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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314

CONFIRMATION NO. 2632

35690
MEYERTONS, HOOD, KIVLIN, KOWERT & GOETZEL, P.C.
P.O. BOX 398
AUSTIN, TX 78767-0398

POA ACCEPTANCE LETTER

OC000000057480511

Date Mailed: 11/09/2012

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/31/2012.

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.

/hchristian/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314

CONFIRMATION NO. 2632

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

POWER OF ATTORNEY NOTICE

OC000000057480493

Date Mailed: 11/09/2012

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/31/2012.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71.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).

/hchristian/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/80 (11-08)
Approved for use through 11/30/2011. OMB 0651-0035
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.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

[x] Practitioners associated with the Customer Number: **35690**

OR

[ ] Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

[x] The address associated with Customer Number: **35690**

OR

[ ] Firm or Individual Name					
Address					
City		State		Zip	
Country		Telephone		Email	

Assignee Name and Address:

OL Security Limited Liability Company
160 Greentree Drive
Suite 101
Dover, Delaware U.S.A.
19904

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

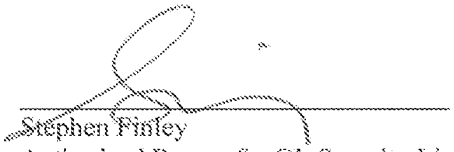
Signature		Date	8-10-2017
Name	Stephen Finley	Telephone	
Title	Authorized Person for OL Security Limited Liability Company		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. 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 3 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.

DECLARATION REGARDING AUTHORITY TO SIGN
ON BEHALF OF A LEGAL ENTITY
37 C.F.R. 3.73(b)(2)(i)

I, Stephen Finley (whose title is supplied below), hereby declare that I am authorized to sign documents on behalf of OL Security Limited Liability Company



Stephen Finley
Authorized Person for OL Security Limited Liability Company

9-16-2022
Date

Electronic Acknowledgement Receipt	
EFS ID:	14121426
Application Number:	07810005
International Application Number:	
Confirmation Number:	2632
Title of Invention:	GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD
First Named Inventor/Applicant Name:	ALAN J. KATZ
Correspondence Address:	RENE E GROSSMAN RAYTHEON COMPANY PO BOX 660246 MS 17 - DALLAS TX 75266 US 972-344-1205 -
Filer:	Dean M. Munyon/Dawn DeLuca
Filer Authorized By:	Dean M. Munyon
Attorney Docket Number:	TI-16314
Receipt Date:	31-OCT-2012
Filing Date:	18-DEC-1991
Time Stamp:	22:57:35
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	Assignee showing of ownership per 37 CFR 3.73.	373b.pdf	40000 70879d12bbd9f39d1d28a537f5a690a239ae98fc	no	3
Warnings:					
Information:					
2	Power of Attorney	POA.pdf	734436 e1aa4175bfcf84eee5a7b8c2bc60a79045cff03b	no	1
Warnings:					
Information:					
3	Miscellaneous Incoming Letter	DRATS.pdf	216902 24564e07ba146ccd5f3ca59a5511f47fab6db1d6	no	1
Warnings:					
Information:					
		Total Files Size (in bytes):	991338		

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.

PTO/SB/96 (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.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: OL SECURITY LIMITED LIABILITY COMPANY

Application No./Patent No.: 6894639 Filed/Issue Date: 05/17/2005

Titled: GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD

OL SECURITY LIMITED LIABILITY COMPANY , a LIMITED LIABILITY COMPANY

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. ☒ the assignee of the entire right, title, and interest in;

2. ☐ an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is _____ %); or

3. ☐ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy therefore is attached.

OR

B. ☒ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Alan J. Katz To: Texas Instruments Incorporated

The document was recorded in the United States Patent and Trademark Office at
Reel 005976 , Frame 0088 , or for which a copy thereof is attached.

2. From: Texas Instruments Incorporated To: Raytheon TI Systems, Inc.

The document was recorded in the United States Patent and Trademark Office at
Reel 008628 , Frame 0414 , or for which a copy thereof is attached.

3. From: Raytheon TI Systems, Inc. To: Raytheon Company

The document was recorded in the United States Patent and Trademark Office at
Reel 011903 , Frame 0684 , or for which a copy thereof is attached.

☒ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Dean M. Munyon/	10/31/2012
Signature	Date
Dean M. Munyon	Reg. No. 42,914
Printed or Typed Name	Title

This collection of information is required by 37 CFR 3.73(b). 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. 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.

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 disclosure of these records is required by the Freedom of Information Act.
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 inspection 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.

Supplemental Sheet

A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee continues as follows:

4. From: Raytheon Company To: OL Security Limited Liability Company
The document was recorded in the United States Patent and Trademark Office at
Reel 029117 , Frame 0335 , or for which a copy thereof is attached.

5. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____ , Frame _____ , or for which a copy thereof is attached.

6. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____ , Frame _____ , or for which a copy thereof is attached.
_____ _____

7. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____ , Frame _____ , or for which a copy thereof is attached.
_____ _____

8. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____ , Frame _____ , or for which a copy thereof is attached.
_____ _____

1-18-05

PART B - FEE(S) TRANSMITTAL

IMAGE

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (703) 746-4000

JAN 14 2005

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 10/18/2004

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

01/19/2005 YPOLITE2 00000048 07810005

01 FC:1501 1400.00 OP
02 FC:8001 30.00 OP

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (703) 746-4000, on the date indicated below.

See attached Certificate of Express	(Depositor's name)
Mail Receipt No. EV 322186248 US	(Signature)
	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

TITLE OF INVENTION: GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1370	$0	$1370	01/18/2005

EXAMINER	ART UNIT	CLASS-SUBCLASS
GREGORY, BERNARR E	3662	342-090000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Baker Botts L.L.P.
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Raytheon Company

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Waltham, MA

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☒ Advance Order - # of Copies 10

4b. Payment of Fee(s):
- ☒ A check in the amount of the fee(s) is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 02-0384 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date 1/14/05

Typed or printed name Bradley P. Williams Registration No. 40,227

This collection of information is required by 37 CFR 1.311. 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, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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OIPE JC37 JAN 14 2005 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Alan J. Katz
Serial No.:	07/810,005
Filed:	December 18, 1991
Group No.:	3662
Examiner:	Bernarr E. Gregory
Notice of Allowance Mailed:	October 18, 2004
Confirmation No.:	2632
Title:	GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHODS

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

RESPONSE TO REASONS FOR ALLOWANCE

Applicant appreciates the Examiner's allowance of Claims 1-20. Pursuant to 37 C.F.R. § 1.104, Applicant respectfully issues a statement commenting on the Examiner's reasons for allowance. Applicant respectfully disagrees with the Examiner's reasons for allowance to the extent that they are inconsistent with applicable case law, statutes, and regulations. Furthermore, Applicant does not admit to any characterization or limitation of the claims or to any characterization of a reference by the Examiner, particularly any that are inconsistent with the language of the claims considered in their entirety and including all of their constituent limitations.

Respectfully submitted,
BAKER BOTTS L.L.P.
Attorneys for Applicant

Bradley P. Williams
Registration No. 40,227

Date: 1/14/05

2001 Ross Avenue, Suite 600
Dallas, TX 75201-2980
(214) 953-6447
Attorney Docket No. 004578.1360
Customer No.: 45,507

DAL01:834235.1



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Alan J. Katz
Serial No.:	07/810,005
Filed:	December 18, 1991
Group No.:	3662
Examiner:	Bernarr E. Gregory
Notice of Allowance Mailed:	October 18, 2004
Confirmation No.:	2632
Title:	GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD

Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

CERTIFICATE OF MAILING BY EXPRESS MAIL

I hereby certify that the attached Issue Fee Transmittal (PTOL-85) (one (1) page), Formal Drawings (seven (7) sheets), Formal Drawings Transmittal (one (1) page) and Response to Reasons for Allowance (one (1) page) are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10 on this 14th day of January 2005 addressed to Mail Stop ISSUE FEE, Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Willie Jiles
Willie Jiles

Express Mail Receipt
No. EV322186248US

DAL01:834231.1

OIPE
JAN 14 2005
JC37
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Alan J. Katz
Serial No.:	07/810,005
Filed:	December 18, 1991
Group No.:	3662
Examiner:	Bernarr E. Gregory
Notice of Allowance Mailed:	October 18, 2004
Confirmation No.:	2632
Title:	GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHODS

ATTENTION: OFFICIAL DRAFTSMAN

Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

TRANSMITTAL OF FORMAL DRAWINGS

Pursuant to the Notice of Allowability mailed October 18, 2004, transmitted herewith for filing in the above-identified patent application are seven (7) sheets of formal drawings.

Respectfully submitted,
BAKER BOTTS L.L.P.
Attorneys for Applicants

Bradley P. Williams
Registration No. 40,227

Date: 1/14/06
2001 Ross Avenue, Suite 600
Dallas, TX 75201-2980
(214) 953-6447
Attorney Docket No. 004578.1360

Customer No.: **45507**

DAL01:834239.1

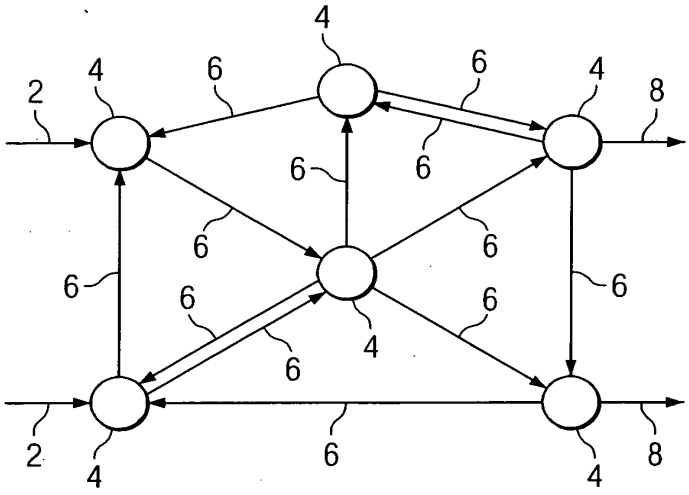


FIG. 1
(PRIOR ART)

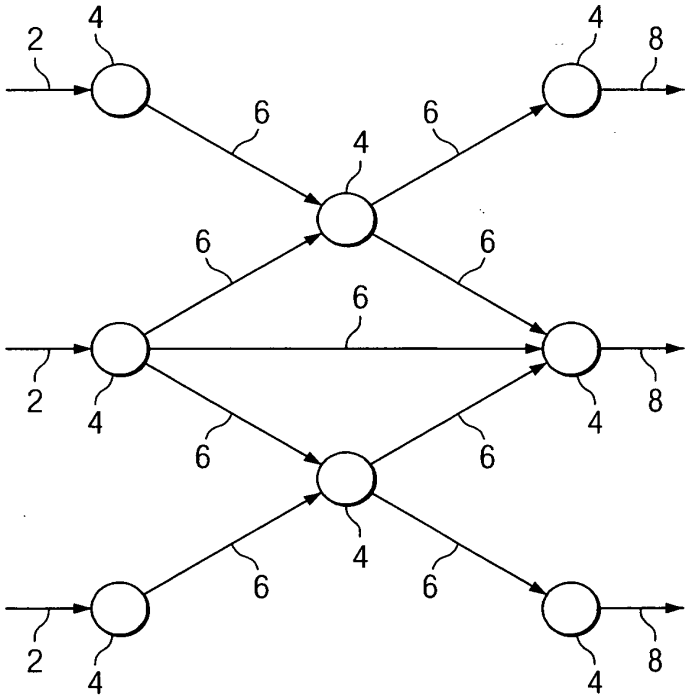


FIG. 2
(PRIOR ART)

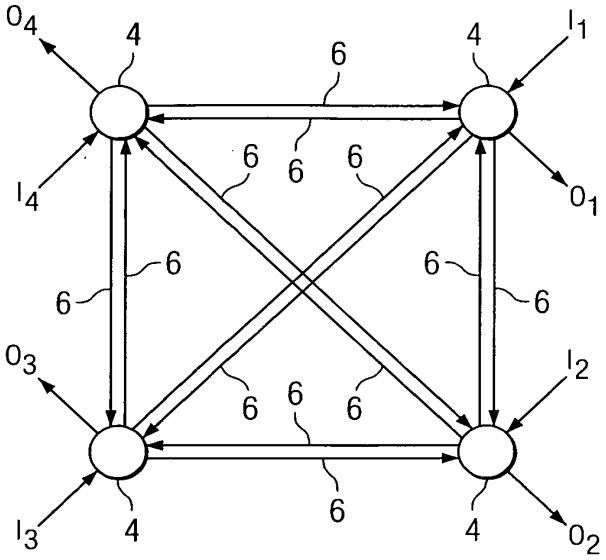


FIG. 3
(PRIOR ART)

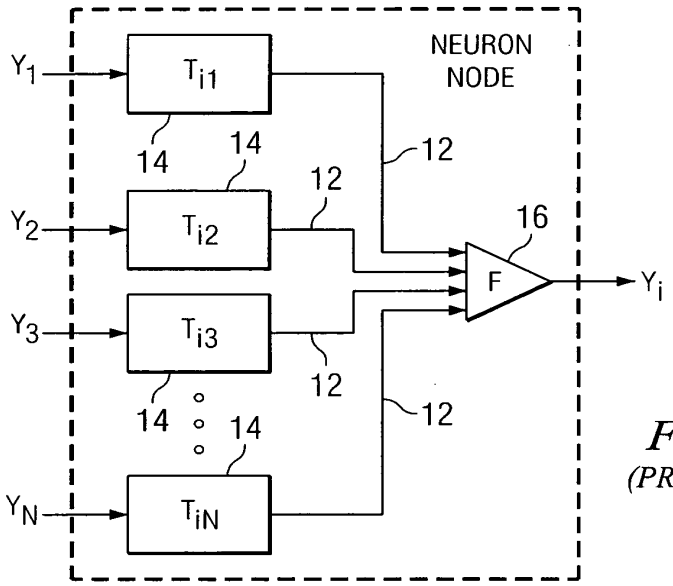


FIG. 4
(PRIOR ART)

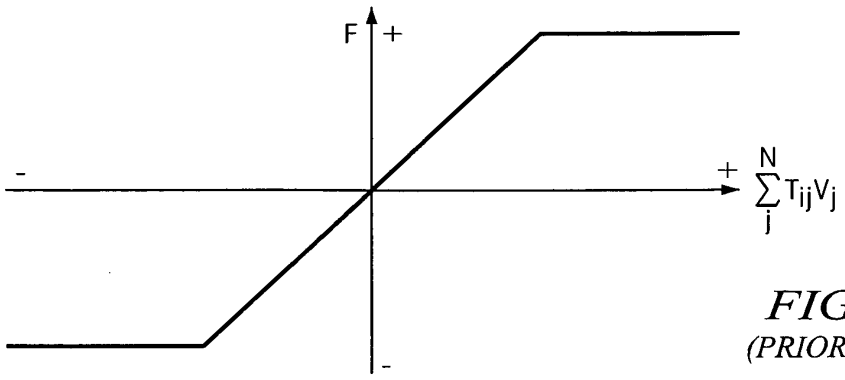


FIG. 5
(PRIOR ART)

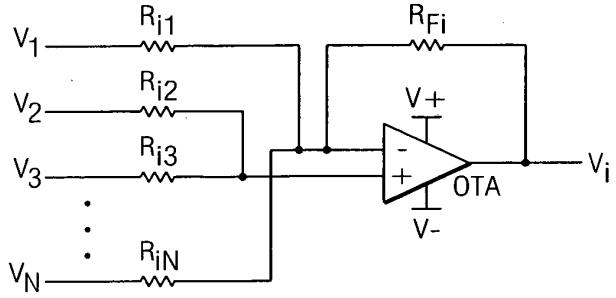


FIG. 6
(PRIOR ART)

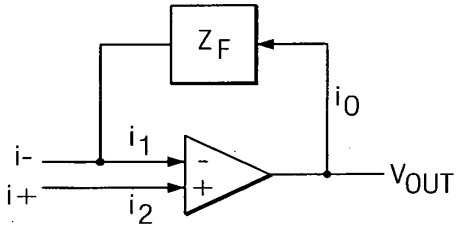


FIG. 7
(PRIOR ART)

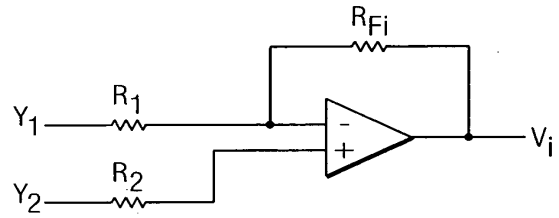


FIG. 8
(PRIOR ART)

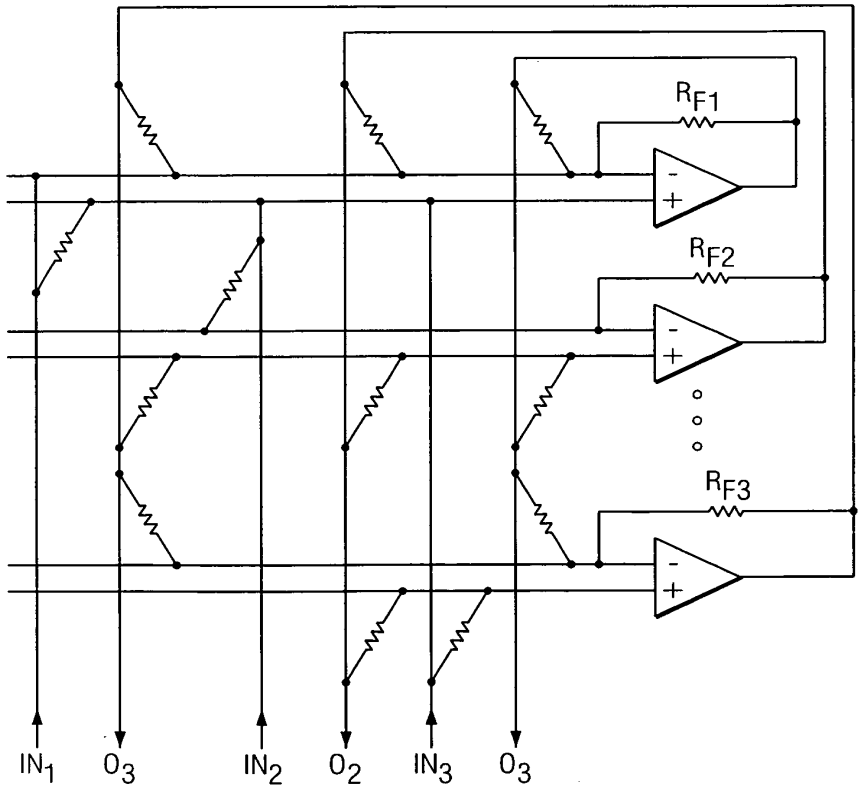


FIG. 9
(PRIOR ART)

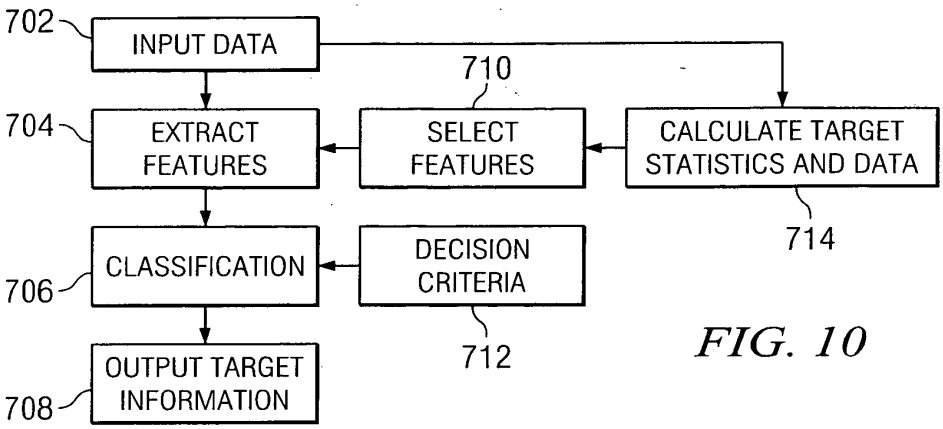

702
INPUT DATA
710
704
EXTRACT FEATURES
SELECT FEATURES
CALCULATE TARGET STATISTICS AND DATA
714
CLASSIFICATION
DECISION CRITERIA
706
712
OUTPUT TARGET INFORMATION
708

