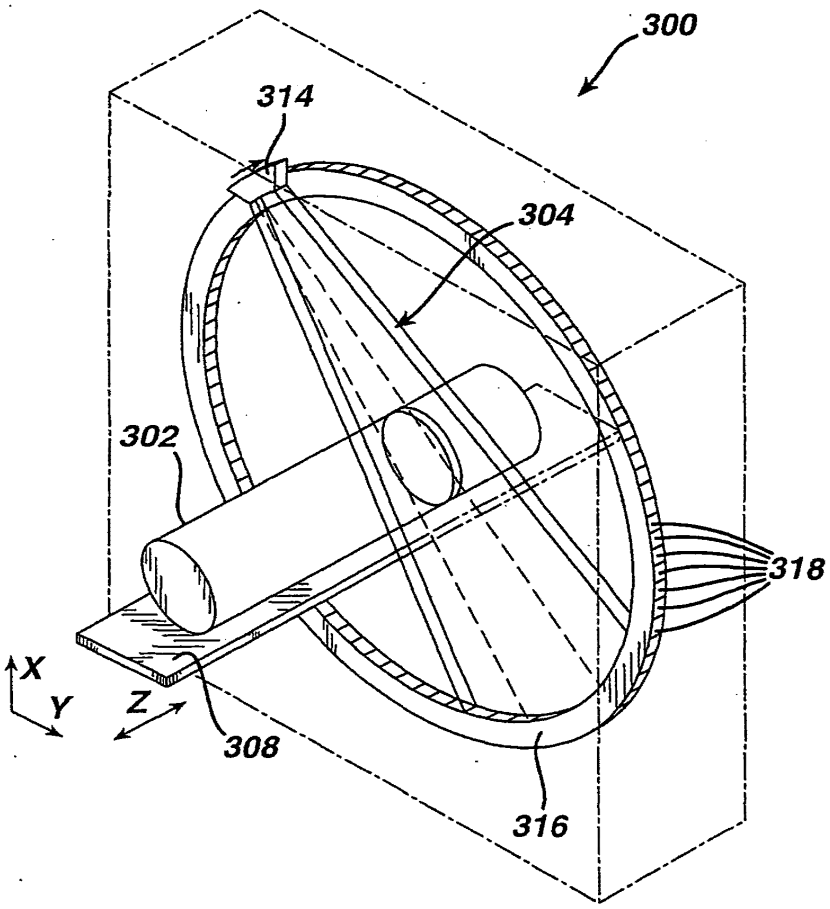
FIG. 1

FIG. 2



BNSDOCID: <WO___0180184A1_I_>

FIG. 3



BNSDOCID: <WO___0180184A1_I_>

FIG. 4

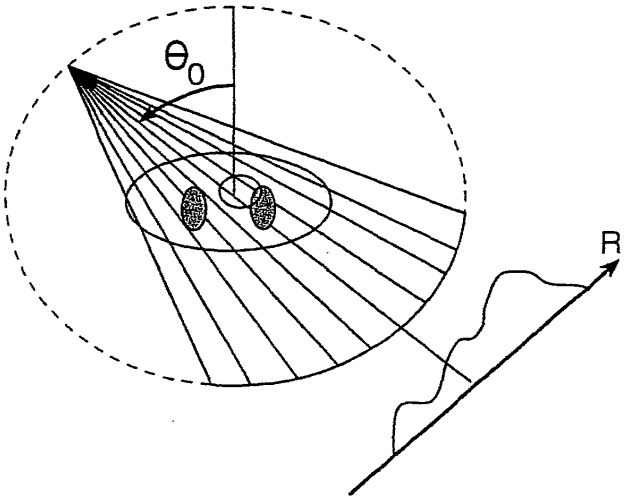
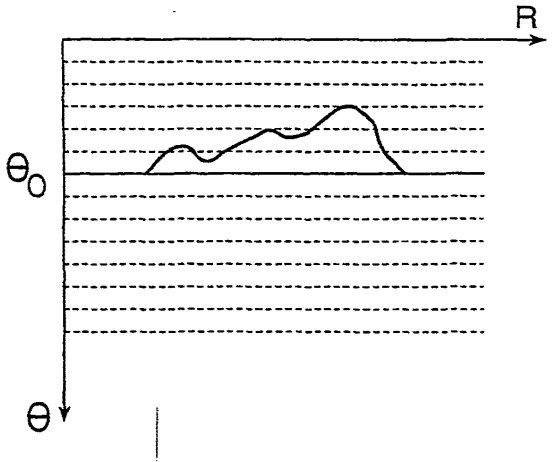


FIG. 5



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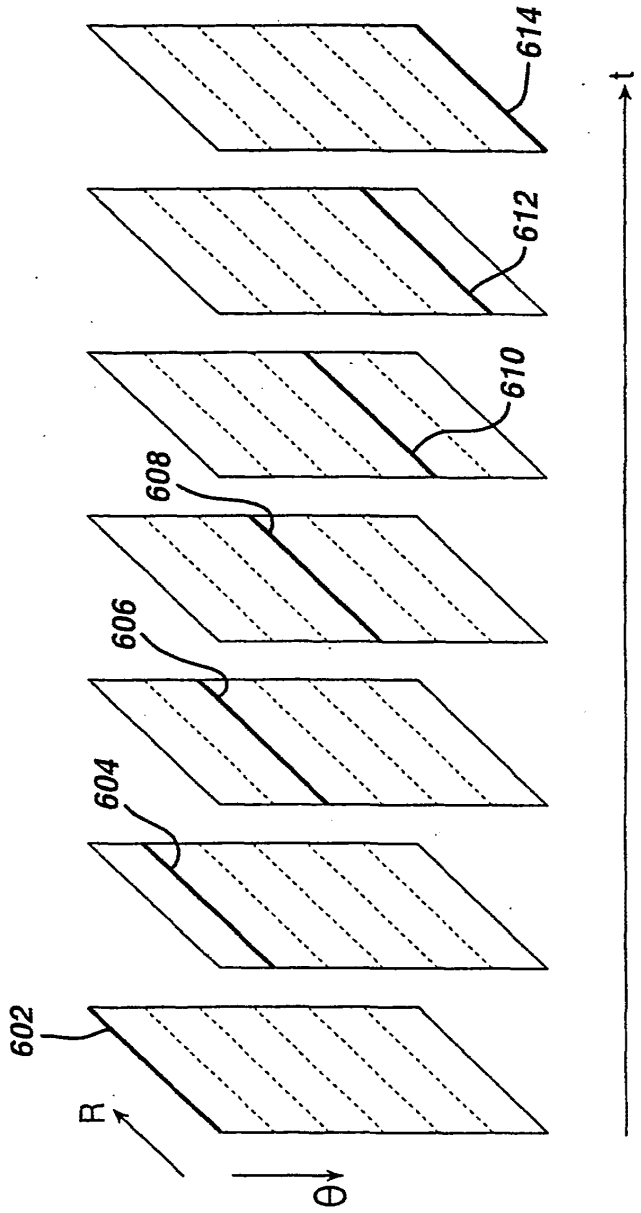
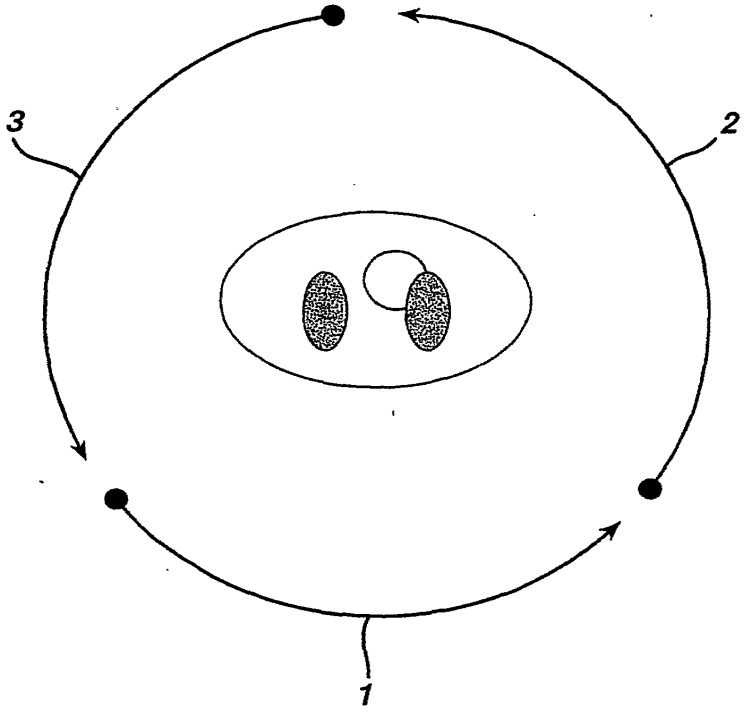


FIG. 6

BNSDOCID: <WO___0180184A1_I_>

FIG. 7



BNSDOCID: <WO___0180184A1_I_>

FIG. 8

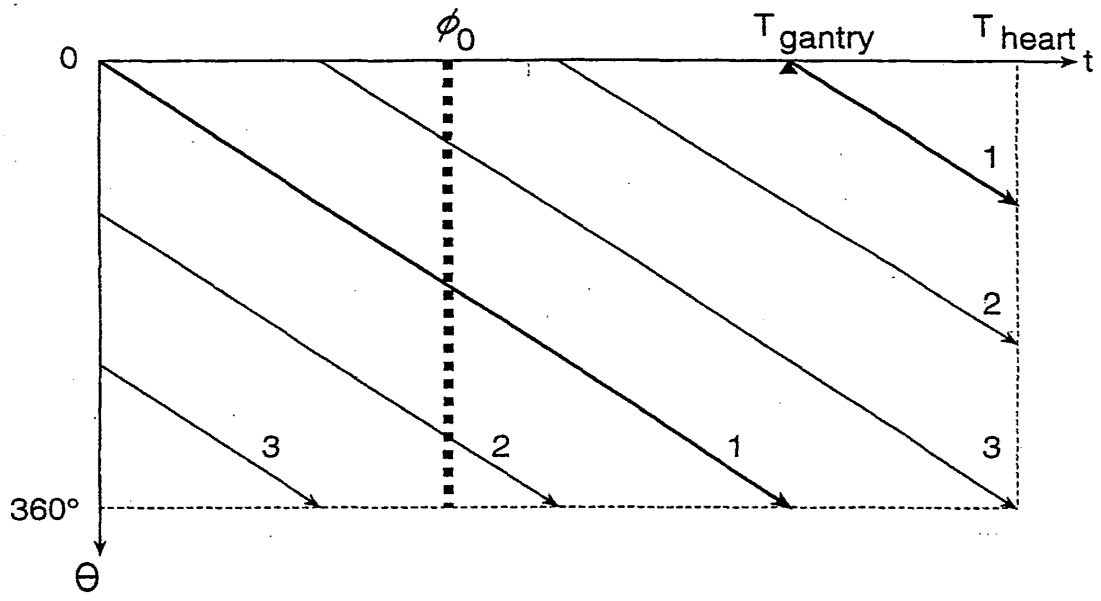
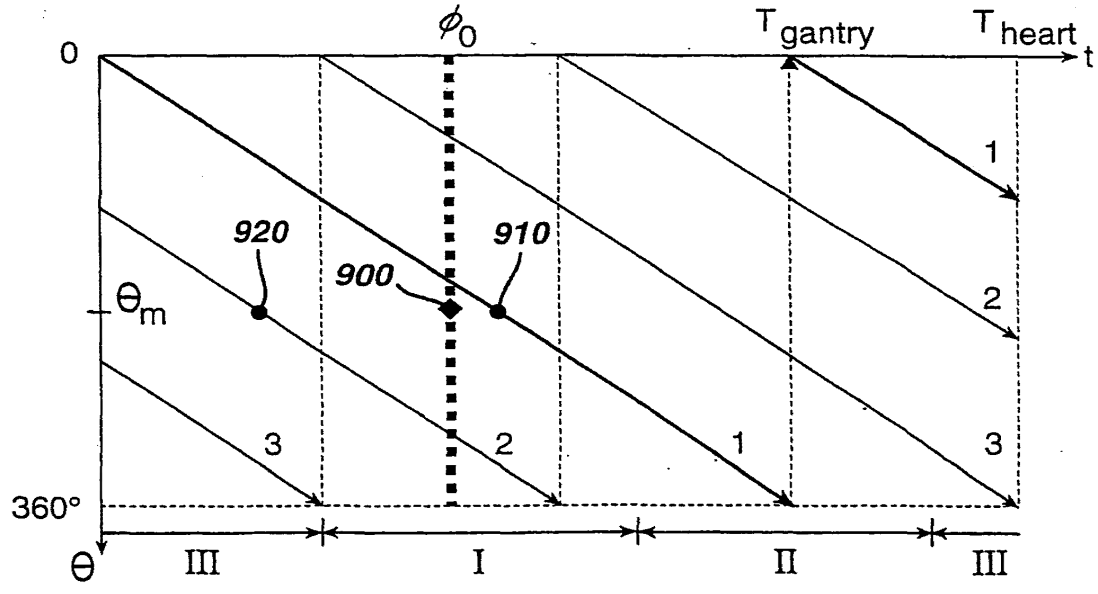
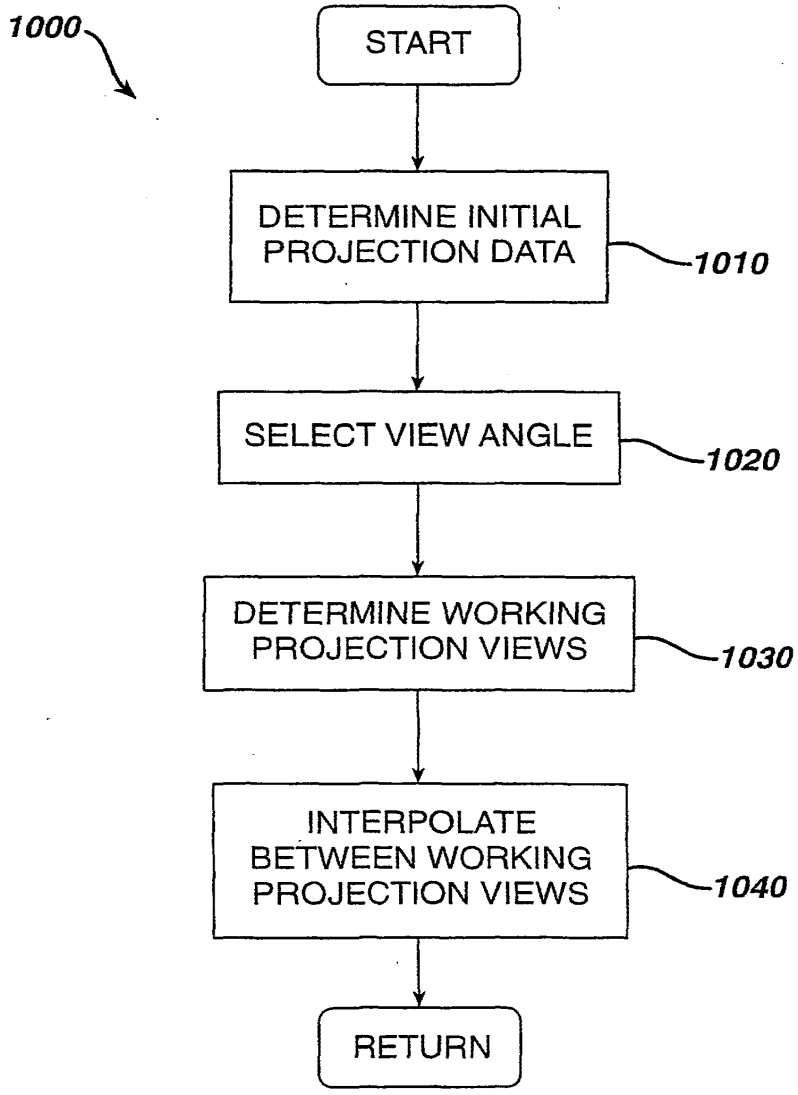


FIG. 9



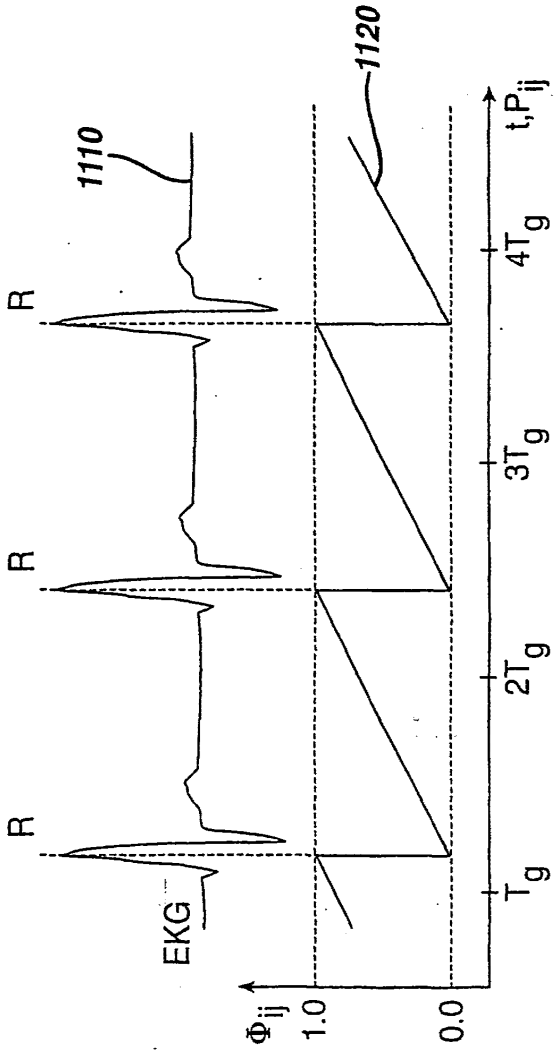
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FIG. 10



BNSDOCID: <WO___0180184A1_I_>

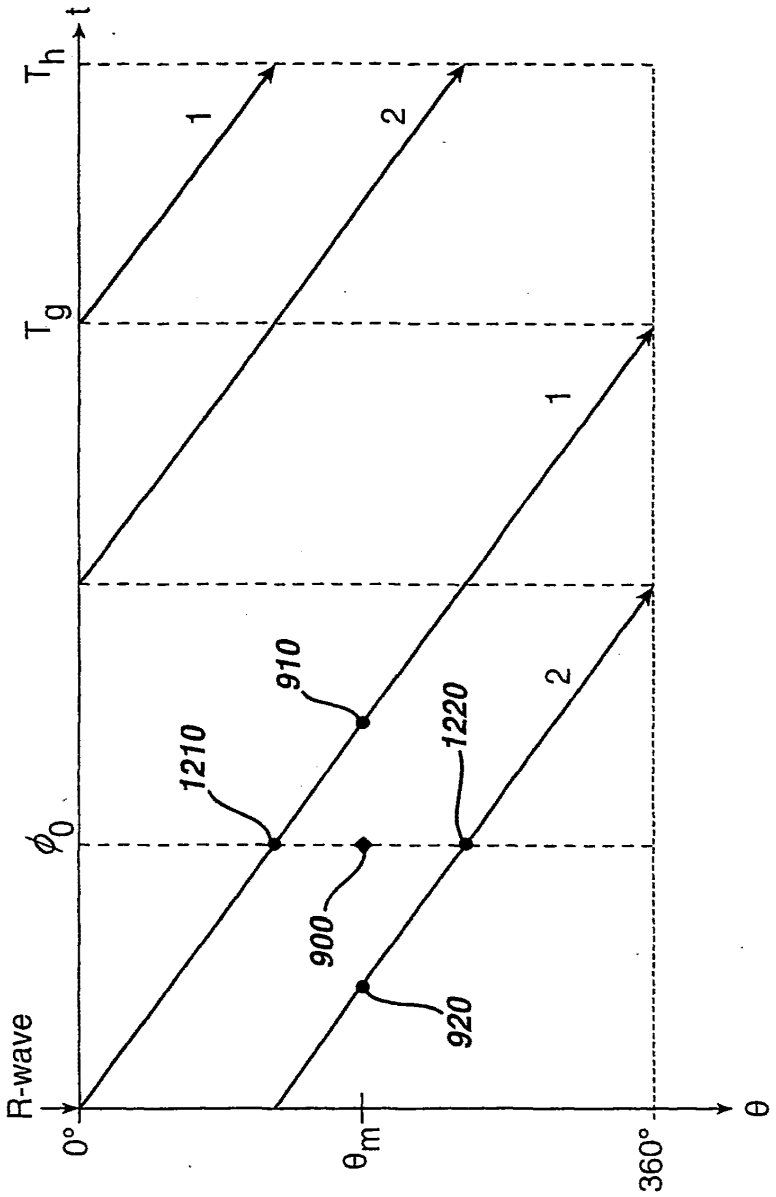
FIG. 11



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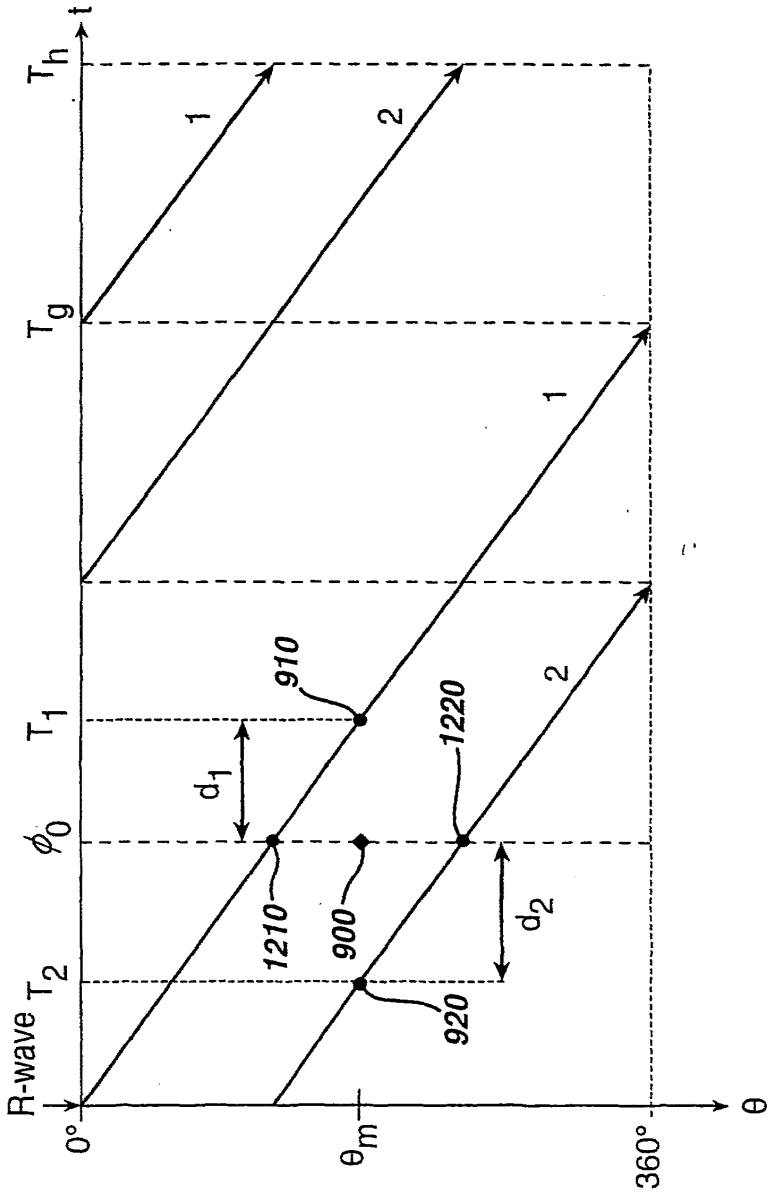
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FIG. 12



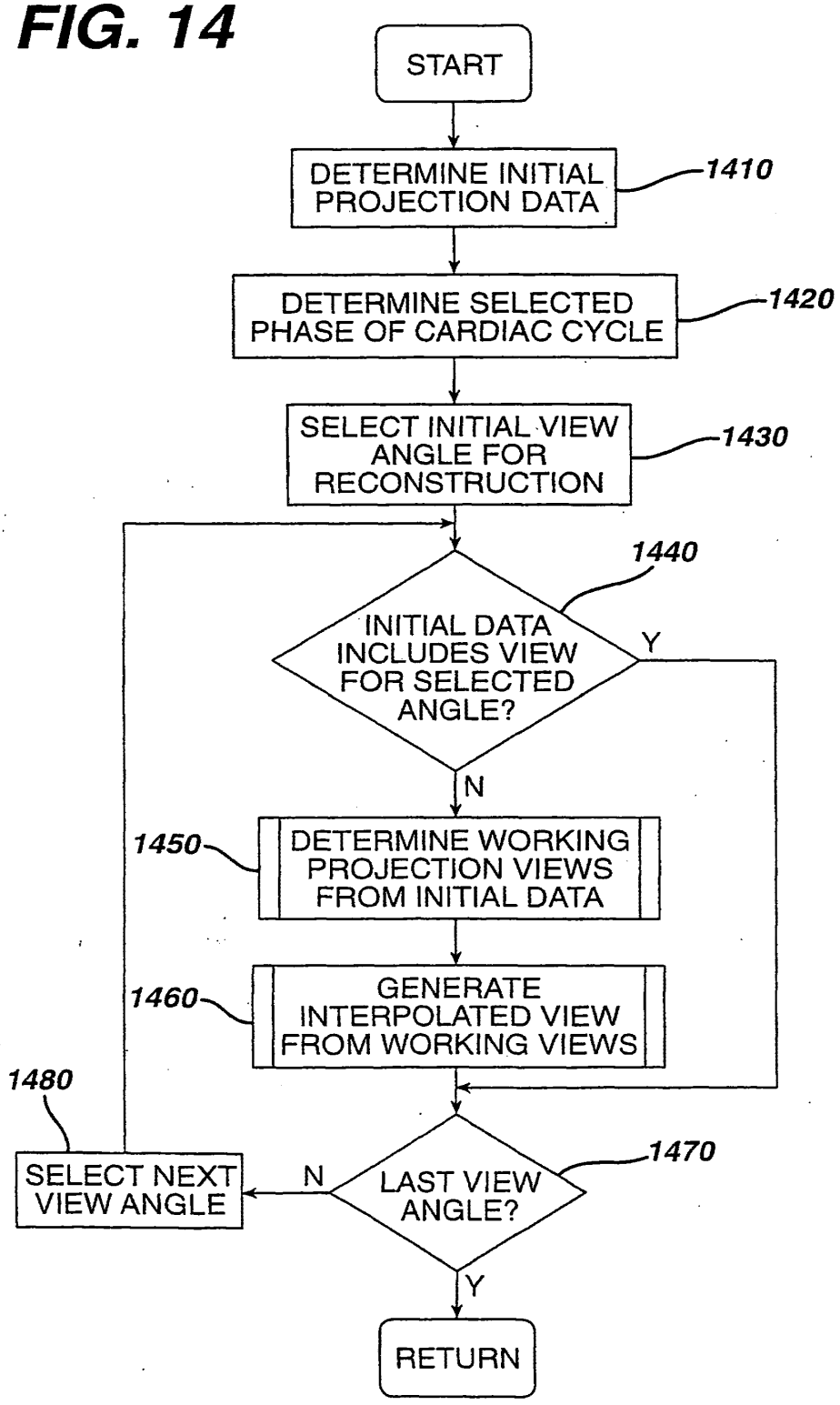
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FIG. 13



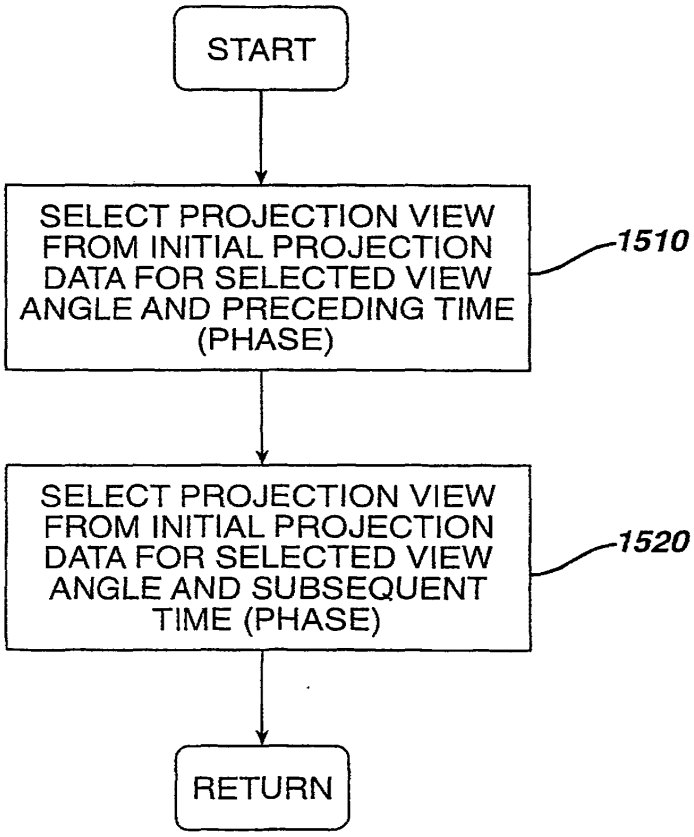
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FIG. 14



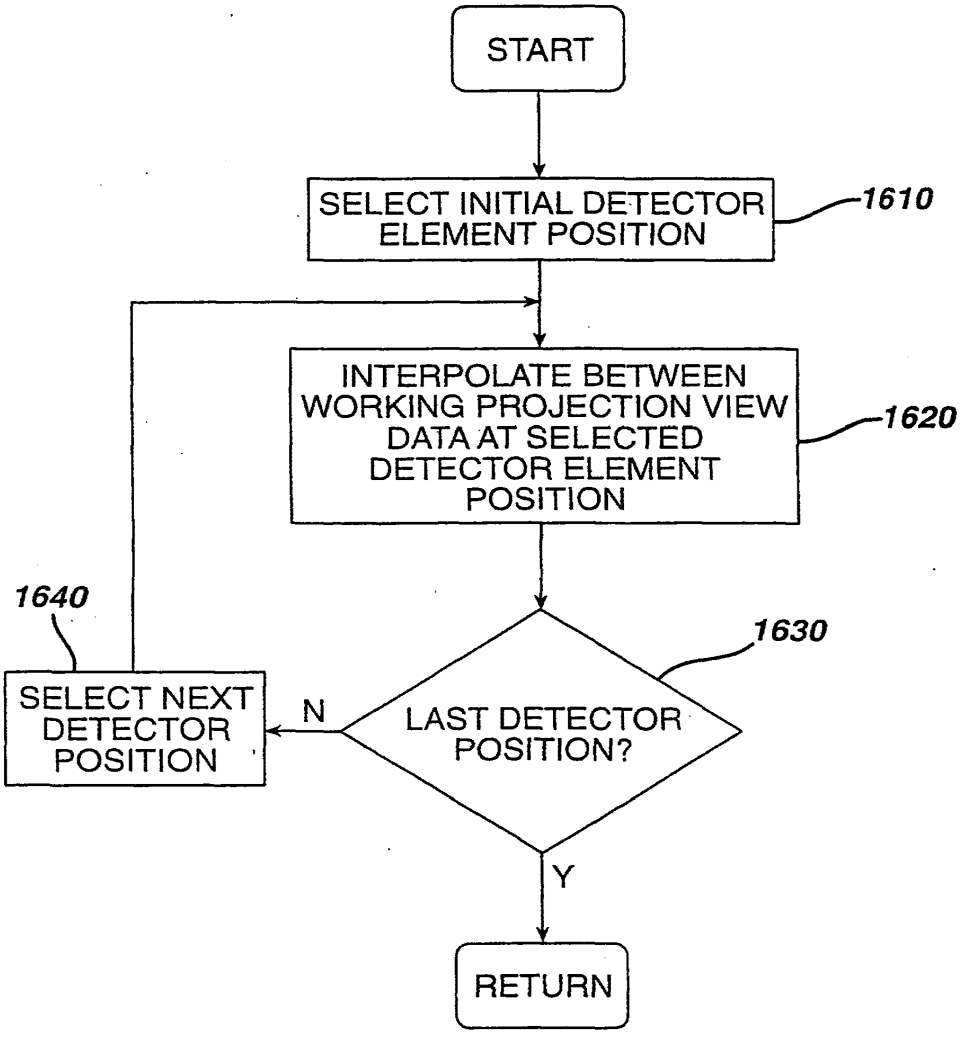
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FIG. 15



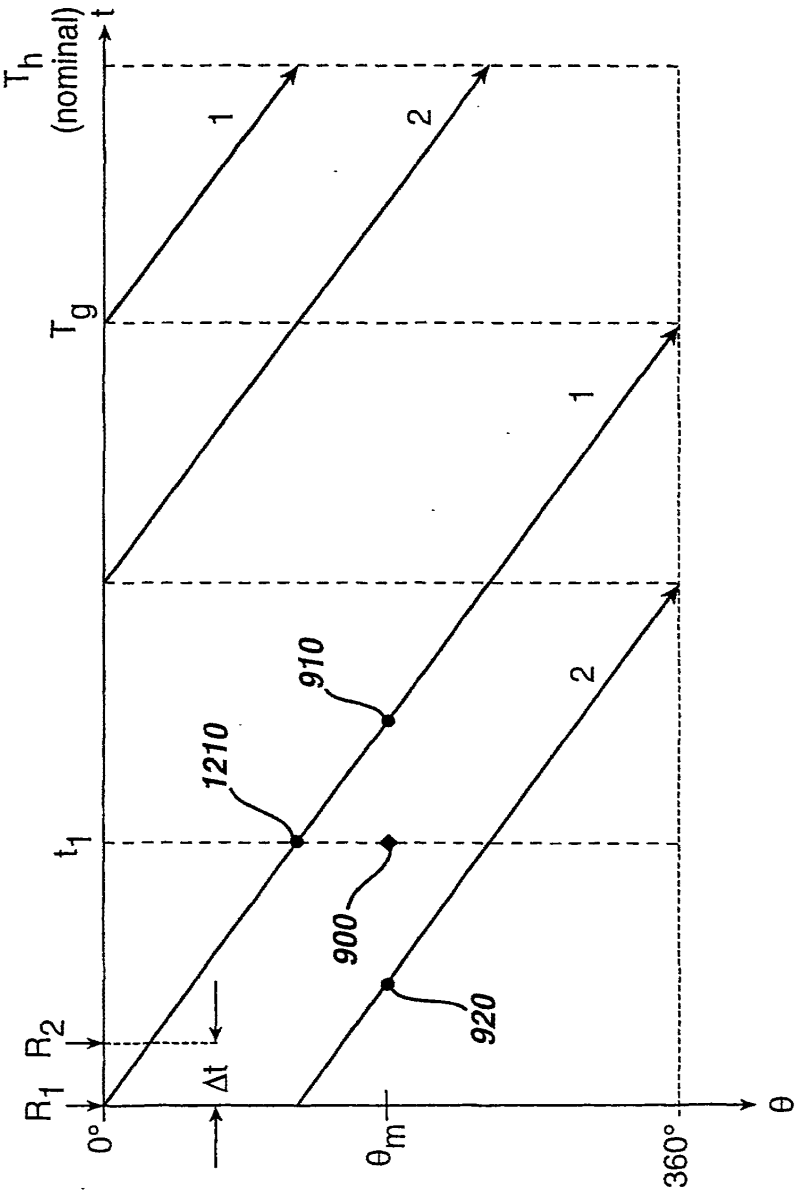
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FIG. 16



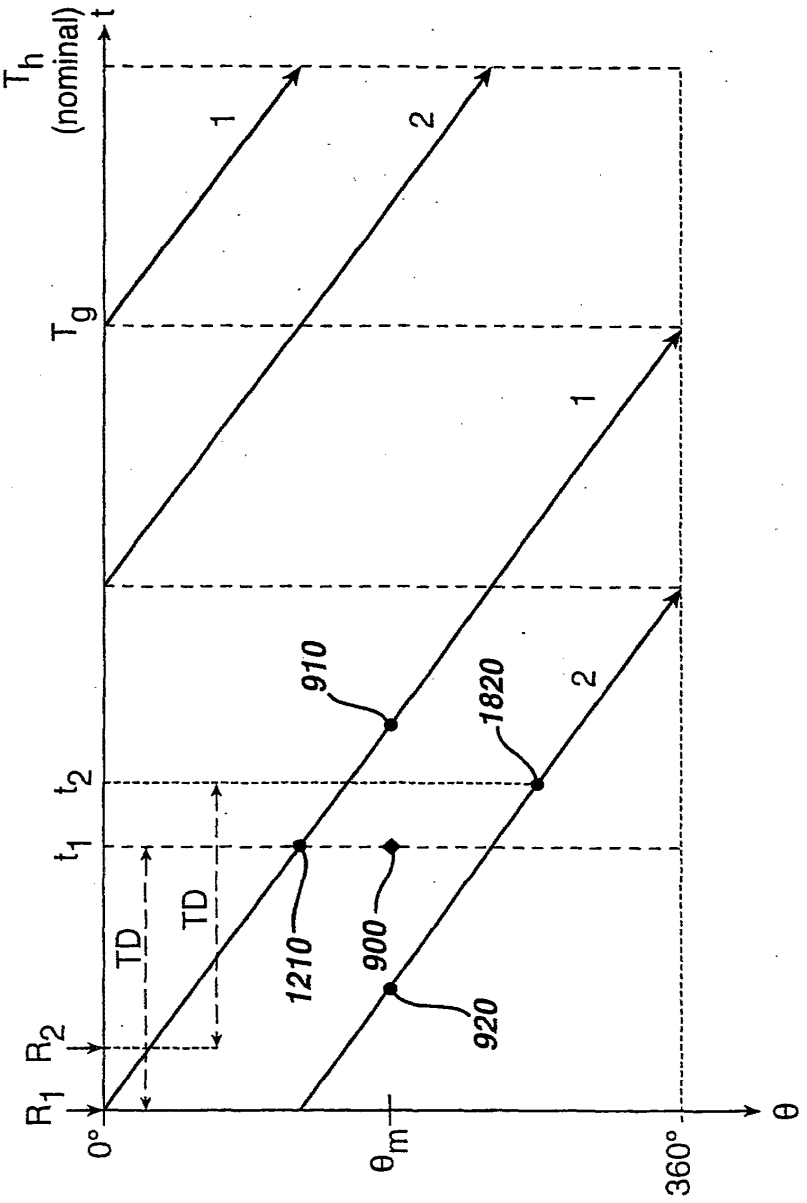
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FIG. 17