FIG. 10

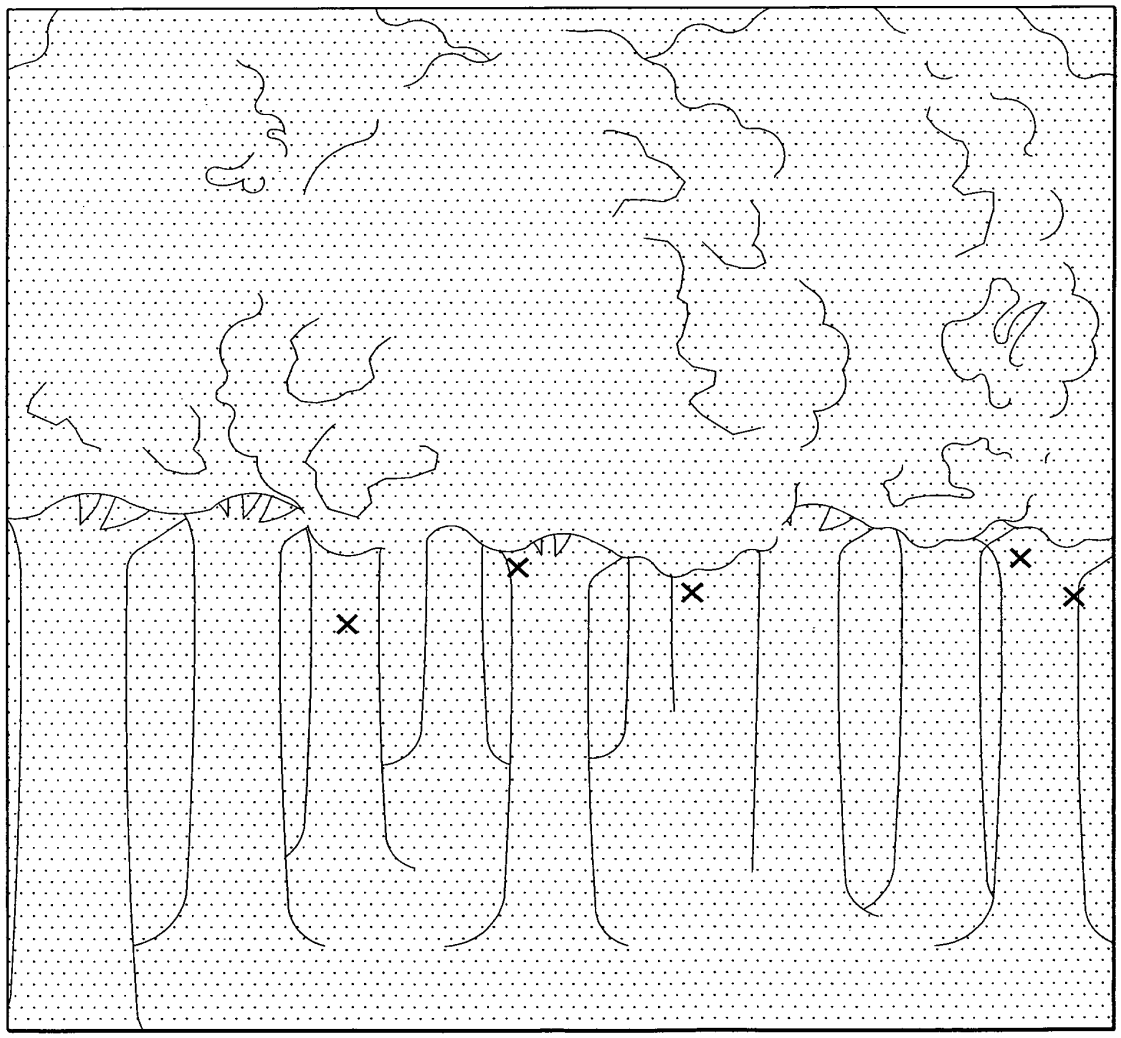


FIG. 11

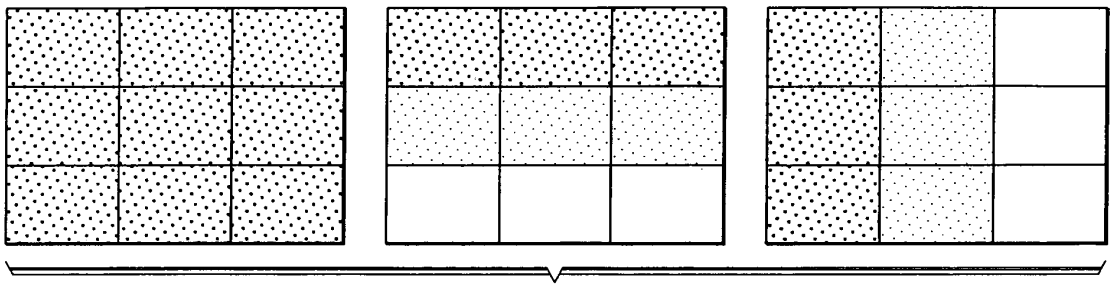


FIG. 12a

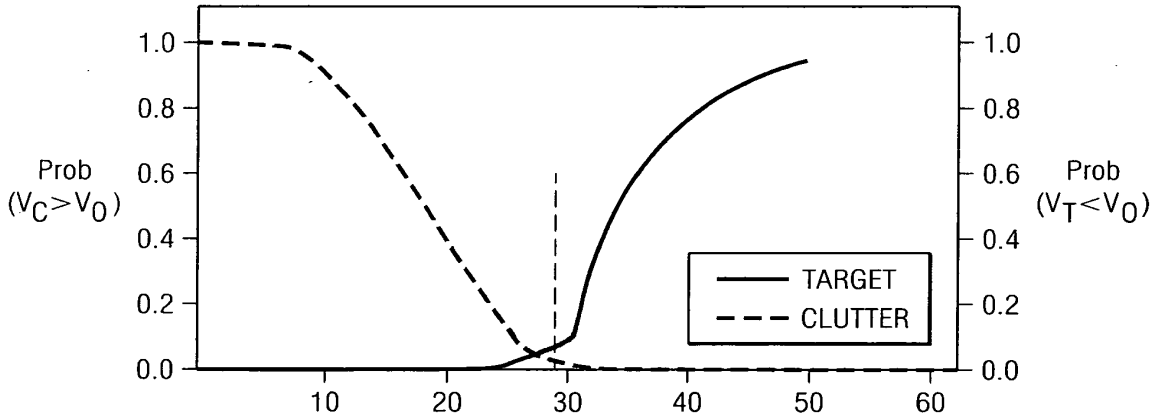


FIG. 12b

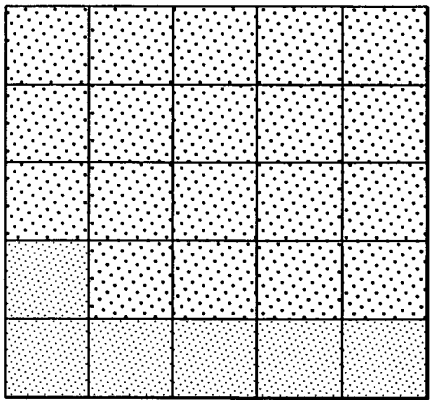


FIG. 13a

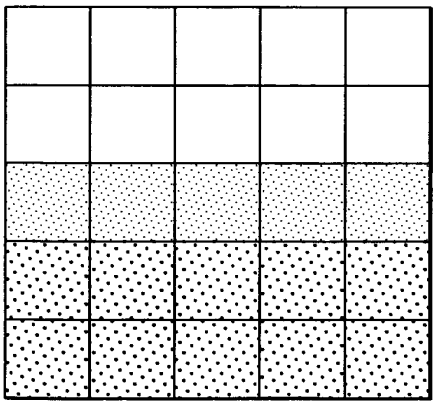


FIG. 13b

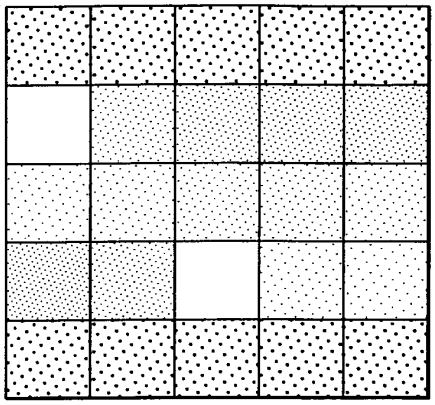


FIG. 13c

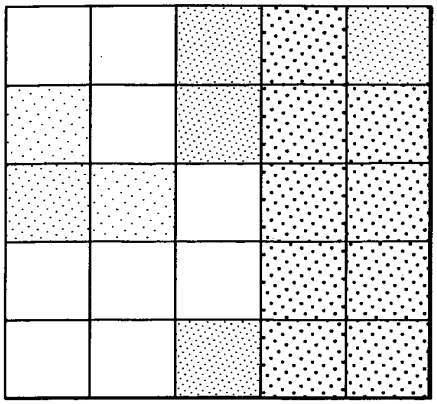


FIG. 13d

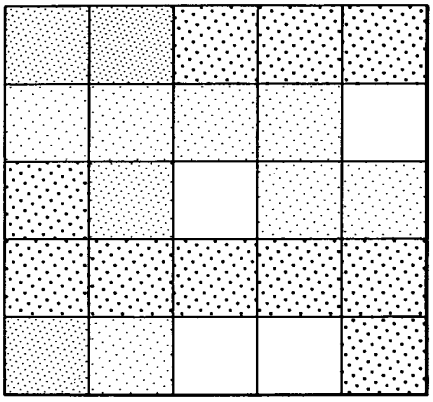


FIG. 13e

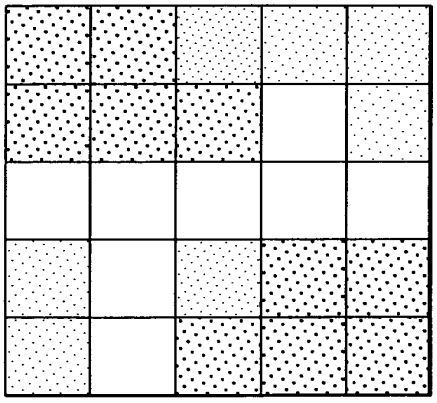


FIG. 13f

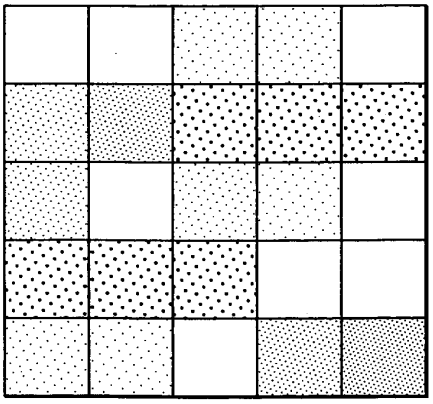


FIG. 13g

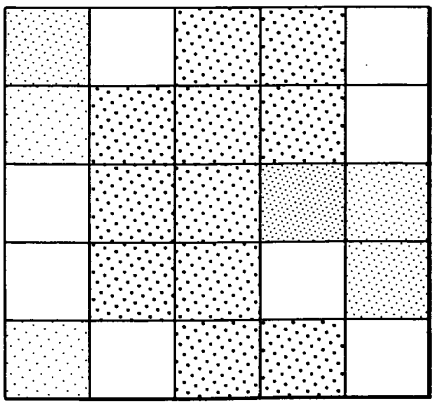


FIG. 13h

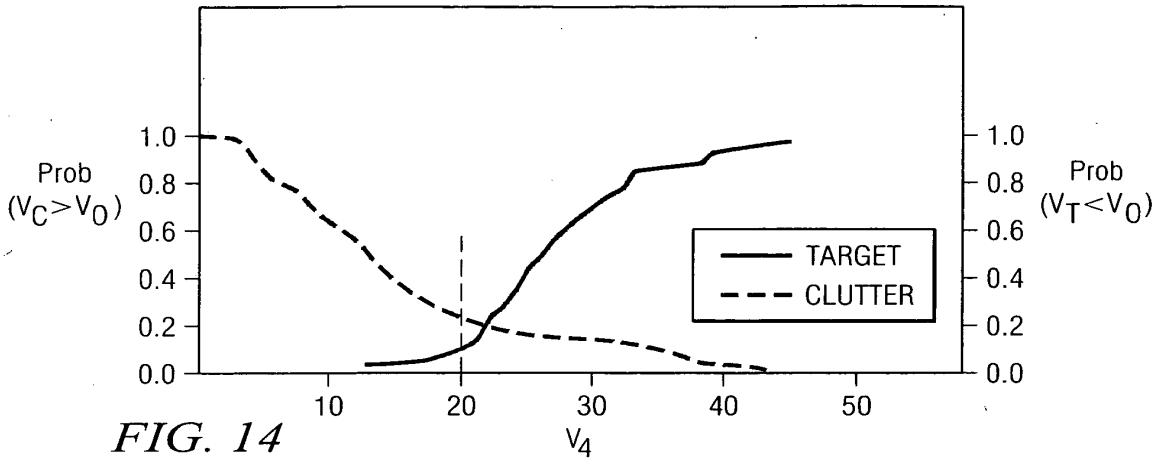


FIG. 14

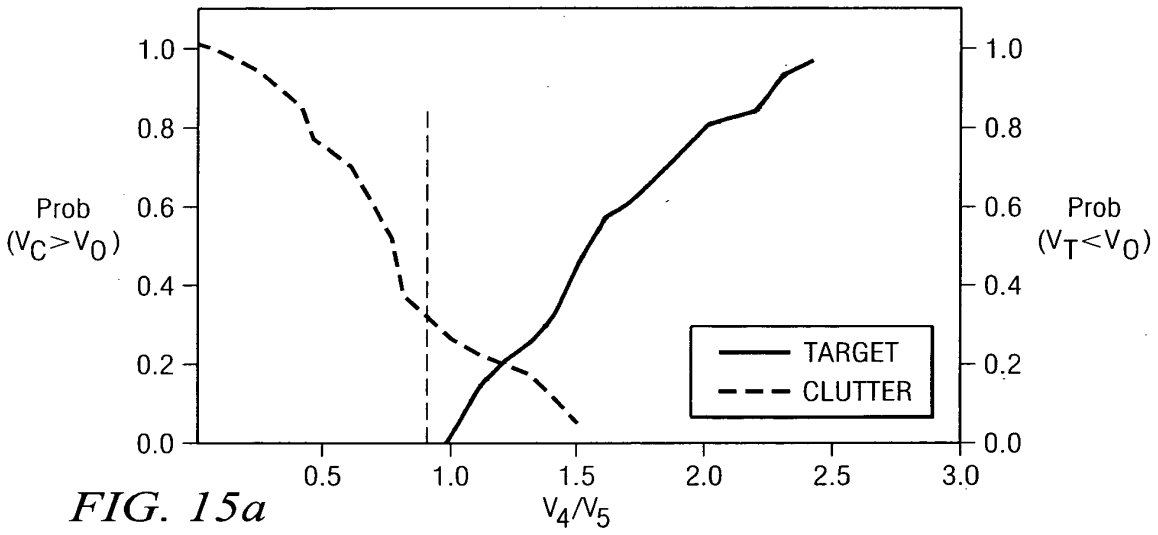


FIG. 15a

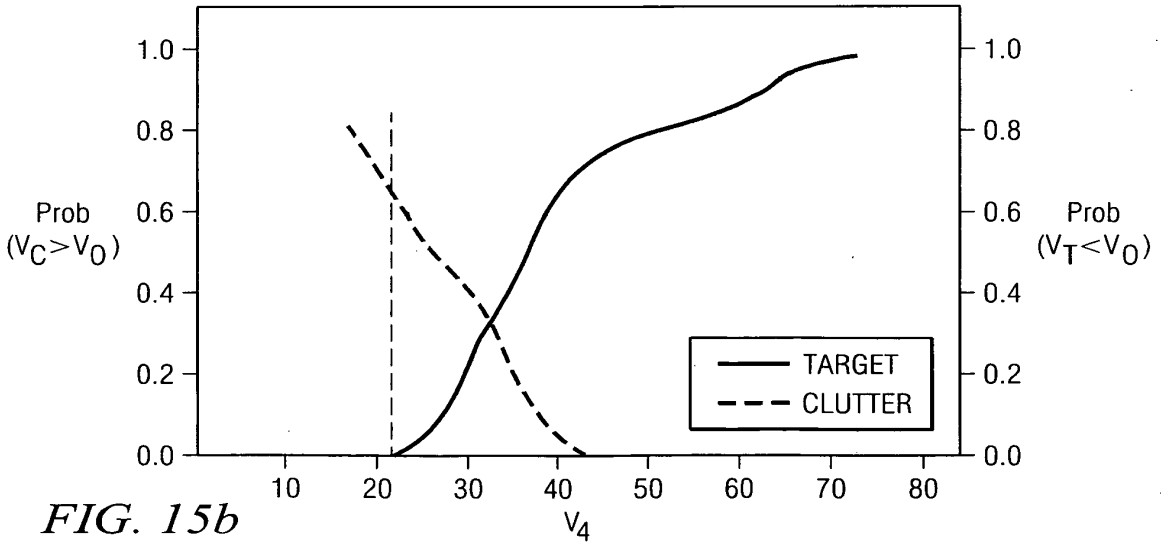


FIG. 15b

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 10/18/2004

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

EXAMINER	
GREGORY, BERNARR E	
ART UNIT	**PAPER NUMBER**
3662	

DATE MAILED: 10/18/2004

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

TITLE OF INVENTION: GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1370	$0	$1370	01/18/2005

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 09/04) Approved for use through 04/30/2007.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (703) 746-4000

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 10/18/2004

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (703) 746-4000, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

TITLE OF INVENTION: GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1370	$0	$1370	01/18/2005

EXAMINER	ART UNIT	CLASS-SUBCLASS
GREGORY, BERNARR E	3662	342-090000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively, 1_____

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2_____ 3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:

☐ Issue Fee

☐ Publication Fee (No small entity discount permitted)

☐ Advance Order - # of Copies _____

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above. NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. 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, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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.

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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

7590 10/18/2004

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

EXAMINER	
GREGORY, BERNARR E	
ART UNIT	**PAPER NUMBER**
3662	

DATE MAILED: 10/18/2004

Determination of Patent Term Extension or Adjustment under 35 U.S.C. 154 (b)
(application filed prior to June 8, 1995)

This patent application was filed prior to June 8, 1995, thus no Patent Term Extension or Adjustment applies.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (703) 305-1383. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

PTOL-85 (Rev. 09/04) Approved for use through 04/30/2007.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

7590 10/18/2004

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

EXAMINER	
GREGORY, BERNARR E	

ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 10/18/2004

Notice of Fee Increase on October 1, 2004

If a reply to a "Notice of Allowance and Fee(s) Due" is filed in the Office on or after October 1, 2004, then the amount due will be higher than that set forth in the "Notice of Allowance and Fee(s) Due" because some fees will increase effective October 1, 2004. See Revision of Patent Fees for Fiscal Year 2005; Final Rule, 69 Fed. Reg. 52604, 52606 (May 10, 2004).

The current fee schedule is accessible from WEB site (http://www.uspto.gov/main/howtofees.htm).

If the fee paid is the amount shown on the "Notice of Allowance and Fee(s) Due" but not the correct amount in view of the fee increase, a "Notice of Pay Balance of Issue Fee" will be mailed to applicant. In order to avoid processing delays associated with mailing of a "Notice of Pay Balance of Issue Fee," if the response to the Notice of Allowance is to be filed on or after October 1, 2004 (or mailed with a certificate of mailing on or after October 1, 2004), the issue fee paid should be the fee that is required at the time the fee is paid. See Manual of Patent Examining Procedure (MPEP), Section 1306 (Eighth Edition, Rev. 2, May 2004). If the issue fee was previously paid, and the response to the "Notice of Allowance and Fee(s) Due" includes a request to apply a previously-paid issue fee to the issue fee now due, then the difference between the issue fee amount at the time the response is filed and the previously-paid issue fee should be paid. See MPEP Section 1308.01.

Effective October 1, 2004, 37 CFR 1.18 is amended by revising paragraphs (a) through (c) to read as set forth below.

Section 1.18 Patent post allowance (including issue) fees.

(a) Issue fee for issuing each original or reissue patent, except a design or plant patent:
- By a small entity (Sec. 1.27(a)) $685.00
- By other than a small entity $1,370.00

(b) Issue fee for issuing a design patent:
- By a small entity (Sec. 1.27(a)) $245.00
- By other than a small entity $490.00

(c) Issue fee for issuing a plant patent:
- By a small entity (Sec. 1.27(a)) $330.00
- By other than a small entity $660.00

Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

PTOL-85 (Rev. 09/04) Approved for use through 04/30/2007.

Notice of Allowability	Application No.	Applicant(s)	
	07/810,005	KATZ, ALAN J.	
	Examiner	Art Unit	
	Bernarr E. Gregory	3662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the amendment of 28 May 2004*.

2. ☒ The allowed claim(s) is/are *1-20*.

3. ☐ The drawings filed on _____ are accepted by the Examiner.

4. ☐ 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 the:
      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)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☒ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☒ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☒ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Bernarr E. Gregory
Primary Examiner
Art Unit 3662
Tel.: (703) 306-5765

1. The following is an examiner's statement of reasons for allowance:

None of the prior art of record either taken alone or taken in any possible combination would anticipate or would tend to render obvious Applicant's method as set forth in independent claim 1 that is particularly characterized at least by parts (b) through (f) of claim 1 taken together and taken in the overall context of independent claim 1.

Dependent claims 2-8 are allowable for at least the reasons for which claim 1 is allowable.

None of the prior art of record either taken alone or taken in any possible combination would anticipate or would tend to render obvious Applicant's apparatus as set forth in independent claim 9 that is particularly characterized at least by parts (b) through (e) of claim 9 taken together and taken in the overall context of independent claim 9.

Dependent claims 10-15 are allowable for at least the reasons for which claim 9 is allowable.

None of the prior art of record either taken alone or taken in any possible combination would anticipate or would tend to render obvious Applicant's apparatus as set forth in independent claim 16 that is particularly characterized at least by parts (b) through (e) of claim 16 taken together and taken in the overall context of independent claim 16.

Dependent claim 17 is allowable for at least the reasons for which claim 16 is allowable.

None of the prior art of record either taken alone or taken in any possible combination would anticipate or would tend to render obvious Applicant's computer program product as set forth in independent claim 18 that is particularly characterized at least by parts (b) through (e) of claim 18 taken together and taken in the overall context of independent claim 18.

Dependent claim 19 is allowable for at least the reasons for which claim 18 is allowable.

None of the prior art of record either taken alone or taken in any possible combination would anticipate or would tend to render obvious Applicant's method as set forth in independent claim 20 that is particularly characterized at least by parts (b) through (e) of claim 20 taken together and taken in the overall context of independent claim 20.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Bernarr E. Gregory whose telephone number is (703) 306-5765. The examiner can normally be reached on weekdays from 7:30 AM to 4:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas H. Tarcza, can be reached on (703) 306-4171. The fax phone

number for the organization where this application or proceeding is assigned is 703-872-9306.

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).

Bernarr E. Gregory
Primary Examiner
Art Unit 3662

PTO FORM 948 (Rev 5-91)

U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

ATTACHMENT TO PAPER NUMBER 5

APPLICATION NUMBER 810005

GROUP

NOTICE OF DRAFTSMAN'S PATENT DRAWING REVIEW

The PTO Draftsmen review all originally filed drawings regardless of whether they were designated as informal or formal.

The drawings filed 12/18/91.

A. ☐ are approved.

B. ☒ are objected to under 37 CFR 1.84 for reason(s) checked below. The examiner will require submission of new, corrected drawings at the appropriate time. Corrected drawings must be submitted according to the instructions listed on the back of this Notice.

1. Paper and ink. 37 CFR 1.84(a)
   - ☐ Poor Quality Paper. Must Be White. Transparent Paper Not Allowed. Sheet(s) _____

2. Size of Sheet and Margins. 37 CFR 1.84(b)
   Acceptable Paper Sizes and Margins

Margin	Paper Size: 8 1/2 by 14 inches	8 1/2 by 13 inches	DIN size A4 21 by 29.7 cm.
Top	2 inches	1 inch	2.5 cm.
Left	1/4 inch	1/4 inch	2.5 cm.
Right	1/4 inch	1/4 inch	1.5 cm.
Bottom	1/4 inch	1/4 inch	1.0 cm.

   - ☐ Proper Size Paper Required. All Sheets Must be Same Size. Sheet(s) _____
   - ☐ Proper Margins Required. Sheet(s) _____
     - ☐ Top ☐ Right
     - ☐ Left ☐ Bottom

3. Character of Lines. 37 CFR 1.84(c)
   - ☒ Lines Pale, Rough and Blurred, or Jagged. Fig(s) 1-10
   - ☒ Solid Black Shading Not Allowed. Fig(s) 12A, 13A, 13B, 13H.

4. ☐ Photographs Not Approved. _____

5. Hatching and Shading. 37 CFR 1.84(d)
   - ☐ Shade Lines are Required. Fig(s) _____
   - ☐ Criss-Cross Hatching Not Allowed. Fig(s) _____
   - ☐ Double Line Hatching Not Allowed. Fig(s) _____
   - ☐ Parts in Section Must be Hatched Properly. Fig(s) _____

6. Reference Characters. 37 CFR 1.84(f)
   - ☒ Reference Characters Poor or Rough and Blurred. Fig(s) 1-10, 12B
   - ☐ Minimum 1/8 inch (3.2 mm.) in height is required. Fig(s) _____
   - ☒ Figure Legends Poor ~~or Placed Incorrectly~~. Fig(s) 1-15B

7. Views. 37 CFR 1.84(i) & (j)
   - ☒ Figures Must be Numbered ~~Seperately~~. As Fig. 1-17 (Table I, II not Allowed).
   - ☐ Figures Must Not be Connected Fig(s) _____

8. Identification of Drawings. 37 CFR 1.84(l)
   - ☒ ~~Extraneous Matter or~~ Copy Machine Marks Not Allowed. Fig(s) 1-10.

9. ☐ Changes Not Completed from Prior PTO-948 dated _____

☒ Comments:

- Full time photographs on photographic sheets req'd. Fig. 11
- Stippings obj. Fig. 12A, 13A-13H

Telephone inquires concerning this review should be directed to the Chief Draftsman at telephone number (703) 557-6404.

AD
Reviewing Draftsman

1/29/92
Date

PTO Copy

BEST AVAILABLE COPY

Index of Claims

Application No.	Applicant(s)	
07/810,005	KATZ, ALAN J.	
Examiner	**Art Unit**	
Bernarr E. Gregory	3662	

√	Rejected	–	(Through numeral) Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

Claim		Date								
Final	Original	10/14/04								
1	1	=								
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Search Notes	Application No.	Applicant(s)	
	07/810,005	KATZ, ALAN J.	
	Examiner	Art Unit	
	Bernarr E. Gregory	3662	

SEARCHED			
Class	Subclass	Date	Examiner
SEARCH	UPDATED	10/14/2004	BEG

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner
706	**15**	10/14/2004	**BEG**
342	27,89	10/14/2004	BEG
342	90,159	10/14/2004	BEG
342/175,195		10/14/2004	BEG

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
Non-patent literature cited in the Specification was checked only if cited on a PTO-1449 or a PTO-892.	10/14/2004	BEG

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
WWW.USPTO.GOV

Bib Data Sheet

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
07/810,005	12/18/1991 RULE _	364	2766	TI-16314

APPLICANTS
ALAN J. KATZ, DALLAS, TX ;

** CONTINUING DATA **********
NONE DLO

** FOREIGN APPLICATIONS **********
NONE DLO

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ yes ☒ no	TX	14	19	4
35 USC 119 (a-d) conditions met ☐ yes ☒ no ☐ Met after Allowance				
Verified and Acknowledged Examiner's Signature Initials				

ADDRESS

GLENN H. LENZEN
RAYTHEON COMPANY
OFFICE OF GENERAL COUNSEL
141 SPRING STREET MAIL STOP 1-1
LEXINGTON, ,MA 02173

TITLE

GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD

FILING FEE RECEIVED		
0	FEES: Authority has been given in Paper 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

Issue Classification	Application No.	Applicant(s)	
	07/810,005	KATZ, ALAN J.	
	Examiner	Art Unit	
	Bernarr E. Gregory	3662	

ISSUE CLASSIFICATION

ORIGINAL CLASS	ORIGINAL SUBCLASS	CROSS REFERENCE(S) CLASS	CROSS REFERENCE(S) SUBCLASS (ONE SUBCLASS PER BLOCK)						
342	90	342	27	89	159	175	195		
INTERNATIONAL CLASSIFICATION		706	15						
G 0 1 S	13/00								
	/								
	/								
	/								
	/								

-------- (Assistant Examiner) (Date)	Bernarr E. Gregory Primary Examiner Art Unit 3662	Total Claims Allowed: 20
Bates 10/15/4 (Legal Instruments Examiner) (Date)	10/14/04 (Primary Examiner) (Date)	O.G. Print Claim(s): 9 / O.G. Print Fig.: 10

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1		31		61		91		121		151		181
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6	6		36		66		96		126		156		186
7	7		37		67		97		127		157		187
8	8		38		68		98		128		158		188
9	9		39		69		99		129		159		189
10	10		40		70		100		130		160		190
11	11		41		71		101		131		161		191
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	28		58		88		118		148		178		208
	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

OIPE
MAY 28 2004
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	Alan Jerry Katz
Serial No.:	07/810,005
Filed:	December 18, 1991
Confirmation No.:	2632
Group No.:	3662
Examiner:	Bernarr E. Gregory
Title:	GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHODS

RECEIVED
JUN 0 7 2004
GROUP 3600

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

"EXPRESS MAIL"

Express Mailing Label Number
EV 324642475 US
I hereby certify that this paper 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 below and is addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Willie Jiles
Willie Jiles

Date: May 28, 2004

Dear Sir:

RESPONSE PURSUANT TO 37 C.F.R. 1.111

In response to the Office Action mailed March 3, 2004, Applicant respectfully requests the Examiner to reconsider the rejection of the claims in view of the following amendments thereto, and the comments as set forth below. Please amend the application as follows:

In the Claims

1. (Original) A method for distinguishing targets from background clutter, comprising the steps of

(a) inputting data;

(b) calculating data statistics from said data and using said data statistics to select target specific feature information to distinguish specific targets from background clutter;

(c) generating said target feature information from said data statistics;

(d) extracting said target specific feature information from said data;

(e) using said target specific feature information to distinguish specific targets from background clutter; and

(f) outputting target and background clutter information.

2. (Original) The method of claim 1, wherein said data is one-dimensional, two-dimensional, or multi-dimensional.

3. (Original) The method of claim 1, wherein said data is digitized imagery, speech signals, or radar signals.

4. (Original) The method of claim 1, wherein parallel hardware architectures are employed to use said feature information to distinguish particular targets from background clutter.

5. (Original) the method of claim 4, wherein said parallel hardware architectures comprise neural networks.

6. (Original) The method of claim 1, wherein said feature information is contrast-based or texture-based.

7. (Original) The method of claim 1, wherein said feature information is further used to distinguish two target classes or a plurality of target classes from one another.

8. (Original) The method of claim 1, wherein Hebbian learning techniques are used to select said target specific feature information.

9. (Original) A classification system, comprising

(a) a calculator to calculate data statistics from a data input;

(b) a selector to use said data statistics outputed from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) a generator to generate said target specific feature information from said data statistics outputed from said calculator;

(d) a feature extractor to extract target specific feature information from said data input; and

(e) a classifier to use said target specific feature information extracted from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

10. (Original) The classification system of claim 9, wherein said data input is one-dimensional, two-dimensional, or multidimensional.

11. (Original) The classification system of claim 9, wherein said data input is digitized imagery, speech signals or radar signals.

12. (Original) The classification system of claim 9, wherein parallel hardware architectures are employed in the classifier to use said feature information to distinguish particular targets from background clutter.

13. (Original) The classification system of claim 12, wherein said parallel hardware architectures comprise neural networks.

14. (Original) The classification system of claim 9, wherein said feature information is contrast-based or texture-based.

15. (Original) The classification system of claim 9, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

16. (Original) A classification hardware system, comprising

(a) a calculator to calculate data statistics from a data input;

(b) a selector to use said data statistics outputed from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) a generator to generate said target specific feature information from said data statistics outputed from said calculator;

(d) a feature extractor to extract target specific feature information from said data input; and

(e) a classifier to use said target specific feature information extracted from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

17. (Original) The classification hardware system of claim 16, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

18. (Currently Amended) A classification software system, comprising

(a) calculation software to calculate data statistics from a data input;

(b) selection software to use said data statistics outputed from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target feature information uniquely describes a target for recognition purposes;

(c) generator software to generate said target specific feature information from said data statistics outputed from said calculator;

(d) feature extraction software to extract target specific feature information from said data input; ~~and~~

(e) classification software to use said target specific feature information extracted from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter ~~data.~~ data; and

(f) wherein the calculation software, selection software, generator software, feature extraction software, and classification software reside on at least one computer-readable medium.

19. (Original) The classification software system of claim 18, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

20. (Previously presented) A method for distinguishing targets from background clutter, comprising the steps of

(a) inputting data having targets and background clutter;

(b) applying neural network learning procedures to said data to construct a set of operators;

(c) applying said set of operators to data to construct a set of features;

(d) choosing optimal features from said set of features to distinguish targets from clutter; and

(e) using said optimal features to distinguishing targets from background clutter.

REMARKS

This application has been carefully reviewed in light of the Office Action mailed March 3, 2004. Claims 1-20 are pending in the Application. Claims 1, 2, 4-10, 12-17, and 20 are allowed. Claims 3, 11, 18 and 19 stand rejected. Claim 18 has been amended. Applicant respectfully requests reconsideration and favorable action of all pending claims in view of the following remarks.

Section 112 Rejections

The Office Action rejects Claims 3 and 11 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim subject matter which Applicant regards as the invention. In particular, the Office Action states: "[i]n dependent Claim 3 and in dependent Claim 11, the use of the term 'speech signals' is indefinite and unclear in the context of either a method of distinguishing targets from clutter (Claim 1) or an apparatus to classify targets (Claim 9). It is unclear how 'speech signals' could have anything to do with either of these." But the application describes in the Summary of the Invention section that both a method for distinguishing targets from background clutter and a classification system are provided that are applicable to speech samples, as well as, among others, digital infrared imaging, digital TV imaging, and radar samples. Given the description of the use of speech samples in the specification as one type of data that a method for distinguishing targets or a classification system acts upon, Applicant respectfully submits that the above Section 112, paragraph 2 rejection is improper. Reconsideration and favorable action are requested.

Allowable Subject Matter

Applicant appreciates the indication at paragraph 2 of the Office Action that Claims 1, 2, 4-10, 12-17, and 20 are allowed over the prior art of record.

Section 101 Rejections

The Office Action rejects Claims 18 and 19 under 35 U.S.C. § 101 alleging that the claimed invention is directed to non-statutory subject matter. In particular, the Office Action states that "[p]articularly, Claim 18 is directed to software per se and fails to recite a medium on which the software resides or a computer on which the software is running." Applicant

has amended Claim 18 to recite a medium on which the software resides. Favorable action is requested.

CONCLUSION

Applicant has now made an earnest attempt to place this case in condition for immediate allowance. For the foregoing reasons and for other apparent reasons, Applicant respectfully requests allowance of all pending claims.

If the Examiner feels that prosecution of the present Application may be advanced in any way by a telephone conference, the Examiner is invited to contact the undersigned attorney at 214-953-6447.

Applicant does not believe that any fees are due. However, the Commissioner is hereby authorized to charge any required fees and credit any overpayments to Deposit Account No. 02-0384 of Baker Botts L.L.P.

Respectfully submitted,

BAKER BOTTS L.L.P.
Attorneys for Applicant

Bradley P. Williams
Reg. No. 40, 227

Date: May 28, 2004

Correspondence Address:
2001 Ross Avenue, Suite 600
Dallas, Texas 75201-2980
Phone: (214) 953-6447

Customer Number: **05073**

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 NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

7590 03/03/2004

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

EXAMINER	
GREGORY, BERNARR E	

ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 03/03/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	07/810,005	KATZ, ALAN J.	
	Examiner	Art Unit	
	Bernarr E. Gregory	3662	

-- 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) 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 the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- 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 *11 January 1993*.

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) *1-20* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *1,2,4-10,12-17 and 20* is/are allowed.

6)☒ Claim(s) *3,11,18 and 19* 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-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

1. Claims 3 and 11 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

In dependent claim 3 and in dependent claim 11, the use of the term "speech signals" is indefinite and unclear in that context of either a method of distinguishing targets from clutter (claim 1) or an apparatus to classify targets (claim 9). It is unclear how "speech signals" could have anything to do with either of these.

2. Claims 1, 2, 4-10, 12-17, and 20 are allowable over the prior art of record.

3. 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 18 and 19 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter.

Independent claim 18 is non-statutory subject matter in that it fails to fall within one of the statutory classes of inventions as set forth in 35 USC 101. Particularly, claim 18 is directed to software per se and fails to recite a medium on which the software resides or a computer on which the software is running. Please see the Guidelines set forth in MPEP 2106. Please particularly noted section IV.B.1. of those Guidelines.

4. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

The examiner-cited prior art herewith is of interest for showing prior art systems and methods of classifying targets and of using target characteristics to remove target signals in a returned-wave system or method from clutter.

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Bernarr E. Gregory whose telephone number is (703) 306-5765. The examiner can normally be reached on weekdays from 7:30 AM to 4:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas H. Tarcza, can be reached on (703) 306-4171. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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).

Bernarr E. Gregory
Primary Examiner
Art Unit 3662

Notice of References Cited	Application/Control No. 07/810,005	Applicant(s)/Patent Under Reexamination KATZ, ALAN J.	
	Examiner Bernarr E. Gregory	Art Unit 3662	Page 1 of 2

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	B	US-3,967,282 A	06-1976	Young et al.	342/22
	C	US-3,992,710 A	11-1976	Gabriele et al.	342/90
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	M	US-4,995,088 A	02-1991	Farhat, Nabil	706/40

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	N	WO91/02323	02-1991	WIPO	CASTELAZ	G06F 15/80
	O					
	P					
	Q					
	R					
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NON-PATENT DOCUMENTS

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	Examiner Bernarr E. Gregory	Art Unit 3662	Page 2 of 2

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-5,040,214 A	08-1991	Grossberg et al.	704/240
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	E	US-			
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392,674 11 August 1989 (11.08.89) US

(71) Applicant: HUGHES AIRCRAFT COMPANY [US/US]; 7200 Hughes Terrace, Los Angeles, CA 90045-0066 (US).

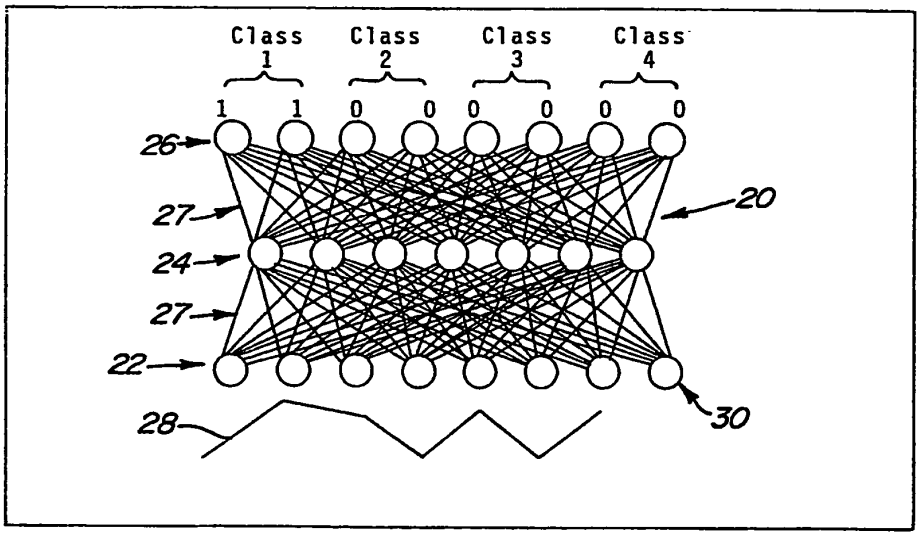
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(74) Agents: DAUBENSPECK, William, C. et al.; Hughes Aircraft Company, Post Office Box 45066, Bldg. C1, M/S A126, Los Angeles, CA 90045-0066 (US).

(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).

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(54) Title: ADAPTIVE NETWORK FOR CLASSIFYING TIME-VARYING DATA



(57) Abstract

An information processor (20) for classifying a set of two-dimensional data. The data represents information from at least two domains. The processor (20) utilizes a neural network architecture having at least N + 1 input neurons (22), where N is the number of values in the first domain. The network (22) is trained to produce an output state that classifies a plurality of input signals belonging to a particular class. In the preferred embodiment the second domain is time.

* See back of page

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ADAPTIVE NETWORK FOR CLASSIFYING TIME-VARYING DATA

Background of the Invention

1. Technical Field

This invention relates to information processors and, more particularly, to a method and apparatus for classifying time varying data.

2. Discussion

Classifying of complex time-varying data poses a number of difficult problems for conventional information processors. The task of classification typically involves recognizing patterns typical of known classes from large amounts of two-dimensional data. Where the patterns to be recognized have subtle variations between the known classes, traditional classifiers often fail to correctly distinguish between the classes. This is due, in part, to the strong assumptions which must be made concerning the underlying distributions of the input data. Algorithms must then be developed to extract these features and to match known features with the input features for classification.

The success of the classifier is dependent on the correctness of these underlying assumptions. Many problems are not susceptible to explicit assumptions in algorithms, due to the subtlety of the patterns involved, as well as the wide variations of such patterns within each class. A further disadvantage

with traditional classifiers is the extensive preprocessing normally required and the extensive time required to develop the algorithm and software to accomplish the pattern matching. Examples of such classification problems include classifying time varying signals from various sources such as speech, image data, radar, sonar, etc. Also, conventional information processor are generally not fault tolerant, and cannot handle certain variations in the input signals such as changes in the orientation of a visual pattern, or differences in speakers, in the case of speech recognition.

In recent years it has been realized that conventional Von Neumann computers, which operate serially, bear little resemblance to the parallel processing that takes place in biological systems such as the brain. It is not surprising, therefore, that conventional information classification techniques should fail to adequately perform the pattern recognition tasks performed by humans. Consequently, new methods based on neural models of the brain are being developed to perform perceptual tasks. These systems are known variously as neural networks, neuromorphic systems, learning machines, parallel distributed processors, self-organizing systems, or adaptive logic systems. Whatever the name, these models utilize numerous nonlinear computational elements operating in parallel and arranged in patterns reminiscent of biological neural networks. Each computational element or "neuron" is connected via weights or "synapses" that typically are adapted during training to improve performance. Thus, these systems exhibit self-learning by changing their synaptic weights until the correct output is achieved in response to a particular input. Once trained, neural

nets are capable of recognizing a pattern and producing a desired output even where the input is incomplete or hidden in background noise. Also, neural nets exhibit greater robustness, or fault tolerance, than Von Neumann sequential computers because there are many more processing nodes, each with primarily local connections. Damage to a few nodes or links need not impair overall performance significantly.

There are a wide variety of neural net models utilizing various topologies, neuron characteristics, and training, or learning, algorithms. Learning algorithms specify an internal set of weights and indicate how weights should be adapted during use, or training, to improve performance. By way of illustration, some of these neural net models include the Perceptron, described in U.S. Patent No. 3,287,649 issued to F. Rosenblatt; the Hopfield Net, described in U.S. Patent Nos. 4,660,166 and 4,719,591 issued to J. Hopfield; the Hamming Net and Kohohonen self-organizing maps, described in R. Lippman, "An Introduction to Computing with Neural Nets", IEEE ASSP Magazine, April 1987, pages 4-22; and "The Generalized Delta Rule for Multilayered Perceptrons", described in Rumelhart, Hinton, and Williams, "Learning Internal Representations by Error Propagation", in D. E. Rumelhart and J. L. McClelland (Eds.), Parallel Distributed Processing; Explorations in the Microstructure of Cognition. Vol. 1: Foundation. MIT Press (1986).

While each of these neural net models achieve varying degrees of success at the particular task to which it is best suited, a number of difficulties in classifying time-varying data still are encountered when using neural network processors. For example, where the time-varying data is complex and involves

large quantities of data, a major problem is in developing a technique for representing the data to the neural network for processing. For example, in classifying radar or sonar doppler time signatures from objects, the minimum amount of data required to adequately represent classifications may involve, for example, fifty time slices of sixteen frequency bands of the doppler data. One way to present this data to a neural net processor would be to utilize a neural network with 800 (50 + 16) input neurons and to present each of the 800 input neurons with one sample of doppler data. The disadvantage of this approach is that such a large number of input neurons and the corresponding large number of total neurons and interconnections would result in a neural network that is very complex and expensive. Further, such a complex network takes a greater period of time to process information and to learn.

Thus, it would be desirable to provide a processor for classifying time-varying data with a minimum of preprocessing and requiring a minimum of algorithm and software development. It would also be desirable to provide a classification processor that is not based on explicit assumptions but instead can adapt by training to recognize patterns. It would also be desirable to provide a means for representing time-varying data to an adaptive processor in a simplified manner which reduces the total number of input values presented to the processor.

SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention, an adaptive network is provided with at least N + 1 input neurons, where N equals the number of values in a first domain associated with a given

value in a second domain. The processor receives one of each of the N values in the first domain in the input neurons, and receives a single associated value from a second domain in the remaining input neuron. The network is trained using known training data to produce an output that serves to classify the known data. The network training is repeated for each value in the second domain by presenting that value together with each of the N values in the first domain as input. Once trained, the adaptive network will produce an output which classifies an unknown input when that input is from a class the adaptive network was trained to recognize.

BRIEF DESCRIPTION OF THE DRAWINGS

The various advantages of the present invention will become apparent to those skilled in the art after reading the following specification and by reference to the drawings in which:

FIG. 1 (A-D) are representative doppler signatures from four classes of multiple moving objects;

FIG. 2 is a diagram of the adaptive network in accordance with the teachings of the present invention; and

FIG. 3 is a representation of doppler data for four classes of objects; and

FIG. 4 is a drawing of an additional embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with the teaching of the present invention, a method and apparatus is provided for classifying two-dimensional data. The two-dimensional data can be derived from a variety of

signal sources such as infrared, optical, radar, sonar, etc. The data may be raw, that is unprocessed, or it may be processed. One example of such processing is doppler processing, wherein the difference in frequency between an outgoing and an incoming signal is analyzed. In general, if the object reflecting the transmitted energy back is stationary with respect to the source there will be no shift in frequency observed in the returning energy. If the object is moving toward the source, the reflected energy will have a higher frequency, and if the object is moving away, the reflected energy will be lowered in frequency.

In FIGS. 1(A-D) four doppler signatures from four different classes of objects are shown. In these figures the doppler frequency, that is, the shift in frequency in the returning object or objects is represented along the horizontal axis. Time is represented along the vertical axis. It can be seen that FIGS. 1(A-D) each have a characteristic shape or pattern. The fact that the pattern changes from the lower portion of each figure to the upper portion, indicates changes in the detected doppler frequencies over time. This would indicate changes in the motion of multiple objects in the particular instance for each of the four classes of objects.

It should be noted that two different instances of multiple objects within a given class will have a doppler signature which resembles, but is not exactly identical, to each other. Thus, while it may be relatively easy for an observer, upon visual inspection, to identify a doppler signature from a given class, because of the subtle variations from instance to instance within a different class, it is difficult, if not impossible, for conventional processors to correctly identify the class of a doppler

signature. For this reason the pattern recognition capabilities of a neural network would seem to be well suited to solving the doppler time signature classifying problem. However, one problem that is encountered is that due to practical limitations in the number of neurons in working neural networks, it would be difficult to provide a neural network with all of the information contained in the doppler signatures shown in FIGS. 1(A-D). To simplify the information, one could compress the data to its most essential characteristics. In this way, the data would be reduced to manageable proportions for processing by a neural network.