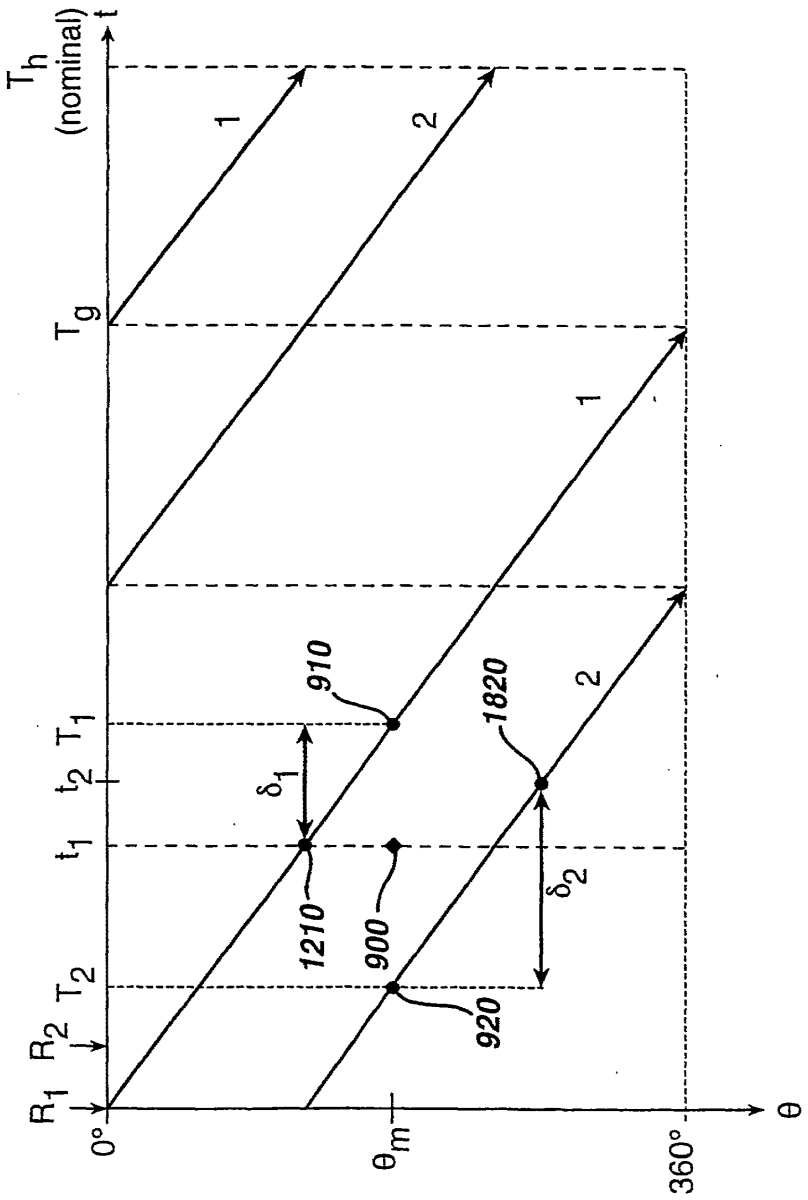
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FIG. 18



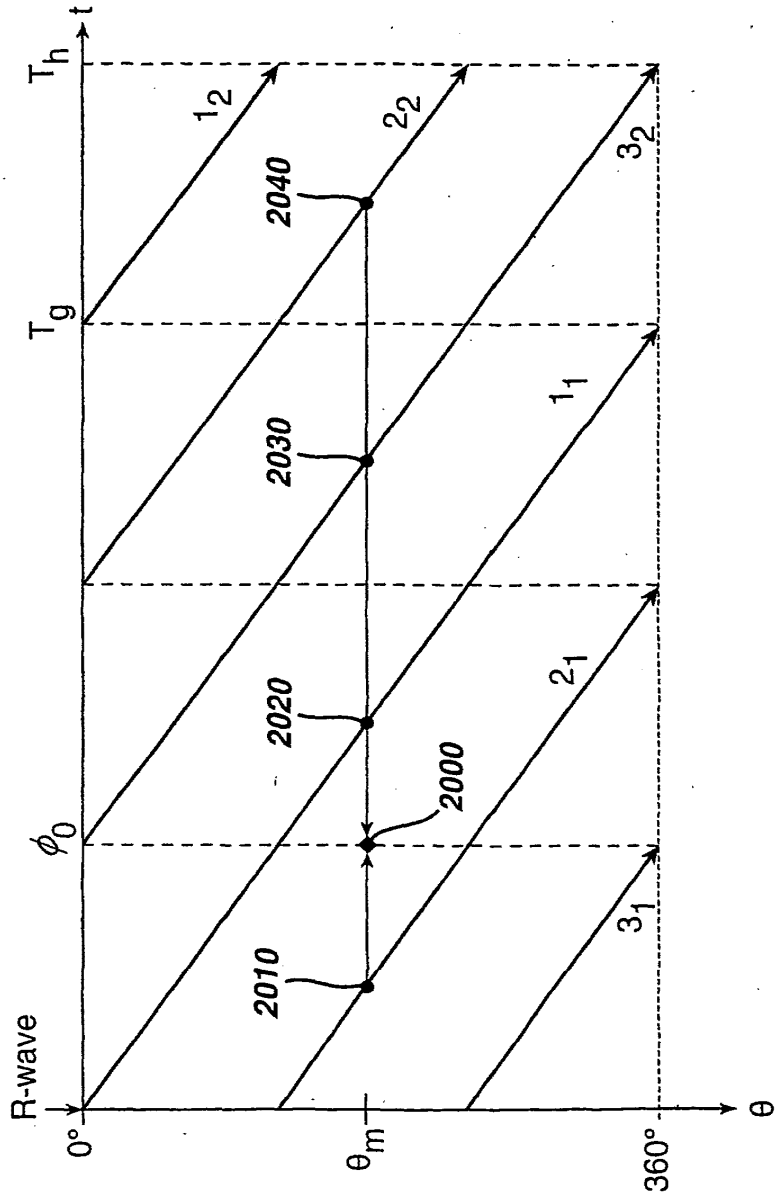
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FIG. 19



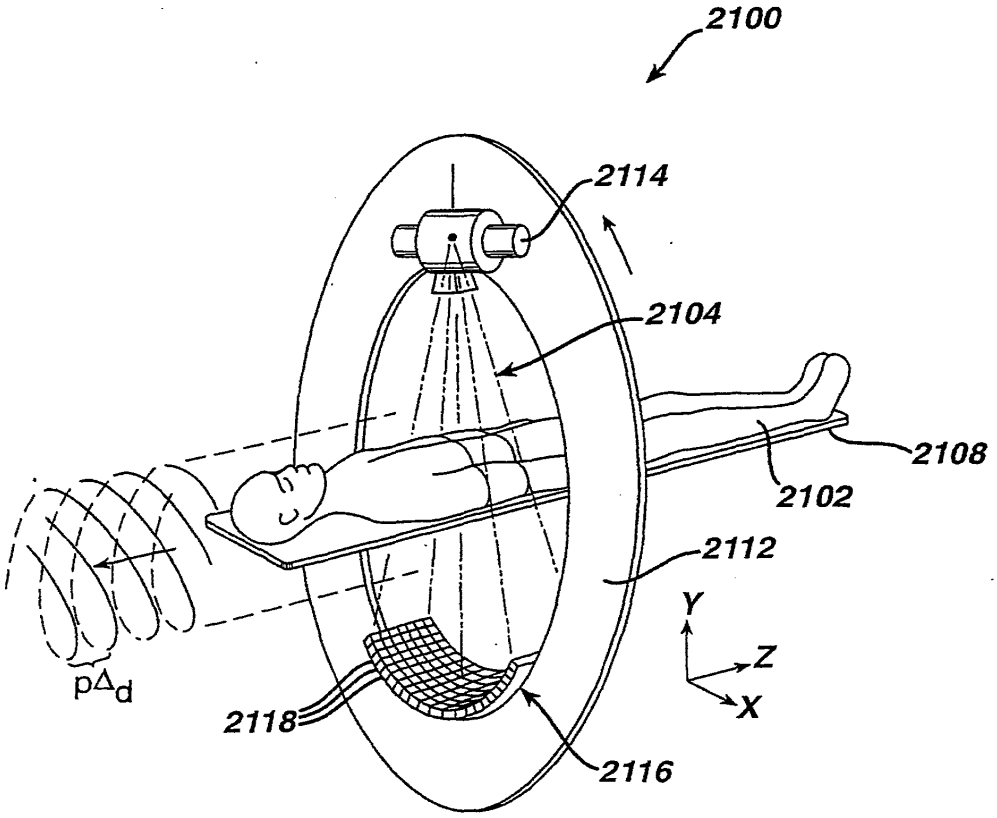
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FIG. 20



BNSDOCID: <WO___0180184A1_I_>

FIG. 21



BNSDOCID: <WO___0180184A1_I_>

FIG. 22

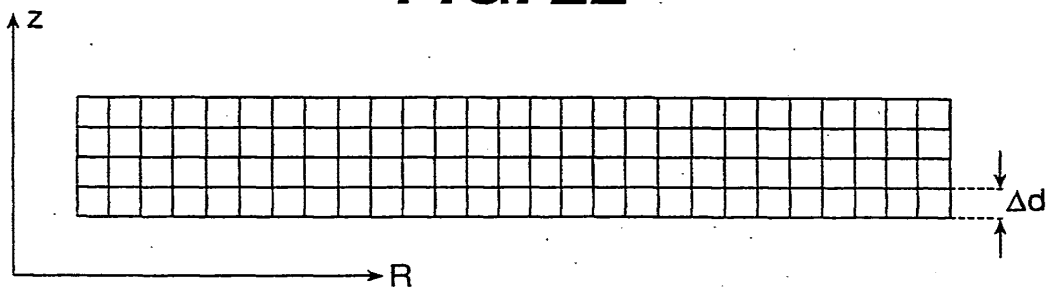
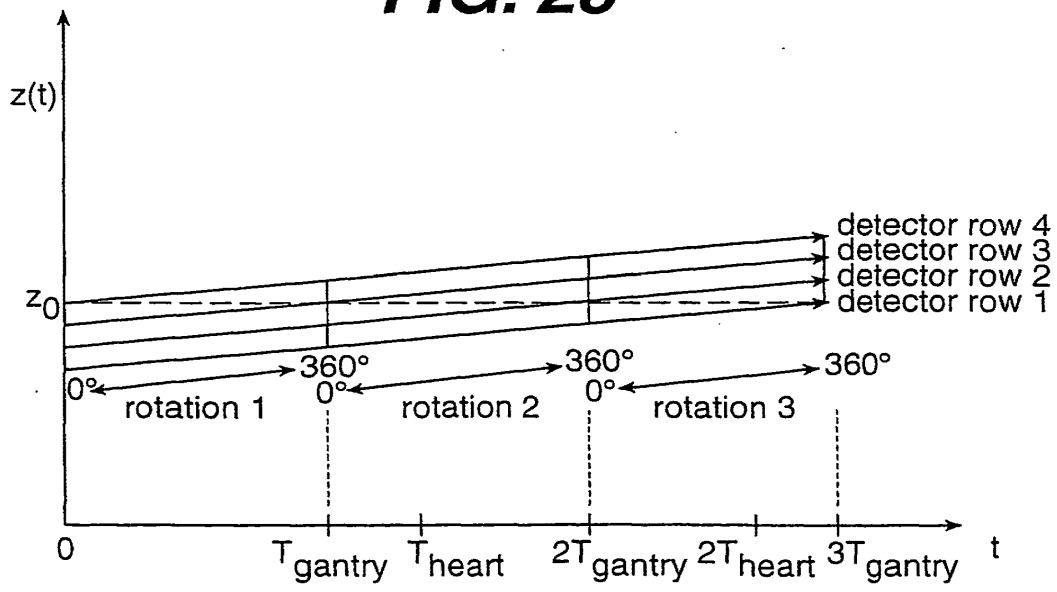
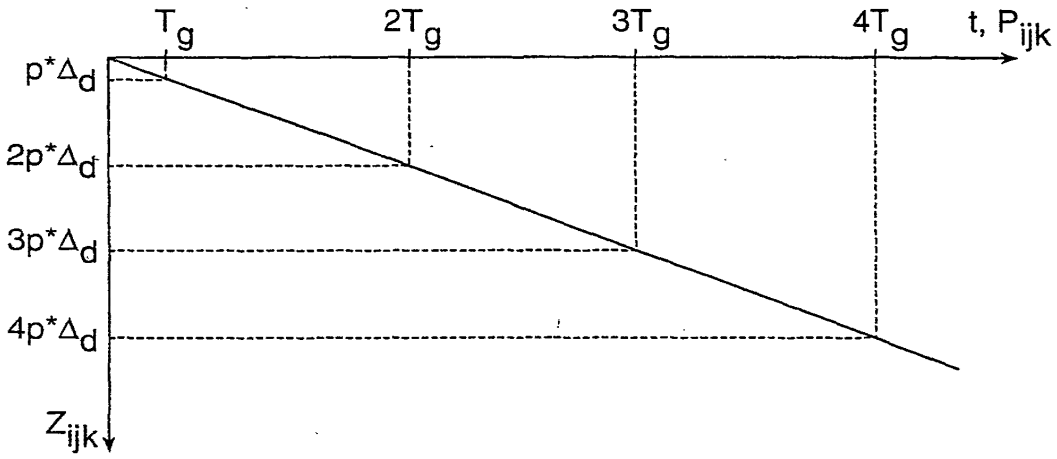


FIG. 23



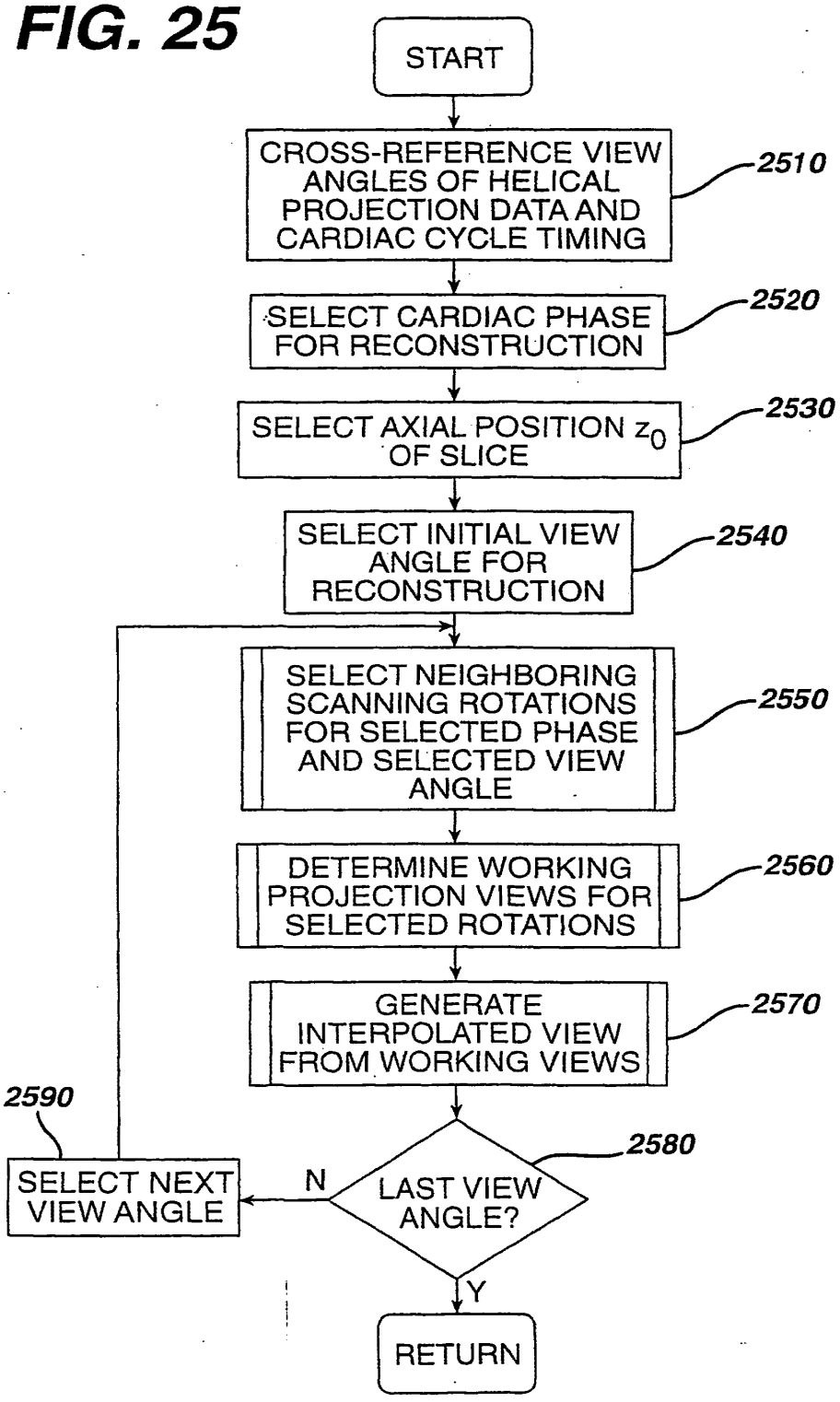
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FIG. 24



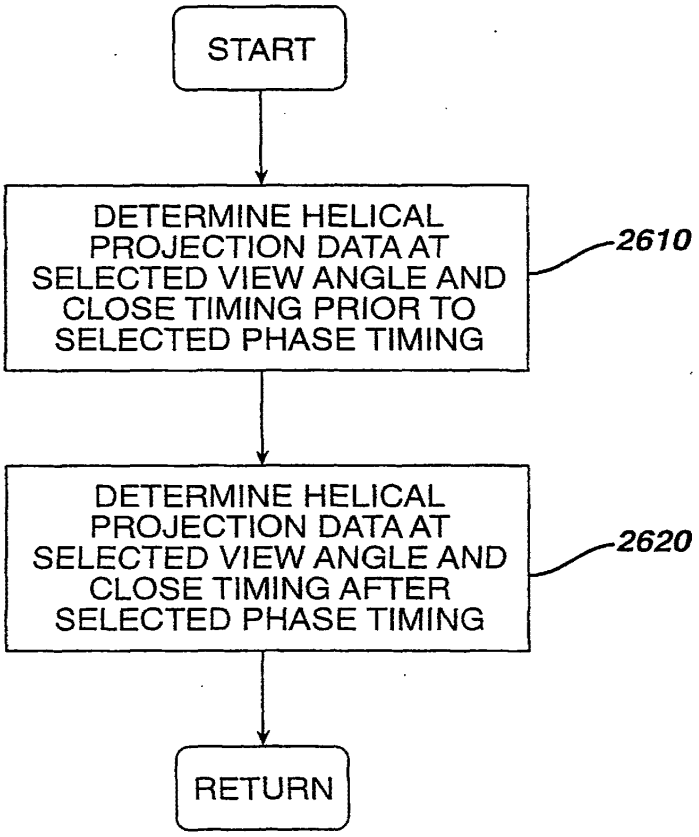
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FIG. 25



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FIG. 26



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FIG. 27

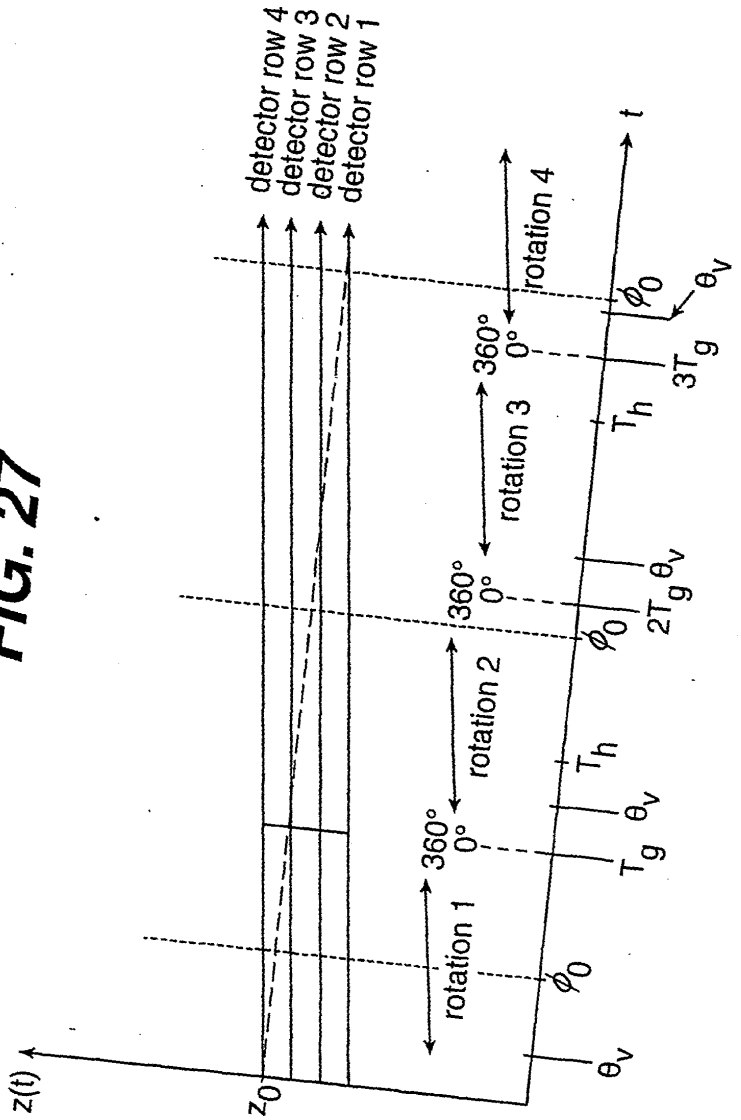

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detector row 3
detector row 2
detector row 1
t
z(t)
z_0
rotation 4
rotation 3
rotation 2
rotation 1
360°
0°
ϕ_0
θ_v
$3T_g$
T_h
$2T_g$
T_h
θ_v
T_g
θ_v

FIG. 28

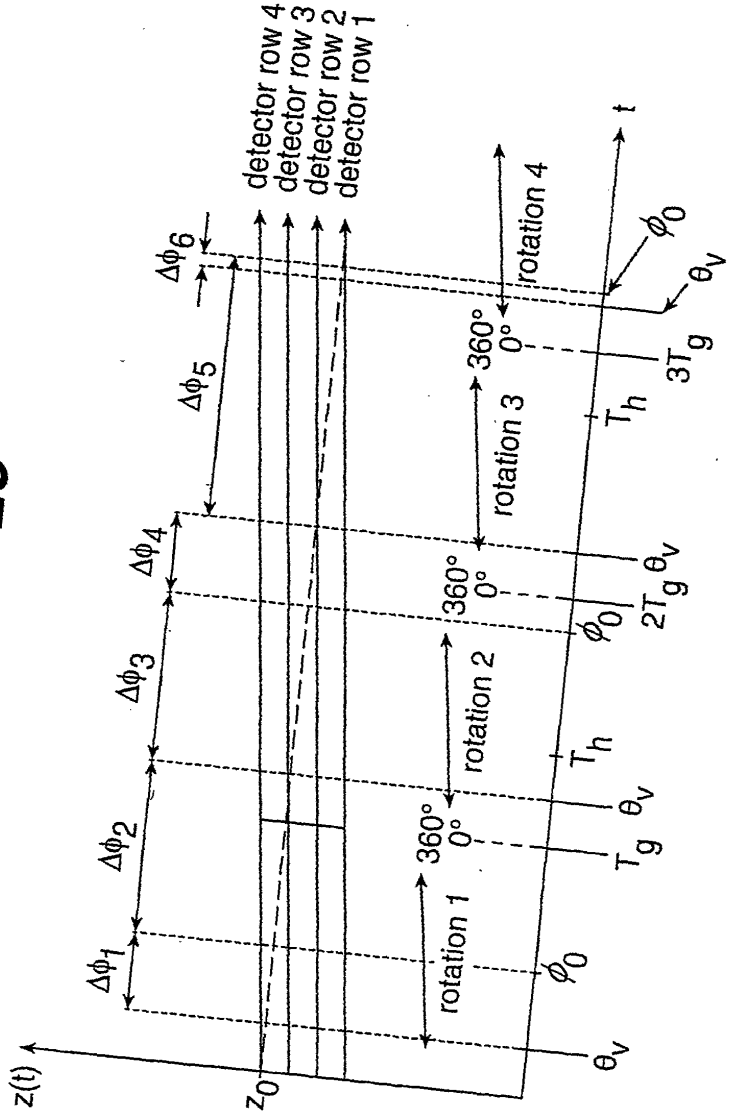
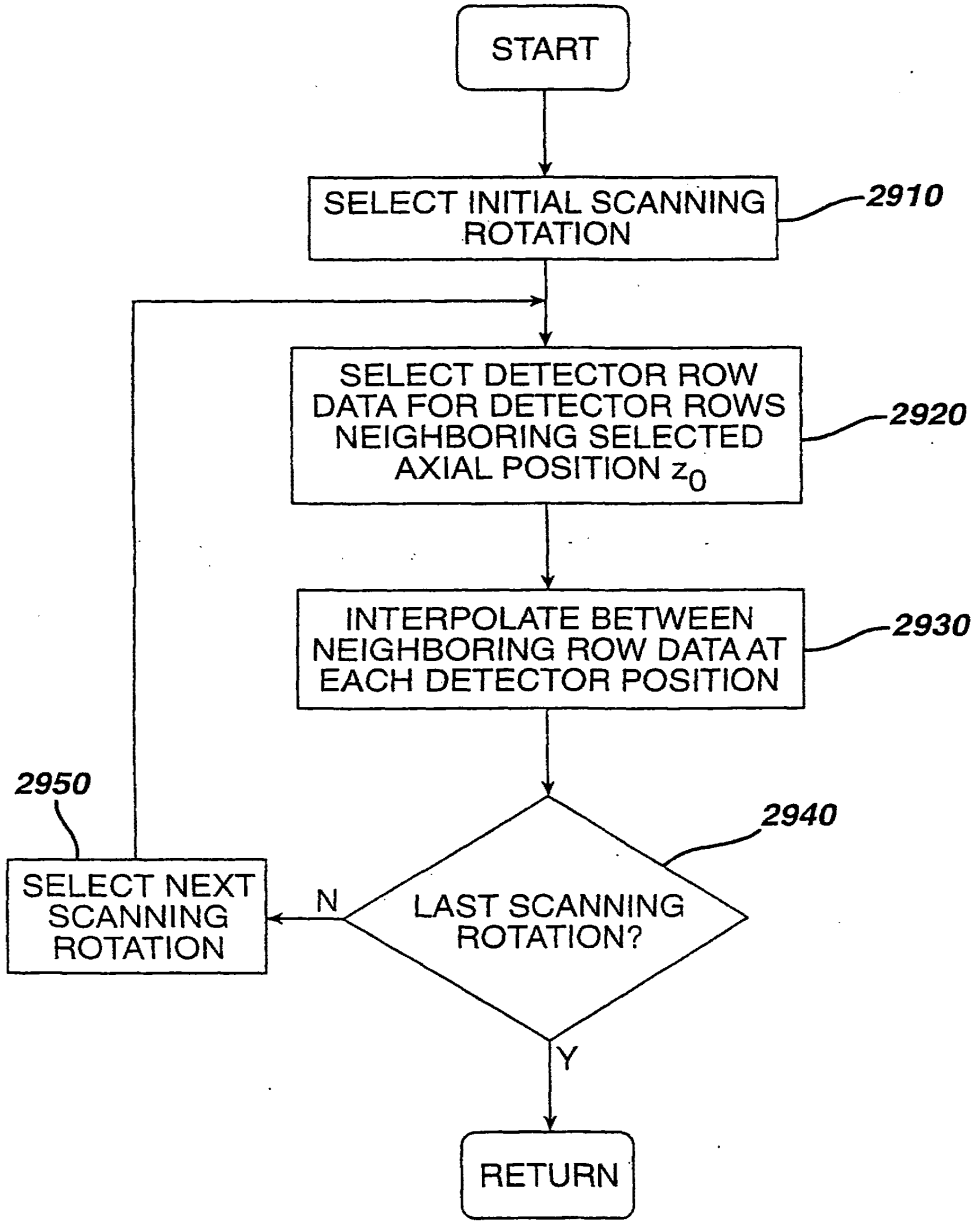

detector row 4
detector row 3
detector row 2
detector row 1
t
z(t)
z_0
$\Delta\phi_6$
$\Delta\phi_5$
$\Delta\phi_4$
$\Delta\phi_3$
$\Delta\phi_2$
$\Delta\phi_1$
rotation 4
rotation 3
rotation 2
rotation 1
360°
0°
ϕ_0
θ_v
$3T_g$
$2T_g$
T_h
T_g

FIG. 29



BNSDOCID: <WO___0180184A1_I_>

FIG. 30

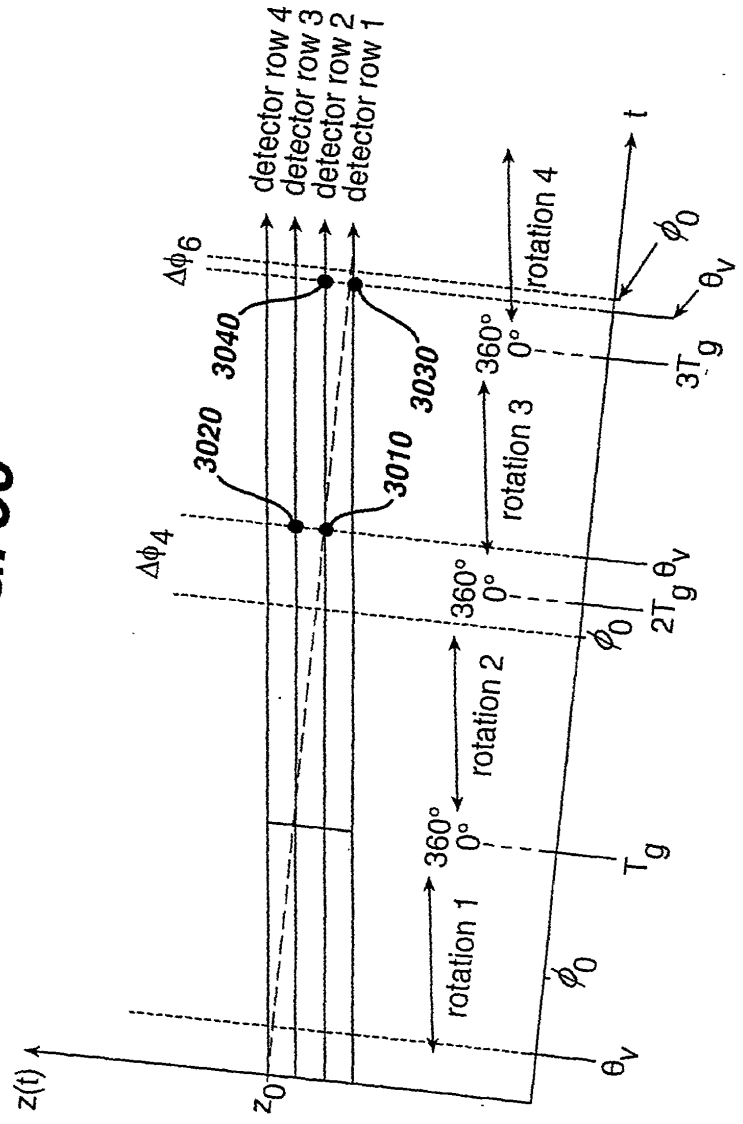
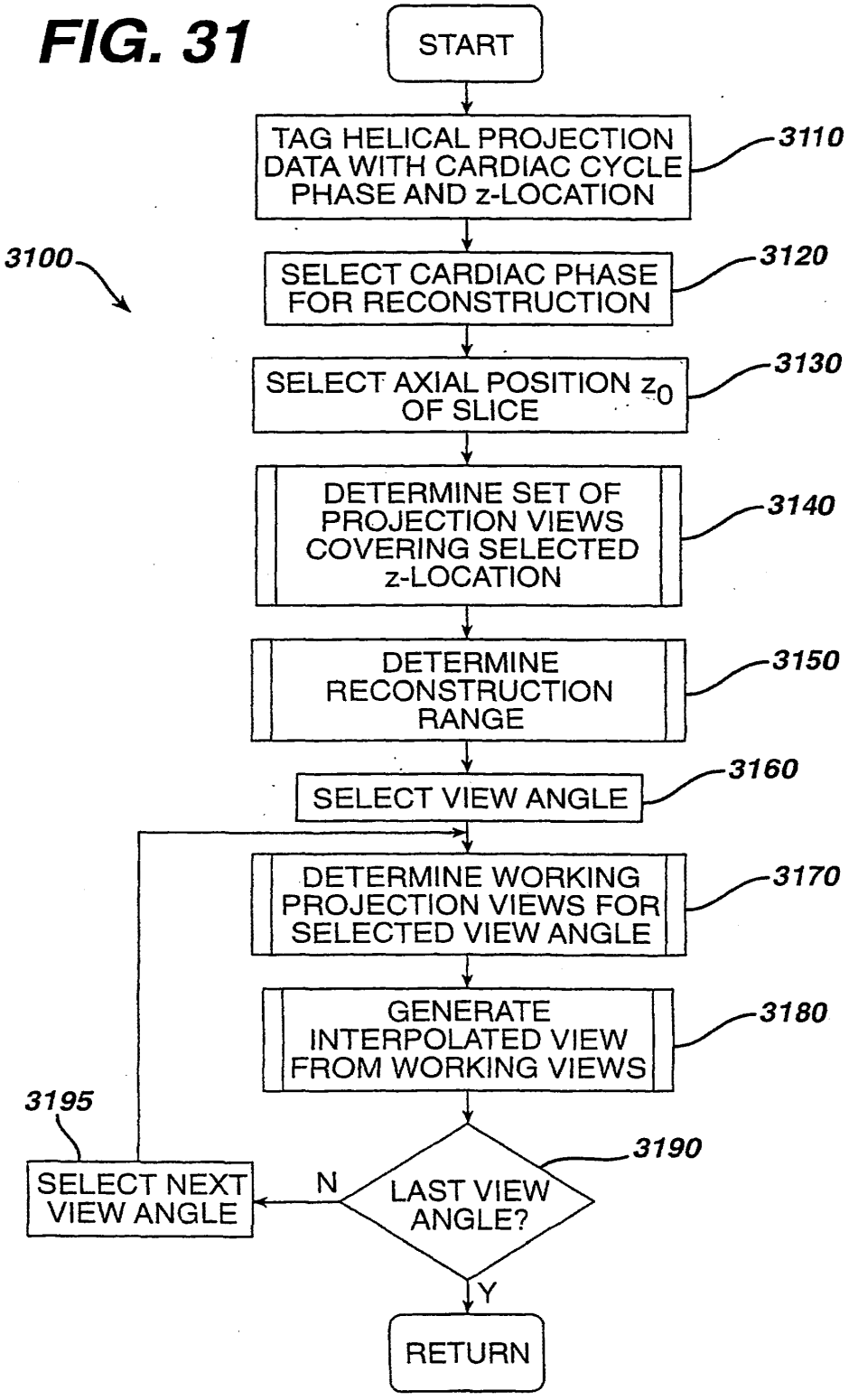
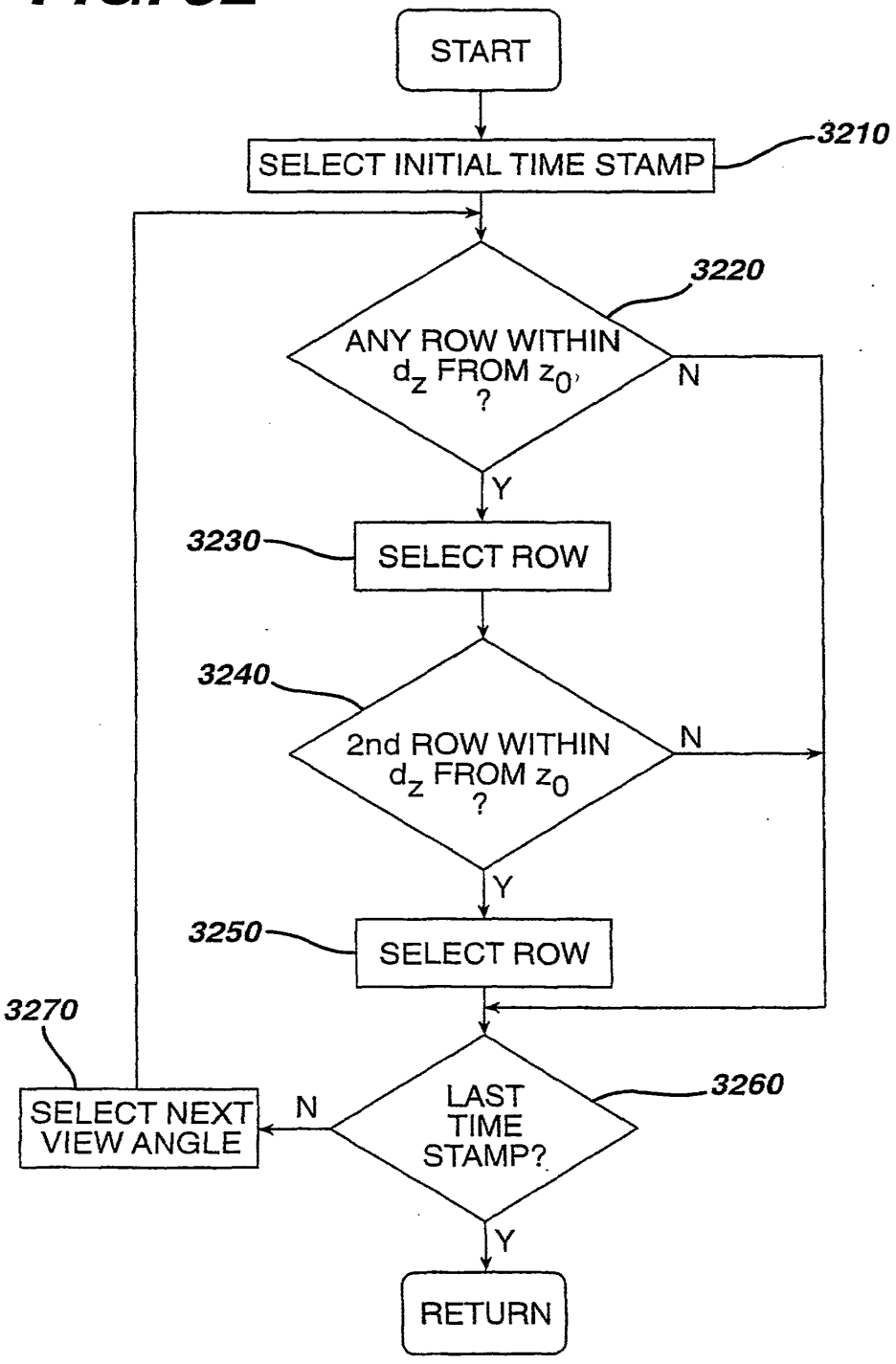

detector row 4
detector row 3
detector row 2
detector row 1
t
$\Delta\phi_6$
3040
3030
rotation 4
ϕ_0
θ_V
360°
0°
$3T_g$
3020
3010
rotation 3
$\Delta\phi_4$
$2T_g$
rotation 2
T_g
rotation 1
z(t)
z_0