Accordingly, In FIG. 3 there is shown a representative simplified doppler signature for four different classes of objects. As in FIGS. 1(A-D), the horizontal axis represents the doppler frequency and the vertical axis represents time. Each horizontal line 10 in FIG. 3 represents the doppler frequencies received at a given time. There are 32 horizontal lines in FIG. 3, each representing a time slice of the doppler signal. The doppler signals in FIG. 3 are divided by means of vertical lines into four classes; a first class 12, a second class 14, a third class 15 and a fourth class 18. Like the four classes shown in FIGS. 1(A-D), the four classes in FIG. 3 represent doppler signals from four different types of objects and each have a pattern that is characteristic of that object, or objects. Even though FIG. 3 represents much more simplified doppler data than that shown in FIGS. 1(A-D), representation of the four patterns in FIG. 3 to a neural network would still involve a large amount of data. In particular, each time slice 10 in each class is drawn from doppler frequencies from 16 frequency bins. There are 32 time slices 10 for each

class. Consequently, there would be 512 individual pieces of information for each class. Using conventional neural network techniques, a neural network having 512 input neurons might be required to process all of the information in each class shown in FIG. 3.

In order to simplify the representation of this data for presentation to the neural network, in accordance with the present invention, the data shown in FIG. 3 may be represented as indicated by FIG. 2. In FIG. 2 an adaptive network 20 in accordance with the preferred embodiment of the present invention is shown. The adaptive network 20 utilizes a conventional neural network architecture known as a multilayer perceptron. It will be appreciated by those skilled in the art that a multilayer perceptron utilizes a layer of input neurons 22, one or more layers of inner neurons 24 and a layer of output neurons 26. Each neuron in each layer is connected to every neuron in the adjacent layer by means of synaptic connections 27, but neurons in the same layer are not typically connected to each other. Each neuron accepts as input either a binary or a continuous-valued input and produces an output which is some transfer function of the inputs to that neuron. The multilayer perceptron shown in FIG. 2 may be trained by the conventional back propagation technique as is known in the art. This technique is described in detail in the above-mentioned article by D. E. Rumelhart and J. L. McClelland, which is incorporated herein by reference.

In accordance with the present invention the adaptive network 20 is configured so that it has a particular number of input neurons 22 determined by the input data. In particular, in the example in FIG. 2, the doppler data contains seven frequency bins. It

will be appreciated that, for example, in FIG. 3 there will be 16 frequency bins, and that the number of doppler frequency bins will depend on the particular data to be analyzed, and the desired complexity of the adaptive network 20.

The doppler frequency curve 28, like the doppler frequency curves in FIG. 3, represents one time slice of doppler data. That is, it represents the doppler frequencies received at a given time. It is preferred that the range of frequencies be normalized so that they may be represented by a signal within a range that is acceptable to the input neurons 22. For example, the doppler frequencies may be normalized to have particular relative values between zero and one.

As shown in FIG. 2, seven input neurons each receive a single doppler frequency value from the doppler frequency curve 28. An eighth input neuron 30 receives a signal which is representative of the time at which the doppler frequency curve 28 was received. The magnitude of the signal used for the time input neuron 30 may be normalized so that the entire range of time values falls within the acceptable range for the input neuron 22. For example, in the data from FIG. 3 there are 32 doppler frequency curves from 32 different time slices and these times may simply be numbered 1 through 32 wherein the range 1 through 32 is normalized for the signal transmitted to input neuron 30. When the doppler frequency curve 28, together with the time is transmitted to the input neurons 22 and 30, the adaptive network 20 will produce some output state at its output neurons 26. To train the adaptive network 20 to produce a desired output, the learning algorithm known as backward error propagation may be used. In this technique a known doppler frequency and time input will be presented to the input neurons and the adaptive

network 20 will be trained to produce an output corresponding to the class of the doppler frequency curve. For example, assuming that the training input is from a first class, the desired output may be to have the first two output neurons 26 produce binary ones and all the other output neurons produce binary zero values. After repeated training procedures the adaptive network 20 will adapt the weights of the synaptic connections 27 until it produces the desired output state. Once the adaptive network 20 is trained with the first doppler frequency curve 28 at a first time slice, it may then be trained for all the successive time slices. For example, the adaptive network 20 may be trained for each of the 32 doppler frequency curves 10 in FIG. 3 to produce an output indicating the first class. Once the training for the first class is complete, an unknown set of doppler frequency curves and times may be transmitted to the adaptive network 20. If the unknown doppler signature has the general characteristics of that of the first class, the adaptive network 20 will produce an output state for each time slice corresponding the first class.

Further, the adaptive network 20 may be trained to recognize multiple classes of doppler signatures. To accomplish this, the steps used to train the adaptive network 20 to recognize the first class of doppler frequency curves is simply repeated for the second, third and fourth classes. As shown in FIG. 2, the adaptive network 20 may be trained to indicate the second, third and fourth classes by producing binary ones in the output neurons 26 associated with those classes as indicated in FIG. 2. The number of classes which the adaptive network 20 may be trained to recognize will depend on a number of

variables such as the complexity of the doppler signals, and the number of neurons, layers and interconnections in the adaptive network 20.

Referring now to FIG. 4, an adaptive network 20 in accordance with the present invention is shown. This embodiment is similar to the one shown in FIG. 2, except that it utilizes 18 input neurons 22, 24 inner neurons 24 and 26 output neurons 26. It will be appreciated that with a larger number of neurons and synaptic connections 27, time-varying data of greater complexity can be classified.

Once the adaptive network 20 has been trained it could be reproduced an unlimited number of times by making a copy of the adaptive network 20. For example the copies may have identical, but fixed weight values for the synaptic connections 27. In this way, mass production of adaptive networks 20 is possible without repeating the training process.

In view of the foregoing, those skilled in the art should appreciate that the present invention provides an adaptive network that can be used in a wide variety of applications. The various advantages should become apparent to those skilled in the art after having the benefit of studying the specification, drawings and following claims.

CLAIMS

What is Claimed is:

1. An information processor (20) for classifying a set of two-dimensional data, said data representing information from at least two domains, including a first and second domain, said information processor including a network of neurons including input (22) and output (26) neurons, there being at least N + 1 input neurons, a plurality of synaptic connections (27) providing weighted interconnections between selected ones of said neurons, characterized by:

said network (20) having at least N + 1 input neurons (22), where N is the number of values in said first domain;

means for transmitting a set of input signals to said input neurons (22), each signal being received by at least one input neuron, said set of input signals including at least a single value from said second domain, and said set of input signals also including N values from said first domain, said N values all being associated with said single value in said second domain; and

means for training (22, 24, 26) said network (20) to produce a desired output including means for presenting a known input signal to said input neurons (22, 30), and means for adjusting (24, 26) said weighted synaptic interconnections (27) in repeated training sessions to cause said network (20) to produce said desired output.

2. The information processor (20) of Claim 1 wherein said second domain is time, and the N values from the first domain associated with a given time value represents the values of those N values at a given time.

3. The information processor of Claim 2 wherein said second domain represents doppler data.

4. The information processor of Claim 3 wherein said classification represents different types of objects from which said doppler signals originate.

5. The information processor of Claim 1 wherein the total number of input neurons (22) is N + 1.

6. The information processor of Claim 1 wherein said desired output represents a classification for a plurality of said known input signals.

7. The information processor of Claim 1 wherein said means for training said network (24, 26) trains said network with multiple input signals that include a plurality of inputs from the second domain along with the associated N inputs from the first domain.

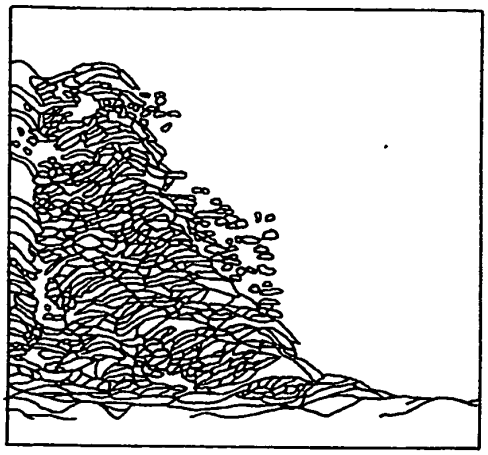


Fig-1A

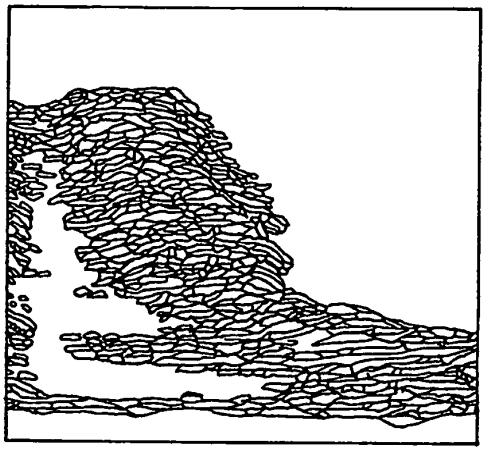


Fig-1B

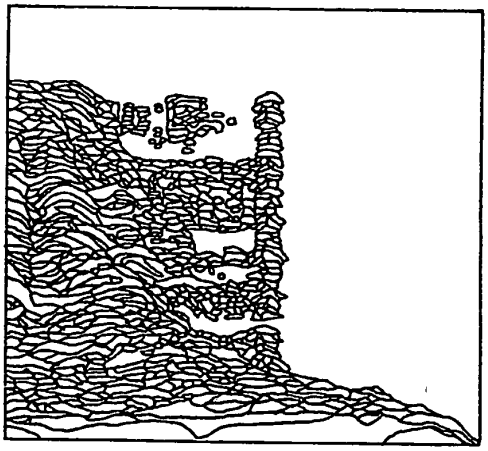


Fig-1C

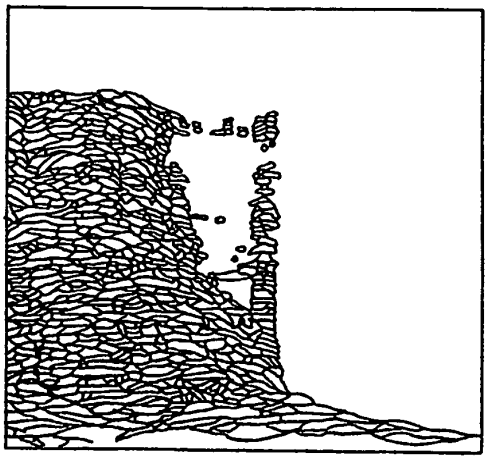


Fig-1D

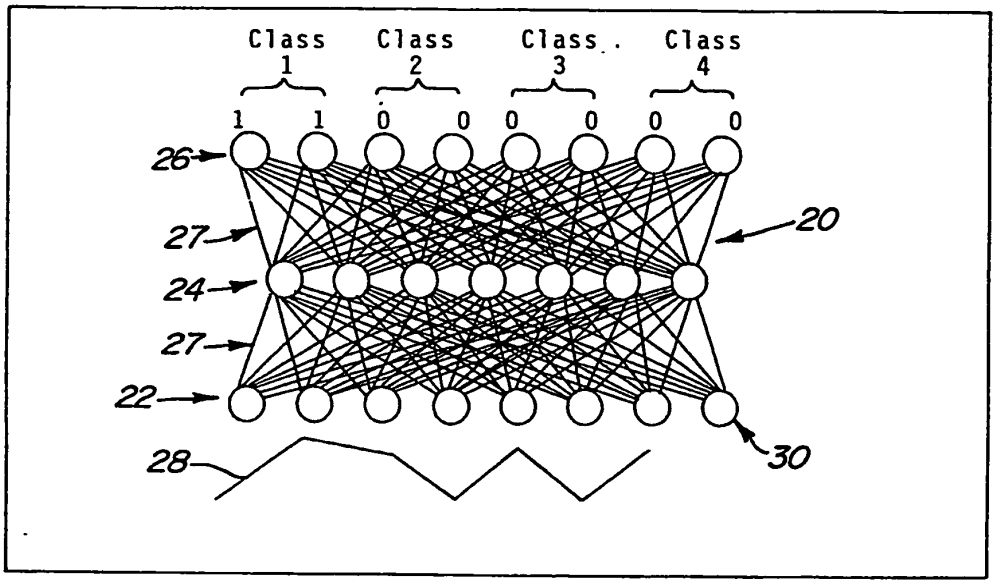

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Class 3
Class 4
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Fig-2

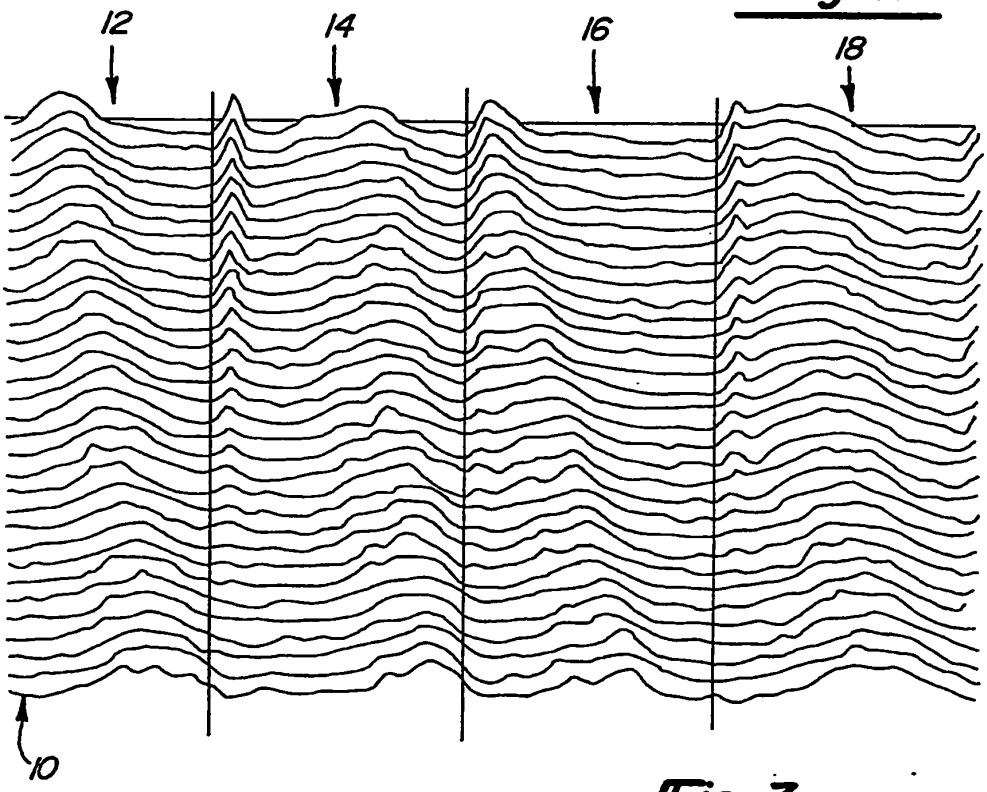
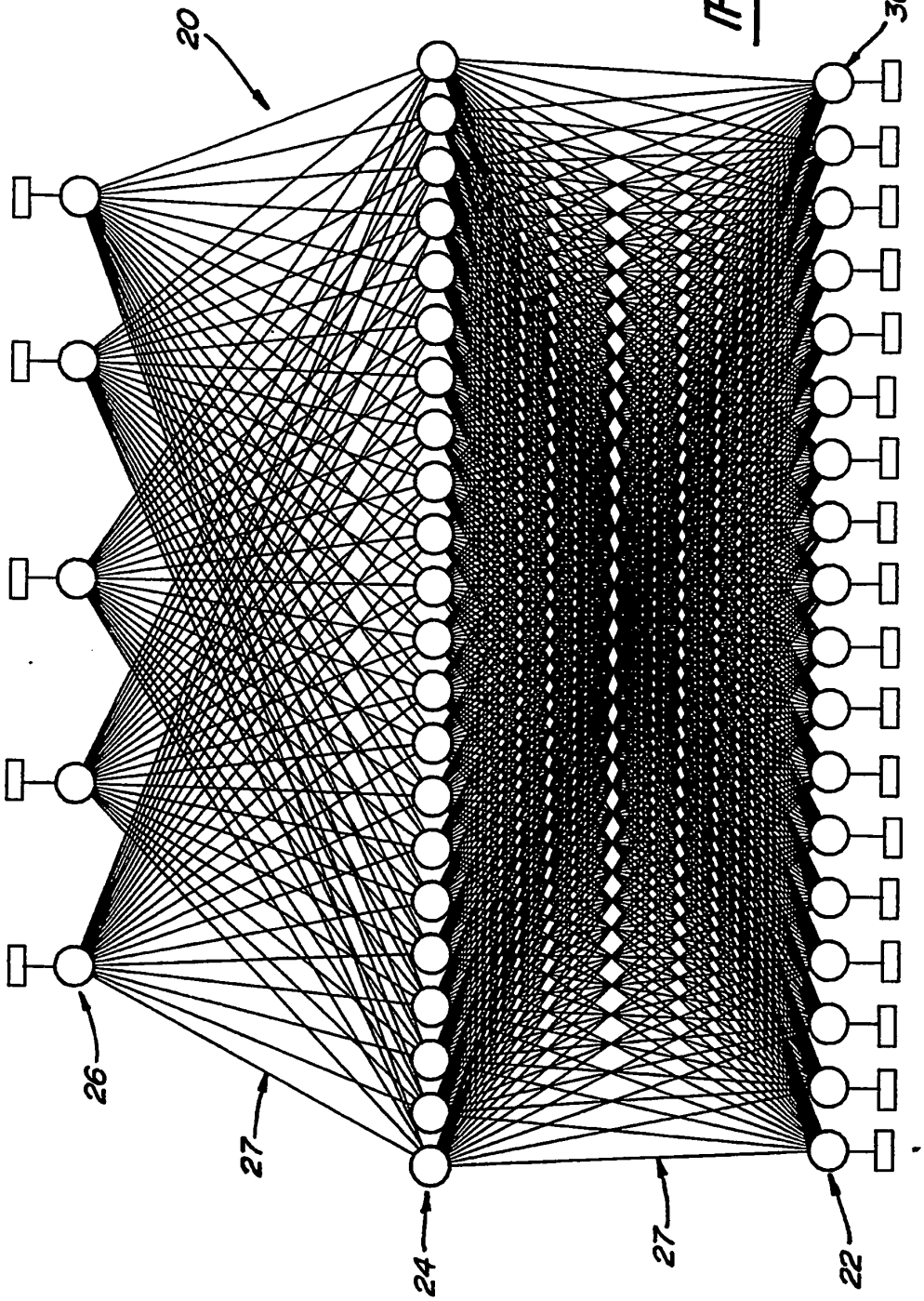

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18
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Fig-3

Fig-4



INTERNATIONAL SEARCH REPORT

International Application No PCT/US 90/04487

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 06 F 15/80, G 01 S 7/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	G 06 F 15/80, G 01 S 7/02

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	IEEE International Conference on Neural Networks, San Diego, California, 24-27 July 1988, P.F. Castelaz: "Neural networks in defense applications", pages 473-480 see page 476, lines 10-31; figure 2 --	1-7
A	IJCNN International Joint Conference on Neural Networks, Sheraton Washington Hotel, 19-22 June 1989, A. Khotanzad et al.: "Target detection using a neural network based passive sonar system", pages I-335-I-340 see abstract; page I-336, column 1, lines 15-32; column 2, lines 30-36; pages I-337, column 1, lines 1-31; column 2, lines 35-49; figure 2 --	1-7

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* Special categories of cited documents: [10]

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"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

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13th November 1990	- 4. 12. 90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. PEIS

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, 11 with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	IEEE First International Conference on Neural Networks, San Diego, California, 21-24 June 1987, H. Boulard et al.: "Multilayer perceptrons and automatic speech recognition", pages IV-407-IV-416 see page IV-413, lines 3-20, page IV-414, lines 1-13; figure 2 ----	1-7

Refine Search

Search Results -

Terms	Documents
L16 and neural	2

Database:
US Pre-Grant Publication Full-Text Database
US Patents Full-Text Database
US OCR Full-Text Database
EPO Abstracts Database
JPO Abstracts Database
Derwent World Patents Index
IBM Technical Disclosure Bulletins

Search: L17

Refine Search

Recall Text | Clear | Interrupt

Search History

DATE: Monday, February 23, 2004 Printable Copy Create Case

Set Name side by side	Query	Hit Count	Set Name result set
DB=TDBD; PLUR=YES; OP=OR			
L17	l16 and neural	2	L17
L16	l15 and target$1	934	L16
L15	l12 and (detect$3 or distinguish$3 or statistic$4 or calculat$4)	965	L15
L14	l12 and ((patern adj recognition) or (target adj recognition) or signature$1)	29	L14
L13	l12 and clutter	12	L13
L12	radar$1 or sonar$1 or ladar$1 or lidar$1 or target$1	2868	L12
L11	hebbian	0	L11
DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI; PLUR=YES; OP=OR			
L10	l9 and (statistic$4 or calculat$4)	138	L10
L9	l8 and (detect$3 or distinguish$3 or statistic$4 or calculat$4)	225	L9
L8	l5 and target$1	231	L8
L7	l4 and neural	51	L7
L6	l4 and hebbian	2	L6

L5	l4 and clutter	257	L5
L4	(radar$1 or sonar$1 or ladar$1 or lidar$1).ti,ab. and ((patern adj recognition) or (target adj recognition) or signature$1)	1025	L4
L3	l1 and (radar$1 or sonar$1 or ladar$1 or lidar$1 or target$1)	67	L3
L2	l1 and clutter	3	L2
L1	hebbian	132	L1

END OF SEARCH HISTORY

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING OR 371(c) DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

7590 05/21/2003

RENE E GROSSMAN
RAYTHEON COMPANY
PO BOX 660246 MS 17
DALLAS, TX 75266

EXAMINER	
HAYES, GAIL O	
ART UNIT	PAPER NUMBER
2131	

DATE MAILED: 05/21/2003

RESCINDING ORDER

The Secrecy Order dated 5-12-92 prohibiting disclosure of publication of the subject matter of the above entitled application under the provisions of Title 35 United States Code (1952) 181-188 is herby rescinded. Normal prosecution is continued and any suspension thereof because of the secrecy order should now be removed. This rescinding order does not affect the provisions of any classified government contract or existing laws relating to espionage and national security.

for Charles T. Jordan
Director
Special Laws Administration Group

PTOL-216 (REV. 6-93)

DEPARTMENT OF THE AIR FORCE
AIR FORCE MATERIEL COMMAND LAW OFFICE (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE OHIO

20 May 2003

MEMORANDUM FOR: COMMISSIONER OF PATENTS AND TRADEMARKS
U.S. PATENT AND TRADEMARK OFFICE
ATTN: LICENSING AND REVIEW
P O BOX 1450
ALEXANDRIA, VA 22313-1450

FROM: AFMC LO/JAZ
2240 B Street, Bldg 11, Room 100
Wright-Patterson AFB OH 45433-7109

SUBJECT: Rescission of Secrecy Order ; Patent Application S.N. 07/810,005

Filed: 12/18/1991 Inventors: Alan J. Katz

Title: Generalized Hebbian Learning for Principal Component Analysis and Automatic Target Recognition Systems and Methods

Prosecuted by ☐ Govt ☐ Contractor ☒ Unknown Party

RECOMMENDATION: Rescission of Secrecy Order

Classification of Application ☐ canceled ☒ changed to SNR

by authority of AFRL/SNOX on 20 May 2003

Our copy of the patent application will be destroyed on rescission of the secrecy order.

The U.S. Patent and Trademark Office is authorized to delete any security markings from the patent application.

Janice L. Kisamore
JANICE L. KISAMORE
Legal Instruments Examiner
Directorate of Intellectual Property Law

937/255-5055 ext. 261

TOTAL P.04

Raytheon

Rene' E. Grossman
Senior Patent Counsel
972-344-1205
972-344-1211 fax
r-grossman@raytheon.com

Raytheon Company
Office of the General Counsel
13510 N. Central Expressway
M/S 200
Dallas, Texas
75243-1108 USA

Mailing Address:
P.O. Box 660246
M/S 200
Dallas, Texas 75266

17 Change address Bates 3-1-02

February 21, 2002

Commissioner of Patents and Trademarks
Washington, DC 20231

RECEIVED
FEB 2 1 2002
LICENSING & REVIEW

Re: TI-16314, SN 07/810,005, Filing Date 12/18/91
Examiner Gail Hayes, Art Unit 2131

Attn: J. C. Samuels

Dear Sir:

This application has been assigned from Texas Instruments Incorporated to Raytheon Company. Accordingly, please change the mailing address on this case to the following:

Rene E. Grossman (ph. 972/344-1205)
Raytheon Company
P. O. Box 660246, MS 17
Dallas, TX 75266

FSC Cage No. 084T3

Thank you.

Yours very truly,

Rene E. Grossman

Rene E. Grossman
Reg. No. 22,656
972/344-1205
972/344-1211 (fax)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314	2632

7590 01/11/2002

GLENN H. LENZEN
RAYTHEON COMPANY
OFFICE OF GENERAL COUNSEL
141 SPRING STREET MAIL STOP 1-1
LEXINGTON,, MA 02173

EXAMINER	
HAYES, GAIL O	

ART UNIT	PAPER NUMBER
2131	

DATE MAILED: 01/11/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
07/810,005	12-18-91	Katz	

EXAMINER	
ART UNIT	PAPER NO.

DATE MAILED: 1-11-02

SECRECY ORDER

35 U.S.C. §§181-188

and

Permit for Disclosing Classified or "Classifiable" Subject Matter

The above-identified patent application contains subject matter which is either **classified** or "**classifiable**"[1] in the opinion of the sponsoring defense agency.

[ ] This application is **CLASSIFIED** at the level of: [ ] TOP SECRET

[X] This application is NOT CLASSIFIED, but would be **CLASSIFIABLE** at the level of: [ ] SECRET

[ ] CONFIDENTIAL

DECLASS By Licensing Review

ALL PRINCIPALS[2] IN THIS APPLICATION ARE ORDERED TO KEEP THE SUBJECT MATTER THEREOF IN SECRECY UNDER 35 U.S.C. §181.

The subject matter of this application may not be published or disclosed to any person except as specifically authorized herein or subsequently authorized by written modification of this Secrecy Order granted by the Commissioner of Patents & Trademarks (see 37 CFR §5.5).

---

[1] The term "classifiable" as used herein refers to subject matter that is not actually classified but is sufficiently sensitive, in the opinion of the sponsoring defense agency named herein, to have been classified under E.O. 12356 if the subject matter were known to be owned by or under control of the U.S. government.

[2] "Principals" include all patent applicants, their heirs, assignees, licensees and their attorneys and agents.

Unauthorized publication or disclosure of the subject matter of this patent application may result in abandonment of the application (35 U.S.C. §182) and additionally subject the person publishing or disclosing the subject matter to the penalties of 35 U.S.C. §186.

The subject matter of this application must be safeguarded under conditions that will provide adequate protection and prevent access by unauthorized persons. When copies of the subject matter are no longer needed, they should be destroyed by a method that will prevent disclosure of the contents or reconstruction of the document.

Any other patent application already or hereafter filed in the U.S. or any foreign country which contains any significant part of the subject matter of the above-identified patent application also falls within the scope of this Order. If such other patent application is not currently under a Secrecy Order imposed by the U.S. Patent and Trademark Office, it and the common subject matter must be brought to the immediate attention of:

Director, Special Laws Administration
Attention: Licensing and Review
U.S. Patent and Trademark Office
Washington, D.C. 20231.

This Order should not be construed in any way to mean that the U.S. Government has adopted or contemplates adoption of the invention disclosed in this application and it is not any indication of the value of such invention. Additionally, this Order is not authority in and of itself for classification of the subject matter of this patent application.

This secrecy order has been recommended under 35 U.S.C. §181 to the Commissioner of Patents & Trademarks by the following sponsoring defense agency:

( ) ARMY ( ) NAVY (X) AIR FORCE

Questions regarding the reasons for imposing this Secrecy Order should be directed to the sponsoring defense agency. A contact for each defense agency is attached. Questions regarding the substantive examination of the patent application should be directed to the patent examiner, and questions pertaining to the administrative handling of the patent application or the Secrecy Order should be directed to the Licensing and Review Branch of the Patent & Trademark Office.

Permit for Disclosing Classified or "Classifiable" Information

A. If the subject matter of this application is classified:
Disclosure of the subject matter of this application is authorized to persons with the appropriate personnel security clearance on a "need-to-know" basis under the provisions

of Executive Orders 10865 and 12356 and the "Industrial Security Manual for Safeguarding Classified Information" provided the authorized person to whom the subject matter is disclosed is furnished with a copy of this Secrecy Order and informed that this Order is applicable to the subject matter disclosed.

Any declassification, in whole or in part, of the subject matter of this application does not modify this Secrecy Order. The requirements of this Secrecy Order remain in effect until it is rescinded or modified in writing by the Commissioner of Patents & Trademarks. If the subject matter is declassified, this fact should be brought to the attention of the sponsoring defense agency.

B. If the subject matter of this application is "**classifiable**" but not classified:
Principals to this Secrecy Order employed at a facility which has a current DoD Security Agreement (DoD Form 441) are authorized to disclose on a "need-to-know" basis the subject matter of this patent application to other persons at that facility having a personnel security clearance at least as high as the level of protection specified on page 1 of this Secrecy Order provided the provisions of the "Industrial Security Manual for Safeguarding Classified Information" (DoD 5220.22-M) are complied with[3] and the authorized person to whom the subject matter is disclosed is furnished with a copy of this Secrecy Order and informed that this Secrecy Order is applicable to the subject matter disclosed.

Principals employed at a facility that does not have a current DoD Security Agreement must obtain prior written modification of this Secrecy Order from the Commissioner of Patents & Trademarks for any further disclosure of the subject matter of this application to any person. See 37 CFR §5.5.

This permit for disclosing classified or "classifiable" information does not authorize disclosure of the subject matter of the patent application through (1) the filing of any foreign application without specific permission of the Patent and Trademark Office, or (2) the export of any item, commodity or technical data without the required export license.

Michael Carone,
Licensing & Review Administrator
U.S. Patent & Trademark Office

[3] Since the subject matter covered by this Secrecy Order is not actually classified, certain provisions of the Industrial Security Manual (ISM) may not strictly apply, such as derivative classification, downgrading/declassification instructions, and portion and page markings. Facilities encountering problems complying with any provisions of the ISM should directly query the defense agency sponsoring this Secrecy Order for appropriate security guidance.

12-6-01

DEPARTMENT OF THE AIR FORCE
AIR FORCE MATERIEL COMMAND LAW OFFICE (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE OHIO

November 29, 2001

MEMORANDUM FOR COMMISSIONER OF PATENTS AND TRADEMARKS
U.S. PATENT AND TRADEMARK OFFICE
ATTN: LICENSING AND REVIEW
WASHINGTON DC 20231

FROM: AFMC LO/JAZ
2240 B Street, Room 100
Wright-Patterson AFB, OH 45433-7109

RECEIVED
JAN 03 2002
LICENSING & REVIEW

SUBJECT: Renewal of Secrecy Order

This is to notify you, on behalf of the head of the agency who caused the secrecy order to be issued on the following identified patent application, that an affirmative determination has been made that the national interest requires that the invention continue to be kept secret and the grant of a patent continue to be withheld.

U.S. Patent Application Serial No.: 07/810,005
Filed: 12/18/1991
Inventor(s): Alan J. Katz
Prosecuted by ☐ Govt. ☐ Contractor ☒ Unknown Party

Accordingly, it is recommended that the order be renewed.

PAMELA J. FULMER
Legal Instruments Examiner
Directorate of Intellectual Property Law

937/255-5055 ext. 262

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office

Address : COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ A	TI-16314

EXAMINER	
HAYES, G	
ART UNIT	PAPER NUMBER
2131	

07M1/1206

GLENN H. LENZEN
RAYTHEON COMPANY
OFFICE OF GENERAL COUNSEL
141 SPRING STREET MAIL STOP 1-1
LEXINGTON, MA 02173

12/06/00

SECRECY ORDER RECEIPT

The Secrecy Order under Title 35, United States Code (1952) Sections 181-188, dated 12/6/00, with permit in the above-identified application is hereby acknowledged.

Glenn H. Lenzen, Jr. #29,320
(signature)

December 12, 2000
(date)

Lexington
(city)

Massachusetts
(state)

RECEIVED
DEC 21 2000
LICENSING & REVIEW

Return only the upper portion to:

Commissioner of Patents and Trademarks
Washington, D.C. 20231

TO THE APPLICANT ABOVE NAMED OR HIS OR HER HEIRS, AND ANY AND ALL ASSIGNEES AND ATTORNEYS OR AGENTS:

Enclosed is your copy of a Secrecy Order under Title 35, United States Code (1952), Sections 181-188. In order that the record of service of this Order may be completed as soon as possible, you are respectfully requested to fill out and personally sign the receipt above and promptly return it to the Commissioner of Patents and Trademarks.

Please advise of any change of address.

Licensing and Review

PTO-218 (rev. 3-79)

U.S. DEPARTMENT of COMMERCE – Patent and Trademark Office

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ	TI-16314

EXAMINER	
A	

ART UNIT	PAPER NO.
2131	

07M1/1206

GLENN H. LENZEN
RAYTHEON COMPANY
OFFICE OF GENERAL COUNSEL
141 SPRING STREET MAIL STOP 1-1
LEXINGTON, MA 02173

HAYES,G

DATE MAILED: 12/06/00

SECRECY ORDER

35 U.S.C. §§181-188

and

Permit for Disclosing Classified or "Classifiable" Subject Matter

The above-identified patent application contains subject matter which is either **classified** or "**classifiable**"[1] in the opinion of the sponsoring defense agency.

[ ] This application is **CLASSIFIED** at the level of: [ ] TOP SECRET

[X] This application is NOT CLASSIFIED, but would be **CLASSIFIABLE** at the level of: [ ] SECRET

DECLASS By Licensing & Review

[X] CONFIDENTIAL

ALL PRINCIPALS[2] IN THIS APPLICATION ARE ORDERED TO KEEP THE SUBJECT MATTER THEREOF IN SECRECY UNDER 35 U.S.C. §181.

The subject matter of this application may not be published or disclosed to any person except as specifically authorized herein or subsequently authorized by written modification of this Secrecy Order granted by the Commissioner of Patents & Trademarks (see 37 CFR §5.5).

---

[1] The term "classifiable" as used herein refers to subject matter that is not actually classified but is sufficiently sensitive, in the opinion of the sponsoring defense agency named herein, to have been classified under E.O. 12356 if the subject matter were known to be owned by or under control of the U.S. government.

[2] "Principals" include all patent applicants, their heirs, assignees, licensees and their attorneys and agents.

Unauthorized publication or disclosure of the subject matter of this patent application may result in abandonment of the application (35 U.S.C. §182) and additionally subject the person publishing or disclosing the subject matter to the penalties of 35 U.S.C. §186.

The subject matter of this application must be safeguarded under conditions that will provide adequate protection and prevent access by unauthorized persons. When copies of the subject matter are no longer needed, they should be destroyed by a method that will prevent disclosure of the contents or reconstruction of the document.

Any other patent application already or hereafter filed in the U.S. or any foreign country which contains any significant part of the subject matter of the above-identified patent application also falls within the scope of this Order. If such other patent application is not currently under a Secrecy Order imposed by the U.S. Patent and Trademark Office, it and the common subject matter must be brought to the immediate attention of:

Director, Special Laws Administration
Attention: Licensing and Review
U.S. Patent and Trademark Office
Washington, D.C. 20231.

This Order should not be construed in any way to mean that the U.S. Government has adopted or contemplates adoption of the invention disclosed in this application and it is not any indication of the value of such invention. Additionally, this Order is not authority in and of itself for classification of the subject matter of this patent application.

This secrecy order has been recommended under 35 U.S.C. §181 to the Commissioner of Patents & Trademarks by the following sponsoring defense agency:

( ) ARMY ( ) NAVY (X) AIR FORCE

Questions regarding the reasons for imposing this Secrecy Order should be directed to the sponsoring defense agency. A contact for each defense agency is attached. Questions regarding the substantive examination of the patent application should be directed to the patent examiner, and questions pertaining to the administrative handling of the patent application or the Secrecy Order should be directed to the Licensing and Review Branch of the Patent & Trademark Office.

Permit for Disclosing Classified or "Classifiable" Information

A. If the subject matter of this application is **classified**:
Disclosure of the subject matter of this application is authorized to persons with the appropriate personnel security clearance on a "need-to-know" basis under the provisions

of Executive Orders 10865 and 12356 and the "Industrial Security Manual for Safeguarding Classified Information" provided the authorized person to whom the subject matter is disclosed is furnished with a copy of this Secrecy Order and informed that this Order is applicable to the subject matter disclosed.

Any declassification, in whole or in part, of the subject matter of this application does not modify this Secrecy Order. The requirements of this Secrecy Order remain in effect until it is rescinded or modified in writing by the Commissioner of Patents & Trademarks. If the subject matter is declassified, this fact should be brought to the attention of the sponsoring defense agency.

B. If the subject matter of this application is "**classifiable**" but not classified:
Principals to this Secrecy Order employed at a facility which has a current DoD Security Agreement (DoD Form 441) are authorized to disclose on a "need-to-know" basis the subject matter of this patent application to other persons at that facility having a personnel security clearance at least as high as the level of protection specified on page 1 of this Secrecy Order provided the provisions of the "Industrial Security Manual for Safeguarding Classified Information" (DoD 5220.22-M) are complied with[3] and the authorized person to whom the subject matter is disclosed is furnished with a copy of this Secrecy Order and informed that this Secrecy Order is applicable to the subject matter disclosed.

Principals employed at a facility that does not have a current DoD Security Agreement must obtain prior written modification of this Secrecy Order from the Commissioner of Patents & Trademarks for any further disclosure of the subject matter of this application to any person. See 37 CFR §5.5.

This permit for disclosing classified or "classifiable" information does not authorize disclosure of the subject matter of the patent application through (1) the filing of any foreign application without specific permission of the Patent and Trademark Office, or (2) the export of any item, commodity or technical data without the required export license.

John F. Terapane
Director, Special Laws Administration

[3] Since the subject matter covered by this Secrecy Order is not actually classified, certain provisions of the Industrial Security Manual (ISM) may not strictly apply, such as derivative classification, downgrading/declassification instructions, and portion and page markings. Facilities encountering problems complying with any provisions of the ISM should directly query the defense agency sponsoring this Secrecy Order for appropriate security guidance.

9-10-99

DEPARTMENT OF THE AIR FORCE
AIR FORCE MATERIEL COMMAND LAW OFFICE (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE OHIO

November 29, 2000

MEMORANDUM FOR COMMISSIONER OF PATENTS AND TRADEMARKS
U.S. PATENT AND TRADEMARK OFFICE
ATTN: SECURITY GROUP, LICENSING AND REVIEW
WASHINGTON DC 20231

RECEIVED
DEC -4 2000
LICENSING & REVIEW

FROM: AFMC LO/JAZ
2240 B Street, Room 100
Wright-Patterson AFB, OH 45433-7109

SUBJECT: Request for Secrecy Order

The following identified application has been examined by the Air Force, under the provisions of 35 U.S.C. 181.

U.S. Patent Application Serial No. 07/810,005
Filed: 12/18/1991
Inventor(s): Alan J. Katz
Prosecuted by ☐Govt. ☐Contractor ☒Unknown Party

This is to notify you in accordance with the above examination that the publication or disclosure of the invention by the granting of a patent therefor would be detrimental to the national security. It is accordingly requested that you order the invention be kept secret and withhold the grant of a patent for such period as the national interest requires.

It is further requested that the following Secrecy order issue

☐ Secrecy Order and Permit for Foreign Filing in Certain Countries
DOD Property Interest/Unclassified export restricted subject matter

☒ Secrecy Order and Permit for Disclosing Classified Information
Level of Classification Confidential

☐ Secrecy Order - It is further requested that this Secrecy Order issue with
☐ Permit A (PTO 229)
☐ No Permit

PAMELA J. FULMER
Legal Instruments Examiner
Directorate of Intellectual Property Law

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
www.uspto.gov

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314

OC000000005507260
OC000000005507260

GLENN H. LENZEN
RAYTHEON COMPANY
OFFICE OF GENERAL COUNSEL
141 SPRING STREET MAIL STOP 1-1
LEXINGTON,, MA 02173

Date Mailed: 10/26/2000

NOTICE REGARDING POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/14/1997.

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.

Customer Service Center
Initial Patent Examination Division (703) 308-1202

OFFICE COPY

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
www.uspto.gov

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
07/810,005	12/18/1991	ALAN J. KATZ	TI-16314

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

OC000000005507220

Date Mailed: 10/26/2000

NOTICE REGARDING POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/14/1997.

- 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).

Customer Service Center
Initial Patent Examination Division (703) 308-1202

OFFICE COPY

GP 2768

RAYTHEON

Rene' E. Grossman
Senior Attorney
972-344-1205
972-344-1211 fax
r-grossman@raytheon.com

Raytheon Company
Office of the General Counsel
13510 N. Central Expressway
M/S 200
Dallas, Texas
75243-1108 USA

Mailing Address:
P.O. Box 660246
M/S 200
Dallas, Texas
75266 USA

OIPE
SEP 20 2000
PATENT & TRADEMARK OFFICE
JC09

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Ch. of address
Copy
3-22-4

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SEP 22 2000
TECH CENTER 2700

RECEIVED
MAR 12 2001
TO 3600 MAIL ROOM

September 8, 2000

Commissioner of Patents and Trademarks
Washington, DC 20231

Re: TI-16314, SN 07/810,005. Filing Date 12/18/91
Examiner Cain, Art Unit 2768

Dear Sir:

Please change the mailing address on this case to the following:

Rene E. Grossman
Raytheon Company
P. O. Box 660246, MS 200
Dallas, TX 75266

Thank you.

RECEIVED
MAR 12 2001
LICENSING & REVIEW

Yours very truly,

Rene E. Grossman
Reg. No. 22,656

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ	A

EXAMINER 6314

07M1/0910

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS TX 75265

ART UNIT	PAPER NUMBER
CAIN,D	

DATE MAILED:
2764

09/10/98

RENEWAL OF SECRECY ORDER
[Title 35, United States Code (1952), Sections 181-188]

NOTICE: To the applicants, heirs of applicants, and any and all assignees, attorneys and agents, the designate principals.

The Armed Services Patent Advisory Board, Department of Defense (DOD), has notified the Commissioner of Patents and Trademarks that an affirmative determination has been made by a DOD agency, identified below, that the national interest required renewal of the secrecy order. The secrecy order is therefore, renewed, effective for a period of **ONE YEAR** from the date of this renewal notice.

The secrecy order may be renewed for additional periods of not more than one year upon notice by a government agency that the national interest so requires.

DOD AGENCY: ☐ **ARMY** ☐ **NAVY** ☒ **AIR FORCE** ☐ **ASPAB**

Director
Special Laws Administration Group

PTOL-416 (REV. 3-96)

DEPARTMENT OF THE AIR FORCE
AIR FORCE LEGAL SERVICES AGENCY (AFLSA)

9/11/98

01 September 1998

Commissioner Of Patents and Trademarks
U.S. Patent and Trademark Office
Attn: Licensing and Review, 4-10C-24
Washington, D.C. 20231

RECEIVED
SEP 0 1 1998
LICENSING & REVIEW

Dear Sirs:

This is to notify you,on behalf of the head of the agency who caused the secrecy order to be issued on the following identified patent application, that an affirmative determination has been made that the national interest requires that the invention continue to be kept secret and the grant of a patent continue to be withheld.

U.S. Patent Application Serial No. 07/810,005
Filed: 18 December 1991
Inventor(s) Alan J. Katz
Prosecuted by ( )Govt ( )Contractor (x)Unknown Party

Accordingly, it is recommended that the order be renewed.

Sincerely

CAROLYN B. SMITH, USAF
Sponsor (ASPAB Member)

DEPARTMENT OF THE AIR FORCE
AIR FORCE LEGAL SERVICES AGENCY (AFLSA)

5/7/97

Commissioner Of Patents and Trademarks
U.S. Patent and Trademark Office
Attn: Licensing and Review, 4-10C-24
Washington, D.C. 20231

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LICENSING & REVIEW

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U.S. Patent Application Serial No. 07/810,005
Filed: 18 December 1991
Inventor(s) Alan J. Katz
Prosecuted by ( )Govt ( )Contractor (x)Unknown Party

Accordingly, it is recommended that the order be renewed.

Sincerely

Mervin L. Jordan

MERVIN L. JORDAN, USAF
Sponsor (ASPAB Member)

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ	A TI-16314

EXAMINER

07M1/0911

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS TX 75265

CAIN,D

ART UNIT	PAPER NO.
2202	

DATE MAILED:
09/11/97

SECRECY ORDER

For Unclassified Patent Application with a DoD Property Interest

Including:
Permit for Disclosing Subject Matter for Legitimate Business Purposes;
Permit for Foreign Filing in Certain Countries

The above-identified patent application discloses subject matter the unauthorized publication or disclosure of which would, in the opinion of the sponsoring defense agency be detrimental to the national security.

ALL PRINCIPALS[1] IN THIS APPLICATION ARE ORDERED TO KEEP THE SUBJECT MATTER THEREOF IN SECRECY UNDER 35 U.S.C. §181.