FIG. 31



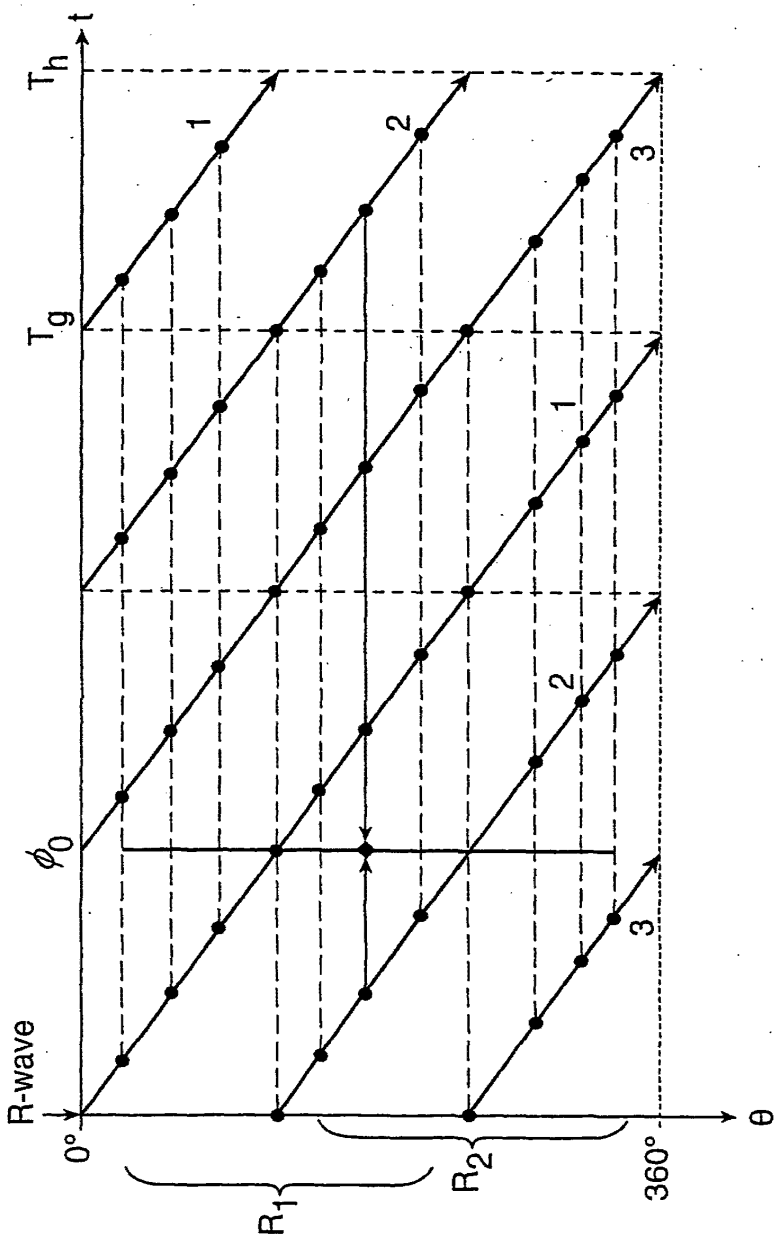
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FIG. 32



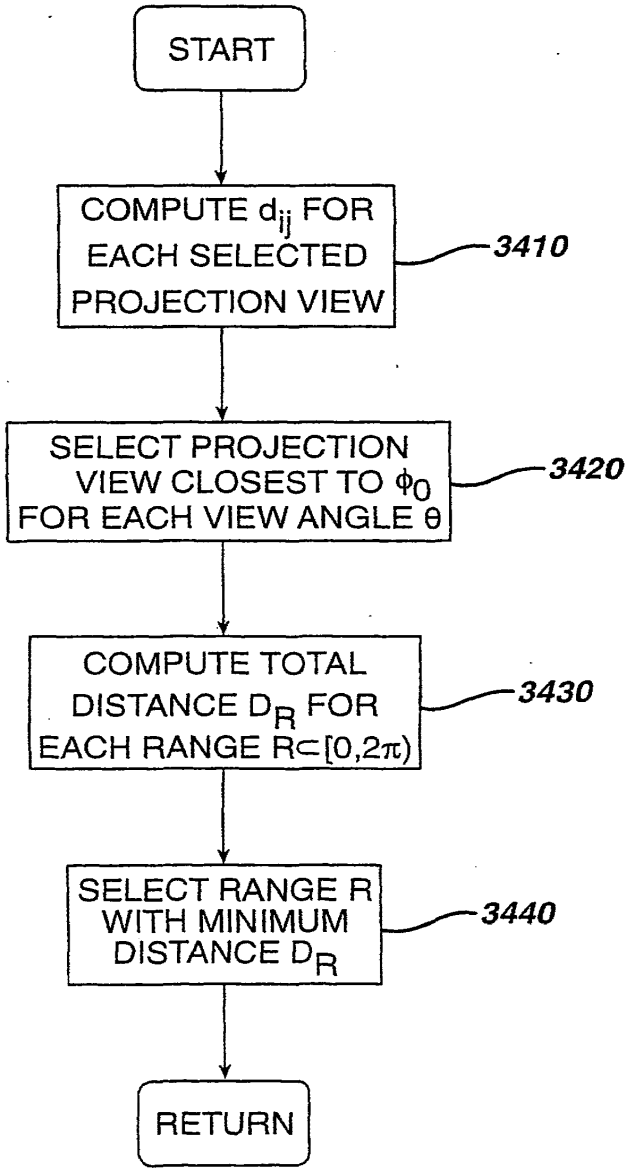
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FIG. 33



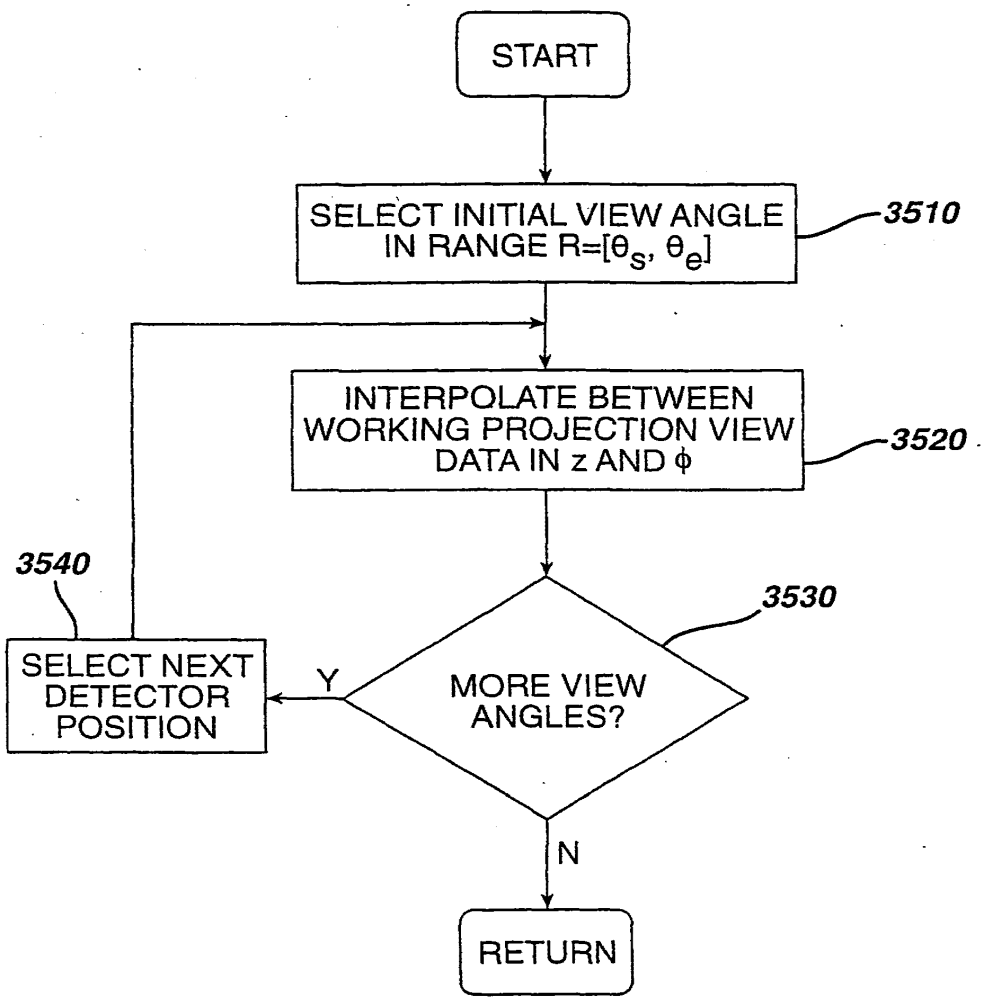
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FIG. 34



BNSDOCID: <WO 0180184A1 | >

FIG. 35



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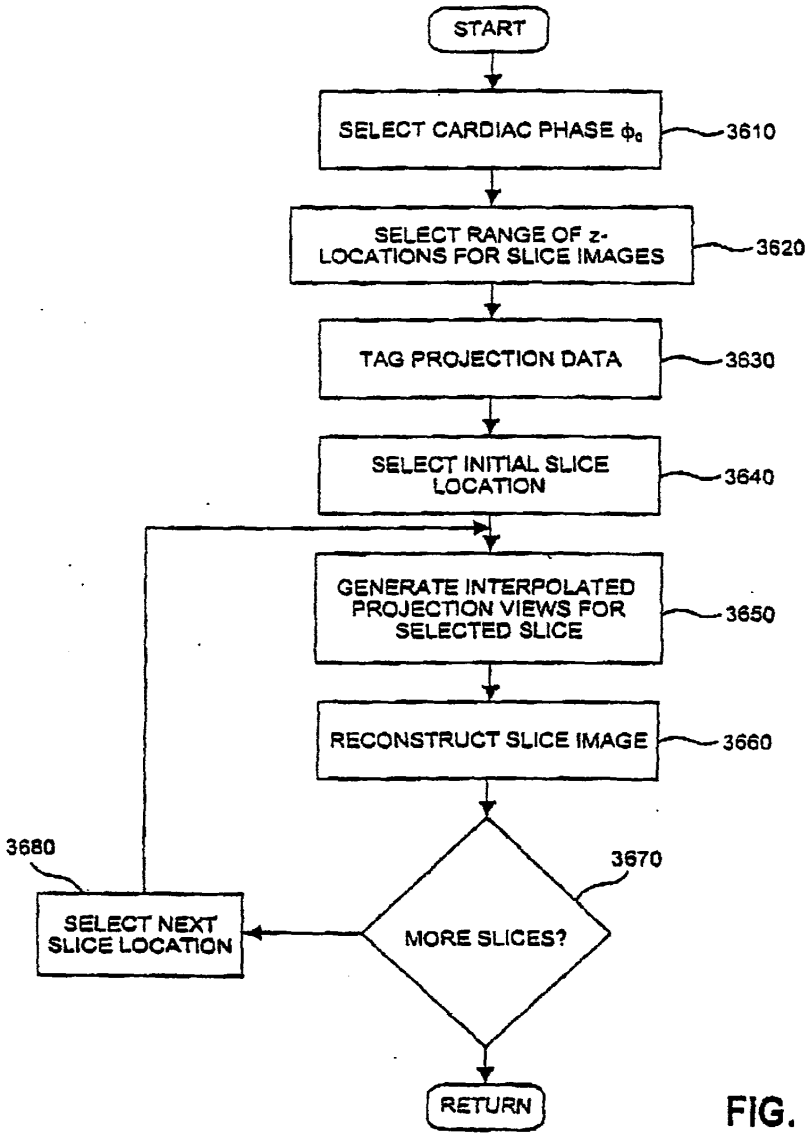
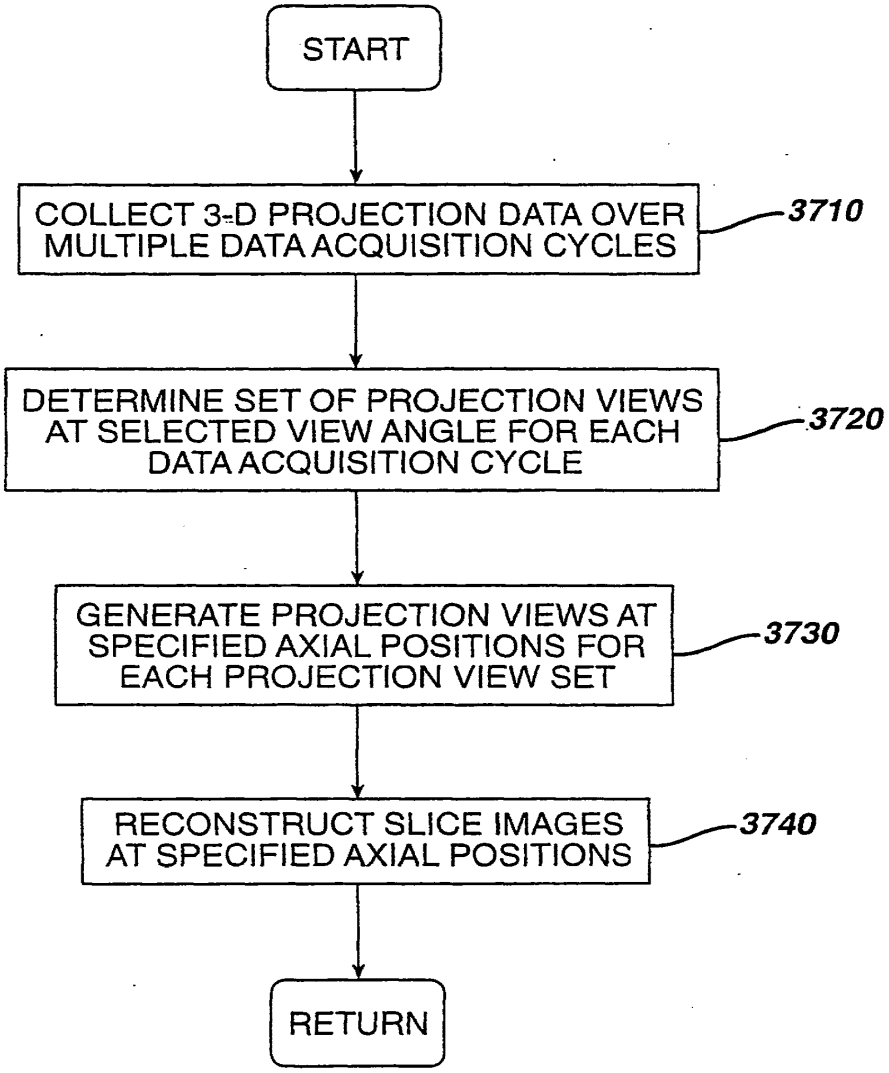


FIG. 36

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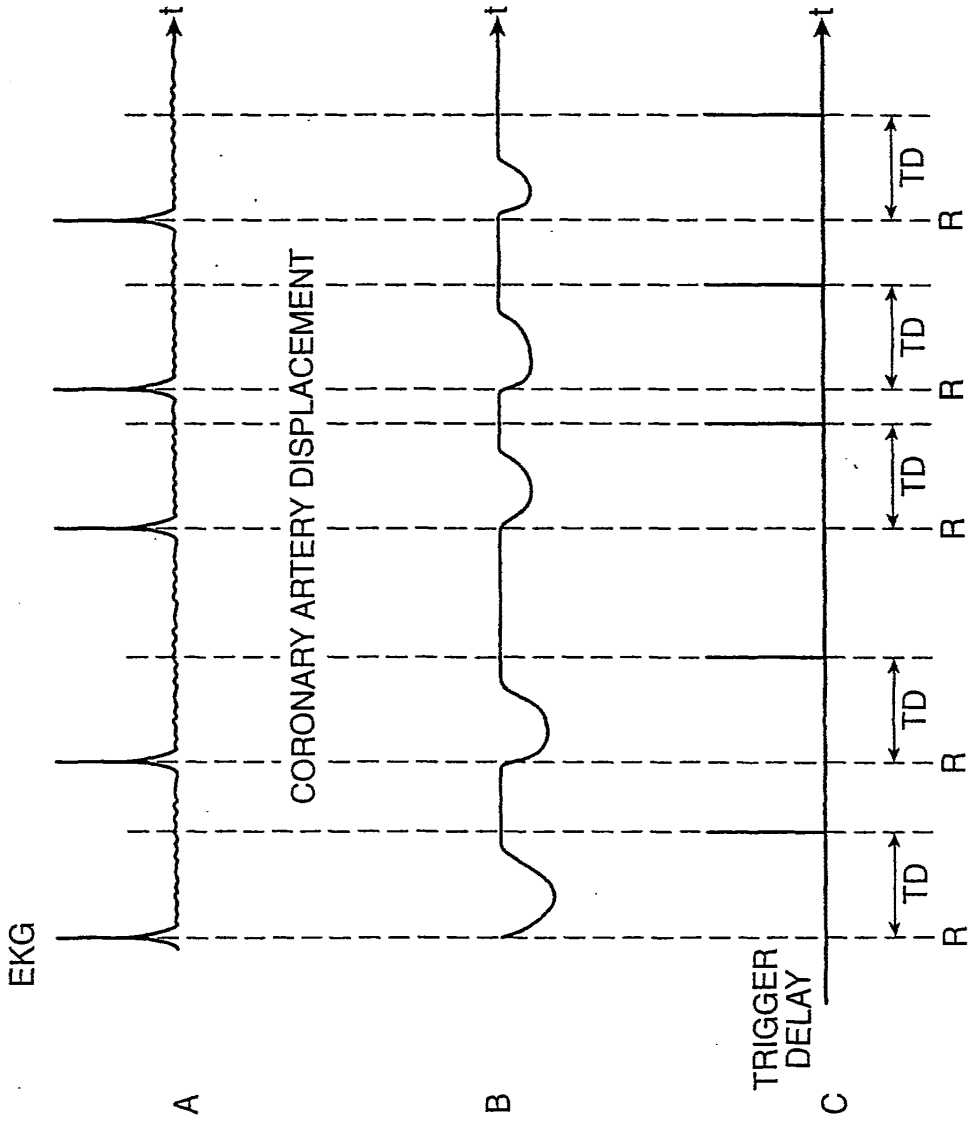
Volkswagen Exhibit 1002, Page 203 of 885

FIG. 37



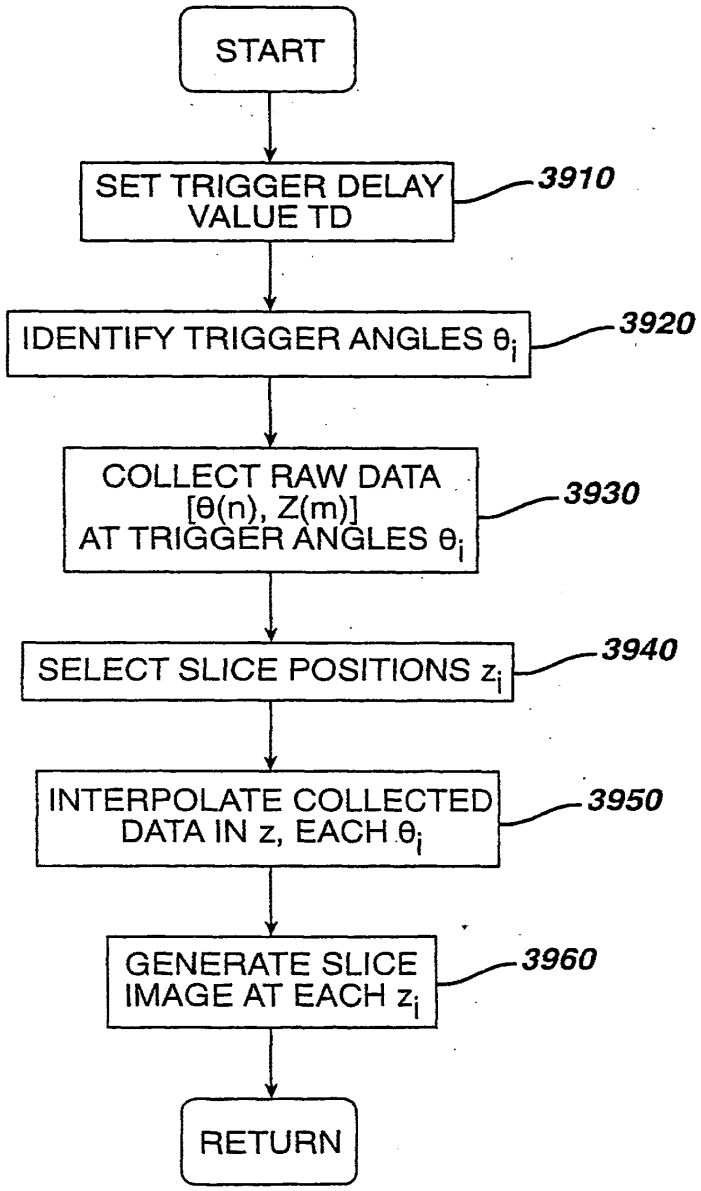
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FIG. 38



BNSDOCID: <WO___0180184A1_I_>

FIG. 39



BNSDOCID: <WO___0180184A1_I_>

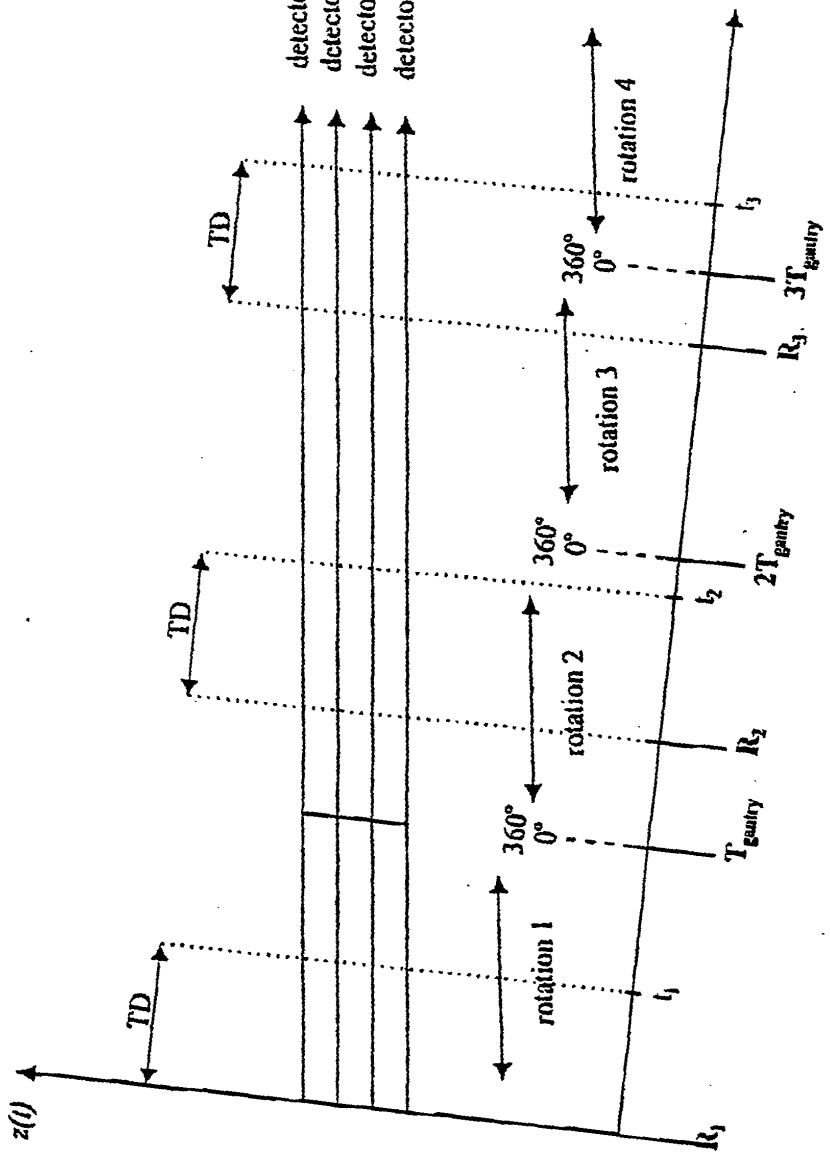
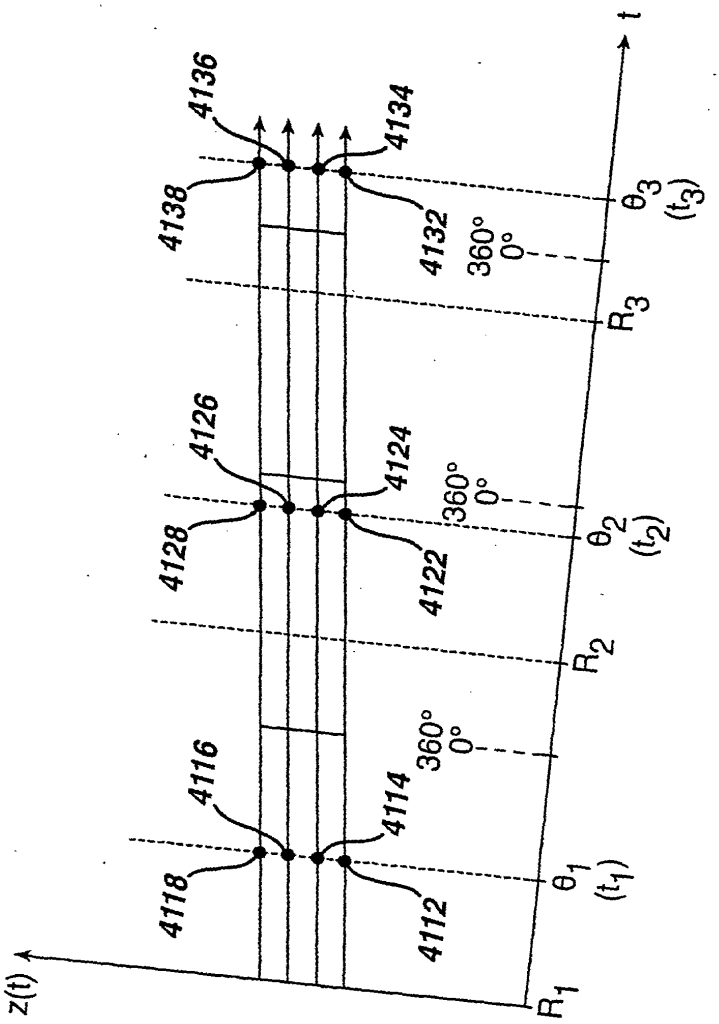

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detector row 3
detector row 2
detector row 1
rotation 4
rotation 3
rotation 2
rotation 1
TD
TD
TD
360°
0°
360°
0°
360°
0°
t_3
t_2
t_1
$3T_{gantry}$
$2T_{gantry}$
T_{gantry}
R_3
R_2
R_1
z(l)

FIG. 40

FIG. 41


t
z(t)
4136
4134
4138
4132
360°
0°
θ3
(t3)
R3
4126
4124
4128
4122
360°
0°
θ2
(t2)
R2
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0°
θ1
(t1)
R1

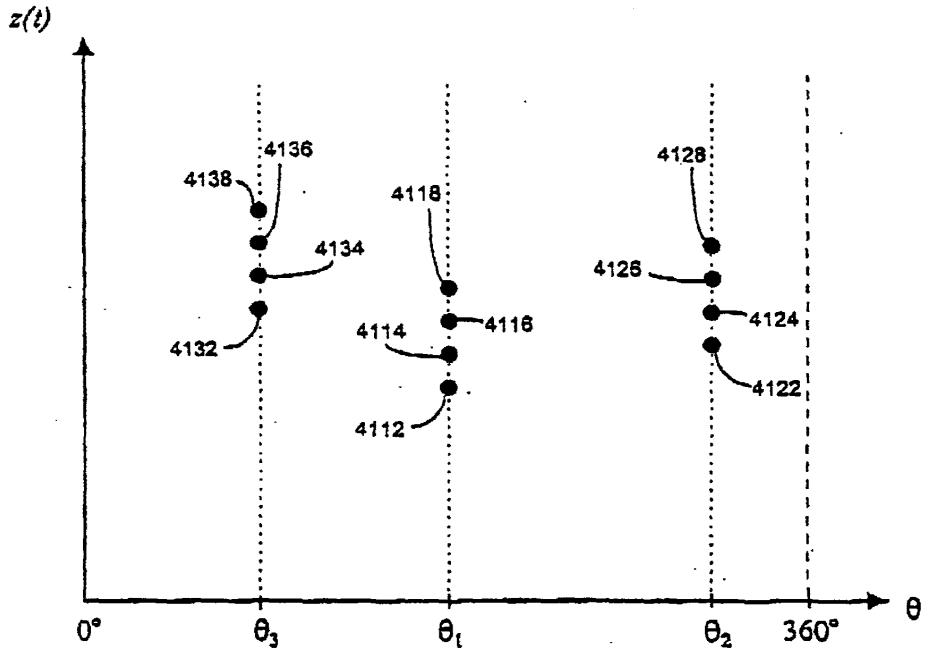


FIG. 42

BNSDOCID: <WO___0180184A1_I_>

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/00904

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06T11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, INSPEC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 627 868 A (TOKI YUSUKE ET AL) 6 May 1997 (1997-05-06) abstract; figures 3,4,6-12 column 2, line 19 - last line column 6, line 47 -column 7, line 22 column 8, line 8 - line 31 column 14, line 26 - line 34	1-9
A	---	10-71
A	US 5 889 833 A (SILVER MICHAEL D) 30 March 1999 (1999-03-30) abstract column 5, line 7 -column 6, line 20	1-71
A	---	
	EP 0 430 549 A (GEN ELECTRIC) 5 June 1991 (1991-06-05) abstract	1-71

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 July 2001	18/07/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Diallo, B

Form PCT/ISA/210 (second sheet) (July 1992)

BNSDOCID: <WO___0180184A1_I_>

Volkswagen Exhibit 1002, Page 210 of 885

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/00904

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 838 756 A (TAGUCHI KATSUYUKI ET AL) 17 November 1998 (1998-11-17)	
A	US 5 243 284 A (NOLL DOUGLAS C) 7 September 1993 (1993-09-07)	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

BNSDOCID: <WO___0180184A1_I_>

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 01/00904

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5627868 A	06-05-1997	JP 3090400 B	18-09-2000
		JP 7323027 A	12-12-1995
		DE 69425631 D	28-09-2000
		DE 69425631 T	19-04-2001
		EP 0655713 A	31-05-1995
		EP 0953942 A	03-11-1999
		JP 7194592 A	01-08-1995
		JP 2000189414 A	11-07-2000
		US 5513237 A	30-04-1996
		US 5566218 A	15-10-1996
		US 5608772 A	04-03-1997
		JP 2000342573 A	12-12-2000
		JP 2000350724 A	19-12-2000
		US 5594772 A	14-01-1997
		US 5612985 A	18-03-1997
US 5889833 A	30-03-1999	JP 11004823 A	12-01-1999
EP 0430549 A	05-06-1991	US 5216601 A	01-06-1993
		CA 2021623 A	23-05-1991
		IL 96320 A	08-12-1995
		JP 1945090 C	23-06-1995
		JP 3186250 A	14-08-1991
		JP 6069452 B	07-09-1994
US 5838756 A	17-11-1998	JP 9187449 A	22-07-1997
		JP 9187450 A	22-07-1997
US 5243284 A	07-09-1993	NONE	

BNSDOCID: <WO___0180184A1_I_>

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EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	0	spatial ADJ synchorniz$5	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/01/04 11:04
L2	0	spatial ADJ synchornization	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/01/04 11:04

EAST Search History

L3	0	spatial ADJ synchornize	US-PG PUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/01/04 11:04
L4	102	spatial ADJ synchronization	US-PG PUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/01/04 11:06
L5	2	L4 AND (moving ADJ object)	US-PG PUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/01/04 11:05

EAST Search History

L6	1	L4 NEAR moving	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/01/04 11:05
S1	1	10/955037	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 09:38
S2	2163	bonnet.IN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 09:38

Volkswagen Exhibit 1002, Page 216 of 885

EAST Search History

S3	9	bonnet-stephane.IN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 09:55
S4	40	grangeat-pierre.IN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 09:41
S5	2127	382/128.CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 10:49

EAST Search History

S6	0	"382.CCLA"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 10:49
S7	0	"382.CLAS"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 10:49
S8	57452	"382".CLAS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 10:49

EAST Search History

S9	80967	"345".CLAS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 10:49
S10	28016	"715".CLAS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 10:49
S11	990	345/420.CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:40

EAST Search History

S12	0	functional ADJ radiation ADJ imagery	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:40
S13	5	functional ADJ radiation ADJ image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:41
S14	0	functional ADJ radiation ADJ emission ADJ image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:42

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EAST Search History

S15	11	radiation ADJ emission ADJ image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:43
S16	8	radiation ADJ attenuation ADJ image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:45
S17	0	S15 AND S16	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:45

EAST Search History

S18	885	reconstruct$4 ADJ image ADJ object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:46
S19	0	S17 AND S8	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:46
S20	71	S18 AND S8	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:48

EAST Search History

S21	1	S18 NEAR movement	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:49
S22	1	S18 NEAR moving	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:50
S23	0	S22 AND estimate	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:49

EAST Search History

S24	0	S22 AND calculation	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:50
S25	0	S22 AND calculte	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:50
S26	7	imagery ADJ mode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:51

EAST Search History

S27	20	S18 AND S9	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 11:51
S28	8	S27 AND moving	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:07
S29	4416	townsend.IN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:07

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EAST Search History

S30	140	"0004405"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:08
S31	0	S29 AND S30	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:08
S32	32	"170246"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:09

EAST Search History

S33	2	"20030004405"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:11
S34	841	PET NEAR CT	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:12
S35	2	"2004170246"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:13

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EAST Search History

S36	9	Koeing.IN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:14
S37	5	"5889525"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:14
S38	17	S8 AND (spatial ADJ synchronization)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/12/26 12:47

PTO/SB/08A(08-03)
Approved for use through 07/31/2006. OMB 0651-0031
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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

SEP 12 2005 PATENT & TRADEMARK OFFICE

Sheet 1 of 1

Complete if Known	
Application Number	10/955,037
Filing Date	September 30, 2004
First Named Inventor	BONNET, Stephane
Group Art Unit	~~2882~~ JWL 2112
Examiner Name	~~Unknown~~ JWL John W. Lee
Attorney Docket No: BRV.10002	

US PATENT DOCUMENTS

Examiner Initial*	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
JWL	US-2003-0004405-A1	01/02/2003	TOWNSEND, David W., et al.
	US-2004-170246-A1	09/02/2004	KOENIG, Anne , et al.
	US-5,889,525	03/30/1999	DE MURCIA, Jérôme , et al.