The subject matter of this application may not be published or disclosed to any person except as specifically authorized herein or subsequently authorized by written modification of this Secrecy Order granted by the Commissioner of Patents & Trademarks (see 37 CFR §5.5).

Unauthorized publication or disclosure of the subject matter of this patent application may result in abandonment of the patent application (35 U.S.C. §182) and additionally subject the person publishing or disclosing the subject matter to the penalties of 35 U.S.C. §186.

[1] "Principals" include all patent applicants, their heirs, assignees, licensees and their attorneys and agents

The principals are permitted, subject to the conditions stated hereinafter, to file and prosecute a corresponding application for patent in each of the following countries: Australia, Belgium, Canada, Denmark, France, Federal Republic of Germany, Greece, Italy, Japan, Korea, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Turkey and the United Kingdom.

The papers for each foreign application and its prosecution shall be transmitted to the sponsoring agency, identified herein, for forwarding through diplomatic channels for filing in the foreign country either directly by the principals or through the principals' foreign patent attorney or agent if authorized by the foreign government. Correspondence exclusively relating to payments of taxes and fees need not be sent through the sponsoring agency and diplomatic channels provided that such correspondence contains no information pertaining to the subject matter of the above-identified application.

International reciprocal agreements providing for the filing of patent applications under a Secrecy Order in the above-identified countries require the principals to furnish to the sponsoring agency identified herein (in addition to the papers to be filed in the foreign patent office) a copy of the specification (including any drawings annexed thereto, any resume and the claims included in the patent application) filed in the patent office of the foreign country. This copy will be furnished to the appropriate defense agency of the foreign government for information only and without prejudice to any rights of the principals. The filing date and serial number of the patent application should also be furnished to the sponsoring agency.

The principals shall request the foreign patent office to place in secrecy the foreign patent applications corresponding to the above-identified application and shall furnish a copy of this Secrecy Order and permit with the first papers to be filed in the foreign patent office.

The use of this permit to file in a foreign country shall constitute a waiver, unless otherwise required by international agreements, of any claim to compensation for loss or damage due solely to the imposition of secrecy or similar treatment of the invention. Belgium, France, the Federal Republic of Germany, the Netherlands, Norway, Turkey and the United Kingdom normally require a separate document confirming such a waiver.

In the case of Japan, the applicant shall ensure in its contract with its patent attorney that the patent attorney shall submit to the Japanese Patent Office a certified copy of this Secrecy Order and Permit. The submission of this permit to the Japanese Patent Office is considered notification to the Government of Japan of the Secrecy Order status of the above-mentioned application and a corresponding Japanese application will be considered an Agreement Application referred to in paragraph 3(a) of the Protocol to the 1956 United States-Japan Agreement.

Robert E. Garrett
Director, Special Laws Administration
U. S. Patent & Trademark Office

General Provisions

Any other patent application already or hereafter filed in the U.S. or any foreign country which contains any significant part of the subject matter of the above-identified patent application also falls within the scope of this Order. If such other patent application is not currently under a Secrecy Order imposed by the U.S. Patent and Trademark Office, it and the common subject matter must immediately be disclosed to the Commissioner of Patents & Trademarks, Washington, D.C. 20231, Attention: Licensing & Review.

This Secrecy Order was recommended to the Patent & Trademark Office by the following defense agency:

( ) ARMY ( ) NAVY (X) AIR FORCE

Questions pertaining to the basis for imposing this Secrecy Order should be directed to the sponsoring defense agency. A contact for each defense agency is attached.

This Order should not be construed in any way to mean that the U.S. Government has adopted or contemplates adoption of the invention disclosed in this application and it is not any indication of the value of such invention.

Safeguarding Provisions

This application is unclassified, and thus not subject to the provisions of Executive Order 12356, entitled "National Security Information," Executive Order 10865, entitled "Safeguarding of Classified Information Within Industry" or the "Industrial Security Manual for Safeguarding Classified Information." However, since disclosure of the subject matter would be detrimental to the national security, it must be safeguarded under conditions that will provide adequate protection and prevent access by unauthorized persons. When copies of the subject matter are no longer needed, they should be destroyed by any method that will prevent disclosure of the contents or reconstruction of the document. While this Order remains in effect, all communications with the Patent & Trademark Office pertaining to this application must be addressed to the Commissioner of Patents & Trademarks, Wahsington, D.C. 20231, Attention: Licensing & Review. Other questions pertaining to the security safeguarding of this application should be directed to the sponsoring defense agency.

Permit for Disclosing Subject Matter for Legitimate Business Purposes

The principals may disclose, for legitimate business purposes, the subject matter of this patent application to a U.S. citizen or to a person who is both admitted lawfully into the United States for permanent residence and is located in the United States provided the U.S. citizen or person is furnished with a copy of this Secrecy Order and is informed that this Secrecy Order is applicable to the subject matter disclosed. The term "legitimate business purposes" is to be interpreted consistent with 32 CFR Part 250. Legitimate business purposes include selling or producing products for the commercial domestic marketplace, or for the commercial foreign marketplace providing that any required export license is obtained. Legitimate business purposes also include selling or otherwise disclosing technical data to foreign contractors or foreign governments after receiving the required export license or approval by the U.S. Government.

The principals shall notify the Commissioner of Patents and Trademarks if a validated license is obtained from the Office of Export Administration, U.S. Department of Commerce, or a license is obtained from the Director, Office of Defense Trade Controls, U.S. Department of State, under regulations governing the export of technical data (15 CFR §379 of the Export Administration Regulations or 22 CFR §125 of the International Traffic in Arms Regulations).

Permit for Foreign Filing in Certain Countries

O.I.P.E.
JUL 14 1997
PATENT TRADEMARK

2202
12

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Rev. + Petty - by Assignee

In re the Application of: **Alan J. Katz**
Serial No. **810,005**
Filed **12/18/91**
For: **UNDER SECRECRY ORDER**

Docket: **TI-16314**
Examiner:
Art Unit: **231**

RECEIVED Copies
AUG - 4 1997 10-26-00
GROUP 2200

REVOCATION OF ALL PRIOR POWERS AND POWER OF ATTORNEY

MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(a)

I hereby certify that the above correspondence is being deposited with the U.S. Postal Service as First Class Mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on

7-10-97
Gracia Sansom

Ok to enter

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

I, Richard L. Donaldson, Senior Vice President of Texas Instruments Incorporated, Assignee of the subject application, hereby revoke all prior powers of attorney in the subject application and appoint the following as principle attorneys with full power to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith: Glenn H. Lenzen, Reg. No. 29,320; Donald F. Mofford, Reg. No. 33,740; Andrew J. Rudd, Reg. No. 36,661; and Philip P. Berestecki, Reg. No. 26,502.

Please address all further correspondence to the following:

RECEIVED
AUG 0 7 1997
LICENSING & REVIEW

Glenn H. Lenzen
Raytheon Company
Office of General Counsel
141 Spring Street Mail Stop 1-1
Lexington, MA 02173

Respectfully submitted,

By: Richard L. Donaldson
Richard L. Donaldson, Reg. No. 25,673
Senior Vice President Corporate Staff and
General Patent Counsel

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ A	TI-16314

EXAMINER
CAIN, D

ART UNIT	PAPER NUMBER
2202	

07M1/0507

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

DATE MAILED: 05/07/96

RENEWAL OF SECRECY ORDER
[Title 35, United States Code (1952), Sections 181-188]

NOTICE: To the applicant(s), heirs of applicant(s), and any and all assignees, attorneys and agents, the designated principals.

The Armed Services Patent Advisory Board, Department of Defense (DOD), has notified the Commissioner of Patents and Trademarks that an affirmative determination has been made by a DOD agency, identified below, that the national interest requires renewal of the secrecy order. The secrecy order is therefore, renewed, effective for a period of **ONE YEAR** from the date of this renewal notice.

The secrecy order may be renewed for additional periods of not more than one year upon notice by a government agency that the national interest so requires.

DOD AGENCY: ☐ **DARCOM** ☐ **NAVY** ☒ **AIR FORCE** ☐ **ASPAB**

for **Director**
Special Laws Administration Group

PTOL-416 (REV. 6-93)

DEPARTMENT OF THE AIR FORCE
AIR FORCE LEGAL SERVICES AGENCY (AFLSA)
1 May 1996

5/8/96

RECEIVED
MAY 0 3 1996
LICENSING & REVIEW

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Attn: Licensing and Review, 4-10C-24
Washington, D.C. 20231

Dear Sirs:

This is to notify you, on behalf of the head of the agency who caused the secrecy order to be issued on the following identified patent application, that an affirmative determination has been made that the national interest requires that the invention continue to be kept secret and the grant of a patent continue to be withheld.

U.S. Patent application Serial No. 07/810,005
Filed: 18 December 1991
Inventor(s) Alan J. Katz
Prosecuted by: ( )Govt ( )Contractor (X)Unknown Party

Accordingly, it is recommended that the order be renewed.

Sincerely

Mervin Jordan

Mervin Jordan, USAF
Sponsor (ASPAB Member)

Organization

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ A	TI-16314

EXAMINER
CAIN, D

ART UNIT	PAPER NUMBER
2202	

07M1/0508

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

DATE MAILED: 05/08/95

RENEWAL OF SECRECY ORDER
[Title 35, United States Code (1952), Sections 181-188]

NOTICE: To the applicant(s), heirs of applicant(s), and any and all assignees, attorneys and agents, the designated principals.

The Armed Services Patent Advisory Board, Department of Defense (DOD), has notified the Commissioner of Patents and Trademarks that an affirmative determination has been made by a DOD agency, identified below, that the national interest requires renewal of the secrecy order. The secrecy order is therefore, renewed, effective for a period of **ONE YEAR** from the date of this renewal notice.

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DOD AGENCY: ☐ **DARCOM** ☐ **NAVY** ☒ **AIR FORCE** ☐ **ASPAB**

for **Director**
Special Laws Administration Group

PTOL-416 (REV. 6-93)

5-10-95

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC 20324-1000

1 May 1995

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MAR 3 1 1995
LICENSING & REVIEW

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Attn: Licensing and Review
4-10C-24
Washington, D.C. 20231

Dear Sir:

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U.S. Patent Application Serial No. 07/810,005
Filed: 18 December 1991
Inventor(s) Alan J. Katz
Prosecuted by: ( )Govt ( )Contractor (x)Unknown Party
Case No.

Accordingly, it is recommended that the order be renewed.

Sincerely
Mervin Jordan
MERVIN JORDAN, USAF

Sponsor (ASPAB Member)

Organization _____

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ A	TI-16314

EXAMINER	
CAIN, D	

07M1/0510

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

ART UNIT	PAPER NUMBER
2502	

DATE MAILED: 05/10/94

RENEWAL OF SECRECY ORDER
[Title 35, United States Code (1952), Sections 181-188]

NOTICE: To the applicant(s), heirs of applicant(s), and any and all assignees, attorneys and agents, the designated principals.

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DOD AGENCY: ☐ **DARCOM** ☐ **NAVY** ☒ **AIR FORCE** ☐ **ASPAB**

for J. J. Bradshaw
Director
Special Laws Administration Group

PTOL-416 (REV. 6-93)

5-12-94

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC 20324-1000

11 April 1994

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Attn: Licensing and Review
4-10C-24
Washington, D.C. 20231

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APR 26 1994
LICENSING & REVIEW

Dear Sir:

This is to notify you, on behalf of the head of the agency who caused the secrecy order to be issued on the following identified patent application, that an affirmative determination has been made that the national interest requires that the invention continue to be kept secret and the grant of a patent continue to be withheld.

U.S. Patent Application Serial No. 07/810,005
Filed: 18 December 1991
Inventor(s) Alan J. Katz
Prosecuted by: ( )Govt ( )Contractor (X)Unknown Party
Case No.

Accordingly, it is recommended that the order be renewed.

Sincerely,

Donald J. Singer

DONALD J. SINGER, USAF
Sponsor (ASPAB Member)

Organization _____

U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

Address : COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.

EXAMINER	
ART UNIT	PAPER NUMBER

DATE MAILED:

This is a communication from the Examiner in charge of your application.

Commissioner of Patents and Trademarks

NOTICE OF ALLOWABILITY (FORM D-10)

This application is now in condition for allowance, and the prosecution is closed. However, in view of the secrecy order issued 5/12/92, under 35 U.S.C. (1952) 181, this application will be withheld from issue during such period as the national interest requires.

The allowable claims are: Claims 1-20 are allowable.

EXAMINER Cain
02-22-93

PTOL-258 (REV. 6-84)

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office

Address : COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ A	TI-16314

CAIN,P

EXAMINER	
ART UNIT	**PAPER NUMBER**
2202	

DATE MAILED: 05/12/93

07M1

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

RENEWAL OF SECRECY ORDER
[Title 35, United States Code (1952), Sections 181-188]

NOTICE: To the applicant(s), heirs of applicant(s), and any and all assignees, attorneys and agents, the designated principals.

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The secrecy order may be renewed for additional periods of not more than one year upon notice by a government agency that the national interest so requires.

DOD AGENCY: ☐ DARCOM ☐ NAVY ☑ AIR FORCE ☐ ASPAB

for Theresa Bradshaw
Director,
Special Laws Administration

PTOL-416 (Rev. 7-83)

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC 20324-1000

5-12-93

19 April 1993

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Attn: Licensing and Review
4-10C-24
Washington, D.C. 20231

RECEIVED
MAY 1) 1993
LICENSING & REVIEW

Dear Sir:

This is to notify you, on behalf of the head of the agency who caused the secrecy order to be issued on the following identified patent application, that an affirmative determination has been made that the national interest requires that the invention continue to be kept secret and the grant of a patent continue to be withheld.

U.S. Patent Application Serial No. 07/810,005
Filed: 18 December 1991
Inventor(s) Alan J. Katz
Prosecuted by: ( )Govt ( )Contractor (x)Unknown Party
Case No.

Accordingly, it is recommended that the order be renewed.

Sincerely

Donald J. Singer

DONALD J. SINGER, USAF
Sponsor (ASPAB Member)

Organization _____

TYPE I Secrecy Order

Cofer
2-8-93

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Katz | Art Unit: 2304
Serial No.: 07/810,005 | Examiner: Zanelli, M.
Filed: 12/18/91 | Docket: TI-16314

For: Generalized Hebbian Learning for Principal Component Analysis and Automatic Target Recognition, Systems and Methods

Re: Attention of Licensing and Review

RECEIVED
JAN 25 1993
LICENSING & PC

AMENDMENT UNDER 37 C.F.R. 1.115

January 8, 1993
Commissioner of Patents and Trademarks
Washington, D.C. 20231

Dear Sir:

The following amendments and remarks are offered in response to the Examiner's Office Action dated 07/08/92. They are respectfully submitted as a full and complete response to that Action.

Please amend the above referenced application as follows:

In the Claims

Please add new Claims as follows:

20. A method for distinguishing targets from background clutter, comprising the steps of

(a) inputting data having targets and background clutter;

(b) applying neural network learning procedures to said data to construct a set of operators;

(c) applying said set of operators to data to construct a set of features;

(d) choosing optimal features from said set of features to distinguish targets from clutter; and

(e) using said optimal features to distinguishing targets from background clutter.

REMARKS

Claims 1-19 are pending. Original Claims 1-19 were rejected under 35 U.S.C. 112, second paragraph. New Claim 20 has also been added hereinabove. Applicants in response now answer the rejections and amend selected claims.

20-0668 010 102 00CH
LA10080 02/05/93 07810005

In response to the drawings objection, it is requested that submission of formal drawings be deferred according to the usual procedure until allowable subject matter is indicated.

The Applicant respectfully submits that Claims 1-19 are fully clear and definite under 35 U.S.C. 112, second paragraph, and they do particularly point out and distinctly claim the subject matters to which they are respectively directed. "Selecting", "generating", and "extracting" are conventional vocabulary terms in the fields of pattern recognition, classification procedures, parallel computer architectures, learning techniques, and neural networks as well as the fields of image processing and speech processing, as the articles and textbooks recited in the specification suggest. Moreover, if the Examiner needs other examples or references to verify the Applicant's contention, the Applicant will be happy to provide any such examples.

In any case, the Applicant respectfully submits that Claims 1-19 clearly and particularly point out and distinctly claim the claimed subject matter and thus distinguish "what infringes from what doesn't", W.L. Gore and Associates v. Garlock, 220 U.S.P.Q. 303, 316 (CAFC, 1983). In addition, MPEP 706.03(d) cautions that "Some latitude in the manner of expression and aptness of terms should be permitted even though the claim language is not as precise as the examiner might desire" and "[i]n non-chemical cases, a claim may, in general, be drawn as broadly as permitted by the prior art." 35 U.S.C. 112, second paragraph, does not call for the claim to require details which are the province of the detailed description. In particular, with respect to "generating", "extracting", and "selecting", the specification explains the procedures used to "generate", to "select", and to "extract" in detail on pages 16-21 along with the discussion of specific cases on pages 21-26.

Accordingly, Applicants request that the 35 U.S.C. 112, second paragraph, rejection directed to Claims 1-19 be reconsidered and that the rejection be withdrawn. New Claim 20 has also been submitted for examination and it is requested that they be allowed

as well.

Reconsideration and allowance of the application with Claims 1-20 is requested.

If the Examiner has any questions or other correspondence regarding this application, Applicant requests that the Examiner contact Applicant's attorney at the below listed telephone number and address to facilitate prosecution.

Texas Instruments Incorporated
P.O. Box 655474 M/S 219
Dallas, Texas 75265
(214)995-1845
Fax: (214)995-3511 or (214)995-3170

Respectfully submitted,

R. Darryl Burke
Reg. No. 35,464

Certificate of Mailing under 37 C.F.R. §1.8

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on January 8, 1993.

Donna J. Otto

JAN 11 1993
61
PATENT & TRADEMARK OFFICE

U.S. PATENT AND TRADEMARK OFFICE

AMENDMENT TRANSMITTAL FORM

Applicant: Alan Katz — Art Unit: 2304

Serial No.: 07/810,005 — Examiner: Zanelli, M.

Filed: 12/18/91 — Docket: TI-16314

For: Generalized Hebbian Learning for Principal Component Analysis and Automatic Target Recognition, Systems and Methods

MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(A)
I hereby certify that the above correspondence is being deposited with the U.S. Postal Service as First Class Mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on January 8, 1993.

Donna J. Otto

Donna J. Otto

Attention: Licensing and Review Group
THE COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D. C. 20231

Sir:

Transmitted herewith is an amendment and certificate of mailing in the above-identified Application. The Fee has been calculated as shown below.

CLAIMS AS AMENDED

	Claims remaining after amendment		Highest Number Previously Paid for	Present Extra	Rate	Additional Fee
TOTAL	20	Minus	20	= -0-	x $20	$ 00.00
Independent Claims	5	Minus	4	= 1	x $74	$ 74.00
Total Additional Fee for this Amendment						$ 74.00

TI-16314 Serial No. 07/810,005

Charge the total additional fee, and any further fees, or credit any overpayment to Deposit Account No. 20-0668. Three copies of this sheet are enclosed.

Respectfully submitted,

Texas Instruments Incorporated
P.O. Box 655474 M/S 219
Dallas, Texas 75265
(214)995-1845
Fax: (214)995-3511 or (214)995-3170

Richter Darryl Burke
Reg. No. 335,464

MAIL ROOM
JAN
11
1993
PAT. & TRADEMARK OFF.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Katz | Art Unit: 2304
Serial No.: 07/810,005 | Examiner: Zanelli, M.
Filed: 12/18/91 | Docket: TI-16314

For: Generalized Hebbian Learning for Principal Component Analysis and Automatic Target Recognition, Systems and Methods

Re: Attention of Licensing and Review

AMENDMENT UNDER 37 C.F.R. 1.115

January 8, 1993
Commissioner of Patents and Trademarks
Washington, D.C. 20231

Dear Sir:

The Applicant hereby petitions to have the secrecy order lifted. The Applicant conducted a poster presentation entitled "Hebbian Learning, Principle Components, and Automatic Target Recognition," at the Neural Networks for Computing Conference, which was held in Snowbird, Utah, on April 8, 1992, that covered the identical material covered in the patent application cited above. A copy of an internal report summarizing this information is included.

This petition is being filed in duplicate along with one copy of the application as originally filed.

If the Examiner has any questions or other correspondence regarding this application, Applicant requests that the Examiner contact Applicant's attorney at the below listed telephone number and address to facilitate prosecution.

Texas Instruments Incorporated
P.O. Box 655474 M/S 219
Dallas, Texas 75265
(214)995-1845
Fax: (214)995-3511 or (214)995-3170

Respectfully submitted,

R. Darryl Burke
Reg. No. 35,464

Certificate of Mailing under 37 C.F.R. §1.8

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on January 8, 1993.

Donna J. Otto

GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHODS

NOTICE

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FIELD OF THE INVENTION

The present invention relates generally to products and methods pertaining to pattern recognition and classification procedures, parallel computer architectures, learning techniques, and neural networks.

BACKGROUND OF THE INVENTION

Target recognition and pattern classification involves the evaluation of new observations on the basis of past observations to distinguish targets or desired patterns from background clutter. This task is complicated by the complex nature of real world environments. Moreover, the computational overhead of many practical classification problems strain serial computer resources.

With respect to the complexity of pattern recognition and pattern classification techniques, many of these techniques rely on feature information to differentiate preferred targets from background clutter. Coordination and selection of this feature information is an ongoing problem, as the desired feature information itself (e.g., contrast-based and texture-based) often varies from target to target (e.g., size, stationary, make-up, composition, orientation), target to background (e.g. location of target), data set to data set (e.g., lighting, time-of-day, ambient temperature, and context of scene, sensor characteristics), and data source to data source (e.g., one-dimensional or multi-dimensional data, such as digitized infrared imagery, digitized TV imagery, digitized Infra-red imagery, speech samples, or radar samples).

Recently, researchers have focused on the perception of features in the visual field by biological visual systems and the organization of these biological visual systems. In short, this research has focused on what features are perceived and how are the receptive fields (e.g. neurons sensitive to particular features) organized. This work contributes to the understanding of biological vision systems and lays the groundwork for artificial vision systems in such areas as robotics and automatic

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target recognition.