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Foreign Document No	Publication Date	Pages,Columns,Lines,Where Relevant Passages or Relevant Figures Appear	Abstract, Translation, English Language Equivalent or Search Report
JWL	EP-1 087 337	03/28/2001		
	FR-2736454	01/10/1997		X
	FR-2826157	12/20/2002		X
	WO-01/80184	10/25/2001		

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	Abstract, Translation, English Language Equivalent or Search Report
JWL	GILLAND, DAVID R.,et al.,"Simultaneous Reconstruction and Motion Estimation for Gated Cardiac ECT", IEEE Trans. on Nuclear Science 49(5):2344-2349 (Oct. 2002)	
JWL	GRANGEAT, PIERRE ,et al.,"Theoretical framework for a dynamic cone-beam reconstruction algorithm based on a dynamic particle model", Phys. Med. Biol. 47:2611-2625 (2002)	
JWL	KACHELRIESS, MARC ,et al.,"Kymogram detection and kymogram-correlated image reconstruction from subsecond spiral computed tomography scans of the heart", Med. Phys. 29(7):1489-1503 (July 2002)	
JWL	KINAHAN, P. E.,et al.,"Attenuation correction for a combined 3D PET/CT scanner", Med. Phys. 25(10):2046-2053 (Oct. 1998)	

EXAMINER /John Lee/ **DATE CONSIDERED** 12/27/2006

Substitute Disclosure Statement Form (PTO-1449)

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional) 2 Applicant is to place a check mark here if English language Translation is attached

Notice of References Cited	Application/Control No. 10/955,037	Applicant(s)/Patent Under Reexamination BONNET ET AL.	
	Examiner John Wahnkyo Lee	Art Unit 2112	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,889,525 A	03-1999	De Murcia et al.	345/420
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Beyer, T. et al., "The use of X-ray CT for Attenuation Correction of PET Data", 1995, IEEE, Vol. 4, page 1573
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

A

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Bib Data Sheet

CONFIRMATION NO. 4535

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/955,037	09/30/2004 RULE	382	2112	BRV.10002

APPLICANTS

Stephane Bonnet, Seyssinet-Pariset, FRANCE; JwL
Pierre Grangeat, Saint Ismier, FRANCE; JwL

** CONTINUING DATA **********

JwL

** FOREIGN APPLICATIONS **********

FRANCE 03 50631 10/01/2003 JwL

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 08/19/2005

		STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed	☑ yes ☐ no	FRANCE	2	8	1
35 USC 119 (a-d) conditions met	☑ yes ☐ no ☐ Met after Allowance				
Verified and Acknowledged	Examiner's Signature / Initials JwL				

ADDRESS
45473

TITLE
Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
900	No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/27/2006								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

SEARCHED			
Class	Subclass	Date	Examiner
382	128	12/26/2006	John W. Lee
345	420	12/26/2006	John W. Lee

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor Search	12/26/2006	John W. Lee
East Search	12/26/2006	John W. Lee
IEEE (Non- Patent Literature Search)	12/26/2006	John W. Lee

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	BRV.10002	4535

45473 7590 01/10/2007
HUTCHISON LAW GROUP PLLC
PO BOX 31686
RALEIGH, NC 27612

EXAMINER	
LEE, JOHN W	
ART UNIT	PAPER NUMBER
2112	

SHORTENED STATUTORY PERIOD OF RESPONSE	MAIL DATE	DELIVERY MODE
3 MONTHS	01/10/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

Office Action Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	John Wahnkyo Lee	2112	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *30 September 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-8* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-8* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *30 September 2004* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *20050912*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Information Disclosure Statement

1. An initialed and dated copy of Applicant's IDS form 1449, Paper No. 20050912, is attached to the instant Office action.

Specification

2. The disclosure is objected to because of the following informalities:

(1) There are miss-spellings and grammar errors in the pages as follows:

From pages 1, 3-9, 11, and 15, the examiner recommends substituting "synchronisation", "ionising", "... the periphery of the object collect radiation ...", "isbn", "recognisable", "regularise", "generalised", "synchronise", "minimised", "minimisation", "characterise" with "synchronization", "ionizing", "... the periphery of the object collects radiation ...", "ISBN", "recognizable", "regularize", "generalize", "synchronize", "minimized", "minimization", "characterize", respectively.

(2) In page 11, it is written about the step of "E17" and "E18." However, referring the drawings of the application, it is believed that "E17" and "E18" have to be replaced with "Et17" and "Et18", respectively.

Appropriate correction is required.

3. The abstract of the disclosure is objected as follows:

(1) There are miss-spellings. The examiner recommends substituting "synchronisation" with "synchronization".

(2) The length of the title is too long.

Correction is required. See MPEP § 608.01(b).

Drawings

4. The drawings are objected to because some parts of the words in Fig. I is written in French rather than in English, which is hard for the examiner to comprehend. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Objections

5. Claims 1-8 are objected to because of the following informalities: All of the claims have miss-spellings. It is recommended to replace "characterised", "synchronisation", and "synchronise" with "characterized", "synchronization", and "synchronize", respectively.

Appropriate correction is required.

Claim Rejections - 35 USC § 102

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

7. Claims 1-3, and 5-8 are rejected under 35 U.S.C. 102(b) as being anticipated by De Murcia et al. (5,889,525).

8. Regarding claim 1, the claim encompasses a method of reconstruction of an image of a mobile object by a first measurement acquisition technique containing at least partial reconstruction of images of the object at corresponding movement states of the object, an estimate of the object movement between the states, and a combination of state images by making compensations of the object movement according to the

estimate at least using partially other images of the object using a second measurement acquisition technique.

De Murcia discloses a process for the reconstruction of three-dimensional images of a mobile or deformable object (col. 1, lines 7-8). An approximate image of the object in each state "f" is reconstituted; a reference state to each of the states are evaluated; the estimation of the image of the object at the reference state is obtained by a convergence towards the information relative to the measurements and to the previously calculated movements of the objects, which implies the reconstruction of the image is from at least a combination of states retrieved by at least two independent techniques (abstract; Fig. 2).

9. Regarding claims 2 and 3, the method recited in claim 1 has a synchronization step applied to measurements originating from the second acquisition technique and comprises a spatial synchronization for estimating the object movement.

De Murcia discloses that the sensors, which have different incidences and take different series of sets of measurements, synchronizes on a given group of states of the heart or phases of its cycle (col. 3, lines 36-39), which can be interpreted as a spatial synchronization process.

10. Regarding claims 5 and 6, the method recited in claim 1 contains a feature of a measurement of a cyclic element of the object movement to synchronize the states on

periodic states of the cyclic element on several phases associated with different periods of the movement cyclic element.

De Murcia discloses that the sensor does a synchronization of states of the heart or the phases of its cycles for series (col. 3, lines 36-39) of sets of successive measurements corresponding to different states of objects (col. 3, lines 49-51).

11. Regarding claims 7 and 8, the method recited in claim 1 uses the independent movement or position sensors to evaluate the movement of the object and/or to place the measurements by the two acquisition techniques and the states of the object on a common time scale, and to estimate the movement for compensation.

De Murcia discloses sensors having different incidences taking a series of sets of measurements synchronized on a given group of states of the heart or the phases of its cycle (col. 3, lines 36-39). De Murcia also discloses an estimation of deformations, which a reference state to each of the states is evaluated (abstract; Fig. 2).

Claim Rejections - 35 USC § 103

12. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

13. Claims 1 and 4 are rejected under 35 U.S.C. 103(a) as being unpatentable over Murcia et al. (5,889,525) in view of Beyer et al.

14. Regarding claim 4, the method recited in claim 1 has a functional radiation emission imagery technique and an anatomic radiation attenuation imagery technique.

As discussed before, De Murcia discloses all the features of claim 1. However, De Murcia does not disclose the feature of claim 4, but Beyer does by disclosing the method of using X-ray CT data for attenuation correction of PET data (abstract). PET is an example of a system using functional radiation emission imagery technique and CT is an example of a system using an anatomic radiation attenuation imagery technique.

De Murcia and Beyer are analogous because they are from the same field of endeavor of method of image manipulation.

It would have been *prima facie* obvious to one of ordinary skill in the art at the time the invention was made to use Beyer's method in De Murcia's process for the reconstruction of three-dimensional images. The motivation would have been to make it possible to acquire rapidly and low-noise transmission scans for PET attenuation correction and to use of a *priori* information to help guide the PET image reconstruction process as suggested by Beyer (page 1573). Therefore, it would have been obvious to combine De Murcia and Beyer to obtain the invention of claim 4.

Conclusion

15. No claims are allowed.

16. Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Wahnkyo Lee whose telephone number is (571) 272-9554. The examiner can normally be reached on Monday - Friday (Alt.) 7:30 a.m. - 5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jeffrey Stucker can be reached on (571) 272-0911. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.





JEFFREY STUCKER
SUPERVISORY PATENT EXAMINER

John W. Lee

Patent
Attorney Docket No. BRV.10002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Stephane BONNET	Mail Stop: Amendment
Application No.: 10/955,037	Group Art Unit: 2112
Filing or 371(c) Date: September 30, 2004	Examiner: John W. Lee
Title: Method of Reconstructing an Image With Data Acquisition According to Several Imagery Modes and Synchronisation of Image Series	Confirmation No.: 4535

AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action mailed January 10, 2007, please amend this application as follows.

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims, which begins on page 6 of this paper.

Amendments to the Drawings begin on page 8 of this paper and include attached Replacement sheet.

Remarks begin on page 9 of this paper.

1 sheet of **Replacement Drawing Figure** is attached following page of this paper.

1 / 2

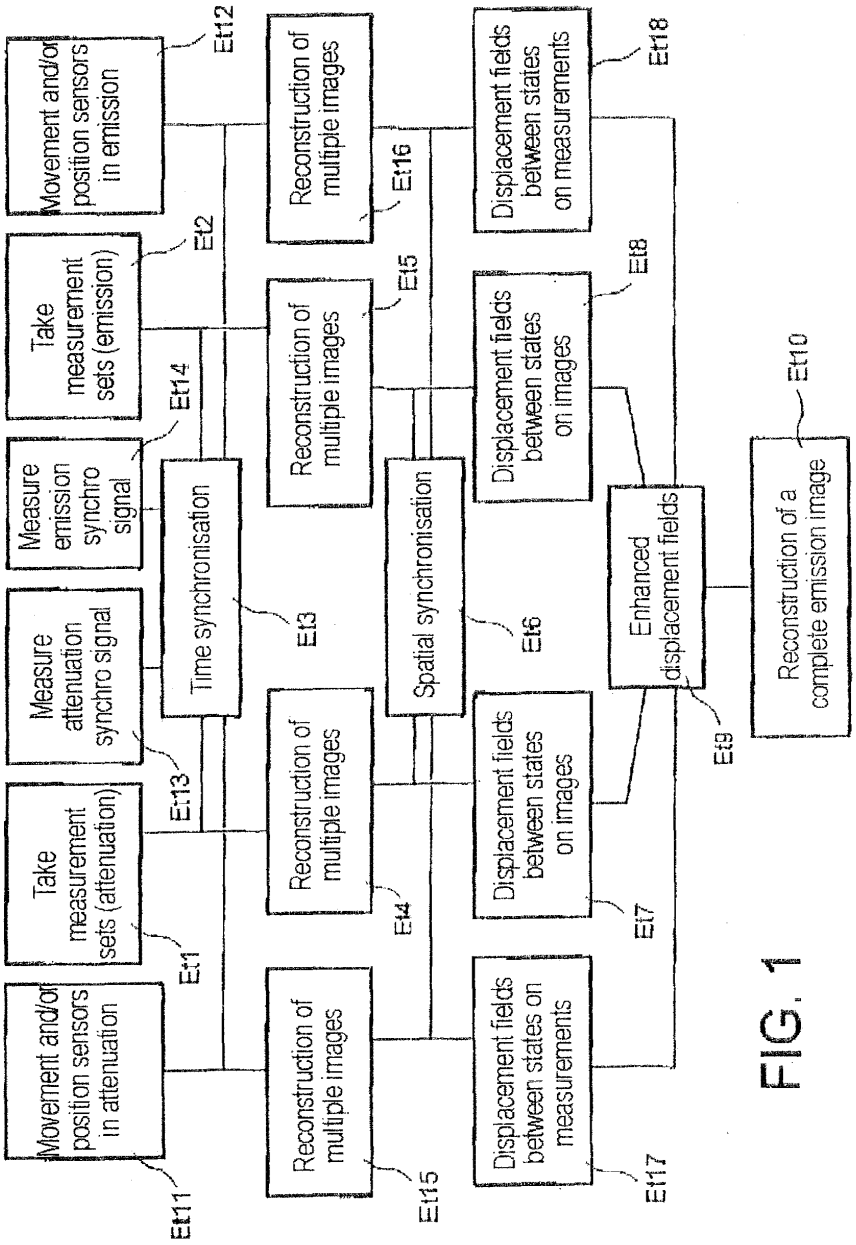


FIG. 1

Volkswagen Exhibit 1002, Page 244 of 885

PTO/SB/21 (04-07)
Approved for use through 09/30/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission: 19

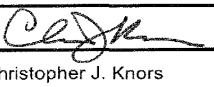
Application Number	10/955,037
Filing Date	September 30, 2004
First Named Inventor	Stephane BONNET
Art Unit	2112
Examiner Name	John W. Lee
Attorney Docket Number	BRV.10002

ENCLOSURES *(Check all that apply)*

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☑ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☑ Extension of Time Request
- ☐ Express Abandonment Request
- ☐ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Reply to Missing Parts/ Incomplete Application
  - ☐ Reply to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s) _____
  - ☐ Landscape Table on CD
- ☐ After Allowance Communication to TC
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☐ Other Enclosure(s) (please Identify below):

Remarks: The Director is hereby authorized to charge any appropriate fees that may be required by this paper, and to credit any overpayment, to Deposit Account No. 50-3218.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Hutchison Law Group PLLC		
Signature			
Printed name	Christopher J. Knors		
Date	July 10, 2007	Reg. No.	45,569

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature			
Typed or printed name		Date	

This collection of information is required by 37 CFR 1.5. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and1.14. This collection is estimated to 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PTO/SB/22 (09-06)
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U.S. Patent and Trademark Office; U.S. DEPARMENT OF COMMERCE
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) **FY 2006** *(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)*	Docket Number (Optional) BRV.10002
Application Number 10/955,037	Filed September 30, 2004
For Method of Reconstructing an Image With Data Acquisition According to	
Art Unit 2112	Examiner John W. Lee

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	
☐	One month (37 CFR 1.17(a)(1))	$120	$60	$
☐	Two months (37 CFR 1.17(a)(2))	$450	$225	$
☑	Three months (37 CFR 1.17(a)(3))	$1020	$510	$ 1020
☐	Four months (37 CFR 1.17(a)(4))	$1590	$795	$
☐	Five months (37 CFR 1.17(a)(5))	$2160	$1080	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 50-3218. I have enclosed a duplicate copy of this sheet.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

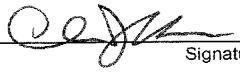
I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed (Form PTO/SB/96).

☑ attorney or agent of record. Registration Number 45,569

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 _____


Signature

July 10, 2007
Date

Christopher J. Knors
Typed or printed name

+1.919.829.9600
Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☐ Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

10955037

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2003

Application or Docket Number
10955037

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	8	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	8 minus 20= *	—
INDEPENDENT CLAIMS	1 minus 3 =	*
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
RATE	FEE		RATE	FEE
BASIC FEE	385.00	OR	BASIC FEE	770.00
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL		OR	TOTAL	720

CLAIMS AS AMENDED - PART II

9/30/2004

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 8	Minus	** 20	= X
Independent	* 1	Minus	*** 3	= X
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	X
X43=		OR	X86=	X
+145=		OR	+290=	X
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	0

9/10/07

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 6	Minus	** 20	= X
Independent	* 1	Minus	*** 3	= X
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claims 1-8 (Cancelled).

Claim 9 (New): A method of at least partial reconstruction of an image of a mobile object, comprising the following steps:

taking first measurements of the object with a first acquisition technique and obtaining a plurality of first images of the object at corresponding movement states of the object;

taking second measurements of the object with a second acquisition technique and obtaining a plurality of second images of the object at corresponding movement states of the object;

estimating a movement of the object according to a time from at least one of the plurality of second images;

estimating the movement of the object at said movement states from when the first measurements are taken;

combining the first images of the object so as to obtain a final image of the object at a reference time, and

compensating for movements of the object from the reference time to at least one of the movement states and in at least one of the first images, respectively.

Claim 10 (New): The method according to claim 9, wherein the first acquisition technique is a radiation emission imagery technique and the second acquisition technique is a radiation attenuation imagery technique.

Claim 11 (New): The method according to claim 9, wherein the movement states when the first measurements are taken are different from the movement states when the second measurements are taken, the method further comprising a step of time synchronization between the different movement states and the movements of the object.

Claim 12 (New): The method according to claim 11, wherein the movement of the object is composed of cycles, wherein said movement states and said movements of the object are related to respective phases in one of said cycles in the time synchronization step.

Claim 13 (New): The method according to claim 11, wherein the time synchronization step is made by taking third measurements of the object using position measurement sensors, wherein the third measurements are related to both the first measurements and the second measurements.

Claim 14 (New): The method according to claim 9, further comprising estimating the movement of the object from movements of control points of the object, said movements of the control points being measured by further sensors, said control points being located at least in the second images.

Electronic Patent Application Fee Transmittal

Application Number:	10955037
Filing Date:	30-Sep-2004
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Filer:	Christopher J. Knors/Jennie Snead
Attorney Docket Number:	BRV.10002
Filed as Large Entity	

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 3 months with $0 paid	1253	1	1020	1020

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**1020**

Electronic Acknowledgement Receipt	
EFS ID:	1956662
Application Number:	10955037
International Application Number:	
Confirmation Number:	4535
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Customer Number:	45473
Filer:	Christopher J. Knors/Jennie Snead
Filer Authorized By:	Christopher J. Knors
Attorney Docket Number:	BRV.10002
Receipt Date:	10-JUL-2007
Filing Date:	30-SEP-2004
Time Stamp:	16:08:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$1020
RAM confirmation Number	1111
Deposit Account	503218
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 and 1.17	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1		BRV10002Amendment.pdf	1575955 9a7215a326b0d320daab7611f863b96467ca15ca	yes	19
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Miscellaneous Incoming Letter		1	1	
	Extension of Time		2	2	
	Amendment - After Non-Final Rejection		3	3	
	Specification		4	7	
	Claims		8	9	
	Drawings		10	10	
	Applicant Arguments/Remarks Made in an Amendment		11	18	
	Drawings		19	19	
Warnings:					
Information:					
2	Fee Worksheet (PTO-06)	fee-info.pdf	8208 1de357fdd9e33d6d10bd709e6701ff97508b400f	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1584163		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Amendments to the Specification:

Please replace the Title, with the following:

Method of reconstructing an image acquired using ~~with data acquisition according to~~ several imagery modes ~~and synchronisation of image series~~

Please replace the second full paragraph of page 1, with the following:

Images may be taken inside objects, and particularly living beings, using several types of methods. Some are attenuative, in other words the attenuation of radiation passing through the object is measured, and others are emissive, in other words ~~ionising~~ ionizing particles originating from a radioactive liquid previously swallowed by the organism to be studied, are collected. In both cases, detector networks rotating around the object or covering the periphery of the object ~~collect~~ collects radiation, and images of the object are obtained by combining measurements of detectors taken at different angles using well-known computed tomography methods (see "Tomography", directed by P. Grangeat Paris: Hermes Science Publications 2002 ~~ibsn~~ ISBN 2.7462-0356-1).

Please replace the first full paragraph of page 3, with the following:

Image correction methods by estimating the displacement field have been applied primarily to attenuation images that can be taken quickly and for which the more distinct contents provide more details about object movements. Emission images have less abundant contents due to the fact that the measurements are more dispersed in time and they are not as easily ~~recognisable~~ recognizable since different categories of tissues are not as clearly distinguished. Therefore, it is difficult to establish a displacement field so that it can be used to compensate for object movements and ~~regularise~~ regularize its image.

Please replace the first full paragraph of page 4, with the following:

These displacement fields are then applied to measurements taken using the emission technique in general after having been modified or adapted by processes that will be

described in detail in the remainder of this document. Thus, these emission measurements may be corrected to compensate for the movement and obtain an improved final functional image. All that is necessary is to ~~synchronise~~ synchronize measurements made using the two techniques on a common time base.

Please replace the last full paragraph of page 4, with the following:

Although the invention is useful at the moment in the special context of acquisition pairs by attenuation and emission, it could be easily be ~~generalised~~ generalized to include any pair of measurement acquisitions and is not limited to the embodiments described below.

Please replace the last paragraph beginning on page 5 and ending on page 6, with the following:

Attenuation and emission measurements are made in steps Et1 and Et2 in FIG. 1. For each measurement category, measurement sets are taken at successive instants, which are usually not simultaneous for the two measurement categories. However, a time ~~synchronisation~~ synchronization of measurement sets is usually necessary, within the two series and between the two series after step Et3. One useful method for achieving this may be to measure a patient movement using an independent sensor such as a breathing sensor, a pressure sensor or an electrocardiogram. Each measurement set is then associated with a determined state of the patient during which a measurement of his movement was made. If this measurement relates to a cyclic phenomenon such as breathing, the measurement sets may be associated with time phases of this movement as suggested in the diagram in FIG. 2, in which six measurement sets M1 to M6 taken over a breathing cycle are associated with average phases $\varphi 1$ to $\varphi 6$.

Please replace the last paragraph beginning on page 6 and ending on page 7, with the following:

Finally, the time may be ~~synchronised~~ synchronized by correlation processes between image projections. The article entitled "Kymogram detection and Kymogram-correlated image

reconstruction from subsecond spiral computed tomography scans of the heart", by Kachelriess et al., Med. Phys. 29 (7), July 2002, p. 1489 to 1503, gives an example.

Please replace the second full paragraph of page 8, with the following:

Time ~~synchronisation~~ synchronization could then have been applied to these state images rather than to measurement sets.

Please replace the fifth full paragraph of page 8, with the following:

This operator is assumed to be invariable throughout the examination period. It is also assumed that the time ~~synchronisation~~ synchronization is sufficiently precise and that the patient's movements (physiological) are reproducible.

Please replace the third full paragraph of page 9, with the following:

If this additional information h_t^{att} and h_t^{mi} is available at time t, then the complete set can be ~~minimised~~ minimized into a single function.

Please replace the second full paragraph of page 11, with the following:

Although this ~~synchronisation~~ synchronization method using a small number of phases is very practical, it is not essential for use of this invention that can be applied to a patient subjected to an arbitrary movement or a cyclic movement.

Please replace the third full paragraph of page 11, with the following:

Steps ~~E17 and E18~~ Et17 and Et18 illustrate that displacement fields can also be calculated using sensor measurements.

Please replace the second full paragraph of page 15, with the following:

This deformation is precisely the deformation required during the spatial ~~synchronisation~~ synchronization step.

Please replace the fourth full paragraph of page 15, with the following:

This partial ~~minimisation~~ minimization has been described above.

Please replace the last full paragraph of page 15, with the following:

In any case, the use of another reference imagery method remains necessary to compensate for the poor spatial resolution and the mediocre image quality (noisy and defined only in regions in which the radioactive product is fixed) which ~~characterise~~ characterize emission images and would result in poor quality displacement fields for areas of interest.

Please replace the Abstract, with the following:

Measurements of a mobile object and particularly a living being are made using two techniques, normally radiation attenuation and radiation emission, in ~~synchronisation~~ synchronization to provide images of the object state. Movement displacement fields from one phase to the next are estimated for both techniques, but the final images obtained by the emission technique are improved by the knowledge of the displacement field obtained by the other technique that is more precise.

Amendments to the Drawings:

Please replace FIG. 1 with the following replacement figure that is attached hereto.

No new matter has been added to the Figure.

REMARKS

Claims 1-8 were pending in the present application. Claims 1-8 have been cancelled. New claims 9-14 are added. Support for the new claims is found at least in the specification, Figures, and originally filed claims. No new matter has been added. Thus, claims 9-14 are now pending in the application.

Reexamination of the application and reconsideration of the objections and rejections are respectfully requested in view of the above amendments and the following remarks, which follow the order set forth in the Office Action.

Objections

A. Specification

(1) The disclosure was objected to because of informalities found on pages 1, 3-9, 11, and 15, regarding spellings of the following: "synchronisation", "ionising", "... the periphery of the object collect radiation ...", "isbn", "recognisable", "regularise", "generalised", "synchronise", "minimised", "minimisation", and "characterise."

Applicants are appreciative of the Examiner's careful review of the application. The above terms have been corrected as suggested by the Examiner. Thus, Applicants request withdrawal of this objection.

(2) The reference to the callout numbers Et17" and "Et18" of FIG. 1 have been corrected as suggested by the Examiner. Thus, Applicants respectfully request withdrawal of this objection.

B. Drawings

FIG. 1 was objected to because some parts of the words were written in French rather than in English. A Replacement Drawing Sheet has been provided with an English translation of the French text. Thus, Applicants request withdrawal of this objection.

C. Claims

New claims 9-14 do not include any of the objectionable terms.

D. Abstract

The Abstract was objected to for containing the above spellings. The Abstract has been corrected as suggested by the Examiner. Thus, Applicants respectfully request withdrawal of this objection.

E. Title

The Title was objected to with regard to its length. The Title has been amended. Thus, Applicants respectfully request withdrawal of this objection.

Rejections under 35 U.S.C. § 102(b) are traversed

Claims 1-3, and 5-8 were rejected under 35 U.S.C. § 102(b) as being anticipated by De Murcia et al. (U.S. Patent No. 5,889,525; hereinafter "De Murcia"). Applicants respectfully traverse these rejections in the order they appear.

Amended claim 1 recites a method of at least partial reconstruction of an image of a mobile object. The method comprises the following steps:

taking first measurements of the object with a first acquisition technique and obtaining a plurality of first images of the object at corresponding movement states of the object;

taking second measurements of the object with a second acquisition technique and obtaining a plurality of second images of the object at corresponding movement states of the object;

estimating a movement of the object according to a time from at least one of the plurality of second images;

estimating the movement of the object at said movement states from when the first measurements are taken;

combining the first images of the object so as to obtain a final image of the object at a reference time, and

compensating for movements of the object from the reference time to at least one of the movement states and in at least one of the first images, respectively.

De Murcia discloses a process for the reconstruction of three-dimensional images of a mobile or deformable object. *Col. 1, lines 7-8.* An approximate image of the object in each state "f" is reconstituted; a reference state to each of the states are evaluated; the estimation of the image of the object at the reference state is obtained by a convergence towards the

information relative to the measurements and to the previously calculated movements of the objects. *Abstract; FIG. 1.* The process of De Murcia comprises taking a series of sets of measurements of a characteristic property of the object by a two-dimensional array of mobile sensors around the object, the sets of measurements consisting of a two-dimensional array of projections of the property on the sensors, the sets of measurements being taken at a group of different states of the object with respect to the variations in the position or shape of the object. *Col. 2, lines 56-63; FIG. 2.* De Murcia details the process of mathematically manipulating a series of sets of successive measurements in col. 3, through col. 4, using a series of calculations governed by defined equations (2)-(7). De Murcia discloses that:

> The performance of all these calculations makes it necessary to find the deformation operator D_{k+1}. For this purpose use is made of the previously obtained image estimate f_0^k and an approximate image f^{k+1} of the object at state k+1 with the aid of projections m_{k+1} taken into consideration, using a conventional three-dimensional image reconstruction algorithm, known as reprojection, with respect to the filtered projections.

Col. 4, line 63, through col. 5, line 3 (emphasis added).

De Murcia further discloses that:

> In the case of the heart muscle, this reference frame has for its origin and for directional axes the centre C and the major axes of an ellipsoid used for modelling the barycentric surface of the heart muscle between its inner and outer surfaces (endocardium and pericardium). This surface can be defined in spherical coordinates for the tip or apex of the heart and cylindrical coordinates for the base of the heart. This system of coordinates is designated (ρ,φ) by the equation:

$$\rho G(\phi G, .) = \frac{\int_0^{\rho_{max}} a(\rho, \phi G, .)\rho d\rho}{\int_0^{\rho_{max}} a(\rho, \phi G, .)d\rho} \qquad (9)$$

> in which a(ρ, φG,.) designates the emission activity at the coordinate point (ρ100 G,.) and ρmax designates the maximum scanning distance. For any angular coordinate (ρ, φG,.), the point of the barycentric surface consequently has the radial coordinate φG.

Col. 4, line 63, through col. 5, line 3 (emphasis added).

De Murcia does not teach or fairly suggest a second measurement acquisition technique or estimating a movement of the object according to a time from at least one of the plurality of second images obtained using a second acquisition technique. De Murcia also does not teach or fairly suggest estimating a movement of the object according to a time from at least one of the plurality of second images.

"A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).*

A. In the Action, it is asserted that claim 1 is anticipated because the disclosure of De Murcia "implies the reconstruction of the image is from at least a combination of states retrieved by at least two independent techniques (abstract, Fig. 2.)" *Office Action mailed January 10, 2007, page 4 through page 5.* Applicants respectfully disagree.

With respect to the new claims 9-14, De Murcia does not teach or fairly suggest another independent acquisition technique. In contrast, De Murcia teaches only a mono-photon emission tomography process (MPET) using an array of mobile sensors or transducers. *Col. 3, lines 25-42; FIG. 1.* With regard to FIG. 2, De Murcia discloses a two-dimensional array of sensors or transducers 3, which are collimated in the same direction. *Col. 3, lines 27-30; FIG.2.* FIG. 2 of De Murcia does not depict or fairly suggest at least two independent acquisition techniques as asserted in the Action. De Murcia discloses "sensors having different incidences taking a series of sets of measurements synchronized on a given group of states of the heart or the phases of its cycle." *Col. 3, lines 36-39.* One of ordinary skill in the art would not interpret "sensors having different incidences and taking different sets of measurements" as different, but only as having different spatial positions about an object based on a fair understanding of FIG. 2 and its description. Moreover, as disclosed in equation 9 of De Murcia, only one acquisition function is recited, the function representing an "emission activity," which is consistent with FIG. 1 of De Murcia. *Col. 6, lines 5-17; FIG. 1.* Therefore, De Murcia does not teach or fairly suggest all the elements of claim 1. Thus, Applicants respectfully request withdrawal of this rejection.

B. Claims 2 and 3 were rejected as anticipated by De Murcia. The Action states:

> De Murcia discloses that the sensors, which have different incidences and take different series of sets of measurements, synchronizes on a given group of states of the heart or phases of its cycle (col. 3, lines 36-39), which can be interpreted as a spatial synchronization process.

Office Action mailed January 10, 2007, page 5.

Applicants respectfully disagree. With respect to new claim 11, De Murcia does not teach or fairly suggest the use of first and second acquisition technique measurements and time synchronization between the movement states and the movements of the object. As required by claim 11, the movement states when the first measurements are taken are different from the movement states when the second measurements are taken. As required by claim 12, the movement states and the movements of the object are related to respective phases in one of the cycles in the time synchronization step. In contrast, De Murcia fairly discloses using only one acquisition technique, a mono-photon emission tomography process (MPET). *Col. 3, lines 25-42; col. 6, lines 5-17; FIG. 1.* Therefore, De Murcia does not teach or fairly suggest all the elements of claims 11-12. Thus, Applicants respectfully request withdrawal of this rejection.

C. Claims 5 and 6 were rejected as anticipated by De Murcia. In the Action, it is asserted that:

> De Murcia discloses that the sensor does a synchronization of states of the heart or the phases of its cycles for series (col. 3, lines 36-39) of sets of successive measurements corresponding to different states of objects (col. 3, lines 49-51).

Office Action mailed January 10, 2007, page 6.

Applicants respectfully disagree. With respect to new claim 12, De Murcia does not teach or fairly suggest the use of first and second acquisition technique measurements and where the movement of the object is composed of cycles. In contrast, De Murcia discloses using only one acquisition technique. *Col. 3, lines 25-42; col. 6, lines 5-17; FIG. 1.* Therefore, De Murcia does not teach or fairly suggest all the elements of claim 12. Thus, Applicants respectfully request withdrawal of this rejection.

D. Claims 7 and 8 were rejected as anticipated by De Murcia. The Action states:

> De Murcia discloses sensors having different incidences taking a series of sets of measurements synchronized on a given group of states of the heart or the phases of its cycle (col. 3, lines 36-39). De

> Murcia also discloses an estimation of deformations, which a reference state to each of the states is evaluated (abstract; Fig. 2).

Office Action mailed January 10, 2007, page 6.

Applicants respectfully disagree. With regard to new claim 13, De Murcia does not teach or fairly suggest the use of a first and second acquisition technique measurements and taking third measurements of the object using position measurement sensors. The third measurements are related to both the first measurements and the second measurements, as required in claim 13. With regard to new claim 14, De Murcia does not teach or fairly suggest the use of a first and second acquisition technique measurements and estimating the movement of the object from movements of control points of the object, the movements of the control points being measured by further sensors, the control points being located at least in the second images, as required in claim 14. In contrast, De Murcia discloses using only one acquisition technique. *Col. 3, lines 25-42; col. 6, lines 5-17; FIG. 1.* Therefore, De Murcia does not teach or fairly suggest all the elements of claims 13-14. Thus, Applicants respectfully request withdrawal of this rejection.

Because De Murcia does not teach each and every element of claim 9 and dependent claims 10-14, for at least the reasons stated above, Applicants respectfully request reconsideration and withdrawal of the rejection.

Rejections under 35 USC § 103 are traversed

Claims 1 and 4 were rejected under 35 U.S.C. § 103(a) as being unpatentable over De Murcia in view of Beyer et al, *IEEE, (1995) 4: 1573-77* (herein after referred to as "Beyer"). Applicants respectfully traverse.

New claim 10 requires the first acquisition technique is a functional radiation emission imagery technique and the second acquisition technique is an anatomic radiation attenuation imagery technique.

De Murcia was discussed above. Beyer discloses evaluating the use of X-ray CT data for attenuation correction of PET data. *Abstract.* Beyer discloses the testing of two methods, scaling and segmentation methods, with data acquired from separate PET and CT scans of a phantom with regions of different densities. Beyer discloses:

> Additional advantages of accurate geometrical information from a combined scanner include the potential for (1) rapidly-acquired,

> low-noise transmission scans for PET attenuation correction, (2) transmission scans performed post-injection, (3) the use of model-based scatter correction methods, and (4) the use of *a priori* information to help guide the PET image reconstruction process.
> *INTRODUCTION, page 1573.*

Beyer also discloses:

> The basic procedure by which the attenuation correction is performed in volume-imaging PET is as follows: (1) acquisition in 2D mode (with septa extended) of a blank and transmission scan, (2) acquisition in 3D mode (with septa retracted) of an emission scan, (3) reconstruction of the 2D transmission scan into a stacked set of transmission images (4) calculation of the attenuation correction factors (ACFs) by forward-projection of the transmission images into sinograms, followed by exponentiation, (5) correction of the 3D emission sinograms by multiplication with the 3D ACF sinograms.
> *ATTENUATION CORRECTION METHODS, page 1573.*

Beyer discloses the scaling and segmentation methods of attenuation correction by acquiring separate CT and PET scans of a "NEMA-PET phantom," which is depicted in figure 3, and comprises three inserts, which are axially uniform but have large transaxial variations in attenuation. *METHODS, page 1575; Figure 3.*

Beyer does not teach or fairly suggest the use of a different acquisition technique to estimate movement of the object states. Beyer also does not teach or fairly suggest the compensation for movement of the object from the reference time to each of the first states and in each of the first images, respectively using different acquisition techniques.

"The prior art reference (or references when combined) must teach or suggest all the claim limitations." *MPEP § 2143.*

The Action acknowledges De Murcia does not disclose a system using functional radiation emission imagery technique and an anatomic radiation attenuation imagery technique as recited in claim 4. In combining Beyer with De Murcia to remedy this deficit, the Action asserts that "[t]he motivation would have been to make it possible to acquire rapidly and low-noise transmission scans for PET attenuation correction and to use [of] *a priori* information to help guide the PET image reconstruction process as suggested by Beyer (page 1573). *Office Action mailed January 10, 2007, page 7.* Applicants respectfully disagree.

De Murcia does not teach or fairly suggest all the features of new claim 9, specifically, the use of a different acquisition technique to estimate movement of the object states, or compensating for movements of the object from the reference time to at least one of the movement states and in at least one of the first images, respectively, as required by claim 9. Beyer fails to remedy the deficit in De Murcia because the process of Beyer also fails to teach or suggest the compensating for movements of the object from the reference time to at least one of the movement states and in at least one of the first images, respectively. In contrast, Beyer teaches processes performed on a stationary object, the NEMA-PET phantom. *METHODS, page 1575*. Therefore, there would be no motivation to combine Beyer with De Murcia as each reference, alone and in combination, fail to teach each and every element of the claim. Thus, Applicants respectfully request reconsideration and withdrawal of the rejection.

For the foregoing reasons, claims 9-14 are considered allowable. A Notice to this effect is respectfully requested. If any questions remain, the Examiner is invited to contact the undersigned at the number given below.

Respectfully submitted,

HUTCHISON LAW GROUP PLLC

Date: July 10, 2007

By: _____
Christopher J. Knors
Registration No. 45,569

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+1.919.829.9600

Notice of References Cited	Application/Control No. 10/955,037	Applicant(s)/Patent Under Reexamination BONNET ET AL.	
	Examiner John Wahnkyo Lee	Art Unit 2624	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,889,525 A	03-1999	De Murcia et al.	345/420
*	B	US-2003/0004405 A1	01-2003	Townsend et al.	600/407
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/27/2006	09/07/2007							
	1	✓	-							
	2	✓	-							
	3	✓	-							
	4	✓	-							
	5	✓	-							
	6	✓	-							
	7	✓	-							
	8	✓	-							
9			✓							
10			✓							
11			✓							
12			✓							
13			✓							
14			✓							

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	BRV.10002	4535

45473 7590 09/13/2007
HUTCHISON LAW GROUP PLLC
PO BOX 31686
RALEIGH, NC 27612

EXAMINER	
LEE, JOHN W	
ART UNIT	PAPER NUMBER
2624	
MAIL DATE	DELIVERY MODE
09/13/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	John Wahnkyo Lee	2624	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *13 July 2007*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-14* is/are pending in the application.

4a) Of the above claim(s) *1-8* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *9-14* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. The response received on 13 July 2007 has been placed in the file and was considered by the examiner. An action on the merits follows.

Response to Amendment

2. The applicant's amendments filed on 13 July 2007 have been fully considered.

Objections

A. Specification

Applicant's arguments to the objection to the specification have been fully considered and are persuasive. The objection to the specification is hereby withdrawn.

B. Drawings

Applicant's arguments to the objection to the drawings have been fully considered and are persuasive. The objection to the drawings is hereby withdrawn.

C. Claims

Applicant's arguments to the objection to the claims have been fully considered and are persuasive. The objection to the claims is hereby withdrawn.

D. Abstract

Applicant's arguments to the objection to the abstract have been fully considered and are persuasive. The objection to the abstract is hereby withdrawn.

E. Title

Applicant's arguments to the objection to the title have been fully considered and are persuasive. The objection to the title is hereby withdrawn.

Response to Arguments

3. Applicant's arguments filed on 13 July 2007 have been fully considered, but are not persuasive.

4. Applicant's arguments with respect to claims 9-14 have been considered but are moot in view of the new ground(s) of rejection.

Claim Rejections - 35 USC § 112

5. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claim 1 recites the limitations, "first image" and "second image." There is insufficient antecedent basis for this limitation in the claim. The examiner is not sure what these terms are pointing out wants the applicant to clarify these terms.

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8. Claims 9, 11-14 are rejected under 35 U.S.C. 102(b) as being anticipated by De Murcia et al. (US 5,889,525).

Regarding claim 9, De Murcia discloses a method of at least partial reconstruction of an image of a mobile object (col.1, lines 6-7), comprising the following

steps: taking first measurements (abstract; col. 2, lines 56-57; claims 1 and 2, "sets of measurements") of the object with a first acquisition technique (col. 2, lines 56-64, "two dimensional array of projections") and obtaining a plurality of first images of the object at corresponding movement states of the object (abstract; claim 1); taking second measurements (abstract; col. 2, lines 56-57; claims 1 and 2, "sets of measurements") of the object with a second acquisition technique (col. 2, lines 56-64, "two dimensional array of projections") and obtaining a plurality of second images of the object at corresponding movement states of the object (abstract; claim 1); estimating a movement of the object according to a time from at least one of the plurality of second images (col. 4, lines 10-25, " $\hat{f}^{k+1}$ "; claim 2, "obtaining an approximate image ..." and "evaluating ..."); estimating the movement of the object at said movement states from when the first measurements are taken (col. 4, lines 10-25, " $\hat{f}^{k+1}$ "; claim 2, "obtaining an approximate image ..." and "evaluating ..."); combining the first images of the object so as to obtain a final image of the object at a reference time (col. 5, lines 13-18), and compensating for movements of the object from the reference time to at least one of the movement states and in at least one of the first images, respectively (col. 5, lines 13-18; claim 1, "m_k" and "D_k")

Regarding claim 11, De Murcia discloses the movement states when the first measurements are taken are different from the movement states when the second measurements are taken (abstract, "sets of measurements ... different states of the object"; col. 3, lines 49-51), the method further comprising a step of time

synchronization between the different movement states and the movements of the object (col. 3, lines 38-43, "synchronized").

Regarding claim 12, De Murcia discloses that the movement of the object is composed of cycles, wherein said movement states and said movements of the object are related to respective phases in one of said cycles in the time synchronization step (col. 3, lines 38-43, "phase of its cycle").

Regarding claim 13, De Murcia discloses that the time synchronization step is made by taking third measurements of the object using position measurement sensors (col. 3, lines 36-38, "sensors ... measurements") wherein the third measurements (col. 3, line 37, "sets of measurements") are related to both the first measurements and the second measurements (col. 3, lines 36-43).

Regarding claim 14, De Murcia discloses comprising estimating the movement of the object from movements of control points (claims 1 and 2, "a two dimensional array") of the object, said movements of the control points being measured by further sensors (claims 1 and 2, "sensors"), said control points being located at least in the second images (claims 1 and 2).

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

10. Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over De Murcia et al. (US 5,889,525) in view of Townsend et al. (US 2003/0004405).

Regarding claim 10, De Murcia discloses all the previous claim limitations except the ones recited in claim 10. However, Townsend discloses that the first acquisition technique is a radiation emission imagery technique (abstract; claim 1, "PET is an example of a system using functional radiation emission imagery technique") and the second acquisition technique is a radiation attenuation imagery technique (abstract; claim 1, "CT is an example of a system using an anatomic radiation attenuation imagery technique").

It would have been *prima facie* obvious to one of ordinary skill in the art at the time the invention was made to use Townsend's invention in De Murcia's invention to obtain satisfactory imaging results as suggested by De Murcia (col. 2, lines 44-55).

Conclusion

11. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of

the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Wahnkyo Lee whose telephone number is (571) 272-9554. The examiner can normally be reached on Monday - Friday (Alt.) 7:30 a.m. - 5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jingge Wu can be reached on (571) 272-7429. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

John W. Lee
(AU 2624)

SUPERVISORY PATENT EXAMINER
JINGGE WU

Electronic Acknowledgement Receipt

EFS ID:	2794647
Application Number:	10955037
International Application Number:	
Confirmation Number:	4535
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Customer Number:	45473
Filer:	Jeffrey W. Gluck
Filer Authorized By:	
Attorney Docket Number:	BRV.10002
Receipt Date:	31-JAN-2008
Filing Date:	30-SEP-2004
Time Stamp:	13:16:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	PoACEA2007.pdf	95793 a49489b336ecaba2bfc93bb6e75b2accddbbb361	no	4
Warnings:					
Information:					

Total Files Size (in bytes):	95793

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application Nos.:
07/310,726; 08/185,472; 08/390,087;
10/955,037; 08/065,142; 08/338,570;
08/761,757; 08/975,459; 09/438,367;
09/583,746; 10/312,489; 10/480,742

Customer No.: 30678

Revocation and Power of Attorney

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

All previous powers of attorney and authorizations of agent are hereby revoked, and the undersigned hereby appoints the attorneys and agents of Connolly Bove Lodge & Hutz LLP associated with U.S. Patent and Trademark Office ("PTO") Customer Number 30678 to prosecute these applications and any U.S., foreign, or international applications under the Patent Cooperation Treaty based on them and to transact all business in the PTO connected therewith, and to receive all communications from the PTO, including the patent documents. Further details about each application are found in the Appendix to this paper. The authority under this Power of Attorney of each person listed under the aforementioned PTO Customer Number shall automatically terminate and be revoked upon such person ceasing to be associated with Connolly Bove Lodge & Hutz LLP.

Designation of Correspondence Address

Please send all notices, official letters, documents, communications, and other correspondence regarding these applications to:

Connolly Bove Lodge & Hutz LLP
1875 Eye Street NW, Suite 1100
Washington, DC 20006

or to the address currently associated with PTO Customer Number 30678. Please also record the respective Attorney Docket Numbers in the attached appendix in any applicable databases.

Certificate Under 37 C.F.R. § 3.73(b)

Intellectual Ventures Fund 23 LLC is the assignee of the entire right, title, and interest in these patents and applications by virtue of an assignment from Commissariat a l'Energie Atomique to Intellectual Ventures Fund 23 LLC, recorded in the records of the PTO on January 17, 2008 at Reel 020371, Frame 0692. To the best of the undersigned's knowledge and belief, the titles are in the name of said assignee. The undersigned, whose title is supplied below, is empowered to sign this certificate on behalf of Intellectual Ventures Fund 23 LLC.

Signed: _____ Date: 1-30-08
Name: Joe Kosiara
Title: Authorized Person
Intellectual Ventures Fund 23 LLC

APPENDIX: DETAILS OF LISTED APPLICATIONS

Appln. No.	Confirmation No.	Patent No.	Filing Date	First Named Inventor	Title	Attorney Docket No.
07/310,726	1706	5,124,914	01-09-1989	Pierre GRANGEAT	METHOD AND DEVICE FOR OBTAINING TRIDIMENSIONAL OPTICAL IMAGE FORMATION FROM BIDIMENSIONAL MEASUREMENTS OF ATTENUATION OF RADIATION THROUGH AN OBJECT	27592-00934-US
08/185,472	3004	5,406,478	01-24-1994	Pierre GRANGEAT	METHOD FOR RECONSTRUCTING THREE-DIMENSIONAL IMAGES OF A CHANGING OBJECT	27592-00954-US
08/390,087	6630	5,574,333	02-17-1995	Jean-Fredric CLERC	METHOD FOR MANUFACTURING A CATHODE FOR FLUORESCENT DISPLAY SCREENS OF THE MICRO-TIP TYPE	27592-00964-US
10/955,037	4535	N/A	09-30-2004	Stephane BONNET	METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATIO N OF IMAGE SERIES	27592-00987-US
08/065,142	2958	5,408,511	05-21-1993	Pierre GRANGEAT	PROCESS FOR THE RECONSTRUCTION OF THREE-DIMENSIONAL IMAGES OF AN OBJECT BY MEASUREMENTS USING A CONICAL RADIATION AND A BIDIMENSIONAL DETECTOR ARRAY	27592-00958-US

Appln. No.	Confirmation No.	Patent No.	Filing Date	First Named Inventor	Title	Attorney Docket No.
08/338,570	3064	5,638,091	11-17-1994	Denis SARRASIN	PROCESS FOR THE DISPLAY OF DIFFERENT GREY LEVELS AND SYSTEM FOR PERFORMING THIS PROCESS	27592-00927-US
08/761,757	1149	5,862,397	12-05-1996	Hassane ESSAFI	ARRAY SYSTEM ARCHITECTURE OF MULTIPLE PARALLEL STRUCTURE PROCESSORS	27592-00971-US
08/975,459	9586	6,115,413	11-21-1997	Didier LATTARD	PROCESS FOR THE TRANSMISSION OF INFORMATION BY PULSE RESPONSE AND THE CORRESPONDING RECEIVER	27592-00978-US
09/438,367	9219	6,296,387	11-12-1999	Regis GUILLEMAUD	METHOD FOR CORRECTING IMAGE DEFECTS FROM A MATRIX-TYPE X OR Y-RAY DETECTOR	27592-00981-US
09/583,746	4147	6,748,007	05-31-2000	Didier LATTARD	METHOD OF PROCESSING A PULSE RESPONSE WITH AN ADAPTIVE THRESHOLD AND CORRESPONDING RECEIVER	27592-00984-US
10/312,489	9090	6,877,986	07-18-2003	Raymond FOURNIER	ELEMENT WITH EXPANSIBLE RELIEF	27592-00985-US
10/480,742	7379	6,888,915	12-11-2003	Anne KOENIG	METHOD FOR RECONSTRUCTION OF AN IMAGE OF A MOVING OBJECT	27592-00986-US

587521

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
10/955,037	09/30/2004	Stephane Bonnet	27592-00987- US

CONFIRMATION NO. 4535

POA ACCEPTANCE LETTER

30678
CONNOLLY BOVE LODGE & HUTZ LLP
1875 EYE STREET, N.W.
SUITE 1100
WASHINGTON, DC 20036

OC000000028148219

Date Mailed: 02/07/2008

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/31/2008.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/sibrahim/

Office of Initial Patent Examination (571) 272-4000 or 1-800-PTO-9199

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
10/955,037	09/30/2004	Stephane Bonnet	BRV.10002

CONFIRMATION NO. 4535

45473
HUTCHISON LAW GROUP PLLC
PO BOX 31686
RALEIGH, NC 27612

POWER OF ATTORNEY NOTICE

OC000000028148183

Date Mailed: 02/07/2008

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/31/2008.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/sibrahim/

Office of Initial Patent Examination (571) 272-4000 or 1-800-PTO-9199

PTO/SB/22 (10-07)
Approved for use through 10/31/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless if displays a valid OMB control number.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) FY 2006 (Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)	Docket Number (Optional) 27592-00987-US
Application Number 10/955,037	Filed September 30, 2004
For METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES	
Art Unit 2624	Examiner John W. Lee

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	
☐	One month (37 CFR 1.17(a)(1))	$120	$60	$
☐	Two months (37 CFR 1.17(a)(2))	$460	$230	$
☒	Three months (37 CFR 1.17(a)(3))	$1050	$525	$ 1050.00
☐	Four months (37 CFR 1.17(a)(4))	$1640	$820	$
☐	Five months (37 CFR 1.17(a)(5))	$2230	$1115	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 22-0185 . I have enclosed a duplicate copy of this sheet.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

☒ attorney or agent of record. Registration Number 44,457

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 _____

/Jeffrey W. Gluck/	March 7, 2008
Signature	Date
Jeffrey W. Gluck	(202) 331-7111
Typed or printed name	Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☐ Total of 1 forms are submitted.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
10/955,037	09/30/2004	

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY ☐ FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	03/07/2008	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 18	Minus	** 20	= 0	X $ =		OR	X $50=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $210=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/THERESA LINDSAY/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Docket No.: 27592-00987-US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Stephane BONNET et al.

Application No.: 10/955,037 | Confirmation No.: 4535

Filed: September 30, 2004 | Art Unit: 2624

For: METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES | Examiner: John W. Lee

RESPONSE TO FINAL OFFICE ACTION

MS RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Office Action dated September 13, 2007, Applicants submit the following response. While Applicants believe that no fees are due other than those that may be indicated on an accompanying paper, if further fees are due, or if an overpayment has been made, such fees are authorized to be charged to, or such overpayment credited to, Deposit Account No. 22-0185, from which the undersigned is authorized to draw, under Order No. 27592-00987-US.

Amendments

Applicants request entry of the amendments found on the following pages. In particular:

Amendments to the Claims may be found beginning at page 3 of this paper; and

Remarks may be found beginning at page 8 of this paper.

Electronic Patent Application Fee Transmittal

Application Number:	10955037
Filing Date:	30-Sep-2004
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Filer:	Jeffrey W. Gluck
Attorney Docket Number:	27592-00987- US

Filed as Large Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 3 months with $0 paid	1253	1	1050	1050

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	1801	1	810	810
		Total in USD ($)		**1860**

PTO/SB/30EFS (08/06)
Approved for use through 08/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	10955037	Filing Date	2004-09-30	Docket Number (if applicable)	27592-00987-US	Art Unit	2624
First Named Inventor	Stephane Bonnet			Examiner Name	John W. Lee		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 220185

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

Signature of Registered U.S. Patent Practitioner			
Signature	/Jeffrey W. Gluck/	Date (YYYY-MM-DD)	2008-03-07
Name	Jeffrey W. Gluck, Ph.D.	Registration Number	44457

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

REMARKS

Applicants thank the Examiner for his careful consideration of this application. Applicants respectfully request reconsideration of this application in view of the above amendments and the following remarks.

Claims 15-32 are now pending in this application, of which Claims 15 and 26 are the independent claims. Claims 1-8 were previously cancelled (without prejudice), and Claims 9-14 are now cancelled without prejudice. It is respectfully submitted that new Claims 15-32 are supported at least by the claims as originally filed, by Fig. 1, and by the specification, in general.

At page 3, the Office Action rejects Claim 1 under 35 U.S.C. § 112, second paragraph, as being indefinite. It is respectfully submitted that this rejection is moot, given the previous cancellation of Claim 1.

At pages 3-5, the Office Action rejects Claims 9 and 11-14 under 35 U.S.C. § 102(b) as being anticipated by DeMurcia et al. (U.S. Patent No. 5,889,525). At page 6, the Office Action rejects Claim 10 under 35 U.S.C. § 103(a) as being unpatentable over DeMurcia et al. in view of Townsend et al. (U.S. Patent Application Publication No. 2003/004405). Applicants respectfully submit that these rejections are moot in view of the cancellation of Claims 9-14.

Applicants note that new independent Claims 15 and 26 now recite the obtaining of pluralities of first images and associated first measurements and second images and associated second measurements and the combination of these images and measurements to obtain an image of a mobile object. The Office Action relies primarily on DeMurcia et al. to reject the previously-presented (and now-cancelled) claims. However, DeMurcia et al., noting, e.g., the abstract and Fig. 2, is directed to a process in which estimation of deformations of an object for which a three-dimensional image is to be formed are used to form a series of deformation

images, relative to a reference image, and the multiple images formed in this fashion are combined to form a three-dimensional image of the object. It is noted that this lacks numerous elements of the claimed invention, for example, obtaining two sets of images using two imaging techniques and obtaining sets of measurements respectively associated with each set of images. It is also noted that the secondary reference, Townsend et al., fails to disclose or suggest such features. For at least these reasons, it is respectfully submitted that new Claims 15-32 are allowable over the cited references.

Applicants may not have presented all possible arguments or have refuted the characterizations of either the claims or the prior art as may be found in the Office Action. However, the lack of such arguments or refutations is not intended to act as a waiver of such arguments or as concurrence with such characterizations.

Conclusion

Applicants believe that the above amendments and remarks address all of the grounds for rejection and place the application in condition for allowance. Applicants, therefore, respectfully request prompt and favorable consideration of this Response and reconsideration of this application.

If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, he is invited to telephone the undersigned at the number provided.

Dated: March 7, 2008

Respectfully submitted,

/Jeffrey W. Gluck/
Jeffrey W. Gluck
Registration No.: 44,457
CONNOLLY BOVE LODGE & HUTZ LLP
1875 Eye Street, NW
Suite 1100
Washington, DC 20006
(202) 331-7111
(202) 572-0322 (Direct Dial)
(202) 293-6229 (Fax)
Attorney for Applicant

CB-591180

Electronic Acknowledgement Receipt

EFS ID:	2965007
Application Number:	10955037
International Application Number:	
Confirmation Number:	4535
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Customer Number:	30678
Filer:	Jeffrey W. Gluck
Filer Authorized By:	
Attorney Docket Number:	27592-00987- US
Receipt Date:	07-MAR-2008
Filing Date:	30-SEP-2004
Time Stamp:	13:39:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1860
RAM confirmation Number	9502
Deposit Account	220185
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)

1	Extension of Time	EoT_3_7_08.pdf	43061 ad5bd1e30d08ace8a468075610cafa0b6a2cdb7b	no	1
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	RCE_3_7_08.pdf	641409 c670eb88671e3ebb68b9b0953810c01dd5027bf0	no	3
Warnings:					
Information:					
3		RCEAmdt_3_7_08.pdf	255952 26d2cb55821abb6dca5727fbddafee8f87e8e943	yes	10

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment Submitted/Entered with Filing of CPA/RCE	1	2
	Claims	3	7
	Applicant Arguments/Remarks Made in an Amendment	8	10

Warnings:					
Information:					
4	Fee Worksheet (PTO-06)	fee-info.pdf	8358 b31af9a0ab21c591257a8f7dc428280ffa82032d	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	948780	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Amendments to the Claims

The following listing of claims shall replace any and all previous listings of the claims in this application.

Listing of Claims:

1.-14. (Cancelled)

15. (New) A method of forming an image of a mobile object, comprising:

obtaining a plurality of first images of the mobile object using a first imaging technique and an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements.

16. (New) The method of Claim 15, further comprising:

time-synchronizing said first measurements and said second measurements.

17. (New) The method of Claim 15, further comprising:

forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

18. (New) The method of Claim 17, further comprising:

spatially-synchronizing said first reconstructed images and said second reconstructed images.

19. (New) The method of Claim 15, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

20. (New) The method of Claim 15, further comprising:

spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements.

21. (New) The method of Claim 15, further comprising:

forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

22. (New) The method of Claim 21, wherein said forming an image of the mobile object comprises combining said displacement fields.

23. (New) The method of Claim 21, wherein said forming displacement fields comprises:

estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

24. (New) The method of Claim 23, wherein at least one of said movement estimates is formed relative to a reference time.

25. (New) The method of Claim 15, wherein said plurality of first measurements and said plurality of second measurements are taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images.

26. (New) An apparatus to form an image of a mobile object, comprising:

means for obtaining a plurality of first images of the mobile object using a first imaging technique;

means for obtaining an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

means for obtaining a plurality of second images of the mobile object using a second imaging technique;

means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

means for forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements.

27. (New) The apparatus of Claim 26, further comprising:

means for forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

28. (New) The apparatus of Claim 26, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

29. (New) The apparatus of Claim 26, further comprising:

means for forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

30. (New) The apparatus of Claim 29, wherein said means for forming an image of the mobile object comprises means for combining said displacement fields.

31. (New) The apparatus of Claim 29, wherein said means for forming displacement fields comprises:

means for estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

32. (New) The apparatus of Claim 31, wherein at least one of said movement estimates is to be formed relative to a reference time.

Volkswagen Exhibit 1002, Page 305 of 885

Notice of References Cited	Application/Control No. 10/955,037	Applicant(s)/Patent Under Reexamination BONNET ET AL.	
	Examiner JOHN Wahnkyo LEE	Art Unit 2624	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,889,525 A	03-1999	De Murcia et al.	345/420
*	B	US-2003/0004405 A1	01-2003	Townsend et al.	600/407
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/27/2006	09/07/2007	05/25/2008						
	1	✓	-	-						
	2	✓	-	-						
	3	✓	-	-						
	4	✓	-	-						
	5	✓	-	-						
	6	✓	-	-						
	7	✓	-	-						
	8	✓	-	-						
9			✓	-						
10			✓	-						
11			✓	-						
12			✓	-						
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14			✓	-						
15				✓						
16				✓						
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24				✓						
25				✓						
26				✓						
27				✓						
28				✓						
29				✓						
30				✓						
31				✓						
32				✓						

Amendments to the Claims

The following listing of claims shall replace any and all previous listings of the claims in this application.

Listing of Claims:

1.-14. (Cancelled)

15. (New) A method of forming an image of a mobile object, comprising:

obtaining a plurality of first images of the mobile object using a first imaging technique and an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements.

16. (New) The method of Claim 15, further comprising:

time-synchronizing said first measurements and said second measurements.

17. (New) The method of Claim 15, further comprising:

forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

18. (New) The method of Claim 17, further comprising:

spatially-synchronizing said first reconstructed images and said second reconstructed images.

19. (New) The method of Claim 15, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

20. (New) The method of Claim 15, further comprising:

spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements.

21. (New) The method of Claim 15, further comprising:

forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

22. (New) The method of Claim 21, wherein said forming an image of the mobile object comprises combining said displacement fields.

23. (New) The method of Claim 21, wherein said forming displacement fields comprises:

estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

24. (New) The method of Claim 23, wherein at least one of said movement estimates is formed relative to a reference time.

25. (New) The method of Claim 15, wherein said plurality of first measurements and said plurality of second measurements are taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images.

26. (New) An apparatus to form an image of a mobile object, comprising:

means for obtaining a plurality of first images of the mobile object using a first imaging technique;

means for obtaining an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

means for obtaining a plurality of second images of the mobile object using a second imaging technique;

means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

means for forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements.

27. (New) The apparatus of Claim 26, further comprising:

means for forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

28. (New) The apparatus of Claim 26, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

29. (New) The apparatus of Claim 26, further comprising:

means for forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

30. (New) The apparatus of Claim 29, wherein said means for forming an image of the mobile object comprises means for combining said displacement fields.

31. (New) The apparatus of Claim 29, wherein said means for forming displacement fields comprises:

means for estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

32. (New) The apparatus of Claim 31, wherein at least one of said movement estimates is to be formed relative to a reference time.

Volkswagen Exhibit 1002, Page 312 of 885

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	27592-00987- US	4535

30678 7590 05/29/2008
CONNOLLY BOVE LODGE & HUTZ LLP
1875 EYE STREET, N.W.
SUITE 1100
WASHINGTON, DC 20036

EXAMINER	
LEE, JOHN W	

ART UNIT	PAPER NUMBER
2624	

MAIL DATE	DELIVERY MODE
05/29/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	JOHN Wahnkyo LEE	2624	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *22 March 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-32* is/are pending in the application.

4a) Of the above claim(s) *1-14* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *15-32* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 7 March 2008 has been entered.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claims 15, 17, 21, 23, 25-27, 29, or 31recite the limitations, “first images”, “first imaging technique", "second images" and "second imaging technique". There is insufficient antecedent basis for these limitations in the claims.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 1-18, 20-24, 26-27 and 29-32 are rejected under 35 U.S.C. 102(b) as being anticipated by De Murcia et al. (US 5,889,525).

Regarding claim 15, De Murcia discloses a method of forming an image (col. 1, line 6-7, “reconstruction o three-dimensional images”) of a mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”), comprising: obtaining a plurality of first images (equation (2); col. 4; lines 1-8, “m_k”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) using a first imaging technique (col. 2, lines 56-64, “two dimensional array of projections”) and an associated plurality of first measurements (col. 2, lines 59-60; col. 4, lines 9-10) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) at movement states corresponding to movement states (col. 4, lines 7-8, “states k”) of said plurality of first images (equation (2); col. 4; lines 1-8, “m_k”); obtaining a plurality of second images (equation (2); col. 4; line 67, “m_{k+1}”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) using a second imaging technique (col. 2, lines 56-64, “two dimensional array of projections”) and an associated plurality of second measurements (col. 2, lines 59-60; col. 4, lines 9-10) of the mobile object at movement states corresponding to movement states (col. 4, line 67, “state k+1”) of said plurality of second images (equation (2); col. 4; line 67, “$m_{k=1}$”); and forming an image (fig. 2, “object reconstructed” and "$\hat{f}_o$") of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated

plurality of second measurements (equations (2)-7; col. 4, lines 1-67; col. 5, lines 1-25).

Regarding claim 16, De Murcia discloses time-synchronizing said first measurements and said second measurements (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 17, De Murcia discloses forming first reconstructed images corresponding to said plurality of first images (col. 4, lines 58-67; col. 5, lines 1-12, "$\hat{f}_o^k$") and second reconstructed images corresponding to said plurality of second images (col. 5, lines 1-25, "f_o^{k+1}").

Regarding claim 18, De Murcia discloses spatially-synchronizing said first reconstructed images and said second reconstructed images (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 20, De Murcia discloses spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 21, De Murcia discloses forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements (col. 2, lines 45-55, "… displacements …").

Regarding claim 22, De Murcia discloses wherein said forming an image of the mobile object comprising combining said displacement fields (equations (8); col. 5, lines 45-67, “v(M)”).

Regarding claim 23, De Murcia discloses wherein said forming displacement fields comprises: estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields (equations (8); col. 5, lines 45-67, “v(M)”; equation (14); col. 7, lines 63-67; col. 8, lines 1-29, “… displacements …”).

Regarding claim 24, De Murcia discloses wherein at least one of said movement estimates is formed relative to a reference time (col. 3, lines 38-44, “phases of its cycle …”).

Regarding claim 26, claim 26 is analogous and corresponds to claim 15. See rejection of claim 15 for further explanation.

Regarding claim 27, claim 27 is analogous and corresponds to claim 17. See rejection of claim 17 for further explanation.

Regarding claim 29, claim 29 is analogous and corresponds to claim 21. See rejection of claim 21 for further explanation.

Regarding claim 30, claim 30 is analogous and corresponds to claim 22. See rejection of claim 22 for further explanation.

Regarding claim 31, claim 31 is analogous and corresponds to claim 23. See rejection of claim 23 for further explanation.

Regarding claim 32, claim 32 is analogous and corresponds to claim 24. See rejection of claim 24 for further explanation.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 19, 25, and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over De Murcia et al. (US 5,889,525) in view of Townsend et al. (US 2003/0004405).

Regarding claim 19, De Murcia discloses all the previous claim limitations except the first imaging technique being a radiation attenuation technique and second imaging technique being a radiation emission technique specified in claim 19. However, Townsend can overcome De Murcia's deficiency by disclosing that the first imaging technique being a radiation attenuation technique (abstract; claim 1, "CT is an example of a system using an anatomic radiation attenuation imagery technique") and second imaging technique being a radiation emission technique (abstract; claim 1, "PET is an example of a system using functional radiation emission imagery technique").

It would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize Townsend's invention in De Murcia's invention to

obtain satisfactory imaging results as suggested by De Murcia (col. 2, lines 44-55).

Regarding claim 25, Townsend further discloses wherein said plurality of first measurements and said plurality of second measurements being taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images (abstract; claim 1, "CT is an example of a system using an anatomic radiation attenuation imagery technique" and "PET is an example of a system using functional radiation emission imagery technique").

Regarding claim 28, claim 28 is analogous and corresponds to claim 19. See rejection of claim 19 for further explanation.

Conclusion

8. No claims are allowed.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to JOHN Wahnkyo LEE whose telephone number is (571)272-9554. The examiner can normally be reached on Monday - Friday (Alt.) 7:30 a.m. - 5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, MATTHEW C. BELLA can be reached on (571) 272-7778. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR)

system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Matthew C Bella/
Supervisory Patent Examiner, Art Unit 2624

/John Wahnkyo Lee/
Examiner, Art Unit 2624

Docket No.: 27592-00987-US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Stephane Bonnet

Application No.: 10/955,037 | Confirmation No.: 4535

Filed: September 30, 2004 | Art Unit: 2624

For: METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES | Examiner: John W. Lee

RESPONSE UNDER 37 C.F.R. 1.112 (NON-FINAL OFFICE ACTION)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Office Action mailed May 29, 2008, the following remarks are respectfully submitted.

Remarks begin on page 2 of this Amendment.

	Claims remaining after Amendment		**Highest number previously paid for**		**Present extra**
Total	18		20		0
Independent	2		3		0

615942

Electronic Acknowledgement Receipt

EFS ID:	3699882
Application Number:	10955037
International Application Number:	
Confirmation Number:	4535
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Customer Number:	30678
Filer:	Burton A. Amernick
Filer Authorized By:	
Attorney Docket Number:	27592-00987- US
Receipt Date:	30-JUL-2008
Filing Date:	30-SEP-2004
Time Stamp:	12:35:48
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1		Response_07_30_08.pdf	96410 475cee9dcc235076c5c3a3d955d6715d7acd6e57	yes	6

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment - After Non-Final Rejection	1	1
	Applicant Arguments/Remarks Made in an Amendment	2	6
Warnings:			
Information:			
	Total Files Size (in bytes):	96410	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

REMARKS

Claims 15-32 are pending in this application. Claims 15 and 26 are independent claims. Reconsideration and allowance of the present application are respectfully requested.

Rejections under 35 U.S.C. §112

Claims 15, 17, 21, 23, 25-27, 29 and 31 stand rejected under 35 USC § 112, first paragraph, for failing to provide sufficient antecedent basis for the limitations in the claims. This rejection is respectfully traversed.

Line 2 of claim 15 and line 2 of claim 26, in part, recite "a plurality of first images" and "a first imaging technique." Line 5 of claim 5 and line 5 of claim 26, in part, recites "a second imaging technique" and "a plurality of second images." Applicant submits that there is clear antecedent basis for "first images," "first imaging technique," "second images," and "second imaging techniques" in each of claims 15-32. Therefore, Applicants respectfully request that the rejections of claims 15, 17, 21, 23, 25-27, 29 and 31 under 35 U.S.C. §112 be withdrawn.

Rejections under 35 U.S.C. §102

Claims 1-18, 20-24, 26-27 and 29-32 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 5,889,525 to De Murcia et al. (hereinafter "De Murcia"). This rejection is respectfully traversed.

Claim 15, upon which claims 16-25 depend, recites "a method of forming an image of a mobile object, comprising: obtaining a plurality of first images of the mobile object using a first imaging technique and an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images; obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements."

Claim 26, upon which claims 27-32 depend, recites "an apparatus to form an image of a mobile object, comprising: means for obtaining a plurality of first images of the mobile object using a first imaging technique; means for obtaining an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images; means for obtaining a plurality of second images of the mobile object using a second imaging technique; means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and means for forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements."

As outlined below, De Murcia does not teach or suggest each of the elements recited in claims 15-32.

De Murcia discloses a process including taking a series of sets of measurements of a characteristic property of an object by a two-dimensional array of mobile sensors around the object. The sets of measurements include a two-dimensional array of projections of the property on the sensors. The sets of measurements are taken at a group of different states of the object with respect to the variations in the position or shape of the object. The process includes reconstructing an approximate image of the object at each of the states, combining their respective sets of measurements, evaluating the variations of the object between an image of the object at a reference state and the approximate images, and modifying the image of the object at the reference state by a combination with the sets of measurements and the variations of the object associated with the sets of measurements. See at least Col. 2, line 56-Col. 3, line 4 of De Murcia.

Applicant submits that De Murcia does not teach or suggest each of the elements recited in claims 15-18, 20-24, 26-27 and 29-32. Each of independent claims 15 and 27, in part, recites "obtaining a plurality of second images of the mobile object using a second imaging technique; obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and forming an image of the mobile object based on said plurality of first images and associated plurality of first

measurements and on said plurality of said second images and associated plurality of second measurements." De Murcia does not teach or suggest these features.

De Murcia merely discloses taking a series of sets of measurements of a characteristic property of an object by a two-dimensional array of mobile sensors around the object. As noted in the Office Action, the two-dimensional array of projections is equivalent to the "first imaging technique" recited in the pending claims. There is no teaching or suggestion in De Murcia of a "second imaging technique," that is, an imaging technique which is different from the first technique. Thus, there is no teaching or suggestion in De Murcia of "obtaining a plurality of second images of the mobile object using a second imaging technique" and "obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images," as recited in the pending claims. There is also no teaching or suggestion in De Murcia of "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements," as recited in the pending claims. Therefore, Applicants respectfully submit the De Murcia does not teach or suggest each of the elements of claims 15 and 27. Each of claims 16-26 and 28-32 are allowable at least because of their dependence on claims 15 and 27, respectively, in addition to the further limitations recited in each of claims 16-26 and 28-31. In light of the distinctions noted above, Applicants respectfully request that this rejection of claims 1-18, 20-24, 26-27 and 29-32 under 35 U.S.C. §102 be withdrawn.

Rejections Under 35 U.S.C. § 103

Claims 19, 25 and 28 stand rejected under 35 U.S.C. §103(a) as being unpatentable over De Murcia et al. in view of U.S. Patent Publication No. 2003/0004405 to Townsend et al. (hereinafter "Townsend"). This rejection is respectfully traversed.

Townsend does not cure the deficiencies of De Murcia, as noted above. Specifically, Townsend does not teach or suggest "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements," as recited in claims 15 and 27, upon which claims 19, 25 and 28 depend.

Townsend merely discloses a combined PET and X-Ray CT tomography for acquiring CT and PET images sequentially in a single device. There is no teaching or suggestion in Townsend of "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements," as recited in claims 15 and 27, upon which claims 19, 25 and 28 depend. Therefore, Applicants respectfully request that this rejection of claims 19, 25 and 28 under 35 U.S.C. §103 be withdrawn.

Disclaimer

Applicants may not have presented all possible arguments or have refuted the characterizations of either the claims or the prior art as found in the Office Action. However, the lack of such arguments or refutations is not intended to act as a waiver of such arguments or as concurrence with such characterizations.

CONCLUSION

In view of the above, consideration and allowance are respectfully solicited.

In the event the Examiner believes an interview might serve in any way to advance the prosecution of this application, the undersigned is available at the telephone number noted below.

The Office is authorized to charge any necessary fees to Deposit Account No. 22-0185.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 22-0185, under Order No. 27592-00987-US from which the undersigned is authorized to draw.