In particular, D.J. Hubel and T.N. Wiesel in their article Hubel, D.J. and Wiesel, T.N, "Receptive Fields, Binocular Interaction, and Functional Architecture in The Cat's Visual Cortex." Journal of Physiology, vol. 160, pp.106-154 (1962) and D. Marr in his book Marr, D. Vision W.H. Freeman and co. San Francisco 1982 are credited with initiating research in this field. Recent work, however, in artificial neural networks suggests mechanisms and optimization strategies that explain the formation of receptive fields and their organization in mammalian vision systems. This work includes Miller, K.d., Keller, J.B. and Stryker, M.P. "Ocular Dominance Column Development: Analysis and Simulation." Science, vol. 245, pp. 605-615 (1989), Durbin, R. and Michison, G. "A Dimension Reduction Framework For Understanding Cortical Maps." Nature, vol. 343, pp. 644-647 (1990), Linsker, R. "Self Self-organization In a Perceptual Network." Computer, vol. 21, pp. 105-117 (1988), and Kammen, D.M. and Yuille, A.L. "Spontaneous Symmetry-breaking Energy Function." Biological Cybernetics, vol. 59, pp. 23-31 (1988). Linsker demonstrated how Hebbian learning algorithms, which change synaptic connections according to the degree of correlation between neuronal inputs and outputs, give rise to layers of center-surround and orientation-selective cell, even if the input to the initial layer is random white Gaussian noise. Kammen and Yuille show that orientation-selective receptive fields can also develop from a symmetry-breaking mechanism. Under certain conditions, the receptive fields perform a principal component analysis of the input data, as was shown in Oja, E.J. "A Simplified Neuron Model As A Principal

Component Analyzer." Mathematics and Biology, vol. 15, pp. 267-273 (1982). Similarly, the article by Brown, T.H., Kairiss, E.W., and Keenan, C.L., "Hebbian synapses: Biophysical mechanisms and algorithms," Annual Review of Neuroscience, vol. 13, pp. 475-511 (1990) suggested Hebbian learning occurs in nature.

With respect to the computational requirements, neural networks provide parallel computational implementations. These networks embody an approach to pattern recognition and classification based on learning. Example patterns are used to train these networks to isolate distinctions between the particular patterns and background clutter for proper classification.

With respect to neural networks, the architecture of a neural network can be simply represented by a data-dependency graph, such as that shown in Figure 1. As shown, this data-dependency graph includes a set of active nodes 4 and a set of passive communicative links 6. The graph nodes 4 represent artificial neurons and the passive communication links 6 define unidirectional communication paths between the artificial neurons 4 (graph nodes 4). Additional links 2 are used as network inputs, which indicate which neurons will receive input signals from outside the network. Similarly, additional links 8 are used as network outputs, which indicate which neurons will transmit output signals to outside the network. A communication link 6 effectively makes the output state of one neuron at the tail of the link available to the neuron at the head of the link. For example, if the neuron states were made available as electrical voltages or currents, the communication links could be provided as simple conductive wires.

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Referring to Figure 2, some architectures are feed-forward, wherein signals are inputed through communication links 2 which direct the input signals, flow through the communication links 6 to the neurons 4 in the neural network in a layer-by-layer fashion, and outputted through the communications links 8 which direct the output signals. No circular path of feedback exists within this type of network. Other networks are fully interconnected, wherein all neurons are connected to all other neurons. Figure 3 shows an example of this type of network, wherein all neurons 4 are connected to all other neurons 4 through corresponding communication links 6 with input and output communication links as shown. In general, each neuron in a neural network architecture has a high fan-in and a high fan-out.

With respect to the neuron function itself, neuron states are generally defined by non-linear local functions. The output value of a neuron is defined by a transfer function, which depends only upon the neurons' current internal state, a set of local parameters called synapses, and the value of signals received from other neurons. Figure 4 shows a simplified schematic of a neuron, along with its network links 12, synaptic parameters 14, and typical input-output transfer function 16. Input voltages V_1, V_2, V_3, ..V_N are received from other neurons and output voltage V_i is outputed to other neurons. The neuron transfer function 16 is usually described as a non-linear function of the sum-of-products of the synapse parameters 14 with their associated input signal values. Figure 5 shows a typical non-linear function that must be

provided by each neuron that operates according to equation 1, which is defined as follows

$$V_i = F\left(\sum_{j=1}^{N} \sigma_{ij}\ V_j\right)$$

In defining the transfer function described by equation 1, V_i is the output value (or state) of neuron i, Σ ij is the value of the synapse parameter that modifies the effect of the output of neuron j on the state of neuron i, and F is a function of the sum-of-products of the synapses with neuron states. With respect to Figure 5, F is a linear function of the sum-of-products input near the zero sum region, while saturating to positive and negative values when the sum exceeds a preset positive or negative value.

With respect to training and using the neural network, the synapses affect the transfer function by modulating the strength of signals received from other neurons in the network. In virtually all models, the behavior of the network as a whole is changed by altering the values of the synaptic parameters. Once the parameters are altered, inputs can be applied to the network, and the processed output taken from the designated set of neurons. The time during which the synapse parameter values are altered is generally called the Training Phase. The time during which input signals flow through the network while the synapse parameters remain fixed is called the Recall or Relaxation Phase.

With respect to neuron circuit embodiments, Figure 6 shows the schematic

diagram of an artificial neuron implemented using resistors and an operational transconductance amplifier. The resistors R_{ij} are associated primarily with the synapses in equation 1, while the operational transconductance amplifier (OTA) and its feedback component R_{fi} is used to provide the desired transfer function F_i.

With respect to the operation of an OTA, as shown in Figure 6, an ideal OTA generates an output voltage proportional to the difference of the currents entering its inputs, multiplied by a very large gain factor. Figure 7 shows an ideal OTA. The defining equation 7 for this circuit may be derived by the analysis, as follows

$$V_{OUT} = A\ (i_2 - i_1) \quad A>>>1$$

$$i_1 = i^- + i_0$$

$$V_{out} = A\ (i^+ - i^- - i_o)$$

$$i_o = \frac{V_{out}}{Z_F}$$

Thus,

$$V_{out} = \frac{Z_F\ A}{A + Z_F}\ (i^+ - i^-)$$

If $A >> Z_F$,

$$V_{out} = Z_F \ (i^+ - i^-)$$

The gain factor A is infinite in the idea case, and very large values of A (Over 1 million) can be obtained in practice using off-the-shelf OTA components. An ideal OTA will have a zero input resistance at its inputs, so that the operation of the circuit may be understood by assuming equation 7, and by assuming that the voltage at either input referenced to ground is always zero. Electrical components placed between the output of an OTA and its negative input induce negative current feedback in the circuit while components placed between the OTA output and its positive input induce positive current feedback. Simple resistive feedback causes the OTA to generate an output voltage proportional to the net current difference at its' positive and negative input terminals, as shown in figure 8 and the corresponding equations 8, 9 and 10, which are as follows

$$V_i = R_{Fi} \left(\frac{V_2}{R_2} - \frac{V_1}{R_1} \right)$$

$$V_i = \sum_{j=1}^{2} \sigma_{ij} V_j$$

$$\sigma_{ij} = \frac{R_{Fi}}{R_j}$$

Using these assumptions, the operation of the neuron circuit can be explained. The resistors attached to the input of the amplifier shown in Figure 6 serve to produce input currents proportional to the product of the input voltages V_j and the conductances of the resistors R_{ij}. The input resistors thus act as the synaptic parameters in Figure 4, while the neuron state values are represented as the output voltages of the OTAs that implement each neuron function. In general, synapse parameters can be bipolar. That is, these parameters can take on positive and negative values. However, it is not simple in general to implement negative conductances that physically represent mathematically negative synaptic parameters. Fortunately, the differencing nature of the OTA can be used to provide the effect of negative conductances using positive conductance elements. This is accomplished by attaching resistors that provide the absolute (positive) value of the desired conductance to the negative input of the OTA. Since the subtraction of a positive current in the OTA is equivalent to the addition of a negative current, negative synapse parameters can be equally well implemented using standard resistive elements. The feedback resistor R_{fi} defines the slope of the OTA transfer function in the linear region, while the power supply voltages determine the limiting values of the transfer function in regions of strong negative and positive bias. The circuit shown in Figure 6 provides the basic functional requirements for a typical neural

network neuron. Using a more complex feedback impedance in place of R_{fi} can provide more complex transfer functions when necessary.

Figure 9 shows a schematic of a general neural network based on the use of resistor elements for the synapse parameters and OTAs for the neurons. A non-intersecting grid of wires is used to allow synapse resistors to be connected from OTA outputs to OTA inputs. Pairs of grid lines are used to allow each synapse resistor to be connected from an OTA output to either a positive or negative OTA input terminal. This functionality may be implemented in a software domain as well. For instance, the software algorithm shown in Table 1 produces a dynamic change in neuron state similar to the dynamic changes expected from the OTA array shown in Figure 9. The synaptic parameters (Resistor values) are assumed to be fixed and pre-stored in a two dimensional matrix R. The OTA feedback resistors are assumed to be the same for all neurons. The neuron states are assumed to be initially preset to certain values and are initially defined by a one dimensional matrix V. All parameters are assumed to be double precision floating point. While only the relaxation model is shown, other models exist and are well known in the art. The training algorithm varies according to the specific neural network type.

SUMMARY OF THE INVENTION

This application discloses a method for distinguishing targets from background clutter, comprising the steps of inputting data (e.g., one-dimensional or multi-dimensional data, such as digitized infrared imagery, digitized TV imagery, speech samples, or radar samples), calculating data statistics from the data and using said data statistics to select target specific feature information (e.g., contrast-based and texture-based) to distinguish specific targets from background clutter, generating the target specific feature information from the data statistics, extracting the target specific feature information from the data, using the target specific feature information to distinguish specific targets from background clutter (e.g., parametric and non-parametric techniques and one-class, two-class, or multi-class classification procedures), and outputting target and background clutter information. In particular, this method uses the Hebbian Learning to distinguish and take advantage of second order correlation information.

The invention may also be incorporated into a classification system, comprising a data input (e.g., one-dimensional or multi-dimensional data, such as digitized infrared imagery, digitized TV imagery, speech samples, or radar samples), a calculator to calculate data statistics from the data input, a selector to use the data statistics to select target specific feature information (e.g., contrast-based and texture-based) to distinguish specific targets from background clutter, a generator to generate the target specific feature information from the data statistics, a feature extractor to extract target specific feature information from the data input, and a classifier to use

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the target specific feature information to distinguish targets from background clutter and output target and background clutter data (e.g., parametric and non-parametric techniques and one-class, two-class, or multi-class classification procedures).

The advantages of this method and system and the corresponding hardware and software embodiments are that they generate and select the target specific feature information for the classification of preferred targets in the context of particular backgrounds, and thereby increases the robustness of the overall classification process. In particular, this method and system uses a variation of the Hebbian learning algorithm and recently discovered relationships between neural network Hebbian learning algorithms and statistically-based principal component analysis to generate a set of distinguishing target characteristics pertinent to the classification and separation of targets from background clutter in automatic target recognition applications.

In addition, advantages also include the tailoring the features (in the form of principal component filters) to reflect the characteristics of a specific target or target class which leads to separability of the targets based on a relatively small number of features, which reduces the size of the feature space and the corresponding size of the training set required for adequate generalization. Similarly, using only target training examples for feature generation removes biases that arise from nonrepresentative clutter training sets and signal-to-noise ratios aid in identifying features that are more robust over the training data. Likewise, hierarchies of feature filters covering relevant length scales in the image set provide further discrimination

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of the object classes and indicate any scale invariant properties of the objects. Finally, carrying out filter convolutions is a local operation and can be parallel over the image to yield fast implementation times.

Although our focus is on automatic target recognition, the described learning and classification methods extend to a variety of pattern recognition domains. The invention may be implemented in software and hardware configurations as well. Parallel computer archetectures, such as neural networks, are used extensively.

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BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages will become apparent from the following and more particular description of the various embodiments of the invention, as illustrated in the accompanying drawing, wherein:

Figure 1 shows a data-dependency graph of a typical neural neural network.

Figure 2 shows an example of a feed-forward neural network.

Figure 3 shows an example of a fully connected neural network.

Figure 4 shows a simplified schematic of a neuron, along with its network links, synaptic parameters, and typical input-output transfer function.

Figure 5 shows a typical non-linear function provided by each neuron operating according to defining equations.

Figure 6 shows the schematic diagram of an artificial neuron implemented using resistors and an operational transconductance amplifier.

Figure 7 shows an ideal operational transconductance amplifier.

Figure 8 is a 2-input operational transconductance amplifier, which shows how equation 1 is provided.

Figure 9 shows a schematic of a general neural network based on the use of resistor elements for the synapse parameters and OTAs for the neurons.

Figure 10 shows a preferred system configuration.

Figure 11 is a TV image from data set I, which contains the five targets (marked with an "x"). that were used for training.

Figure 12a shows 3 x 3 pixel filters determined by learning with the

generalized Hebbian algorithm, which are the first three principal components for the training target regions from data set I.

Figure 12b is a graph showing the separability of target and clutter objects based on variance values derived from the third filter in Figure 12a.

Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h show the 5 x 5 pixel filters derived from training data set II, which represent top eight principal components ordered by decreasing eigenvalue.

Figure 14 is a graph showing variances derived from Filter 5 in Figure 13e in conjunction with the probability of detection and the false alarm rate.

Figure 15a is a graph showing the ratio of variances derived from Filters 4 and 5 in Figures 13d and 13e.

Figure 15b is a graph showing the variance derived from Filter 4 in a second set of 5 x 5 pixel filters described in the detailed description in conjunction with the probability of detection and the false alarm rate.

Table 1 shows a software algorithm that produces a dynamic change in neuron state similar to the dynamic changes expected from the OTA array shown in Figure 9.

Table 2 is a description of the two data sets discussed in text.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 10 shows a preferred classification system configuration. As shown in Figure 10, the classification system inputs the data in module 2, extracts feature information from the inputted data in module 4 and inputs the feature information into the classification module 6 which uses decision criteria 12 to classify the target from background clutter and outputs this information in module 8. The feature selection module 10 uses target statistics and data which are extracted from the input data in module 14 to select and generate features specific to a given target class and inputs this information into module 4 that extracts features. These distinguishing target characteristics help the classifier separate targets from background clutter, which makes the classification system more robust.

In particular, the preferred system shown in Figure 10 accepts primarily long-wavelength infrared (IR) and television (TV) imagery to be analyzed. As discussed, infra, the data inputs are primarily derived from two data sets that characterize two target scenarios: targets that are partially occluded (e.g., targets along tree lines) and targets that resemble background clutter. Various procedures are used to extract feature information, which will be discussed infra in conjunction with the feature selection process. The preferred system shown in Figure 10 uses binary tree structure to classify inputted feature information, wherein the parameters defined by the eigenvalues associated with the principal components, discussed infra in conjunction with the feature selection process, constitute the decision criteria.

With respect to the feature selection process, the preferred embodiment uses

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target statistics and a neural network that implements a generalized Hebbian learning algorithm to select and generate features specific to a given target class. The generalized Hebbian learning algorithm employed, which was discussed in the Sanger, T.D. "Optimal Unsupervised Learning." Neural Networks vol. 2, pp. 459-473 (1989), selects features for automatic target recognition from the inputted imagery. The generalized Hebbian Learning algorithm generates principal components or receptive features that resemble those found in Linsker's work, discussed supra. Inter alia, Sanger shows that the GHA determines the principal components of the data set in order of decreasing eigenvalue, which is important because the higher eigenvalue components are generally the most important or prominent features.

The generalized Hebbian learning algorithm trains a one-layer neural network, where the input nodes define arrays of pixel intensity values from image data and the output nodes index the principal components. Sanger describes the procedure with the following equation:

$$c_{ij}(T+1)=c_{ij}(T)+\gamma(T)\left[Y_i(T)x_j(T)-Y_i(T)\sum_{k<i} c_{kj}(T)y_k(T)\right]$$

where c_{ij} is the weight or connection strength between the j^{th} input neuron and the i^{th} output neuron, x_j is the j^{th} component of the input vector, y_i is the i^{th} component of the output vector, and Y(T) is a learning parameter that decreases with time such that

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$$\lim_{T\to\infty} \gamma(T)=0 \text{ and } \sum_{T=0}^{T=\infty} \gamma(T)=\infty$$

The second term on the rhs of equation 1 is the Hebbian term and the third term ensures that the algorithm learns successive eigenvectors (which are the principal components) of the co-variance matrix of the input vectors ordered by decreasing eigenvalue. This decomposition of the co-variance matrix in terms of eigenvectors is the well-known Karhunen-Loeve transform. Local operations affect equation 1, which distinguishes the relationship described in equation 1 from other relationships characterized by the Karhunen-Loeve transform and underscores the importance of equation 1 for training neural networks. Whereas Sanger applies equation 1 to image coding, texture segmentation, and the generation of receptive fields, principal components have been used to characterize image texture, as discussed in Ade, F. "Characterization Of Textures By Eigenfilters." Signal Processing,vol. 5, pp. 451-457 (1983) and are used in the preferred embodiment.

The preferred embodiment uses equation 1 to develop receptive fields for identifying a specific target object. The extracted characteristics of the target object are embedded in the second-order image statistics. Inputs to the network are r x s arrays of pixel values, which are rastered into r x s component vectors, from image subregions that contain the target of interest. The resulting principal components are directions in the r x s dimensional input space with maximum variance. Projections of input vectors along the principal component directions are

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maximally distinguishable. Eigenvalues corresponding to the principal components determined from equation 1 provide a measure of the variance in the principal component directions. Since vectors in the input space are made up of pixel intensities, the principal components generally correspond to prominent intensity patterns or features in the object of interest. The preferred embodiment trains on several examples of the target object to smooth out noise present in individual examples and to generate principal components that signify features common to different occurrences of the object.

The generated principal components are arrayed in r x s matrices to produce receptive fields or filters that are convolved with the original image data during classification. The preferred embodiment convolves these filters such that the spatial sampling of pixel intensities used to construct the input vectors is preserved. Next, every r x s array of pixels contained in the image subregion of interest is multiplied by the generated filters and then compute the variances of the resulting convolutions. Variances (these are related to the eigenvalues of the principal components) or ratios of the variances (these provide a measure of the relative content of two patterns) compose the parameter sets used for classification. The preferred embodiment uses range information, if available, to scan the image to properly adjust the size of the box or window circumscribing the subregion of interest to reflect the target size.

The spatial sampling density entering into the construction of the input vectors is an important parameter in the generation of the receptive fields. This parameter

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corresponds to the synaptic connection density in Linsker's Hebbian algorithm, discussed supra, which only yields principal components if the connection density is held fixed. The preferred embodiment uses the spatial sampling density to determine the scale of the feature. Please note that the spatial sampling density must be appropriately scaled to ensure that the same feature scale is measured in all cases, if the target object occurs at different ranges in the image data, as in the inputted data reviewed in the preferred embodiment. As the spatial sampling density for targets at nearer ranges are reduced, the preferred embodiment averages over the shorter length scales to avoid aliasing effects. Thus, the preferred embodiment assumes that the target at the longest range fits into a u x v pixel box. Input vectors for this case are formed from intensity values of r x s blocks of pixels (where these blocks are smaller than the box size) extracted from the box circumscribing the target object. The preferred embodiment composes input vectors from 2r x 2 s blocks of pixels for targets at half the initial range and extracts the intensity value from every second pixel. The preferred embodiment continues in this fashion in closer ranges.

The preferred embodiment also scales the spatial sampling density for a given target sample to generate a hierarchy of receptive fields at different scales. The relevant scales are set by the smallest scale detectable (effectively the resolution) for the target seen at longest range and the size of the target object. This hierarchy characterizes the target object in terms of what features become relevant at different length scales. For example, self-similar objects, which are objects that look the same at any scale, are expected to have an invariant feature set as a function of scale.

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Scaling of the spatial sampling density resembles renormalization group analysis that assumes system behavior is governed by how the physical operators scale, discussed in Wilson, K.G. "The Renormalization Group: Critical Phenomena And The Kondo Problem." Review of Modern Physics vol. 47, PP. 773-840 (1975).

The inventor used test data sets with military targets to evaluate the effectiveness of the preferred system implementation, described supra. Table 2 shows a description of the two data sets used. Images in data set I were TV whereas those in data set II were long-wavelength IR. Target objects for both data sets were of several different types, so the preferred embodiment needed to find receptive fields common to all types. Different orientations of the target objects in these data sets did not appear to generate problems. Apparently, targets from data set I were positioned in the field-of-view at long enough range that there was little sensitivity to orientation, and targets from data set II were sufficiently spherically symmetric to neutralize orientation effects. Preprocessing procedures were used to normalize linearly the pixel intensities so they fell in the range from 0 to 255.

The inventor defined clutter objects for both data sets as any region in the image passed by the screener and not a target fell into the clutter class, which is consistent with conventional screeners. The inventor then used this definition to measure the capability of the principal component features to distinguish targets from objects similar in appearance.

Figure 11 is a TV image from data set I, which contains the five targets (marked with an "x") that were used for training. For data set I, the experiments

used 3 x 3 pixel filters using five targets contained in a single image and tested filter performance on 9 additional images. Targets in the training image represented different types of the target class. Target heights in data set I ranged from 4 pixels to 32 pixels.

Figure 12a displays the 3 x 3 pixel filters determined by learning with the generalized Hebbian algorithm, which are the first three principal components for the training target regions from data set I. The first filter emphasizes regions that have strong grayshade contrast with the background environment; most of the targets show strong contrast with background. The second and third features highlight regions with strong horizontal and vertical grayshade gradients, respectively; target regions all have sharp transitions in grayshade, from pixels within the targets to pixels outside the targets.

Figure 12b shows the separability of target and clutter objects based on variance values derived from the third filter in Figure 12a. Abscissa values V_3 are the variances derived from Filter 3 in Figure 12a. The left-hand curve is the probability for a clutter region to have a variance V_c larger than variance V_o; the right-hand curve is the probability for a target region to have a variance V_t smaller than variance V_o. The dotted line indicates the lower-bound on V_t determined from the training data. Please note the dotted line lies close to the point where the two probability curves cross, which marks the demarcation point in a Bayes classification approach. In particular, Figure 12b indicates that most of the background clutter has a much smaller vertical gradient content than the targets; tree lines and roads and

horizons in the image set extend mostly parallel to the horizontal edges of the image and provide little vertical gradient content. The inventor also examined the same images with a feature set based on contrast and edge measures and found that between 8 and 16 of these features were required to achieve the same level of separability found in Figure 12b and that the discriminant surface, which divided targets and clutter, was highly nonlinear.

The experiments generated eight 5 x 5 pixel filters, which are shown in Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h for target set II from four examples in a single image and tested filter performance on 23 images. The 5 x 5 pixel filters were derived from training data for data set II. The filters shown represent the top eight principal components and are ordered by decreasing eigenvalue. Only filters 4 and 5 were used for classification. S/N denotes the signal to noise ratio defined infra. In addition, the 5 x 5 pixel filters shown in Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h represent top eight principal components ordered by decreasing eigenvalue. Target heights ranged from 15 pixels in the far range to 175 pixels in the near range. Data set II was in several ways more challenging than the first data set because the noise level was higher and the target texture was very similar to the texture of the clutter. The filters were ranked by a signal-to-noise ratio (S/N), as shown in Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h, where S is the mean of the variances from the four examples in the training set and N is the variance of the variances from the same training examples. S/N is a natural criterion, since the target characteristics sought are both prominent and invariant over the data set, which leads to large

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values of S/N.