Dated: July 30, 2008

Respectfully submitted,

Electronic signature: /Arlene P. Neal/
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APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
10/955,037		2624	26M1

OC000000032096402

Correspondence Address/Fee Address Change

The following fields have been set to Customer Number 30678 on 09/15/2008

- **Correspondence Address**
- **Power of Attorney Address**

The address of record for Customer Number 30678 is:

30678
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WASHINGTON, DC 20006

Notice of References Cited	Application/Control No. 10/955,037	Applicant(s)/Patent Under Reexamination BONNET ET AL.	
	Examiner JOHN Wahnkyo LEE	Art Unit 2624	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-4,694,156 A	09-1987	Swanberg, Melvin E.	250/214RC
*	B	US-5,889,525 A	03-1999	De Murcia et al.	345/420
*	C	US-2003/0004405 A1	01-2003	Townsend et al.	600/407
*	D	US-6,885,702 B1	04-2005	Goudezeune et al.	375/240.12
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

SEARCHED			
Class	Subclass	Date	Examiner
382	128	12/26/2006	John W. Lee
345	420	12/26/2006	John W. Lee
382	128	11/06/2008	John W. Lee

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor Search	12/26/2006	John W. Lee
East Search	12/26/2006	John W. Lee
IEEE (Non- Patent Literature Search)	12/26/2006	John W. Lee
EAST Search	11/06/2008	John W. Lee

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

/JOHN W LEE/ Examiner.Art Unit 2624	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/27/2006	09/07/2007	05/25/2008	11/07/2008					
	1	✓	-	-	-					
	2	✓	-	-	-					
	3	✓	-	-	-					
	4	✓	-	-	-					
	5	✓	-	-	-					
	6	✓	-	-	-					
	7	✓	-	-	-					
	8	✓	-	-	-					
9			✓	-	-					
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29				✓	✓					
30				✓	✓					
31				✓	✓					
32				✓	✓					

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1	10/955037	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:20
L2	3258	382/128.ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
L3	3206	2 AND IMAG$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
L4	593	3 and CYCLE	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30

L5	358	4 AND state	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
L6	8	\2003/0004405	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
L7	2	"20030004405"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:31
L8	5	"5889525"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:31

11/6/2008 3:32:50 PM
C:\Documents and Settings\jlee15\My Documents\EAST\Workspaces\10955037RCEF.wsp

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	1	10/955037	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:20
S2	3258	382/128.ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S3	3206	S2 AND IMAG$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S4	593	S3 and CYCLE	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30

S5	358	S4 AND state	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S6	8	\2003/0004405	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S7	2	"20030004405"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:31
S8	5	"5889525"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:31

11/7/2008 6:13:09 PM
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Amendments to the Claims

The following listing of claims shall replace any and all previous listings of the claims in this application.

Listing of Claims:

1.-14. (Cancelled)

15. (New) A method of forming an image of a mobile object, comprising:

obtaining a plurality of first images of the mobile object using a first imaging technique and an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements.

16. (New) The method of Claim 15, further comprising:

time-synchronizing said first measurements and said second measurements.

17. (New) The method of Claim 15, further comprising:

forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

18. (New) The method of Claim 17, further comprising:

spatially-synchronizing said first reconstructed images and said second reconstructed images.

19. (New) The method of Claim 15, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

20. (New) The method of Claim 15, further comprising:

spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements.

21. (New) The method of Claim 15, further comprising:

forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

22. (New) The method of Claim 21, wherein said forming an image of the mobile object comprises combining said displacement fields.

23. (New) The method of Claim 21, wherein said forming displacement fields comprises:

estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

24. (New) The method of Claim 23, wherein at least one of said movement estimates is formed relative to a reference time.

25. (New) The method of Claim 15, wherein said plurality of first measurements and said plurality of second measurements are taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images.

26. (New) An apparatus to form an image of a mobile object, comprising:

means for obtaining a plurality of first images of the mobile object using a first imaging technique;

means for obtaining an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

means for obtaining a plurality of second images of the mobile object using a second imaging technique;

means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

means for forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements.

27. (New) The apparatus of Claim 26, further comprising:

means for forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

28. (New) The apparatus of Claim 26, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

29. (New) The apparatus of Claim 26, further comprising:

means for forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

30. (New) The apparatus of Claim 29, wherein said means for forming an image of the mobile object comprises means for combining said displacement fields.

31. (New) The apparatus of Claim 29, wherein said means for forming displacement fields comprises:

means for estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

32. (New) The apparatus of Claim 31, wherein at least one of said movement estimates is to be formed relative to a reference time.

Volkswagen Exhibit 1002, Page 342 of 885

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	27592-00987- US	4535

30678 7590 11/14/2008
CONNOLLY BOVE LODGE & HUTZ LLP
1875 EYE STREET, N.W.
SUITE 1100
WASHINGTON, DC 20006

EXAMINER	
LEE, JOHN W	
ART UNIT	PAPER NUMBER
2624	

MAIL DATE	DELIVERY MODE
11/14/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	JOHN Wahnkyo LEE	2624	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *30 August 2008*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-32* is/are pending in the application.

4a) Of the above claim(s) *1-14* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *15-32* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. The response received on 30 August 2008 has been placed in the file and was considered by the examiner. An action on the merits follows.

Response to Amendment

2. The applicant's amendments filed on 30 July 2008 have been fully considered.

Rejection under 35 U.S.C. § 112

Applicant's arguments to the rejection under 35 U.S.C. § 112 with respect to claims 15-32 have been fully considered. However, examiner can admit that claims 19, 25 and 28 have overcome this issue, but not the rest of the claims. It is still unclear and vague what the "first image", "first measurements", "first imaging technique", "second image" , "second measurements" and "second imaging technique" is trying to indicate. Moreover, it is also unclear whether the "first measurement" and "first imaging technique" are different with the "second measurement" and "second imaging technique", respectively. If the applicant does not specify this, then the examiner will interpretate the "first measurement" and "first imaging technique" are same with the "second measurement" and "second imaging technique", respectively. So, the rejection under 35 U.S.C. § 112 with respect to claims 15-18, 20-24, 26-27 and 29-32 will not be withdrawn and claims 19, 25 and 28 will be withdrawn.

Response to Arguments

3. Applicant's arguments filed on 30 July 2008 have been fully considered, but are not persuasive. After the response to the applicant's arguments, the rejection will be provided.

Rejection under 35 U.S. C. § 102

Applicant argues that De Murcia does not disclose all the claim limitations of claims 15 and 26. However, the examiner respectively traverses it. De Murcia might not implement the exact invention comparing to the application, but it is good enough to read on the claims. As discussed before, the applicant does not distinguish or specify whether the “first measurement” and “first imaging technique" are different with the “second measurement" and “second imaging technique", respectively, in the independent claims. In the specification, the applicant might have disclosed that the “first measurement” and “first imaging technique" are different with the “second measurement" and “second imaging technique", respectively, but what it matters the limitations recited in the claims. The examiner only reviews the claims with the broadest claim interpretation without reading the specifications on the claims. So, the rejection under 35 U.S.C. § 102 with respect to claims 1-18, 20-24, 26-27 and 29-32 cannot be withdrawn.

Rejection under 35 U.S. C. § 103

The combination of the two references, De Murcia and Townsend do disclose or teach all the claim limitations of claims 19, 25 and 28. So, the rejection under 35 U.S.C. § 103 with respect to claims 19, 25 and 28 cannot be withdrawn.

Claim Rejections - 35 USC § 101

4. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Claims 15-25 are rejected under 35 U.S.C. 101 as not falling within one of the four statutory categories of invention. While the claims recite a series of steps or acts to be performed, a statutory "process" under 35 U.S.C. 101 must (1) be tied to another statutory category (such as a particular apparatus), or (2) transform underlying subject matter (such as an article or material) to a different state or thing (Reference the May 15, 2008 memorandum issued by Deputy Commissioner for Patent Examining Policy, John J. Love, titled "Clarification of 'Processes' under 35 U.S.C. 101" – publicly available at USPTO.GOV, "memorandum to examining corp"). The instant claims neither transform underlying subject matter nor positively tie to another statutory category that accomplishes the claimed method steps, and therefore do not qualify as a statutory process. In order for a process to be "tied" to another statutory category, the structure of another statutory category should be positively recited in a step or steps significant to the basic inventive concept, and NOT just in association with statements of intended use or purpose, insignificant pre or post solution activity, or implicitly.

Claim Rejections - 35 USC § 112

5. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claims 15-18, 20-24, 26-27 and 29-32 recite the limitations, “first images”, “first imaging technique", “first measurement”, "second images", "second measurement” and "second imaging technique". There are insufficient antecedent basis for these limitations in the claims.

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8. Claims 1-18, 20-24, 26-27 and 29-32 are rejected under 35 U.S.C. 102(b) as being anticipated by De Murcia et al. (US 5,889,525).

Regarding claim 15, De Murcia discloses a method of forming an image (col. 1, line 6-7, “reconstruction o three-dimensional images”) of a mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”), comprising: obtaining a plurality of first images (equation (2); col. 4; lines 1-8, “m_k”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) using a first imaging technique (col. 2, lines 56-64, “two dimensional array of projections”) and an associated plurality of first measurements (col. 2, lines 59-60; col. 4, lines 9-10, “the sets of measurements”) of the mobile object (fig. 1; col. 1, line 6-7,

"mobile object"; col. 2, lines 10-11, "mobile organs such as heart") at movement states corresponding to movement states (col. 4, lines 7-8, "states k") of said plurality of first images (equation (2); col. 4; lines 1-8, "m_k"); obtaining a plurality of second images (equation (2); col. 4; line 67, "m_{k+1}") of the mobile object (fig. 1; col. 1, line 6-7, "mobile object"; col. 2, lines 10-11, "mobile organs such as heart") using a second imaging technique (col. 2, lines 56-64, "two dimensional array of projections") and an associated plurality of second measurements (col. 2, lines 59-60; col. 4, lines 9-10) of the mobile object at movement states corresponding to movement states (col. 4, line 67, "state k+1") of said plurality of second images (equation (2); col. 4; line 67, "$m_{k=1}$"); and forming an image (fig. 2, "object reconstructed" and "$\hat{f}_o$") of the mobile object based on said plurality of first images (equation (2); col. 4; lines 1-8, "m_k") and associated plurality of first measurements (col. 2, lines 59-60; col. 4, lines 9-10, "the sets of measurements") and on said plurality of said second images (equation (2); col. 4; line 67, "$m_{k=1}$") and associated plurality of second measurements (equations (2)-7; col. 4, lines 1-67; col. 5, lines 1-25, "the sets of measurements").

Regarding claim 16, De Murcia discloses time-synchronizing said first measurements and said second measurements (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 17, De Murcia discloses forming first reconstructed images corresponding to said plurality of first images (col. 4, lines 58-67; col. 5, lines 1-12,

"$\hat{f}_o^k$") and second reconstructed images corresponding to said plurality of second images (col. 5, lines 1-25, "f_o^{k+1}").

Regarding claim 18, De Murcia discloses spatially-synchronizing said first reconstructed images and said second reconstructed images (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 20, De Murcia discloses spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 21, De Murcia discloses forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements (col. 2, lines 45-55, "… displacements …").

Regarding claim 22, De Murcia discloses wherein said forming an image of the mobile object comprising combining said displacement fields (equations (8); col. 5, lines 45-67, "v(M)").

Regarding claim 23, De Murcia discloses wherein said forming displacement fields comprises: estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields (equations (8); col. 5, lines 45-67, "v(M)"; equation (14); col. 7, lines 63-67; col. 8, lines 1-29, "… displacements …").

Regarding claim 24, De Murcia discloses wherein at least one of said movement estimates is formed relative to a reference time (col. 3, lines 38-44, "phases of its cycle …").

Regarding claim 26, claim 26 is analogous and corresponds to claim 15. See rejection of claim 15 for further explanation.

Regarding claim 27, claim 27 is analogous and corresponds to claim 17. See rejection of claim 17 for further explanation.

Regarding claim 29, claim 29 is analogous and corresponds to claim 21. See rejection of claim 21 for further explanation.

Regarding claim 30, claim 30 is analogous and corresponds to claim 22. See rejection of claim 22 for further explanation.

Regarding claim 31, claim 31 is analogous and corresponds to claim 23. See rejection of claim 23 for further explanation.

Regarding claim 32, claim 32 is analogous and corresponds to claim 24. See rejection of claim 24 for further explanation.

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

10. Claims 19, 25, and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over De Murcia et al. (US 5,889,525) in view of Townsend et al. (US 2003/0004405).

Regarding claim 19, De Murcia discloses all the previous claim limitations except the first imaging technique being a radiation attenuation technique and second imaging technique being a radiation emission technique specified in claim 19. However, Townsend can overcome De Murcia's deficiency by disclosing that the first imaging technique being a radiation attenuation technique (abstract; claim 1, "CT is an example of a system using an anatomic radiation attenuation imagery technique") and second imaging technique being a radiation emission technique (abstract; claim 1, "PET is an example of a system using functional radiation emission imagery technique").

It would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize Townsend's invention in De Murcia's invention to obtain satisfactory imaging results as suggested by De Murcia (col. 2, lines 44-55).

Regarding claim 25, Townsend further discloses wherein said plurality of first measurements and said plurality of second measurements being taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images (abstract; claim 1, "CT is an example of a system using an anatomic radiation attenuation imagery technique" and "PET is an example of a system using functional radiation emission imagery technique").

Regarding claim 28, claim 28 is analogous and corresponds to claim 19. See rejection of claim 19 for further explanation.

Conclusion

11. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to JOHN Wahnkyo LEE whose telephone number is (571)272-9554. The examiner can normally be reached on Monday - Friday (Alt.) 7:30 a.m. - 5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jingge Wu can be reached on (571) 272-7429. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Jingge Wu/
Supervisory Patent Examiner, Art Unit 2624

/John Wahnkyo Lee/

Examiner, Art Unit 2624

PTO/SB/30 (01)
Approved for use through 02/28/2009. OMB 0651-0031
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Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	10/955,037-Conf. #4535
Filing Date	September 30, 2004
First Named Inventor	Stephane Bonnet
Art Unit	2624
Examiner Name	J. W. Lee
Attorney Docket Number	27592-00987-US

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.

Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. [ ] Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.
      i. [ ] Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
      ii. [ ] Other _____

   b. [x] Enclosed
      i. [x] Amendment/Reply
      ii. [ ] Affidavit(s)/Declaration(s)
      iii. [ ] Information Disclosure Statement (IDS)
      iv. [ ] Other _____

2. Miscellaneous

   a. [ ] Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. [ ] Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. [ ] The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any Overpayments, to Deposit Account No. 22-0185 .
      i. [x] RCE fee required under 37 CFR 1.17(e)
      ii. [ ] Extension of time fee (37 CFR 1.136 and 1.17)
      iii. [ ] Other _____

   b. [ ] Check in the amount of $ _____ enclosed

   c. [x] Payment by credit card (Form PTO-2038 enclosed)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Arlene Neal/	Date	February 13, 2009
Name (Print/Type)	Arlene Neal	Registration No.	43,828

Docket No.: 27592-00987-US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Stephane Bonnet

Application No.: 10/955,037 | Confirmation No.: 4535

Filed: September 30, 2004 | Art Unit: 2624

For: METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES | Examiner: John W. Lee

RESPONSE UNDER 37 C.F.R. 1.116 (FINAL OFFICE ACTION)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Madam:

INTRODUCTORY COMMENTS

In response to the Office Action mailed November 14, 2008, the following amendments and remarks are respectfully submitted.

Amendments to the claims begin on page 2 of this Amendment.
Remarks begin on page 7 of this Amendment.

	Claims remaining after Amendment		Highest number previously paid for		Present extra
Total	18		20		0
Independent	2		3		0

648536

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 10/955,037	Filing Date 09/30/2004	☐ To be Mailed

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)		OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	02/13/2009									
	Total (37 CFR 1.16(i))	* 18	Minus	** 20	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/DEBRA a. SAVOY/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Patent Application Fee Transmittal	
Application Number:	10955037
Filing Date:	30-Sep-2004
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Filer:	Burton A. Amernick/Mary Ann Taylor
Attorney Docket Number:	27592-00987- US
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	1801	1	810	810
		Total in USD ($)		**810**

Electronic Acknowledgement Receipt	
EFS ID:	4788631
Application Number:	10955037
International Application Number:	
Confirmation Number:	4535
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Customer Number:	30678
Filer:	Burton A. Amernick/Mary Ann Taylor
Filer Authorized By:	Burton A. Amernick
Attorney Docket Number:	27592-00987- US
Receipt Date:	13-FEB-2009
Filing Date:	30-SEP-2004
Time Stamp:	10:58:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$810
RAM confirmation Number	5997
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Request for Continued Examination (RCE)	RCE_02_13_09.pdf	65492 4312648738fb82dc68000a696e4f49f89677d47b	no	1
Warnings:					
This is not a USPTO supplied RCE SB30 form.					
Information:					
2		Response_02_13_09.pdf	139854 1dd1318a0eedc77b7591a5f6c0a4c69dd8564197	yes	14
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Amendment After Final		1	1	
	Claims		2	6	
	Applicant Arguments/Remarks Made in an Amendment		7	14	
Warnings:					
Information:					
3	Fee Worksheet (PTO-06)	fee-info.pdf	30153 729692a10227a239fb7b4b1dfda90ef9b4443240	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	235499		

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<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Amendments to the Claims

The following listing of claims shall replace any and all previous listings of the claims in this application.

Listing of Claims:

1.-14. (Cancelled)

15. (Currently Amended) A method of forming an image of a mobile object, comprising:

obtaining a plurality of first images of the mobile object using a first imaging technique and an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements,

wherein the first imaging technique is different from the second imaging technique.

16. (Previously Presented) The method of Claim 15, further comprising:

time-synchronizing said first measurements and said second measurements.

17. (Previously Presented) The method of Claim 15, further comprising:

forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

18. (Previously Presented) The method of Claim 17, further comprising:

spatially-synchronizing said first reconstructed images and said second reconstructed images.

19. (Previously Presented) The method of Claim 15, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

20. (Previously Presented) The method of Claim 15, further comprising:

spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements.

21. (Previously Presented) The method of Claim 15, further comprising:

forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

22. (Previously Presented) The method of Claim 21, wherein said forming an image of the mobile object comprises combining said displacement fields.

23. (Previously Presented) The method of Claim 21, wherein said forming displacement fields comprises:

estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

24. (Previously Presented) The method of Claim 23, wherein at least one of said movement estimates is formed relative to a reference time.

25. (Previously Presented) The method of Claim 15, wherein said plurality of first measurements and said plurality of second measurements are taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images.

26. (Currently Amended) An apparatus to form an image of a mobile object, comprising:

means for obtaining a plurality of first images of the mobile object using a first imaging technique;

means for obtaining an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

means for obtaining a plurality of second images of the mobile object using a second imaging technique;

means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

means for forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements,

wherein the first imaging technique is different from the second imaging technique.

27. (Previously Presented) The apparatus of Claim 26, further comprising:

means for forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

28. (Previously Presented) The apparatus of Claim 26, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

29. (Previously Presented) The apparatus of Claim 26, further comprising:

means for forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

30. (Previously Presented) The apparatus of Claim 29, wherein said means for forming an image of the mobile object comprises means for combining said displacement fields.

31. (Previously Presented) The apparatus of Claim 29, wherein said means for forming displacement fields comprises:

means for estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

32. (Previously Presented) The apparatus of Claim 31, wherein at least one of said movement estimates is to be formed relative to a reference time.

REMARKS

Claims 15-32 are pending in this application. Claims 15 and 26 are independent claims. Claims 15 and 26 are amended. Reconsideration and allowance of the present application are respectfully requested.

Claim Rejections under 35 U.S.C. §101

Claims 15-25 stand rejected under 35 U.S.C. §101 as allegedly being directed to non-statutory subject matter. This rejection is respectfully traversed.

According to the Office Action, "while the claims recite a series of steps to be performed, a statutory "process" under 35 U.S.C. 101 must be (1) tied to another statutory process (such as a particular apparatus), or (2) transform underlying subject matter (such as an article or material) to a different state or thing (Reference the May 15 2008 memorandum issued by Deputy Commissioner for Patent Examining Policy, John J. Love, titled "Clarification of 'Processes' under 35 U.S.C. 101")." Applicant notes that the memorandum discussed in the Office Action was issued in anticipation of a ruling by the Court of Appeals for the Federal Circuit. See *In re Bilski,* 545 F.3d *943,* 88 USPQ2d 1385 (Fed. Cir. 2008). The Federal Circuit's opinion, issued after the memorandum was written, clarifies the standards applicable in determining whether a claimed method constitutes a statutory "process" under 35 U.S.C 101.

The Federal Circuit noted that the Supreme Court held that "a claimed process is surely patent-eligible under §101 if: (1) it is tied to a particular machine or apparatus, or (2) it transforms a particular article into a different state or thing." *In re Bilski,* 545 F.3d at 953, 88 USPQ2d at 1395. Also see *Gottschalk v. Benson*, 409 U.S. 63, 72 (1972) and *Diamond v. Diehr*, 450 U.S. 175, 182 (1981). The Federal Circuit then held that the true test in determining whether a process transforms underlying subject matter to a different state is whether the "applicant is seeking to claim a fundamental principle (such as an abstract idea) or a mental process." *In re Bilski,* 545 F.3d at 949, 88 USPQ2d at 1392. The Federal Circuit, therefore, used the machine-or-transformation test, noted in the Office Action, to determine if the Applicant is seeking to claim a fundamental principle or a mental process. The Federal Circuit primarily considered the transformation part of this test.

According to the Federal Circuit, "a claimed process is patent-eligible if it transforms an article into a different state or thing." *Id.* 567 F.3d at 949, 88 USPQ2d at 1429. In defining an article, the Federal Circuit noted that "the raw materials of many information-age processes, however, are electronic signals and electronically-manipulated data." *Id.* at F.3d at 950, 88 USPQ2d at 1430. The Federal Circuit also noted the difference between electrical signals and electronically-manipulated data and "manipulation of even more abstract constructs such as legal obligations, organizational relationships, and business risks." *Id.* at F.3d at 951, 88 USPQ2d at 1431. The Federal Circuit further noted that the transformation of electronic data is "not required to involve any transformation of the underlying physical object that the data represented." *Id.* at F.3d at 953, 88 USPQ2d at 1433. Therefore, the Federal Circuit clearly accepted that transforming of electrical signals and electronically-manipulated data would satisfy the transformation element of its machine-or-transformation test. In fact, the Federal Circuit continued to follow the current rule that the claim must be considered as a whole to determine whether it is for a particular application and not directed to a fundamental principle. See MPEP 2106 IV C.

Independent claim 15, upon which claims 16-25 depend, in part, recites "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements." The plurality of first images and associated plurality of first measurements and the plurality of said second images and associated plurality of second measurements are transformed into the image. The transformed image and hence the associated data being transformed represent a physical object. As noted above, the Federal Circuit held that "a claimed process is patent-eligible if it transforms an article into a different state or thing." *Id.* 567 F.3d at 949, 88 USPQ2d at 1429. Therefore, this element of claim 15 clearly satisfies the transformation step as required in the machine-or-transformation test, in particular, the transforming of two images and measurements into a single image. Therefore, Applicant submits that each of the pending claims recites statutory subject matter and Applicant respectfully requests that the rejections of claims 15-25 under 35 U.S.C. §101 be withdrawn.

Claim Rejections under 35 U.S.C. §112

Claims 15-18, 20-24, 26-27 and 29-32 stand rejected under 35 USC § 112, as being indefinite on the grounds of insufficient antecedent basis. This rejection is respectfully traversed.

As noted in the Response to the previous Office Action, line 2 of claim 15 and line 2 of claim 26, in part, recite "a plurality of first images" and "a first imaging technique." Line 5 of claim 15 and line 5 of claim 26, in part, recites "a second imaging technique" and "a plurality of second images." Line 3 of claim 15 and line 3 of claim 26, in part, recite "an associated plurality of first measurements" and line 6 of claim 15 and line 6 of claim 26, in part, recite "an associated plurality of second measurements."

In the Response to Amendment Section, the Office Action indicated that with regards to claims 15-18, 20-24, 26-27 and 29-32, it is unclear what the "first image," "first measurements," "first imaging technique," "second image," second measurements," and "second imaging technique" is trying to indicate. According to the MPEP, "a claim is indefinite when it contains words or phases whose meaning is unclear. The lack of clarity could arise where a claim refers to "said lever" or "the lever", where the claim contains no earlier recitation or limitation of a lever where it would be unclear as to what element the limitation was making reference." See MPEP 2173.05(e).

As noted above, each of independent claims 15 and 26, upon which claims 16-25 and 27-32 depend, clearly recites "a plurality of first images," "a first imaging technique," "a second imaging technique," "a plurality of second images," "an associated plurality of first measurements," and "an associated plurality of second measurements." Therefore, it is clear that recitations of the "first images," "first imaging technique," "first measurements," "second images," "second imaging technique," and "second measurements" in the pending claims are referencing "a plurality of first images," "a first imaging technique," "a second imaging technique," "a plurality of second images," "an associated plurality of first measurements," and "an associated plurality of second measurements," as recited in claims 15 and 26. Therefore, Applicant submits that rejection of claims 15-18, 20-24, 26-27 and 29-32 under 35 USC § 112, as being indefinite on the grounds of insufficient antecedent basis is in error and should be withdrawn.

Furthermore, the Office Action alleged that it is also unclear whether the "first measurements" and the "first imaging technique" are different from the "second measurements"

and "second imaging technique", respectively. The pending claims clearly recite two different measurements, that is, the first measurements and the second measurements. The claims also clearly recite two different imaging techniques, that is, the first and second imaging techniques, "wherein the first imaging technique is different from the second imaging technique."

Based on the discussion above, Applicant submits that there is clear antecedent basis for "first images," "first measurement," "first imaging technique," "second images," "second measurement" and "second imaging techniques" in each of claims 15-18, 20-24, 26-27 and 29-32. The pending claims also recite two different measurements, that is, the first measurements and the second measurements and two different imaging techniques, that is, the first and second imaging techniques. Therefore, Applicants respectfully request that the rejections of claims 15, 17, 21, 23, 25-27, 29 and 31 under 35 U.S.C. §112 be withdrawn.

Claim Rejections under 35 U.S.C. §102

Claims 1-18, 20-24, 26-27 and 29-32 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 5,889,525 to De Murcia et al. (hereinafter "De Murcia"). This rejection is respectfully traversed.

As submitted in the previous Response, De Murcia discloses a process including taking a series of sets of measurements of a characteristic property of an object by a two-dimensional array of mobile sensors around the object. The sets of measurements include a two-dimensional array of projections of the property on the sensors. The sets of measurements are taken at a group of different states of the object with respect to the variations in the position or shape of the object. The process includes reconstructing an approximate image of the object at each of the states, combining their respective sets of measurements, evaluating the variations of the object between an image of the object at a reference state and the approximate images, and modifying the image of the object at the reference state by a combination with the sets of measurements and the variations of the object associated with the sets of measurements. See at least Col. 2, line 56-Col. 3, line 4 of De Murcia.

Applicant submits that De Murcia does not teach or suggest each of the elements recited in claims 15-18, 20-24, 26-27 and 29-32. Each of independent claims 15 and 26, in part, recites "obtaining a plurality of second images of the mobile object using a second imaging technique; obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements, wherein the first imaging technique is different from the second imaging technique." De Murcia does not teach or suggest these features.

De Murcia merely discloses taking a series of sets of measurements of a characteristic property of an object by a two-dimensional array of mobile sensors around the object. As noted in the Office Action, the two-dimensional array of projections is equivalent to the "first imaging technique" recited in the pending claims. There is no teaching or suggestion in De Murcia of a "second imaging technique," that is, an imaging technique which is different from the first technique. Thus, there is no teaching or suggestion in De Murcia of "obtaining a plurality of second images of the mobile object using a second imaging technique" and "obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images," as recited in the pending claims. There is also no teaching or suggestion in De Murcia of "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements," as recited in the pending claims.

In the Response to Arguments Section, the Office Action indicated that "applicant does not distinguish or specify whether the "first measurement" and "first imaging technique" are different with the "second measurement" and "second imaging technique", respectively, in the independent claims." As noted above, each of the pending claims clearly recites two types of measurements, that is, the first and second measurements and two types of imaging techniques, that is, the first and second imaging techniques.

By defining the measurements as the first and second measurements, the claims clearly recite two different/types of measurements. The same is true that by defining the imaging

techniques as the first and second imaging techniques, the claims clearly recite two types of imaging techniques. If the measurements and imaging techniques were the same, then there would be no need to differentiate between them by defining one measurement/imaging technique as the first measurements/imaging technique and defining the other measurement as the second measurements/imaging technique. Instead, the claims clearly recite two types of measurements and types of imaging techniques. Therefore, the broadest interpretation of these claims would conclude that the first measurements/imaging technique is of one type and the second measurements/imaging technique is of a different type. Nevertheless, the claims have been amended to clearly recite that "the first imaging technique is different from the second imaging technique."

Therefore, Applicants respectfully submit the De Murcia does not teach or suggest each of the elements of claims 15 and 27. Each of claims 16-26 and 28-32 are allowable at least because of their dependence on claims 15 and 27, respectively, in addition to the further limitations recited in each of claims 16-26 and 28-31. In light of the distinctions noted above, Applicants respectfully request that this rejection of claims 1-18, 20-24, 26-27 and 29-32 under 35 U.S.C. §102 be withdrawn.

Claim Rejections Under 35 U.S.C. §103

Claims 19, 25 and 28 stand rejected under 35 U.S.C. §103(a) as being unpatentable over De Murcia et al. in view of U.S. Patent Publication No. 2003/0004405 to Townsend et al. (hereinafter "Townsend"). This rejection is respectfully traversed.

Townsend does not cure the deficiencies of De Murcia, as noted above. Specifically, Townsend does not teach or suggest "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements, wherein the first imaging technique is different from the second imaging technique," as recited in claims 15 and 27, upon which claims 19, 25 and 28 depend.

Townsend merely discloses a combined PET and X-Ray CT tomography for acquiring CT and PET images sequentially in a single device. There is no teaching or suggestion in Townsend of "forming an image of the mobile object based on said plurality of first images and

associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements," as recited in claims 15 and 27, upon which claims 19, 25 and 28 depend. Therefore, Applicants respectfully request that this rejection of claims 19, 25 and 28 under 35 U.S.C. §103 be withdrawn.

Disclaimer

Applicants may not have presented all possible arguments or have refuted the characterizations of either the claims or the prior art as found in the Office Action. However, the lack of such arguments or refutations is not intended to act as a waiver of such arguments or as concurrence with such characterizations.

CONCLUSION

In view of the above, consideration and allowance are respectfully solicited.

In the event the Examiner believes an interview might serve in any way to advance the prosecution of this application, the undersigned is available at the telephone number noted below.

The Office is authorized to charge any necessary fees to Deposit Account No. 22-0185.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 22-0185, under Order No. 27592-00987-US from which the undersigned is authorized to draw.

Dated: February 13, 2009

Respectfully submitted,

Electronic signature: /Arlene P. Neal/
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Notice of References Cited	Application/Control No. 10/955,037	Applicant(s)/Patent Under Reexamination BONNET ET AL.	
	Examiner JOHN Wahnkyo LEE	Art Unit 2624	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-4,694,156 A	09-1987	Swanberg, Melvin E.	250/214RC
*	B	US-5,889,525 A	03-1999	De Murcia et al.	345/420
*	C	US-2003/0004405 A1	01-2003	Townsend et al.	600/407
*	D	US-6,885,702 B1	04-2005	Goudezeune et al.	375/240.12
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/27/2006	09/07/2007	05/25/2008	11/07/2008	04/22/2009				
	1	✓	-	-	-	-				
	2	✓	-	-	-	-				
	3	✓	-	-	-	-				
	4	✓	-	-	-	-				
	5	✓	-	-	-	-				
	6	✓	-	-	-	-				
	7	✓	-	-	-	-				
	8	✓	-	-	-	-				
9			✓	-	-	-				
10			✓	-	-	-				
11			✓	-	-	-				
12			✓	-	-	-				
13			✓	-	-	-				
14			✓	-	-	-				
15				✓	✓	✓				
16				✓	✓	✓				
17				✓	✓	✓				
18				✓	✓	✓				
19				✓	✓	✓				
20				✓	✓	✓				
21				✓	✓	✓				
22				✓	✓	✓				
23				✓	✓	✓				
24				✓	✓	✓				
25				✓	✓	✓				
26				✓	✓	✓				
27				✓	✓	✓				
28				✓	✓	✓				
29				✓	✓	✓				
30				✓	✓	✓				
31				✓	✓	✓				
32				✓	✓	✓				

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

SEARCHED			
Class	Subclass	Date	Examiner
382	128	12/26/2006	John W. Lee
345	420	12/26/2006	John W. Lee
382	128	11/06/2008	John W. Lee

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor Search	12/26/2006	John W. Lee
East Search	12/26/2006	John W. Lee
IEEE (Non- Patent Literature Search)	12/26/2006	John W. Lee
EAST Search	11/06/2008	John W. Lee
EAST Search	4/22/2009	John W. Lee

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

/JOHN W LEE/ Examiner.Art Unit 2624	

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	1	10/955037	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:20
S2	3258	382/128.ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S3	3206	S2 AND IMAG$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S4	593	S3 and CYCLE	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30

S5	358	S4 AND state	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S6	8	\2003/0004405	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S7	2	"20030004405"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:31
S8	5	"5889525"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:31

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	27592-00987- US	4535

30678 7590 04/28/2009
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EXAMINER	
LEE, JOHN W	
ART UNIT	PAPER NUMBER
2624	

MAIL DATE	DELIVERY MODE
04/28/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	JOHN Wahnkyo LEE	2624	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *24 February 2009*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-32* is/are pending in the application.

4a) Of the above claim(s) *1-14* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *15-32* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 13 February 2009 has been entered.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claims 15-18, 20-24, 26-27 and 29-32 recite the limitations, “first images”, “first imaging technique", “first measurement”, "second images", "second measurement” and "second imaging technique". There are insufficient antecedent basis for these limitations in the claims. It is still unclear and vague what the "first image", "first measurements”, "first imaging technique", "second image" , "second measurements" and "second imaging technique" is trying to indicate. Moreover, it is also unclear whether the “first measurement” and “first imaging technique" are different with the “second measurement" and “second imaging technique", respectively. If the applicant does not specify this, then the examiner will consider the “first measurement” and “first imaging

technique" are same with the “second measurement" and “second imaging technique", respectively.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 15-32 are rejected under 35 U.S.C. 103(a) as being unpatentable over De Murcia et al. (US 5,889,525) in view of Townsend et al. (US 2003/0004405).

Regarding claim 15, De Murcia discloses a method of forming an image (col. 1, line 6-7, “reconstruction o three-dimensional images”) of a mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”), comprising: obtaining a plurality of first images (equation (2); col. 4; lines 1-8, “m_k”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) using a first imaging technique (col. 2, lines 56-64, “two dimensional array of projections”) and an associated plurality of first measurements (col. 2, lines 59-60; col. 4, lines 9-10, “the sets of measurements”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) at movement states corresponding to movement states (col. 4, lines 7-8, “states k”) of said plurality of first images (equation (2); col. 4; lines 1-8, “m_k”); obtaining a plurality of second images (equation (2); col. 4; line 67, “m_{k+1}”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) using a second imaging

technique (col. 2, lines 56-64, “two dimensional array of projections”) and an associated plurality of second measurements (col. 2, lines 59-60; col. 4, lines 9-10) of the mobile object at movement states corresponding to movement states (col. 4, line 67, “state k+1”) of said plurality of second images (equation (2); col. 4; line 67, “$m_{k=1}$”); and forming an image (fig. 2, “object reconstructed” and "$\hat{f}_o$") of the mobile object based on said plurality of first images (equation (2); col. 4; lines 1-8, “m_k”) and associated plurality of first measurements (col. 2, lines 59-60; col. 4, lines 9-10, “the sets of measurements”) and on said plurality of said second images (equation (2); col. 4; line 67, “$m_{k=1}$”) and associated plurality of second measurements (equations (2)-7; col. 4, lines 1-67; col. 5, lines 1-25, “the sets of measurements”). However, De Murcia does not disclose all the claim limitations. Instead of De Murcia, Townsend discloses the first imaging technique (abstract; claim 1, “CT is an example of a system using an anatomic radiation attenuation imagery technique”) is different from the second imaging technique (abstract; claim 1, “PET is an example of a system using functional radiation emission imagery technique”).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize Townsend’s invention in De Murcia’s invention to obtain satisfactory imaging results as suggested by De Murcia (col. 2, lines 44-55).

Regarding claim 16, De Murcia further discloses time-synchronizing said first measurements and said second measurements (col. 3, lines 38-44, “… synchronized … phases of its cycle …”).

Regarding claim 17, De Murcia further discloses forming first reconstructed images corresponding to said plurality of first images (col. 4, lines 58-67; col. 5, lines 1-12, "$\hat{f}_o^k$") and second reconstructed images corresponding to said plurality of second images (col. 5, lines 1-25, "f_o^{k+1}").

Regarding claim 18, De Murcia further discloses spatially-synchronizing said first reconstructed images and said second reconstructed images (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 19, Townsend further discloses the first imaging technique being a radiation attenuation technique (abstract; claim 1, "CT is an example of a system using an anatomic radiation attenuation imagery technique") and second imaging technique being a radiation emission technique (abstract; claim 1, "PET is an example of a system using functional radiation emission imagery technique").

Regarding claim 20, De Murcia further discloses spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 21, De Murcia further discloses forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements (col. 2, lines 45-55, "… displacements …").

Regarding claim 22, De Murcia further discloses wherein said forming an image of the mobile object comprising combining said displacement fields (equations (8); col. 5, lines 45-67, “v(M)”).

Regarding claim 23, De Murcia further discloses wherein said forming displacement fields comprises: estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields (equations (8); col. 5, lines 45-67, “v(M)”; equation (14); col. 7, lines 63-67; col. 8, lines 1-29, “… displacements …”).

Regarding claim 24, De Murcia further discloses wherein at least one of said movement estimates is formed relative to a reference time (col. 3, lines 38-44, “phases of its cycle …”).

Regarding claim 25, Townsend further discloses wherein said plurality of first measurements and said plurality of second measurements being taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images (abstract; claim 1, “CT is an example of a system using an anatomic radiation attenuation imagery technique” and “PET is an example of a system using functional radiation emission imagery technique”).

Regarding claim 26, claim 26 is analogous and corresponds to claim 15. See rejection of claim 15 for further explanation.

Regarding claim 27, claim 27 is analogous and corresponds to claim 17. See rejection of claim 17 for further explanation.

Regarding claim 28, claim 28 is analogous and corresponds to claim 19. See rejection of claim 19 for further explanation.

Regarding claim 29, claim 29 is analogous and corresponds to claim 21. See rejection of claim 21 for further explanation.

Regarding claim 30, claim 30 is analogous and corresponds to claim 22. See rejection of claim 22 for further explanation.

Regarding claim 31, claim 31 is analogous and corresponds to claim 23. See rejection of claim 23 for further explanation.

Regarding claim 32, claim 32 is analogous and corresponds to claim 24. See rejection of claim 24 for further explanation.

Conclusion

6. No claims are allowed.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to JOHN Wahnkyo LEE whose telephone number is (571)272-9554. The examiner can normally be reached on Monday - Friday (Alt.) 7:30 a.m. - 5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Samir Ahmed can be reached on (571) 272-7413. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/John Wahnkyo Lee/
Examiner, Art Unit 2624

/Samir A. Ahmed/
Supervisory Patent Examiner, Art Unit 2624

Docket No.: 27592-00987-US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Stephane Bonnet et al.

Application No.: 10/955,037 | Confirmation No.: 4535

Filed: September 30, 2004 | Art Unit: 2624

For: METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES | Examiner: J. W. Lee

RESPONSE UNDER 37 C.F.R. 1.112 (NON-FINAL OFFICE ACTION)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Madam:

INTRODUCTORY COMMENTS

This is in response to the non-final Office Action mailed April 28, 2009, in the above-captioned case.

Amendments to the Claims are reflected in the Listing of Claims which begins on page 2 of this paper.

Remarks begin on page 7 of this paper.

	Claims remaining after Amendment		**Highest number previously paid for**		**Present extra**
Total	18		20		0
Independent	2		3		0

683810

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 10/955,037	Filing Date 09/30/2004	☐ To be Mailed

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
AMENDMENT	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1)		(Column 2)	(Column 3)					
	07/27/2009	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
AMENDMENT	Total (37 CFR 1.16(i))	* 18	Minus	** 20	= 0	X $ =		OR	X $52 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0	X $ =		OR	X $220 =	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/THERESA LINDSAY/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt	
EFS ID:	5775959
Application Number:	10955037
International Application Number:	
Confirmation Number:	4535
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Customer Number:	30678
Filer:	Burton A. Amernick/Mary Ann Taylor
Filer Authorized By:	Burton A. Amernick
Attorney Docket Number:	27592-00987- US
Receipt Date:	27-JUL-2009
Filing Date:	30-SEP-2004
Time Stamp:	16:33:02
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Response_07_27_09.pdf	112838 91552b6a3df617b16882c187720762f9b592f450	yes	11

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	6
	Applicant Arguments/Remarks Made in an Amendment	7	11
Warnings:			
Information:			
	Total Files Size (in bytes):	112838	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

AMENDMENTS TO THE CLAIMS

This Listing of Claims will replace all prior versions and listings of claims in this application.

Listing of Claims:

1.-14. (Cancelled)

15. (Previously Presented) A method of forming an image of a mobile object, comprising:

obtaining a plurality of first images of the mobile object using a first imaging technique and an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements,

wherein the first imaging technique is different from the second imaging technique.

16. (Previously Presented) The method of Claim 15, further comprising:

time-synchronizing said first measurements and said second measurements.

17. (Previously Presented) The method of Claim 15, further comprising:

forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

18. (Previously Presented) The method of Claim 17, further comprising:

spatially-synchronizing said first reconstructed images and said second reconstructed images.

19. (Previously Presented) The method of Claim 15, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

20. (Previously Presented) The method of Claim 15, further comprising:

spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements.

21. (Previously Presented) The method of Claim 15, further comprising:

forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

22. (Previously Presented) The method of Claim 21, wherein said forming an image of the mobile object comprises combining said displacement fields.

23. (Previously Presented) The method of Claim 21, wherein said forming displacement fields comprises:

estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

24. (Previously Presented) The method of Claim 23, wherein at least one of said movement estimates is formed relative to a reference time.

25. (Previously Presented) The method of Claim 15, wherein said plurality of first measurements and said plurality of second measurements are taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images.

26. (Previously Presented) An apparatus to form an image of a mobile object, comprising:

means for obtaining a plurality of first images of the mobile object using a first imaging technique;

means for obtaining an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

means for obtaining a plurality of second images of the mobile object using a second imaging technique;

means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and

means for forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements,

wherein the first imaging technique is different from the second imaging technique.

27. (Previously Presented) The apparatus of Claim 26, further comprising:

means for forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

28. (Previously Presented) The apparatus of Claim 26, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

29. (Previously Presented) The apparatus of Claim 26, further comprising:

means for forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

30. (Previously Presented) The apparatus of Claim 29, wherein said means for forming an image of the mobile object comprises means for combining said displacement fields.

31. (Previously Presented) The apparatus of Claim 29, wherein said means for forming displacement fields comprises:

means for estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

32. (Previously Presented) The apparatus of Claim 31, wherein at least one of said movement estimates is to be formed relative to a reference time.

REMARKS

Applicants thank the Examiner for the careful consideration given to this application. Claims 15-32 are pending in this application. Claims 15 and 26 are independent claims. Reconsideration and allowance of the present application are respectfully requested.

As a preliminary matter, Applicants' representative thanks the Examiner for discussing the rejections under 35 U.S.C 112 and 35 U.S.C 103 and for agreeing to reconsider those rejections.

Claim Rejections under 35 U.S.C. §112

Claims 15-18, 20-24, 26-27 and 29-32 stand rejected under 35 USC §112, second paragraph, as being indefinite. This rejection is respectfully traversed.

Claims 15-18, 20-24, 26-27 and 29-32 stand rejected under 35 USC § 112, as being indefinite on the grounds of insufficient antecedent basis. This rejection is respectfully traversed.

As noted in the Response to the previous Office Action, line 2 of claim 15 and line 2 of claim 26, in part, recite "a plurality of first images" and "a first imaging technique." Line 5 of claim 15 and line 5 of claim 26, in part, recites "a second imaging technique" and "a plurality of second images." Line 3 of claim 15 and line 3 of claim 26, in part, recite "an associated plurality of first measurements" and line 6 of claim 15 and line 6 of claim 26, in part, recite "an associated plurality of second measurements."

In the Response to Amendment Section, the Office Action indicated that with regards to claims 15-18, 20-24, 26-27 and 29-32, it is unclear what the "first image," "first measurements," "first imaging technique," "second image," second measurements," and "second imaging technique" is trying to indicate. According to the MPEP, "a claim is indefinite when it contains words or phases whose meaning is unclear. The lack of clarity could arise where a claim refers to "said lever" or "the lever", where the claim contains no earlier recitation or limitation of a lever where it would be unclear as to what element the limitation was making reference." See at least MPEP 2173.05(e).

As noted above, each of independent claims 15 and 26, upon which claims 16-25 and 27-32 depend, clearly recites "a plurality of first images," "a first imaging technique," "a second imaging technique," "a plurality of second images," "an associated plurality of first measurements," and "an associated plurality of second measurements." Therefore, it is clear that recitations of the "first images," "first imaging technique," "first measurements," "second images," "second imaging technique," and "second measurements" in the pending claims are referencing "a plurality of first images," "a first imaging technique," "an associated plurality of first measurements," "a plurality of second images," and "a second imaging technique," and "an associated plurality of second measurements," as recited in claims 15 and 26. Therefore, Applicant submits that rejection of claims 15-18, 20-24, 26-27 and 29-32 under 35 USC § 112, as being indefinite on the grounds of insufficient antecedent basis is in error and should be withdrawn.

Furthermore, the Office Action alleged that it is also unclear whether the "first measurements" and the "first imaging technique" are different from the "second measurements" and "second imaging technique", respectively. The pending claims clearly recite two different measurements, that is, the first measurements and the second measurements. The claims also clearly recite two different imaging techniques, that is, the first and second imaging techniques. In fact, the claims clearly recite that "the first imaging technique is different from the second imaging technique."

Based on the discussion above, Applicant submits that there is clear antecedent basis for "first images," "first measurement," "first imaging technique," "second images," "second measurement" and "second imaging techniques" in each of claims 15-18, 20-24, 26-27 and 29-32. The pending claims also recite two different measurements, that is, the first measurements and the second measurements and two different imaging techniques, that is, the first and second imaging techniques. Therefore, Applicants respectfully request that the rejections of claims 15, 17, 21, 23, 25-27, 29 and 31 under 35 U.S.C. §112, second paragraph, be withdrawn. Applicants also respectfully request that the rejections of claims 15-18, 20-24, 26-27 and 29-32 under 35 U.S.C. §112 be withdrawn.

Claim Rejections Under 35 U.S.C. §103

Claims 15-32 stand rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,889,525 to De Murcia et al. (hereinafter "De Murcia") in view of U.S. Patent Publication No. 2003/0004405 to Townsend et al. (hereinafter "Townsend"). This rejection is respectfully traversed.

Applicant submits that the combination of De Murcia and Townsend does not teach or suggest each of the elements recited in claims 15-18, 20-24, 26-27 and 29-32. Each of independent claims 15 and 26, in part, recites "obtaining a plurality of second images of the mobile object using a second imaging technique; obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images; and forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements, wherein the first imaging technique is different from the second imaging technique." De Murcia does not teach or suggest these features.

De Murcia merely discloses taking a series of sets of measurements of a characteristic property of an object by a two-dimensional array of mobile sensors around the object. The Office Action equates the two-dimensional array of projections to the "first imaging technique" recited in the pending claims. There is no teaching or suggestion in De Murcia of a "second imaging technique," that is, an imaging technique which is different from the first technique. Thus, there is no teaching or suggestion in De Murcia of "obtaining a plurality of second images of the mobile object using a second imaging technique" and "obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images," as recited in the pending claims. There is also no teaching or suggestion in De Murcia of "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements," as recited in the pending claims.

The Office Action indicated that "applicant does not distinguish or specify whether the "first measurement" and "first imaging technique" are different with the "second measurement" and "second imaging technique", respectively, in the independent claims." As noted above, with

respect to the 112 rejections and as submitted during a telephone discussion with the Examiner, each of the pending claims clearly recites two different imaging techniques, that is, the first and second imaging techniques, "wherein the first imaging technique is different from the second imaging technique." Therefore, as also provided in the discussion above directed to the 112 rejections, Applicant does specify that the "first measurement" and "first imaging technique" are different from the "second measurement" and "second imaging technique", respectively, in the independent claims.

Townsend does not cure the deficiencies of De Murcia. Specifically, Townsend does not teach or suggest "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements, wherein the first imaging technique is different from the second imaging technique," as recited in claims 15 and 27, upon which claims 19, 25 and 28 depend.

Townsend merely discloses a combined PET and X-Ray CT tomography for acquiring CT and PET images sequentially in a single device. So in Townsend the CT images are separate from the PET images. There is no teaching or suggestion in Townsend of forming an image by combining the separate CT and PET images. Thus, there is no teaching or suggestion in Townsend of "forming an image of the mobile object based on said plurality of first images and associated plurality of first measurements and on said plurality of said second images and associated plurality of second measurements," as recited in claims 15 and 27, upon which claims 19, 25 and 28 depend. Therefore, Applicants respectfully request that this rejection of claims 15-32 under 35 U.S.C. §103 be withdrawn.

Disclaimer

Applicants may not have presented all possible arguments or have refuted the characterizations of either the claims or the prior art as found in the Office Action. However, the lack of such arguments or refutations is not intended to act as a waiver of such arguments or as concurrence with such characterizations.

CONCLUSION

In view of the above, consideration and allowance are respectfully solicited.

In the event the Examiner believes an interview might serve in any way to advance the prosecution of this application, the undersigned is available at the telephone number noted below.

The Office is authorized to charge any necessary fees to Deposit Account No. 22-0185.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 22-0185, under Order No. 27592-00987-US from which the undersigned is authorized to draw.

Dated: July 27, 2009

Respectfully submitted,

Electronic signature: /Arlene P. Neal/
Arlene P. Neal
Registration No.: 43,828
CONNOLLY BOVE LODGE & HUTZ LLP
1875 Eye Street, NW
Suite 1100
Washington, DC 20006
(202) 331-7111
(202) 293-6229 (Fax)
Attorney for Applicant

Notice of References Cited	Application/Control No. 10/955,037	Applicant(s)/Patent Under Reexamination BONNET ET AL.	
	Examiner JOHN Wahnkyo LEE	Art Unit 2624	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-4,694,156 A	09-1987	Swanberg, Melvin E.	250/214RC
*	B	US-5,889,525 A	03-1999	De Murcia et al.	345/420
*	C	US-2003/0004405 A1	01-2003	Townsend et al.	600/407
*	D	US-6,885,702 B1	04-2005	Goudezeune et al.	375/240.12
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/27/2006	09/07/2007	05/25/2008	11/07/2008	04/22/2009	11/20/2009			
	1	✓	-	-	-	-	-			
	2	✓	-	-	-	-	-			
	3	✓	-	-	-	-	-			
	4	✓	-	-	-	-	-			
	5	✓	-	-	-	-	-			
	6	✓	-	-	-	-	-			
	7	✓	-	-	-	-	-			
	8	✓	-	-	-	-	-			
9			✓	-	-	-	-			
10			✓	-	-	-	-			
11			✓	-	-	-	-			
12			✓	-	-	-	-			
13			✓	-	-	-	-			
14			✓	-	-	-	-			
15				✓	✓	✓	✓			
16				✓	✓	✓	✓			
17				✓	✓	✓	✓			
18				✓	✓	✓	✓			
19				✓	✓	✓	✓			
20				✓	✓	✓	✓			
21				✓	✓	✓	✓			
22				✓	✓	✓	✓			
23				✓	✓	✓	✓			
24				✓	✓	✓	✓			
25				✓	✓	✓	✓			
26				✓	✓	✓	✓			
27				✓	✓	✓	✓			
28				✓	✓	✓	✓			
29				✓	✓	✓	✓			
30				✓	✓	✓	✓			
31				✓	✓	✓	✓			
32				✓	✓	✓	✓			

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

SEARCHED			
Class	Subclass	Date	Examiner
382	128	12/26/2006	John W. Lee
345	420	12/26/2006	John W. Lee
382	128	11/06/2008	John W. Lee

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor Search	12/26/2006	John W. Lee
East Search	12/26/2006	John W. Lee
IEEE (Non- Patent Literature Search)	12/26/2006	John W. Lee
EAST Search	11/06/2008	John W. Lee
EAST Search	4/22/2009	John W. Lee
EAST Search	11/20/2009	John W. Lee

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

/JOHN W LEE/ Examiner.Art Unit 2624	

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	136269	different NEAR2 imag $4	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/11/20 20:19
L2	4064	382/128.ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/11/20 21:54
L3	1747	L1 and L2	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/11/20 21:54

S1	1	10/955037	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:20
S2	3258	382/128.ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S3	3206	S2 AND IMAG$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S4	593	S3 and CYCLE	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30
S5	358	S4 AND state	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/11/06 15:30

S6	8	\ 2003/ 0004405	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/ 11/ 06 15:30
S7	2	"20030004405"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/ 11/ 06 15:31
S8	5	"5889525"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/ 11/ 06 15:31

11/ 20/ 2009 9:54:56 PM
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	27592-00987- US	4535

30678 7590 11/27/2009

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EXAMINER	
LEE, JOHN W	

ART UNIT	PAPER NUMBER
2624	

MAIL DATE	DELIVERY MODE
11/27/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	JOHN Wahnkyo LEE	2624	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *09 September 2009*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-32* is/are pending in the application.

4a) Of the above claim(s) *1-14* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *15-32* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

- The application was forwarded to the examiner on 9 September 2009.

Response to Arguments/Amendments

1. Applicant's arguments and amendments filed on 27July 2009 have been fully considered.

2. Applicant's arguments, with respect to claims 15-32 under 35 U.S.C. 112, second paragraph have been considered, but are not persuasive. The reason why the rejection cannot be withdrawn will be provide below.

3. Applicant's arguments, with respect to claims 15-32, under 35 U.S.C. 103 have been considered, but are not persuasive. Applicant argues that De Murcia does not disclose or distinguish that the “first measurement” and the “first imaging technique” are different with the “second measurement” and the "second imaging technique", respectively. However, the applicant did not mention any in the claims that the "first measurement" and the "second measurement" are different. Arguing about whether the prior art distinguishes whether the “first measurement” and the “second measurement” are different is irrelevant. Of course, the imaging technique is different. It is recited that “the first imaging technique” and the “second imaging technique” are different. The applicant is right that De Murica does not disclose that the first imaging technique and the second imaging technique are different. For that reason, Townsend was cited as a secondary reference to cure the deficiency of De Murcia. Townsend discloses a

combined PET and X-Ray CT tomograph for acquiring CT and PET images, which can be imaging techniques, sequentially in a single device.

The Supreme Court in KSR International Co. v. Teleflex Inc., 550 U.S. ___, ___, 82 USPQ2d 1385, 1395-97 (2007) identified a number of rationales to support a conclusion of obviousness which are consistent with the proper "functional approach" to the determination of obviousness as laid down in Graham. The key to supporting any rejection under 35 U.S.C. 103 is the clear articulation of the reason(s) why the claimed invention would have been obvious. Moreover, according to the Supreme Court, the teaching, suggestion, or motivation (TSM) is one of a number of valid rationales that could be used to determine obviousness, but not the only rationale that may be relied upon to support a conclusion of obviousness.

Adding the combined PET and X-Ray CT tomography for acquiring CT and PET images taught by Townsend to De Murcia's process for reconstructing of 3D images does no more to De Murcia's process than it would do if it were added to any other systems or method. The function remains that same. Predictably, combined PET and X-Ray CT tomography for acquiring CT and PET images adds greater reliability. Thus, it would have been obvious one of ordinary skill in the art would have been motivated to update De Murcia's process with Townsend's combined PET and X-Ray CT tomography for acquiring CT and PET images to gain, predictably, the commonly understood benefits of such adaptation, that is, a having a reliable process, because the both advantages of the PET and X-Ray CT can be used for a better quality of acquiring the images.

Because of the reason discussed above, the rejection cannot be withdrawn.

Claim Rejections - 35 USC § 112

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claims 15-32 have insufficient antecedent basis for these limitations in the claims. In claim 15, lines 9 and 10, “associated plurality of first measurements" and “associated plurality of second measurements" are mentioned in the previous claim limitations. So, it needs a “the” or a “said" before the “associated plurality of first measurements" and the “associated plurality of second measurements." Same reason applies for claim 26 as well.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 15-32 are rejected under 35 U.S.C. 103(a) as being unpatentable over De Murcia et al. (US 5,889,525) in view of Townsend et al. (US 2003/0004405).

Regarding claim 15, De Murcia discloses a method of forming an image (col. 1, line 6-7, “reconstruction o three-dimensional images”) of a mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”), comprising:

obtaining a plurality of first images (equation (2); col. 4; lines 1-8, “m_k”) of the mobile

object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) using a first imaging technique (col. 2, lines 56-64, “two dimensional array of projections”) and an associated plurality of first measurements (col. 2, lines 59-60; col. 4, lines 9-10, “the sets of measurements”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) at movement states corresponding to movement states (col. 4, lines 7-8, “states k”) of said plurality of first images (equation (2); col. 4; lines 1-8, “m_k”); obtaining a plurality of second images (equation (2); col. 4; line 67, “m_{k+1}”) of the mobile object (fig. 1; col. 1, line 6-7, “mobile object”; col. 2, lines 10-11, “mobile organs such as heart”) using a second imaging technique (col. 2, lines 56-64, “two dimensional array of projections”) and an associated plurality of second measurements (col. 2, lines 59-60; col. 4, lines 9-10) of the mobile object at movement states corresponding to movement states (col. 4, line 67, “state k+1”) of said plurality of second images (equation (2); col. 4; line 67, “$m_{k=1}$”); and forming an image (fig. 2, “object reconstructed” and "$\hat{f}_o$") of the mobile object based on said plurality of first images (equation (2); col. 4; lines 1-8, “m_k”) and associated plurality of first measurements (col. 2, lines 59-60; col. 4, lines 9-10, “the sets of measurements”) and on said plurality of said second images (equation (2); col. 4; line 67, “$m_{k=1}$”) and associated plurality of second measurements (equations (2)-7; col. 4, lines 1-67; col. 5, lines 1-25, “the sets of measurements”). However, De Murcia does not disclose all the claim limitations. Instead of De Murcia, Townsend discloses the first imaging technique (abstract; claim 1, “CT is an example of a system using an anatomic radiation attenuation imagery technique”) is different from the second imaging technique

(abstract; claim 1, “PET is an example of a system using functional radiation emission imagery technique”).

Adding the combined PET and X-Ray CT tomography for acquiring CT and PET images taught by Townsend to De Murcia's process for reconstructing of 3D images does no more to De Murcia’s process than it would do if it were added to any other systems or method. The function remains that same. Predictably, combined PET and X-Ray CT tomography for acquiring CT and PET images adds greater reliability. Therefore, it would have been obvious one of ordinary skill in the art would have been motivated to update De Murcia's process with Townsend's combined PET and X-Ray CT tomography for acquiring CT and PET images to gain, predictably, the commonly understood benefits of such adaptation, that is, a having a reliable process, because the both advantages of the PET and X-Ray CT can be used for a better quality of acquiring the images.

Regarding claim 16, De Murcia further discloses time-synchronizing said first measurements and said second measurements (col. 3, lines 38-44, “… synchronized … phases of its cycle …”).

Regarding claim 17, De Murcia further discloses forming first reconstructed images corresponding to said plurality of first images (col. 4, lines 58-67; col. 5, lines 1-12, "$\hat{f}_o^k$") and second reconstructed images corresponding to said plurality of second images (col. 5, lines 1-25, “f_o^{k+1}”).

Regarding claim 18, De Murcia further discloses spatially-synchronizing said first reconstructed images and said second reconstructed images (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 19, Townsend further discloses the first imaging technique being a radiation attenuation technique (abstract; claim 1, "CT is an example of a system using an anatomic radiation attenuation imagery technique") and second imaging technique being a radiation emission technique (abstract; claim 1, "PET is an example of a system using functional radiation emission imagery technique").

Regarding claim 20, De Murcia further discloses spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements (col. 3, lines 38-44, "… synchronized … phases of its cycle …").

Regarding claim 21, De Murcia further discloses forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements (col. 2, lines 45-55, "… displacements …").

Regarding claim 22, De Murcia further discloses wherein said forming an image of the mobile object comprising combining said displacement fields (equations (8); col. 5, lines 45-67, "v(M)").

Regarding claim 23, De Murcia further discloses wherein said forming displacement fields comprises: estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said

plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields (equations (8); col. 5, lines 45-67, “v(M)”; equation (14); col. 7, lines 63-67; col. 8, lines 1-29, “… displacements …”).

Regarding claim 24, De Murcia further discloses wherein at least one of said movement estimates is formed relative to a reference time (col. 3, lines 38-44, “phases of its cycle …”).

Regarding claim 25, Townsend further discloses wherein said plurality of first measurements and said plurality of second measurements being taken using separate measurement systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images (abstract; claim 1, “CT is an example of a system using an anatomic radiation attenuation imagery technique” and “PET is an example of a system using functional radiation emission imagery technique”).

Regarding claim 26, claim 26 is analogous and corresponds to claim 15. See rejection of claim 15 for further explanation.

Regarding claim 27, claim 27 is analogous and corresponds to claim 17. See rejection of claim 17 for further explanation.

Regarding claim 28, claim 28 is analogous and corresponds to claim 19. See rejection of claim 19 for further explanation.

Regarding claim 29, claim 29 is analogous and corresponds to claim 21. See rejection of claim 21 for further explanation.

Regarding claim 30, claim 30 is analogous and corresponds to claim 22. See rejection of claim 22 for further explanation.

Regarding claim 31, claim 31 is analogous and corresponds to claim 23. See rejection of claim 23 for further explanation.

Regarding claim 32, claim 32 is analogous and corresponds to claim 24. See rejection of claim 24 for further explanation.

Conclusion

8. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JOHN Wahnkyo LEE whose telephone number is (571)272-9554. The examiner can normally be reached on Monday - Friday (Alt.) 7:30 a.m. - 5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Samir Ahmed can be reached on (571) 272-7413. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/John Wahnkyo Lee/
Examiner, Art Unit 2624

/Samir A. Ahmed/
Supervisory Patent Examiner, Art Unit 2624

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	27592-00987- US	4535

30678 7590 01/19/2010
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EXAMINER	
LEE, JOHN W	
ART UNIT	PAPER NUMBER
2624	

MAIL DATE	DELIVERY MODE
01/19/2010	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Interview Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	JOHN Wahnkyo LEE	2624	

All participants (applicant, applicant's representative, PTO personnel):

(1) *Samir Ahmed*. (3)*Jeffery Gluck*.

(2) *JOHN Wahnkyo LEE*. (4)_____.

Date of Interview: *5 January 2009*.

Type: a)☒ Telephonic b)☐ Video Conference
c)☐ Personal [copy given to: 1)☐ applicant 2)☐ applicant's representative]

Exhibit shown or demonstration conducted: d)☐ Yes e)☒ No.
If Yes, brief description: _____.

Claim(s) discussed: *1*.

Identification of prior art discussed: *De Murcia et al. and Townsend et al.*.

Agreement with respect to the claims f)☐ was reached. g)☒ was not reached. h)☐ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: *The examiners and the attoreny discussed about the rejections under 35 U.S.C. 112, second paragraph and 35 U.S.C. 103 (a).The attorney argued that the claims which the examiner pointed out as lack of antecedent basis are incorrect. Moreover, the attorney also argued that Townsend does not implement the invention the same way with the applicant's invention does.* .

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN A NON-EXTENDABLE PERIOD OF THE LONGER OF ONE MONTH OR THIRTY DAYS FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

/John Wahnkyo Lee/ Examiner, Art Unit 2624	

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

———

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:

- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:

1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

PTO/SB/30 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	10/955,037-Conf. #4535
Filing Date	September 30, 2004
First Named Inventor	Stephane Bonnet
Art Unit	2624
Examiner Name	J. W. Lee
Attorney Docket Number	27592-00987-US

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.

Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. [ ] Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.
      i. [ ] Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
      ii. [ ] Other _____

   b. [x] Enclosed
      i. [x] Amendment/Reply
      ii. [ ] Affidavit(s)/Declaration(s)
      iii. [ ] Information Disclosure Statement (IDS)
      iv. [ ] Other _____

2. Miscellaneous

   a. [ ] Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. [ ] Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. [ ] The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any Overpayments, to Deposit Account No. 22-0185 .
      i. [x] RCE fee required under 37 CFR 1.17(e)
      ii. [ ] Extension of time fee (37 CFR 1.136 and 1.17)
      iii. [ ] Other _____

   b. [ ] Check in the amount of $ _____ enclosed

   c. [x] Payment by credit card

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Jeffrey W. Gluck/	Date	February 19, 2010
Name (Print/Type)	Jeffrey W. Gluck	Registration No.	44,457

Docket No.: 27592-00987-US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Stephane Bonnet et al.

Application No.: 10/955,037 | Confirmation No.: 4535

Filed: September 30, 2004 | Art Unit: 2624

For: METHOD OF RECONSTRUCTING AN IMAGE WITH DATA ACQUISITION ACCORDING TO SEVERAL IMAGERY MODES AND SYNCHRONISATION OF IMAGE SERIES | Examiner: J. W. Lee

AMENDMENT FILED WITH RCE UNDER 37 C.F.R. 1.114

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This is in response to the final Office Action mailed November 27, 2009, in the above-captioned case and is intended to be filed with a Request for Continued Examination (RCE). If no RCE accompanies this paper, continued examination is hereby requested.

Amendments to the Claims are reflected in the Listing of Claims which begins on page 2 of this paper.

Remarks begin on page 6 of this paper.

	Claims remaining after Amendment		**Highest number previously paid for**		**Present extra**
Total	18		20		0
Independent	2		3		0

737171

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 10/955,037	Filing Date 09/30/2004	☐ To be Mailed

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
	02/19/2010	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 18	Minus	** 20	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		(Column 1)		(Column 2)	(Column 3)					
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/MARQUETTA MCGEE/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Patent Application Fee Transmittal	
Application Number:	10955037
Filing Date:	30-Sep-2004
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Filer:	Burton A. Amernick/Mary Ann Taylor
Attorney Docket Number:	27592-00987- US
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	1801	1	810	810
		Total in USD ($)		**810**

Electronic Acknowledgement Receipt	
EFS ID:	7048540
Application Number:	10955037
International Application Number:	
Confirmation Number:	4535
Title of Invention:	Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series
First Named Inventor/Applicant Name:	Stephane Bonnet
Customer Number:	30678
Filer:	Burton A. Amernick/Mary Ann Taylor
Filer Authorized By:	Burton A. Amernick
Attorney Docket Number:	27592-00987- US
Receipt Date:	19-FEB-2010
Filing Date:	30-SEP-2004
Time Stamp:	15:24:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$810
RAM confirmation Number	1825
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Request for Continued Examination (RCE)	RCE_Transmittal_02_19_10.pdf	65729 b6054b8cb331e080db4dec43331b3bdb543b1ca5	no	1
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This is not a USPTO supplied RCE SB30 form.					
Information:					
2		Response_02_19_10.pdf	115050 1f0db8eee7fdf097fb489c2cea52ec884a725a66	yes	11
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Amendment Submitted/Entered with Filing of CPA/RCE		1	1	
	Claims		2	5	
	Applicant Arguments/Remarks Made in an Amendment		6	11	
Warnings:					
Information:					
3	Fee Worksheet (PTO-875)	fee-info.pdf	30155 41ac729fe932609bc7af92b07527d0f5e7d3b6fc	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	210934		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

AMENDMENTS TO THE CLAIMS

This Listing of Claims will replace all prior versions and listings of claims in this application.

Listing of Claims:

1.-14. (Cancelled)

15. (Currently Amended) A method of forming an image of a mobile object, comprising:

obtaining a plurality of first images of the mobile object using a first imaging technique and an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images, wherein the plurality of second measurements are distinct from the plurality of first measurements; and

forming an image of the mobile object based on said plurality of first images and said associated plurality of first measurements and on said plurality of said second images and said associated plurality of second measurements,

wherein the first imaging technique is different from the second imaging technique.

16. (Previously Presented) The method of Claim 15, further comprising:

time-synchronizing said first measurements and said second measurements.

17. (Previously Presented) The method of Claim 15, further comprising:

forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

18. (Previously Presented) The method of Claim 17, further comprising:

spatially-synchronizing said first reconstructed images and said second reconstructed images.

19. (Previously Presented) The method of Claim 15, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

20. (Previously Presented) The method of Claim 15, further comprising:

spatially-synchronizing information based on said plurality of first measurements and information based on said plurality of second measurements.

21. (Previously Presented) The method of Claim 15, further comprising:

forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

22. (Previously Presented) The method of Claim 21, wherein said forming an image of the mobile object comprises combining said displacement fields.

23. (Previously Presented) The method of Claim 21, wherein said forming displacement fields comprises:

estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

24. (Previously Presented) The method of Claim 23, wherein at least one of said movement estimates is formed relative to a reference time.

25. (Previously Presented) The method of Claim 15, wherein said plurality of first measurements and said plurality of second measurements are taken using separate measurement

systems respectively associated with separate imaging systems used to obtain said plurality of first images and said plurality of second images.

26. (Currently Amended) An apparatus to form an image of a mobile object, comprising:

means for obtaining a plurality of first images of the mobile object using a first imaging technique;

means for obtaining an associated plurality of first measurements of the mobile object at movement states corresponding to movement states of said plurality of first images;

means for obtaining a plurality of second images of the mobile object using a second imaging technique;

means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images, wherein the plurality of second measurements are distinct from the plurality of first measurements; and

means for forming an image of the mobile object based on said plurality of first images and said associated plurality of first measurements and on said plurality of said second images and said associated plurality of second measurements,

wherein the first imaging technique is different from the second imaging technique.

27. (Previously Presented) The apparatus of Claim 26, further comprising:

means for forming first reconstructed images corresponding to said plurality of first images and second reconstructed images corresponding to said plurality of second images.

28. (Previously Presented) The apparatus of Claim 26, wherein said first imaging technique is a radiation attenuation technique and said second imaging technique is a radiation emission technique.

29. (Previously Presented) The apparatus of Claim 26, further comprising:

means for forming displacement fields corresponding, respectively, to said plurality of first images, said plurality of first measurements, said plurality of second images, and said plurality of second measurements.

30. (Previously Presented) The apparatus of Claim 29, wherein said means for forming an image of the mobile object comprises means for combining said displacement fields.

31. (Previously Presented) The apparatus of Claim 29, wherein said means for forming displacement fields comprises:

means for estimating movement of the mobile object based, respectively, on said plurality of first images, said plurality of second images, said plurality of first measurements, and said plurality of second measurements, in order to form said displacement fields.

32. (Previously Presented) The apparatus of Claim 31, wherein at least one of said movement estimates is to be formed relative to a reference time.

REMARKS

Applicants thank the Examiner for the careful consideration given to this application and for the very helpful telephone interview conducted on January 5, 2010 (summarized below). Reconsideration is now respectfully requested in view of the amendment above and the following remarks.

Claims 15-32 are pending in this application. Claims 15 and 26 are independent claims. Claims 15 and 26 are amended. Claims 1-14 were previously cancelled without prejudice or disclaimer. Reconsideration and allowance of the present application are respectfully requested.

Summary of Interview of January 5, 2010

Again, Applicants are grateful for the very helpful telephone interview held on January 5, 2010. The participants were Examiner John Lee, Supervisory Patent Examiner Samir Ahmed, and Applicants' undersigned representative. The first topic of discussion was the rejection of all claims under 35 U.S.C. § 112, second paragraph. Messrs. Lee and Ahmed explained their position, and the undersigned explained Applicants' position. While Applicants disagree with this rejection, the undersigned indicated that amendments to Claims 15 and 26 would be considered by Applicants. The second topic of discussion related to the art-based rejections under 35 U.S.C. § 103, based on DeMurcia et al. and Townsend et al. (see below for further details). Messrs. Lee and Ahmed explained how the two references were being combined; namely, DeMurcia et al. was used in the Office Action to teach obtaining a set of images with corresponding measurements and using the images and measurements to reconstruct an object, while Townsend et al. was being used to teach the use of obtaining two types of images and combining their results (paragraph [0080] of Townsend et al. was specifically discussed). The undersigned pointed to reasons why the two references may not be combined to obtain the claimed invention. Possible amendments to the independent claims to clarify such differences were discussed. No firm agreement was reached on any of the rejections.

Claim Rejections under 35 U.S.C. § 112

Claims 15-32 stand rejected under 35 USC § 112, second paragraph, as being indefinite. This rejection is respectfully traversed in view of the amendments to Claims 15 and 26, which Applicants believe address the concerns stated in the rejection. Therefore, Applicants respectfully request that the rejection of Claims 15-32 under 35 U.S.C. § 112 be withdrawn.

Claim Rejections Under 35 U.S.C. §103

Claims 15-32 stand rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,889,525 to De Murcia et al. (hereinafter "De Murcia et al.") in view of U.S. Patent Publication No. 2003/0004405 to Townsend et al. (hereinafter "Townsend et al."). This rejection is respectfully traversed for at least the following reasons.

Claim 15, as amended, includes the recitations, "obtaining a plurality of second images of the mobile object using a second imaging technique and an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images, wherein the plurality of second measurements are distinct from the plurality of first measurements," and, "forming an image of the mobile object based on said plurality of first images and said associated plurality of first measurements and on said plurality of said second images and said associated plurality of second measurements." Claim 26, as amended, includes the recitations, "means for obtaining an associated plurality of second measurements of the mobile object at movement states corresponding to movement states of said plurality of second images, wherein the plurality of second measurements are distinct from the plurality of first measurements," and, "means for forming an image of the mobile object based on said plurality of first images and said associated plurality of first measurements and on said plurality of said second images and said associated plurality of second measurements." Applicants respectfully submit that the combination of DeMurcia et al. with Townsend et al. fails to teach or suggest at least these claim elements, for at least the following reasons.

As noted above (see Summary of Interview) and discussed, e.g., at page 5 of the Office Action, DeMurcia et al. teaches obtaining a single set of images and a single set of associated measurements and uses them to form an image. Also as discussed above and, e.g., at pages 5-6 of the Office Action, Townsend et al. teaches the use of CT and PET imaging and, at paragraph

[0080] discusses "image 'fusion'" to combine their results. Applicants note that paragraph [0080] of Townsend et al. specifically states:

> The PET images are therefore fully quantitative and are interpolated and displayed with the same pixel size as the CT images. PET images are displayed either adjacent to, or superimposed on, CT images for simultaneous interpretation of functional and morphological information. In one embodiment, the PET and CT images are displayed side by side in a viewing tool with linked cross-hair cursors, so that positional correspondence between the two image sets is easily established. A second technique of image `fusion` is also employed, where the two different image sets are combined into a single image. See FIG. 3. For display of the fused PET and CT images, an alternating pixel method is extended to a 3D display format. Since the PET images have an isotropic resolution of approximately 10 mm for whole-body oncology imaging, the images are interpolated into the CT image space without loss of information in the PET image, thus preserving the resolution of the CT image. Because image fusion methods can obscure low-contrast objects, the CT display panel can be toggled between CT only and fused PET/CT mode. The viewing panels also have independent color scales and can be switched between transverse, sagittal, and coronal viewing modes.

Townsend et al. at paragraph [0080]. It is significant that the word "fusion" is in quotation marks, namely, because, as is subsequently explained in paragraph [0080], "For display of the fused PET and CT images, an alternating pixel method is extended to a 3D display format," and "the [PET] images are interpolated into the CT image space." That is, Townsend et al. creates a combined image based on two different imaging techniques, but it specifically uses combining techniques that ***do not use associated sets of measurements***, as presently claimed. In fact, for example, in the abstract and paragraph [0035], Townsend et al. provides a system in which such measurements are not necessary because, due to the physically-known relationship between the CT and PET scans, the resulting images may be combined without registration (i.e., they are inherently co-registered; see, also, paragraph [0036]). If one were to attempt to combine, for example, CT and PET images based on both the images and distinct associated measurements

(i.e., sets of measurements associated with each set of images), such as those found in DeMurcia et al., then one would need to provide an altogether different technique from that found in Townsend et al. for combining the images obtained using the two techniques and the associated sets of measurements, and neither reference provides or suggests such a technique (i.e., a technique that would provide for the claimed "forming an image of the mobile object based on said plurality of first images and said associated plurality of first measurements and on said plurality of said second images and said associated plurality of second measurements" of Claim 15, and similar language in Claim 26). In particular, as discussed above, Townsend et al. does not use such a technique because there is no need for such a technique due to the inherent "co-registration" of the images, and DeMurcia et al. does not include such a technique because it is not combining multiple images/measurements obtained distinctly. Therefore, Applicants respectfully submit that the combination of DeMurcia et al. with Townsend et al. fails to teach or suggest the subject matter as claimed in Claims 15 and 26, and therefore, in their respective dependent claims (Claims 16-25 and 27-32).

Applicants also note that there are further reasons for which various dependent claims are allowable over the cited combination of references. For example, Claim 16 recites, "time-synchronizing said first measurements and said second measurements." The Office Action, at page 6, alleges that DeMurcia et al. discloses this at col. 3, lines 38-44. This portion of DeMurcia et al. states, "The sensors 3 having different incidences take a series of sets of measurements being receptive to photons at certain instants, synchronized on a given group of states of the heart 1, or the phases of its cycle. The means for the synchronization, control of sensors 3, displacement of the two-dimensional array 2 and the storage of measurements, which are already known, will not be described here." This fails to teach or suggest what is claimed in Claim 16 at least because there is no teaching or suggestion of synchronizing two (distinct) sets of measurements, as claimed.

Therefore, Applicants respectfully request that this rejection of Claims 15-32 under 35 U.S.C. § 103 be withdrawn.

Disclaimer

Applicants may not have presented all possible arguments or have refuted the characterizations of either the claims or the prior art as found in the Office Action. However, the lack of such arguments or refutations is not intended to act as a waiver of such arguments or as concurrence with such characterizations.

Volkswagen Exhibit 1002, Page 439 of 885

CONCLUSION

In view of the above, consideration and allowance are respectfully solicited.

In the event the Examiner believes an interview might serve in any way to advance the prosecution of this application, the undersigned is available at the telephone number noted below.

The Office is authorized to charge any necessary fees to Deposit Account No. 22-0185.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 22-0185, under Order No. 27592-00987-US from which the undersigned is authorized to draw.

Dated: February 19, 2010

Respectfully submitted,

Electronic signature: /Jeffrey W. Gluck/
Jeffrey W. Gluck
Registration No.: 44,457
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Washington, DC 20006
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(202) 293-6229 (Fax)
Attorney for Applicant

PLUS Search Results for S/N 10955037, Searched Tue Jul 06 09:19:15 EDT 2010

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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6907100 72
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PLUS Search Results for S/N 10955037, Searched Tue Jul 06 09:19:12 EDT 2010

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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5361070 53
5430297 53
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5541725 53
5552606 53
5576545 53

Notice of References Cited	Application/Control No. 10/955,037	Applicant(s)/Patent Under Reexamination BONNET ET AL.	
	Examiner JOHN Wahnkyo LEE	Art Unit 2624	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,246,784 B1	06-2001	Summers et al.	382/128
*	B	US-2003/0004405 A1	01-2003	Townsend et al.	600/407
*	C	US-2003/0212320 A1	11-2003	Wilk et al.	600/407
*	D	US-2004/0141638 A1	07-2004	Acar et al.	382/131
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Perona et al., "Scale-Space and Edge Detection using Anisotropic Diffusion," July 1990, IEEE, vol. 12, pages 629-639
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/27/2006	09/07/2007	05/25/2008	11/07/2008	04/22/2009	11/20/2009	07/09/2010		
	1	✓	-	-	-	-	-	-		
	2	✓	-	-	-	-	-	-		
	3	✓	-	-	-	-	-	-		
	4	✓	-	-	-	-	-	-		
	5	✓	-	-	-	-	-	-		
	6	✓	-	-	-	-	-	-		
	7	✓	-	-	-	-	-	-		
	8	✓	-	-	-	-	-	-		
	9		✓	-	-	-	-	-		
	10		✓	-	-	-	-	-		
	11		✓	-	-	-	-	-		
	12		✓	-	-	-	-	-		
	13		✓	-	-	-	-	-		
	14		✓	-	-	-	-	-		
	15			✓	✓	✓	✓	✓		
	16			✓	✓	✓	✓	✓		
	17			✓	✓	✓	✓	✓		
	18			✓	✓	✓	✓	✓		
	19			✓	✓	✓	✓	✓		
	20			✓	✓	✓	✓	✓		
	21			✓	✓	✓	✓	✓		
	22			✓	✓	✓	✓	✓		
	23			✓	✓	✓	✓	✓		
	24			✓	✓	✓	✓	✓		
	25			✓	✓	✓	✓	✓		
	26			✓	✓	✓	✓	✓		
	27			✓	✓	✓	✓	✓		
	28			✓	✓	✓	✓	✓		
	29			✓	✓	✓	✓	✓		
	30			✓	✓	✓	✓	✓		
	31			✓	✓	✓	✓	✓		
	32			✓	✓	✓	✓	✓		

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10955037	BONNET ET AL.
	Examiner	Art Unit
	Lee, John W	2112

SEARCHED			
Class	Subclass	Date	Examiner
382	128	12/26/2006	John W. Lee
345	420	12/26/2006	John W. Lee
382	128	11/06/2008	John W. Lee

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor Search	12/26/2006	John W. Lee
East Search	12/26/2006	John W. Lee
IEEE (Non- Patent Literature Search)	12/26/2006	John W. Lee
EAST Search	11/06/2008	John W. Lee
EAST Search	4/22/2009	John W. Lee
EAST Search	11/20/2009	John W. Lee
Inventor Search (using EDAN)	7/9/2010	John W. Lee
Inventor Search (using EAST)	7/9/2010	John W. Lee
Assignee Search (using EAST)	7/9/2010	John W. Lee
EAST Search	7/1/2010	John W. Lee
Plus Search	7/6/2010	John W. Lee
NPL search (using google)	7/5/2010	John W. Lee
382/128, 345/420 and 600/427 (combined with keyword search)	7/1/2010	John W. Lee

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

/JOHN W LEE/ Examiner.Art Unit 2624	

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/955,037	09/30/2004	Stephane Bonnet	27592-00987- US	4535

30678 7590 07/12/2010
CONNOLLY BOVE LODGE & HUTZ LLP
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EXAMINER	
LEE, JOHN W	
ART UNIT	PAPER NUMBER
2624	

MAIL DATE	DELIVERY MODE
07/12/2010	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/955,037	BONNET ET AL.	
	Examiner	Art Unit	
	JOHN Wahnkyo LEE	2624	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *19 February 2010*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-32* is/are pending in the application.

4a) Of the above claim(s) *1-14* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *15-32* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *30 September 2004* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

- Claims 15-32 are pending; claims 1-14 are canceled; claims 15 and 26 are amended.

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 19 February 2010 has been entered.

Response to Amendments/Arguments

2. Applicant's amendment filed 19 February 2010 is entered and has been fully considered.

3. Applicant's arguments of the rejected claims 15-32 under 35 U.S.C. § 112 have been considered. The claims was amended to the way to overcome the rejection under 35 U.S.C. § 112. So, the rejection will be withdrawn.

4. Applicant's arguments of the rejected claims 15-32 under 35 U.S.C. § 103(a)[1] have been considered but are moot in view of the new ground(s) of rejection.

---

[1] Claims 15-32 are rejected under 35 U.S.C. 103(a) as being unpatentable over De Murcia et al. (US 5,889,525) in view of Townsend et al. (US 2003/0004405)

Priority

5. Acknowledgment is made of applicant's claim benefit for foreign priority under 35 U.S.C. 119(a)-(d) or (f). The certified copy has been filed in parent Application (FR 03 50631), filed on 1 October 2003.

6. Receipt is acknowledged of papers submitted under 35 U.S.C. 119(a)-(d) or (f), which papers have been placed of record in the file.

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8. Claims 15-20 and 25-28 are rejected under 35 U.S.C. 102(b) as being anticipated by Townsend et al. (US 2003/0004405 A1).

a. Regarding claim 15, Townsend discloses a method of forming an image (Fig.3; “image fusion” at ¶ 0080) of a mobile object (Fig. 2b; “patient” at ¶¶ 0070 and 0073), comprising:

obtaining a plurality of first images (“CT images” at ¶ 0075) of the mobile object (Fig. 2b; “patient” at ¶¶ 0070 and 0073) using a first imaging technique (“X-ray CT” at ¶¶ 0070 and 0073) and an associated plurality of first measurements (Fig. 2b-12; “X-ray CT detectors” at ¶ 0073) of the mobile object (Fig. 2b; “patient” at ¶¶ 0070 and 0073) at

movement states (Fig. 2b-18; "patient bad [being] movable") corresponding to movement states ("a patient may be … moved into position for … X-ray CT scan" at ¶ 0071) of said plurality of first images ("CT images" at ¶ 0075);

obtaining a plurality of second images ("PET images" at ¶0075) of the mobile object (Fig. 2b; "patient" at ¶¶ 0070 and 0073) using a second imaging technique ("PET" at ¶¶ 0070 and 0073) and an associated plurality of second measurements (Fig. 2b-14; "PET tomograph detectors" at ¶ 0073) of the mobile object (Fig. 2b; "patient" at ¶¶ 0070 and 0073) at movement states (Fig. 2b-18; "patient bad [being] movable") corresponding to movement states ("a patient may be … moved into position for … PET scan" at ¶ 0071) of said plurality of second images ("PET images" at ¶0075), wherein the plurality of second measurements (Fig. 2b-14; "PET tomograph detectors" at ¶ 0073) are distinct from the plurality of first measurements(Fig. 2b-12; "X-ray CT detectors" at ¶ 0073; "The second measurements are PET tomograph detectors that are different and distinct with the first measurements, which are X-ray CT detectors"); and

forming an image (Fig.3; "image fusion" at ¶ 0080) of the mobile object (Fig. 2b; "patient" at ¶¶ 0070 and 0073) based on said plurality of first images ("CT images" at ¶ 0075) and said associated plurality of first measurements (Fig. 2b-12; "X-ray CT detectors" at ¶ 0073) and on said plurality of said second images ("PET images" at ¶0075) and said associated plurality of second measurements (Fig. 2b-14; "PET tomograph detectors" at ¶ 0073),

wherein the first imaging technique ("X-ray CT" at ¶¶ 0070 and 0073) is different from the second imaging technique ("PET" at ¶¶ 0070 and 0073; "The first imaging

technique is a X-ray CT that is different with the second imaging technique, which is a PET.") .

b. Regarding claim 16, Townsend discloses further comprising:

time-synchronizing said first measurements (Fig. 2b-12; "X-ray CT detectors" at ¶ 0073) and said second measurements(Fig. 2b-14; "PET tomograph detectors" at ¶ 0073; "The invention shows that synchronization, which "the CT scan is acquired before the PET scan, following a sixty (60) minute uptake period F-FDG activity has been injected into the patient"" at ¶ 0075).

c. Regarding claim 17, Townsend discloses further comprising:

forming first reconstructed images corresponding to said plurality of first images ("[t]he CT images [being] reconstructed" at ¶ 0075) and second reconstructed images corresponding to said plurality of second images ("the PET images [being] then reconstructed" ¶ 0075).

d. Regarding claim 18, Townsend discloses further comprising:

spatially-synchronizing ("image fusion" at ¶ 0080) said first reconstructed images and said second reconstructed images ("fused PET and CT images" at ¶ 0080).

e. Regarding claim 19, Townsend discloses wherein said first imaging technique being a radiation attenuation technique ("X-ray CT" at ¶¶ 0070 and 0073) and said second imaging technique being a radiation emission technique ("PET" at ¶¶ 0070 and 0073).

f. Regarding claim 20, Townsend discloses further comprising:

spatially-synchronizing information ("positional correspondence between the two image sets" at ¶ 0080) based on said plurality of first measurements (Fig. 2b-12; "X-ray CT detectors" at ¶ 0073) and information based on said plurality of second measurements (Fig. 2b-14; "PET tomograph detectors" at ¶ 0073).

g. Regarding claim 25, Townsend discloses wherein said plurality of first measurements (Fig. 2b-12; "X-ray CT detectors" at ¶ 0073) and said plurality of second measurements (Fig. 2b-14; "PET tomograph detectors" at ¶ 0073) are taken using separate measurement systems (Figs. 2b-12 and 2b-14; "X-ray CT detectors and PET tomograph detectors are different measurements in separate gantries" at ¶ 0073) respectively associated with separate imaging systems (Figs. 2b-12, 2b-14, 16A and 16b; "X-ray CT detectors are disposed in gantry 16A and PET tomograph detectors are disposed in gantry 16B. Gentries 16A and 16B are separate platforms." at ¶ 0073) used to obtain said plurality of first images ("CT images" at ¶ 0075) and said plurality of second images ("PET images" at ¶0075).

h. Regarding claim 26, claim 26 is a system claim analogous and corresponds to claim 15. See rejection of claim 15 for further explanation.

i. Regarding claim 27, claim 27 is a system claim analogous and corresponds to claim 17. See rejection of claim 17 for further explanation.

j. Regarding claim 28, claim 28 is a system claim analogous and corresponds to claim 19. See rejection of claim 19 for further explanation.

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

10. Claims 21-23 and 29-31 are rejected under 35 U.S.C. 103(a) as being unpatentable over Townsend et al. (US 2003/0004405 A1) in view of Acar et al. (US 2004/0141638 A1).

a Regarding claim 21, Townsend discloses all the previous claim limitations including said plurality of first images ("CT images" at ¶ 0075), said plurality of first measurements (Fig. 2b-12; "X-ray CT detectors" at ¶ 0073), said plurality of second images ("PET images" at ¶0075) and said plurality of second measurements (Fig. 2b-14; "PET tomograph detectors" at ¶ 0073).

However, Townsend does not disclose forming displacement fields.

Instead of Townsend, Acar, the same field of medical image processing discloses forming displacement fields (equation (1); FIG. 1; "It is shown that the EDF, "$v_{z=k}$ (x,y)" is computed from z=k to z=k+1" at ¶¶ 0013-0014 and 0015-0017).

Townsend and Acar are combinable because both are related to the field of medical image processing.

It would have been obvious at the tie the invention was made to one of the ordinary skill in the art to utilize the step of computing "EDF, $v_{z=k}$ (x,y) from z=k to z=k+1" (Acar; equation (1); FIG.1; ¶¶ 0013-0014 and 0015-0017) taught by Acar to the plurality

of first images (Townsend; "CT images" at ¶ 0075) obtained by the plurality of first measurements (Townsend; Fig. 2b-12; "X-ray CT detectors" at ¶ 0073) and to the plurality of second images ("PET images" at ¶0075) obtained by the plurality of second measurements (Fig. 2b-14; "PET tomograph detectors" at ¶ 0073) of Townsend's "PET/CT scanner" (Townsend; FIG. 2B; ¶ 0073).

The suggestion/motivation for doing so would have been to "characteriz[e] the topology of the vector field for detection, identification or recognition tasks of a structure of interest" (Acar; ¶ 0006) "with a high specificity without sacrificing the sensitivity of detection" (Acar; ¶ 0006).

Therefore, it would have been obvious to combine Townsend and Acar to obtain the invention specified in claim 21.

b. Regarding claim 22, the combination of Townsend and Acar, as applied in claim 21, discloses all the previous claim limitations including said forming an image (Townsend; Fig.3; "image fusion" at ¶ 0080) of the mobile object (Townsend; Fig. 2b; "patient" at ¶¶ 0070 and 0073).

Moreover, Acar discloses combining said displacement fields (FIG. 1; "$v_{z=k}$ (x,y) for all k are summed ,,, to get a composite EDF" at ¶ 0017).

Townsend and Acar are combinable because both are related to the field of medical image processing.

It would have been obvious at the tie the invention was made to one of the ordinary skill in the art to utilize the step of computing "$v_{z=k}$ (x,y) for all k being summed ,,, to get a composite EDF" (Acar; FIG.1; ¶ 0017) taught by Acar to the step of forming an

image (Townsend; Fig.3; "image fusion" at ¶ 0080) of the mobile object (Townsend; Fig. 2b; "patient" at ¶¶ 0070 and 0073) of the combination of Townsend and Acar.

The suggestion/motivation for doing so would have been to "determine parameters … [which] are used to classify the structure of interest" (Acar; ¶ 0007) and "refine the results of high sensitivity, low specificity pre-detection by increasing specificity without sacrificing sensitivity" (Acar; ¶ 0013).

Therefore, it would have been obvious to combine Townsend and Acar to obtain the invention specified in claim 22.

c. Regarding claim 23, the combination of Townsend and Acar, as applied in claim 21, discloses wherein said forming displacement fields (Acar; equation (1); FIG. 1; "It is shown that the EDF, "$v_{z=k}$ (x,y)" is computed from z=k to z=k+1" at ¶¶ 0013-0014 and 0015-0017) comprises:

estimating movement (Acar; equation (1); "EDF computation to represent the changes in the location of edges" at ¶ 0015) of the mobile object (Acar; "images such as tissue/air boundaries" at ¶ 0015) based, respectively, on said plurality of first images (Townsend; "CT images" at ¶ 0075), said plurality of second images (Townsend; "PET images" at ¶0075), said plurality of first measurements (Townsend; Fig. 2b-12; "X-ray CT detectors" at ¶ 0073), and said plurality of second measurements (Townsend; Fig. 2b-14; "PET tomograph detectors" at ¶ 0073), in order to form said displacement fields (Acar; equation (1); FIG. 1; "It is shown that the EDF, "$v_{z=k}$ (x,y)" is computed from z=k to z=k+1" at ¶¶ 0013-0014 and 0015-0017).

d. Regarding claim 29, claim 29 is analogous and corresponds to claim 21. See rejection of claim 21 for further explanation.

e. Regarding claim 30, claim 30 is analogous and corresponds to claim 22. See rejection of claim 22 for further explanation.

f. Regarding claim 31, claim 31 is analogous and corresponds to claim 23. See rejection of claim 23 for further explanation.

11. Claims 24 and 32 are rejected under 35 U.S.C. 103(a) as being unpatentable over Townsend et al. (US 2003/0004405 A1) in view of Acar et al. (US 2004/0141638 A1), and further in view of Perona et al. ("Scale-Space and Edge Detection Using Anisotropic Diffusion").

a. Regarding claim 24, the combination of Townsend and Acar, as applied in claim 23, discloses all the previous claim limitations including wherein at least one of said movement estimates (Acar; equation (1); "EDF computation to represent the changes in the location of edges" at ¶ 0015).

However, the combination of Townsend and Acar does not disclose the estimates being formed relative to a reference time.

Instead of the combination of Townsend and Acar, Perona, the same field of endeavor of image processing, discloses the estimates being formed relative to a reference time (equation (1); "It is shown that I (x, y, t) is obtained by convolving the original image I_0 (x,y) with a Gaussian kernel G (x,y; t) of variance t, which can be the reference time" at chapter I, page 629)

Townsend, Acar and Perona are combinable because all of them are related to the field of image processing.

It would have been obvious at the time the invention was made one of ordinary skill in the art to utilize the step of “I (x, y, t) [being] obtained by convolving the original image I_0 (x,y) with a Gaussian kernel G (x,y; t) of variance t", which can be the reference time (Perona; equation (1); chapter I, page 629) taught by Perona to the “EDF computation [] [representing] the changes in the location of edges” (Acar; ¶ 0015) when "[t]he EDF equation for the xy plane is $\nabla I_{z=k} \cdot v_{z=k} + \frac{\partial I_{z=k}}{\partial z} = 0$" (Acar; equation (1); ¶ 0016) and "$I_{z=k}(x, y)$ is the associate image" (Acar; ¶ 0017) of the combination of Townsend and Acar.

The suggestion/motivation for doing so would have been to provide "[c]ausality [,] [which] [a]ny feature at a coarse level of resolution is required to possess (not a necessarily unique) "cause" at a finer level of resolution" (Perona; chapter 1, page 629) and "no spurious detail should be generated when the resolution is diminished" (Perona; chapter 1, page 629), "[h]omogenity [and] [i]sotropy … for the sake of simplicity” (Perona; chapter 1, page 629).

Therefore, it would have been obvious to combine Townsend, Acar and Perona to obtain the invention specified in claim 24.

b. Regarding claim 32, claim 32 is analogous and corresponds to claim 24. See rejection of claim 24 for further explanation.

Conclusion

12. No claims are allowed.

13. The prior art made of record is considered pertinent to the disclosure of the application:

- Summers et al. (US 6,246,784 B1): A region growing method segments three-dimensional image data of an anatomical structure using a tortuous path length limit to constrain voxel growth. The path length limit constrains the number of successive generations of voxel growth from a seed point to prevent leakage of voxels outside the boundary of the anatomical structure. Once segmented, a process for detecting surface anomalies performs a curvature analysis on a computer model of the surface of the structure. This process detects surface anomalies automatically by traversing the vertices in the surface model, computing partial derivatives of the surface at the vertices, and computing curvature characteristics from the partial derivatives. To identify possible anomalies, the process compares the curvature characteristics with predetermined curvature characteristics of anomalies and classifies the vertices. The process further refines potential anomalies by segmenting neighboring vertices that are classified as being part of an anomaly using curvature characteristics. Finally, the process colorizes the anomalies and computes a camera position and direction for each one to assist the user in viewing 2D renderings of the computer model.

- Wilk et al. (US 2003/0212320): A method of determining linear and angular displacements of a first coordinate system of a field of view of a first imaging system relative to a second a coordinate system of a field of view of a second imaging system, the method comprising: providing a phantom having a plurality of fiducial regions that can be imaged by both imaging systems; acquiring first and second images of the phantom with the first and second imaging systems wherein spatial coordinates of features in the first and second images reference the first and second coordinate systems respectively; determining positions of a plurality of features of the fiducials in the first image and spatial coordinates of the same features in the second image; and using the coordinates to determine the linear and angular displacements.

14. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JOHN Wahnkyo LEE whose telephone number is (571)272-9554. The examiner can normally be reached on Monday - Friday (Alt.) 7:30 a.m. - 5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Samir Ahmed can be reached on (571) 272-7413. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For

more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/John Wahnkyo Lee/
Examiner, Art Unit 2624

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L15	11431	(commissariat$5.asnm. or intellectual$7.asnm.)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/09 00:52
L16	2593	(bonnet-stephane.in. or bonnet.in.)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/09 00:52
L17	96	(grangeat-pierre.in. or grangeat.in.)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/09 00:52
L18	2686	L16 or L17	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/09 00:52

L19	30	15 and L18	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/09 00:52
L20	284977	(mobile or techinque or measurement).clm.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/09 00:53
L21	17	19 and L20	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/09 00:53
S1	96	"6490476"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:10
S2	5	09/685222	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:11
S3	6	"6527090"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:15

S4	41	"5124914"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:18
S5	5	"5333107"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:18
S6	1	07/788179	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:18
S7	9	"5408511"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:19
S8	8	"5475726"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:19
S9	4	"5406478"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:19

S10	1	08/249993	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:20
S11	9	"5444792"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:21
S12	6	"5814817"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/06/30 16:21
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	10/955,037-Conf. #4535
Filing Date	September 30, 2004
First Named Inventor	Stephane Bonnet
Art Unit	2624
Examiner Name	J. W. Lee
Attorney Docket Number	27592-00987-US

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	AA*	US-20030004405	01-02-2003	Townsend et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	BA	WO-200180184-A1	10-25-2001	Gen Electric		
	BB	EP-1087337-A1	03-28-2001	Ge Medical Syst Sa		

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(Use as many sheets as necessary)

Sheet 2 of 2

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Attorney Docket Number	27592-00987-US

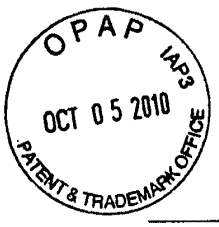
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Examiner Initials	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	CA	Timo Makela et al., "A Review of Cardiac Image Registration Methods," IEEE Transactions on Medical Imaging, IEEE Service Center, Piscataway, NJ, vol. 21, no. 9, 1 Sept. 2002	
	CB	Calvert et al., "Crossmodal identification," Trends in Cognitive Sciences, Elsevier Science, Oxford, GB, vol. 2, no. 7, 1 July 1998, pages 247-253	
	CC	J. Ashburner et al., "Multimodal image coregistration and partitioning - a unified framework," Neuroimage, vol. 6, no. 3, October 1997, pages 209-217	

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Docket No.: 27592-00987-US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Stephane Bonnet et al.

Application No.: 10/955,037 | Confirmation No.: 4535

Filed: September 30, 2004 | Art Unit: 2624

For: Method of reconstructing an image with data acquisition according to several imagery modes and synchronisation of image series | Examiner: J. W. Lee

INFORMATION DISCLOSURE STATEMENT (IDS)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Pursuant to 37 CFR 1.56, 1.97 and 1.98, the attention of the Patent and Trademark Office is hereby directed to the references listed on the attached PTO/SB/08. It is respectfully requested that the information be expressly considered during the prosecution of this application, and that the references be made of record therein and appear among the "References Cited" on any patent to issue therefrom.

This Information Disclosure Statement is filed more than three months after the U.S. filing date, OR more than three months after the date of entry of the national stage of a PCT application, AND after the mailing date of the first Office Action on the merits, whichever occurs first, but before the mailing date of any of a Final Office Action, a Notice of Allowance (37 CFR 1.97(c)) or an action that otherwise closes prosecution in the application.

I hereby certify, pursuant to 37 CFR 1.97(e)(1), that each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign

patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement.

In accordance with 37 CFR 1.98(a)(2)(ii), Applicant has not submitted copies of U.S. patents and U.S. patent applications. Applicant submits herewith copies of foreign patents and non-patent literature in accordance with 37 CFR 1.98(a)(2).

In accordance with 37 CFR 1.97(g), the filing of this Information Disclosure Statement shall not be construed to mean that a search has been made or that no other material information as defined in 37 CFR 1.56(a) exists. In accordance with 37 CFR 1.97(h), the filing of this Information Disclosure Statement shall not be construed to be an admission that any patent, publication or other information referred to therein is "prior art" for this invention unless specifically designated as such.

It is submitted that the Information Disclosure Statement is in compliance with 37 CFR 1.98 and the Examiner is respectfully requested to consider the listed references.

The Director is hereby authorized to charge any deficiency in the fees filed, asserted to be filed or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our Deposit Account No. 22-0185, under Order No. 27592-00987-US.

Dated: October 5, 2010

Respectfully submitted,

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(54) Process for reconstructing a tri-dimensional image of a moving object

(57) A process for reconstructing a tri-dimensional image of an object moving with a substantially cyclic motion, for example the vessels of the human heart, in which, for an acquisition duration extending over several cycles of the movement of the object, an acquisition of a plurality of initial digital radiographic images is performed using a snapshot apparatus rotating around the object. Initial images having the same temporal occurrence in the course of each cycle are selected respectively in successive cycles so as to form a group of images which is associated with this same temporal occurrence. Several different groups of initial images corresponding respectively to several different temporal occurrences are formed. An intermediate tri-dimensional representation of the object is reconstructed on the basis of each group of initial images and of an iterative image reconstruction algorithm. A law of spatial deformation between two intermediate tri-dimensional representations is formulated on the basis of the two intermediate tri-dimensional representations corresponding to two successive temporal occurrences, and a final tri-dimensional representation of the object is reconstructed on the basis of the initial images successively acquired, of the spatial deformation laws successively formulated and of an iterative image reconstruction algorithm.

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Description

[0001] The invention relates to the reconstruction of a tri-dimensional image of a moving object, in particular moving with a substantially cyclic motion.

[0002] The invention finds a particularly interesting application in the medical field, in which the reconstruction of the internal structures of patients under examination, in particular the reconstruction of images of vessels of the heart, is undertaken.

[0003] The invention can however find applications in other fields, especially in industrial non-destructive testing in which examinations of the same type as medical examinations are carried out.

[0004] The tri-dimensional reconstruction of images is generally performed on the basis of bi-dimensional projected images of the object. However, difficulties arise in this image reconstruction when the object is moving, as is the case for the heart.

[0005] Another difficulty encountered in the reconstruction of tri-dimensional images on the basis of bi-dimensional images resides in the difficulty of matching between the images, that is to say of being able to tag with minimum error the same elements of the object, for example certain vessels, from one image to another. The difficulty is further increased here owing to the movement of the object, for example the heart.

[0006] Certain reconstruction techniques require the intervention of the user, in this instance the doctor, to solve the matching problems more easily.

[0007] he invention proposes a fully automatic reconstruction of images of a moving object, and which requires minimum, or even zero interaction with the doctor.

[0008] In an embodiment of the invention, there is proposed a process for reconstructing a tri-dimensional image of an object moving with a substantially cyclic motion, for example the vessels of the human heart, in which, for an acquisition duration extending over several cycles of the movement of the object, an acquisition of a plurality of initial digital radiographic images is performed using a snapshot apparatus rotating around the object. Initial images having the same temporal occurrence in the course of each cycle are selected respectively in successive cycles in such a way as to form a group of images which is associated with this same temporal occurrence. Several different groups of initial images corresponding respectively to several different temporal occurrences are formed. An intermediate tri-dimensional representation of the object is reconstructed on the basis of each group of initial images and of an iterative image reconstruction algorithm. A law of spatial deformation between two intermediate tri-dimensional representations is formulated on the basis of the two intermediate tri-dimensional representations corresponding to two successive temporal occurrences, and a final tri-dimensional representation of the object is reconstructed on the basis of the initial images successively acquired, of the spatial deformation laws successively formulated and of an iterative image reconstruction algorithm.

[0009] An embodiment of the invention makes it possible ultimately to obtain a tri-dimensional representation of the object which takes its movement into account. The user, in this instance the doctor, can then easily be provided, on his screen, with a projected bi-dimensional image of this object on the basis of the final tri-dimensional representation obtained. Moreover, given that successive laws or models of spatial deformation corresponding to different temporal occurrences have moreover been formulated, it is also possible to provide the user, for example the doctor, with projected bi-dimensional images of the object, and especially of certain vessels, at successive time instants.

[0010] Stated otherwise, the process according to the invention allows the reconstruction of an image in "four" dimensions, namely a tri-dimensional image furthermore assigned a time parameter.

[0011] The selection, in the successive cycles, of the images having the same temporal occurrence can be performed by using an auxiliary control signal representative of the cyclic motion of the object. Thus, it will be possible to use a physiological signal such as for example an electrocardiogram representative of the movement of the heart and making it possible to determine accurately the cycles of the cardiac movement.

[0012] The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:-

Figure 1 illustrates an acquisition of digital radiographic images in a cardiac application, and

Figures 2 to 4 very schematically illustrate the various steps making it possible to obtain the final tri-dimensional representation of the object.

[0013] Although the invention is not limited thereto, the application of the process according to the invention to the reconstruction of an image of vessels VS of the heart OBJ of a patient will now be described.

[0014] In Figure 1, the references PVi designate various snapshots acquired by rotating Rot an X-ray source (not represented here for the sake of simplification) around the chest of the patient.

[0015] Each initial image acquired IMi is obtained on the basis of a bi-dimensional radiation detector, for example of the luminance amplifier type used in radiology, disposed opposite the X-ray tube in a projection plane.

[0016] In the case of an X-ray imaging system composed of an X-ray source and a bi-dimensional detector, the geometrical operation involved in producing the image acquired is a conical projection of an analysed object deployed in a three-dimensional space, onto a two-dimensional space which is that of the projection

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plane corresponding to the detection plane. The calibration of an imaging system, that is to say the operation which culminates in accurate indirect knowledge of the geometrical parameters which are involved in producing an image is conventional and well known to the person skilled in the art.

[0017] As illustrated in Figure 1, a continuous acquisition is performed for a predetermined duration, for example 5 seconds, corresponding to 5 cycles CYC1-CYC5 of the movement of the heart. With an acquisition rate of 10 images per second, substantially 10 acquired initial images are therefore obtained per cycle of the cardiac movement.

[0018] The cycles of the cardiac movement are tagged by using an auxiliary control signal ECG, which can be in this instance an electrocardiogram. The systolic and diastolic phases of the movement of the heart are thus determined in particular.

[0019] Once the acquisition of the initial images has been performed, an initial image, whose temporal occurrence is the same for all the cycles, is selected in each cycle. For example, the first initial image IM1 after the start of the cycle of the cardiac movement is selected. 5 initial images IM1 (Figure 2) are then obtained on the basis of which a reconstruction of an intermediate tri-dimensional representation of the vessels VS of the heart is performed using an iterative image reconstruction algorithm. The principle of such an iterative image reconstruction algorithm is fully known to the person skilled in the art and has already formed the subject of numerous publications. Mention will be made in particular of the article by Gordon, Bender, and Herman entitled "Algebraic reconstruction technique for tri-dimensional electron microscopy and X-ray photography", Journal of Theol. Biol. 29, pages 9471 to 781 (1970) or else French patent applications no. 89 03606 or 89 16906.

[0020] The process for reconstructing a tri-dimensional image of an object as described in French patent application no. 2 752 975 can also be implemented.

[0021] The person skilled in the art will be able to refer to these prior art documents for further details regarding a mode of implementation of the image reconstruction algorithm and/or the phase for calibrating the snapshot apparatus.

[0022] At the conclusion of this intermediate reconstruction step, a first intermediate tri-dimensional representation of the blood vessels of the heart RT1 is obtained. The same operations are performed with the images IM2, each initial image IM2 of the cycle being the second initial image acquired after the start of the cycle. A second intermediate tri-dimensional representation RT2 is then obtained.

[0023] The same operations are preferably performed for each image of the cycle so as finally to obtain in the present case 10 tri-dimensional intermediate representations.

[0024] The next step consists, as illustrated in Figure 3, in formulating for two successive intermediate tri-dimensional representations RT1 and RT2 for example, a law of spatial deformation making it possible to formulate a model of deformation between the two tri-dimensional representations RT1 and RT2. The same operations are performed in a general manner so as to obtain between two successive intermediate representations RTi and RTj a model of geometrical deformation LDij.

[0025] By way of example, one manner of obtaining such a law of spatial deformation, representative of the movement of the heart between two successive temporal occurrences, can be performed by a conventional technique for tracking elements of interest (for example a specific vessel) between the various successive tridimensional representations.

[0026] Such matching techniques are for example described in the article by Singh A. and Allen P.K. entitled "Image flow computation: an estimation theoretic Framework and a unified perspective", Computer Vision Graphics and Image Processing, Vol. 56, number 2, September 1992, pages 152-177. The person skilled in the art may optionally refer thereto.

[0027] Once all the spatial deformation laws have been obtained, a final tri-dimensional representation RTF of the vessels of the heart is reconstructed by applying the iterative image reconstruction algorithm and this time using all the initial images acquired IMi in the course of the total duration of acquisition. Moreover, the iterative image reconstruction algorithm will successively take into account, from one initial image to another, the corresponding spatial deformation law previously formulated in such a way as ultimately to obtain a correct representation of the vessels of the heart, given the latter's movement.

[0028] From a hardware point of view, in addition to the conventional snapshot apparatus, the device allowing the implementation of the process includes a computer implementing the various software means such as the iterative image reconstruction algorithm and equipped with a screen for displaying the final projected images obtained on the basis of the final tri-dimensional representation.

[0029] Moreover, although all the initial images of the cycle have been taken into account so as to formulate as many intermediate tri-dimensional representations, it would have been possible to take just one out of two, or one out of three into account so as to formulate fewer intermediate representations. This would however have led to less accurate spatial deformation laws.

Claims

1. A process for reconstructing a tri-dimensional image of an object moving with a substantially cyclic motion, in which, for an acquisition duration extending over several cycles of the movement of the object, an acquisition of a plurality of initial dig-

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ital radiographic images (IMi) is performed using a snapshot apparatus rotating around the object, initial images having the same temporal occurrence in the course of each cycle are selected respectively in successive cycles in such a way as to form a group of images which is associated with this same temporal occurrence, several different groups of initial images corresponding respectively to several different temporal occurrences are formed, an intermediate tri-dimensional representation of the object (RTi) is reconstructed on the basis of each group of initial images and of an iterative image reconstruction algorithm, a law of spatial deformation (LDIj) between two intermediate tri-dimensional representations is formulated on the basis of the two intermediate tri-dimensional representations corresponding to two successive temporal occurrences, and a final tri-dimensional representation of the object is reconstructed on the basis of the initial images successively acquired, of the spatial deformation laws successively formulated and of an iterative image reconstruction algorithm.

2. The process according to claim 1 wherein the images having the same temporal occurrence are selected in successive cycles by using an auxiliary control signal (ECG) representative of the cyclic motion of the object.

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