Figure 14 is a graph showing variances derived from Filter 5 in Figure 13e in conjunction with the probability of detection and the false alarm rate. V_5 denotes variances derived from Filter 5 in Figures 13e. The dotted line is the lower bound on V_t determined from the training data. With the lower bound, the probability of detection, P_d, is 0.89 and the false alarm rate, P_{fa}, is 0.27. As shown in Figure 14, filter 5 had the largest S/N ratio among the eight generated and alone provides considerable separation of targets and clutter. Figure 14 also shows a lower cutoff for the target region, as the training examples establish a lower bound on the target region in the feature space due to the higher degree of noise and corresponding smaller variance values associated with these examples. The use of noisy examples, (and, hence, examples more easily confused with clutter) helps estimate the true position (as determined from an infinitely large data set) of the classification discriminant surface from examples that lie close to the boundary between target and clutter than from examples that lie further away.

To achieve further separability of targets from clutter, the inventor also examined ratios of the variance values from the filters and found the ratios of the variance outputs from filters 4 and 5 in Figures 13d and 13e further distinguish targets and clutter, as shown in Figure 15a. In particular, Figure 15a is a graph showing the ratio of variances derived from Filters 4 and 5 in Figures 13d and 13e. V_c, V_t, and V_o indicate the ratio of variances from Filters 4 and 5. The dotted line is determined from training data. The clutter curve uses only false alarms from the

results in Figure 14, whereas the target curve uses all the target points. Using the dotted line to discriminate targets and clutter (together with results from Figure 14), the detection probability is defined to be 0.89 and the false alarm rate is defined to be 0.10, which is a significant improvement over 0.27.

In addition, the experiments used the training image to generate a second set of eight 5 x 5 pixel filters at a larger length scale by halving the spatial sampling density of the input vectors to the neural network. The filter with the second largest S/N ratio was the same as filter 5 in Figure 13. This same filter further reduces the number of clutter points mistakenly identified as targets, as shown in Figure 15b, which suggests some self-similarity in the target characteristics and indicates the persistence of a particular feature over a factor of two in length scales. In particular, Figure 15b is a graph showing the variance derived from Filter 4 in a second set of 5 x 5 pixel filters described in the detailed description in conjunction with the probability of detection and the false alarm rate. V_4 is the variance derived from Filter 4 in a second set of 5 x 5 pixel filters, described infra. The clutter curve uses only false alarms from the results in Figure 15a. All target points, however, are used. The dotted line is the discriminator between targets and clutter set by the training data. If the results shown in Figures 14, 15a, and 15b are used in sequence, the detection probability is determined to be 0.89 and the false alarm rate is determined to be 0.07, which is another significant improvement in performance. As a group, the three filters and their corresponding variance outputs establish a binary classification tree for distinguishing targets from background clutter. The final

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probability of detection (ratio of the number of targets detected to total number of targets) was 0.89, whereas the false alarm rate (ratio of the number of clutter points mistakenly classified as targets to total number of clutter points) was 0.07.

The values and ranges disclosed herein are given for a preferred embodiment of the present invention, of course these values may vary as the parameters are changed. Therefore it is to be understood that many changes in detail may be made as a matter of engineering choices without departing from the spirit and scope of the invention, as defined by the appended claims. In particular, alternate procedures that share the same functionally as the procedures discussed, supra, such as alternate classification techniques or data inputs, are plainly within the scope of the invention.

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CLAIMS

I claim:

1. A method for distinguishing targets from background clutter, comprising the steps of

(a) inputting data;

(b) calculating data statistics from said data and using said data statistics to select target specific feature information to distinguish specific targets from background clutter;

(c) generating said target specific feature information from said data statistics;

(d) extracting said target specific feature information from said data;

(e) using said target specific feature information to distinguish specific targets from background clutter; and

(f) outputting target and background clutter information.

2. The method of claim 1, wherein said data is one-dimensional, two-dimensional, or multi-dimensional.

3. The method of claim 1, wherein said data is digitized imagery, speech signals, or radar signals.

4. The method of claim 1, wherein parallel hardware architectures are employed to use said feature information to distinguish particular targets from background clutter.

5. The method of claim 4, wherein said parallel hardware architectures

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comprise neural networks.

6. The method of claim 1, wherein said feature information is contrast-based or texture-based.

7. The method of claim 1, wherein said feature information is further used to distinguish two target classes or a plurality of target classes from one another.

8. The method of claim 1, wherein Hebbian learning techniques are used to select said target specific feature information.

9. A classification system, comprising

(a) a calculator to calculate data statistics from a data input;

(b) a selector to use said data statistics outputted from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) a generator to generate said target specific feature information from said data statistics outputted from said calculator;

(d) a feature extractor to extract target specific feature information from said data input; and

(e) a classifier to use said target specific feature information extracted from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

10. The classification system of claim 9, wherein said data input is one-dimensional, two-dimensional, or multidimensional.

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11. The classification system of claim 9, wherein said data input is digitized imagery, speech signals or radar signals.

12. The classification system of claim 9, wherein parallel hardware architectures are employed in the classifier to use said feature information to distinguish particular targets from background clutter.

13. The classification system of claim 12, wherein said parallel hardware architectures comprise neural networks.

14. The classification system of claim 9, wherein said feature information is contrast-based or texture-based.

15. The classification system of claim 9, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

16. A classification hardware system, comprising

(a) a calculator to calculate data statistics from a data input;

(b) a selector to use said data statistics outputed from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) a generator to generate said target specific feature information from said data statistics outputed from said calculator;

(d) a feature extractor to extract target specific feature information from said data input; and

(e) a classifier to use said target specific feature information extracted

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from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

17. The classification hardware system of claim 16, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

18. A classification software system, comprising

(a) calculation software to calculate data statistics from a data input;

(b) selection software to use said data statistics outputed from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) generator software to generate said target specific feature information from said data statistics outputed from said calculator;

(d) feature extraction software to extract target specific feature information from said data input; and

(e) classification software to use said target specific feature information extracted from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

19. The classification software system of claim 18, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

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ABSTRACT

This application discloses a method for distinguishing targets from clutter, comprising the steps inputting data, calculating data statistics from said data and using said data statistics to select target specific feature information to distinguish specific targets from background clutter, generating said target specific feature information from said data statistics, extracting said target specific feature information from said data, using said target specific feature information to distinguish specific targets from background clutter, and outputting target and background clutter information. Classification systems, including hardware and software embodiments, are also disclosed.

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Hebbian Learning, Principal Components and Automatic Target Recognition

Alan J. Katz

TECHNICAL REPORT

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TI Overview: A key TI problem domain is automatic target recognition (ATR). ATR requires determining image features to distinguish targets from background clutter. Determining a set of robust image features that work well under a variety of conditions (time-of-day, season, geographic location, etc.) has proven extremely challenging. Even the simpler problem of finding a suitable set of image features for a fixed set of conditions is often difficult and requires considerable development time.

In this paper, we use a neural network learning technique that is closely related to a well-known statistical method to automatically generate image features for distinguishing targets from clutter. Extraction of these features from the images takes only local operations that can be parallelized to yield fast implementation times. We test our approach on two DSEG data sets: in the first, the targets are vehicles of military interest and, in the second, the targets are camouflage nets. We obtain robust image features that separate targets from clutter under a variety of conditions.

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HEBBIAN LEARNING, PRINCIPAL COMPONENTS AND AUTOMATIC TARGET RECOGNITION

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Abstract

We apply a neural network generalized Hebbian learning algorithm, which is closely related to statistically-based principal component analysis, to the problem of automatic target recognition. Although our focus is on automatic target recognition, the described learning and classification methods extend to a variety of pattern recognition domains. We use the learning algorithm to generate features specific to a given target class and present results for two image sets. The resulting features provide more robust classification of target objects.

Introduction

Since the groundbreaking work of Hubel and Wiesel[1] and Marr[2], much attention has been focused on what features in the visual field are perceived by the visual system and how the receptive fields, neurons sensitive to particular features, are organized. Not only does this work provide important clues for understanding biological vision systems, it lays groundwork for artificial vision systems in such areas as robotics and automatic target recognition.

Recent work[3,4,5,6] in artificial neural networks suggests mechanisms and optimization strategies that explain the formation of receptive fields and their organization in mammalian vision systems. Linsker[5] has demonstrated how Hebbian learning algorithms, which change synaptic connections according to the degree of correlation between neuronal inputs and outputs, give rise to layers of center-surround and orientation-selective cells, even if the input to the initial layer is random white Gaussian noise.

Kammen and Yuille[6] show that orientation-selective receptive fields can also develop from a symmetry-breaking mechanism. Under certain conditions, the receptive fields perform a principal component analysis of the input data, as was first shown by Oja[7]. Since Hebbian learning occurs

in nature[8], the intimate connection between certain forms of Hebbian learning and the well-known statistical technique of principal components is compelling.

In this paper, we apply a generalized Hebbian learning algorithm (GHA) due to Sanger[9] to extract features for automatic target recognition from long-wavelength infrared (IR) and TV images. Sanger has proven that GHA determines the principal components of the data set in order of decreasing eigenvalue. Principal components or receptive features generated with GHA are very similar in appearance to those found in Linsker's work[5]. The novelty of our work lies in the use of GHA to generate a set of distinguishing target characteristics that separates targets from background clutter, where clutter is defined by a conventional screener algorithm to be non-target regions in the image that have target-like characteristics. We use only target statistics to generate the distinguishing features to enhance the robustness of the feature set: the background clutter can change significantly from one scene to the next, so using any particular set of clutter statistics to do feature generation can introduce unwanted biases[10]. We compute a signal-to-noise ratio to select which of the learned receptive fields to use for target recognition. When further discrimination is necessary, we generate a hierarchy of receptive fields over the spatial length scales covering the target and examine relationships between receptive fields at different length scales. We perform classification in terms of a binary tree structure, where the decision criteria are parameters defined by the eigenvalues associated with the principal components. We provide results from two data sets, which include examples of partially occluded targets, targets along tree lines, and targets very similar in appearance to background clutter.

Algorithm

We use the generalized Hebbian learning algorithm to train a one-layer neural network, where the input nodes define arrays of pixel intensity values from image data and the output nodes index the principal components. The form of the algorithm is[9]:

$$c_{ij}(\mathrm{T}+1) = c_{ij}(\mathrm{T}) + \gamma(\mathrm{T})[y_i(\mathrm{T})x_j(\mathrm{T}) - y_i(\mathrm{T})\sum_{k\le i} c_{kj}(\mathrm{T})y_k(\mathrm{T})] \qquad (1)$$

where c_{ij} is the weight or connection strength between the j^{th} input neuron and the i^{th} output neuron (c_{ij} is initially assigned random weights), x_j is the j^{th} component of the input vector, y_i is the i^{th} component of the output vector, and $\gamma(T)$ is a learning parameter that decreases with time such that

$$\lim_{T\to\infty} \gamma(T) = 0 \ \textit{and} \ \sum_{T=0}^{T=\infty} \gamma(T) = \infty$$

The second term on the rhs of equation 1 is the Hebbian term and the third term ensures that the algorithm learns successive eigenvectors (which are the principal components) of the covariance matrix of the input vectors ordered by decreasing eigenvalue. This decomposition of the covariance matrix in terms of eigenvectors is the well-known Karhunen-Loeve transform. Sanger[9] shows how equation 1 can be effected using only local operations; such a local implementation distinguishes equation 1 from other algorithms for computing the Karhunen-Loeve transform and underscores the importance of equation 1 for training neural networks. Sanger[9] applies equation 1 to image coding, texture segmentation, and the generation of receptive fields; other authors[11] have also used principal components to characterize image texture.

Experiments

We apply equation 1 to the development of receptive fields for identifying a specific target object. The extracted characteristics of the target object are embedded in its covariance statistics. Inputs to the network are r × s arrays of pixel values, which are rastered into r × s component vectors, from image subregions that contain the target of interest. The resulting principal components (extracted from the weight matrix c_{ij}) are directions in the r × s dimensional input space with maximum variance: these directions are the most informative ones in the sense that projections of input vectors along the principal component directions are maximally distinguishable. Eigenvalues corresponding to the principal components determined from equation 1 provide a measure of the variance in the principal component directions. Since vectors in the input space are made up of pixel intensities, the principal components correspond to prominent intensity patterns or features in the object of interest. We train on several examples of the target object to smooth out noise present in individual examples and to generate principal components that signify features common to different occurrences of the object.

The generated principal components are arrayed in r × s matrices to produce receptive fields or filters that are convolved with the original image data during classification. We convolve these filters in a way that preserves the spatial sampling of pixel intensities used to construct the input vectors. We multiply every r × s array of pixels contained in the image subregion of interest by the generated filters and then compute the variances of the resulting convolutions. Variances (these are related to the eigenvalues of the principal components) or ratios of the variances (these provide a measure of the relative content of two patterns) compose the parameter sets used for classification.

In our approach, we assume that range information is available, so that as we scan the image, we can properly adjust the size of the box or window circumscribing the subregion of interest to reflect the target size.

An important parameter in the generation of the receptive fields is the spatial sampling density that enters into the construction of the input vectors. This parameter corresponds to the synaptic connection density in Linsker's Hebbian algorithm[5], which only yields principal components if the connection density is held fixed. In our approach, the spatial sampling density determines the scale of the feature. Since the target object occurs at different ranges in the image data (note that range information is provided in our data sets), the spatial sampling density must be appropriately scaled to ensure that the same feature scale is measured in all cases. As we reduce the spatial sampling density for targets at nearer ranges, we average over the shorter length scales to avoid aliasing effects, though we found averaging had little effect on results from test cases we examined.

To illustrate how scaling of the spatial sampling density is done, we assume that the target at the longest range fits into a $u \times v$ pixel box. Input vectors for this case are formed from intensity values of $r \times s$ blocks of pixels (where these blocks are smaller than the box size) extracted from the box circumscribing the target object. For targets at half the initial range, we compose input vectors from $2r \times 2s$ blocks of pixels, where we extract the intensity value from every second pixel. We continue in this fashion as we move to closer ranges.

We also scale the spatial sampling density for a given target sample to generate a hierarchy of receptive fields at different scales. The relevant scales are set by the smallest scale detectable (effectively the resolution) for the target seen at longest range and the size of the target object. This hierarchy characterizes the target object in terms of what features become relevant at different length scales. For self-similar objects, we expect to find an invariant feature set as a function of scale. There are similarities here to renormalization group analysis[12] where system behavior is governed by how the physical operators scale.

Data and Results

The data sets studied are characterized in Table 1; the targets were objects of military interest. Images in data set I were TV whereas those in data set II were long-wavelength IR. Target objects for both data sets were of several different types[10], so it was important to find receptive fields common to all types. Different orientations of the target objects in these data sets did not generate problems (though, in general, they could): targets from data set I were positioned in the field-of-

view at long enough range that there was little sensitivity to orientation, and those from data set II were sufficiently spherically symmetric to ignore orientation effects. No preprocessing of the images was done except to normalize linearly the pixel intensities so they fell in the range from 0 to 255.

Clutter objects for both data sets were defined in terms of a conventional screener algorithm: any region in the image passed by the screener and not a target fell into the clutter class. With this definition of clutter, we measured the capability of the principal component features to distinguish targets from objects similar in appearance.

For data set I, we generated 3×3 pixel filters using five targets contained in a single image and tested filter performance on 9 additional images; the targets in the training image represented different types of the target class (See Figure 1). Target heights in data set I ranged from 4 pixels to 32 pixels . The first three learned filters, which are displayed in Figure 2a, are intuitively plausible. The first filter emphasizes regions that have strong grayshade contrast with the background environment: most of the targets show strong contrast with background. The second and third features highlight regions with strong horizontal and vertical grayshade gradients, respectively; target regions all have sharp transitions in grayshade, from pixels within the targets to pixels outside the targets.

Figure 2b shows the separability of target and clutter objects based on variance values derived from the third filter in Figure 2a. Figure 2b indicates that most of the background clutter has much smaller vertical gradient content than the targets: tree lines and roads and horizons in the image set extend mostly parallel to the horizontal edges of the image and provide little vertical gradient content. We also examined the same images with a standard in-house feature set, which is used for automatic target recognition. We found that between 8 and 16 of these features were required to achieve the same level of separability found in Figure 2b and that the discriminant surface, which divided targets and clutter, was highly nonlinear.

We generated eight 5×5 pixel filters (shown in Figure 3) for target set II from four examples in a single image and tested filter performance on 23 images. Target heights ranged from 15 pixels in the far range to 175 pixels in the near range. Data set II was in several ways more challenging than the first data set because the noise level was higher and the target texture was very similar to the texture of the clutter. We ranked the filters by a signal-to-noise ratio S/N (see Figure 3), where S is the mean of the variances from the four examples in the training set and N is the variance of the variances from the same training examples. This criterion is a natural one, since we seek target

characteristics that are both prominent and invariant over the data set, and that, therefore, lead to large values of S/N. Filter 5 had the largest S/N ratio among the eight generated and alone provides considerable separation of targets and clutter (see Figure 4). In Figure 4, we show a lower cutoff for the target region: the training examples only establish a lower bound on the target region in the feature space since these examples were particularly noisy ones and gave smaller variance values than more prototypical examples. Choosing noisy examples (and, therefore, examples more easily confused with clutter) for training is important for purposes of classification and generalization, because we can better estimate the true position (as determined from an infinitely large data set) of the classification discriminant surface from examples that lie close to the boundary between target and clutter than from examples that lie further away[13].

To achieve further separability of targets from clutter, we also examined ratios of the variance values from the filters: the ratio of the variance outputs from filters 4 and 5 in Figure 3 further distinguish targets and clutter (as seen from Figure 5a). In addition, we used the training image to generate a second set of eight 5×5 pixel filters at a larger length scale by halving the spatial sampling density of the input vectors to the neural network. The filter with the second largest S/N ratio was the same as filter 5 in Figure 3; this filter further reduces the number of clutter points mistakenly identified as targets (Figure 5b). This points to some self-similarity in the target characteristics (though a factor of two in length scales is not sufficient to establish any sort of fractal[4] characteristics) and indicates the persistence of a particular feature over a factor of two in length scales. Together the three filters and their corresponding variance outputs establish a binary classification tree for distinguishing targets from background clutter. The final probability of detection (ratio of the number of targets detected to total number of targets) was 0.89 whereas the false alarm rate (ratio of the number of clutter points mistakenly classified as targets to total number of clutter points) was 0.07.

Conclusions

Connections between biologically motivated learning algorithms and statistical classification techniques provide important clues for generating features for artificial vision applications and for a variety of pattern recognition applications where feature extraction plays an important role. Tailoring the features (in the form of principal component filters) to reflect the characteristics of a specific target or target class leads to separability of the targets based on a relatively small number of features. Reducing the size of the feature space reduces the size of the training set required for adequate generalization[15]. Using only target training examples for feature generation removes biases that arise from nonrepresentative clutter training sets. Signal-to-noise ratios aid in

identifying features that are more robust over the training data. Hierarchies of feature filters that cover the relevant length scales in the image set can provide further discrimination of the object classes and indicate any scale invariant properties of the objects. Finally, carrying out filter convolutions is a local operation and can be parallelized over the image to yield fast implementation times.

Acknowledgement

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Figure Captions

Table 1. Description of two data sets discussed in text.

Figure 1. TV image from data set I. This image contains the five targets (marked with an "x") that were used used for training.

Figure 2a. 3 x 3 pixel filters determined by learning with the generalized Hebbian algorithm. These filters are the first three principal components for the training target regions from data set I. Dark gray shade corresponds to positive numbers, white corresponds to negative numbers, and lighter gray shade corresponds to numbers near zero.

Figure 2b. Abscissa values V_3 are the variances derived from Filter 3 in Figure 2a. The left-hand curve is the probability for a clutter region to have a variance V_c larger than variance V_o; the right-hand curve is the probability for a target region to have a variance V_t smaller than variance V_o. The dotted line indicates the lower-bound on V_t determined from the training data. Observe that the dotted line lies close to the point where the two probability curves cross (which marks the demarcation point in a Bayes classification approach).

Figure 3. 5 x 5 pixel filters derived from training data for data set II. Filters represent top eight principal components and are ordered by decreasing eigenvalue. Only filters 4 and 5 were used for classification. S/N denotes the signal-to-noise ratio defined in the text. Dark gray shades correspond to positive numbers, white corresponds to numbers near zero, and lighter gray shades correspond to negative numbers.

Figure 4. V_5 denotes variances derived from Filter 5 in Figure 3. The curves are defined in the figure caption for Figure 2b. The dotted line is the lower bound on V_t determined from the training data. With this lower bound, the probability of detection, P_d, is 0.89 and the false alarm rate, P_{fa}, is 0.27.

Figure 5a. V_4/V_5 is the ratio of variances derived from Filters 4 and 5 in Figure 3. The curves are defined in the figure caption for Figure 2b, except V_c, V_t, and V_o here indicate the ratio of variances from Filters 4 and 5. The dotted line is determined from training data. The clutter curve uses only false alarms from the results in Figure 4 whereas

the target curve uses all of the target points. Using the dotted line to discriminate targets and clutter (together with results from Figure 4), we obtain a detection probability of 0.89 and a false alarm rate of 0.10.

Figure 5b. V_4 is the variance derived from Filter 4 in a second set of 5 x 5 pixel filters (not shown but described in text). The clutter curve uses only false alarms from the results in Figure 5a; all target points, however, are used. The dotted line is the discriminator between targets and clutter set by the training data. If we use results from Figures 4, 5a, and 5b in sequence, we obtain a detection probability of 0.89 and a false alarm rate of 0.07. The three discriminators can be viewed as forming a three-level binary classification tree.

Image Set	Number of Images	Location	Scene Description
1	4	G	a
2	2	G	b
3	1	S	c
4	1	S	d
5	2	N	e

a. Fields and Trees; Urban Clutter; Open and Partially Occluded Targets
b. Fields; Urban Clutter; Targets in Open
c. Fields; Urban Clutter; Targets in Open
d. Heavy Forests; Partially Occluded Targets
e. Fields and Heavy Forests; Partially Occluded Targets

Data Set I

Image Set	Number of Images	Location	Scene Description
1	21	S	Fields With Clusters of Trees; Urban Clutter; Open and Partially Occluded Targets.
2	3	N	Heavy Vegetation; Rural Clutter; Open targets.

Data Set II

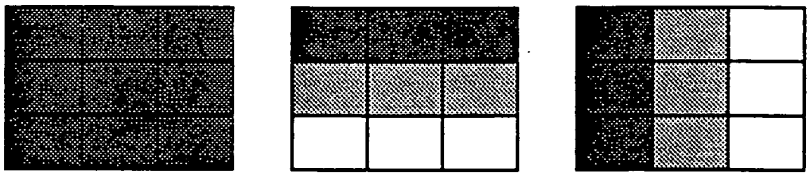
04650

Table I



Figure 1

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Filter 1 Filter 2 Filter 3

Figure 2a

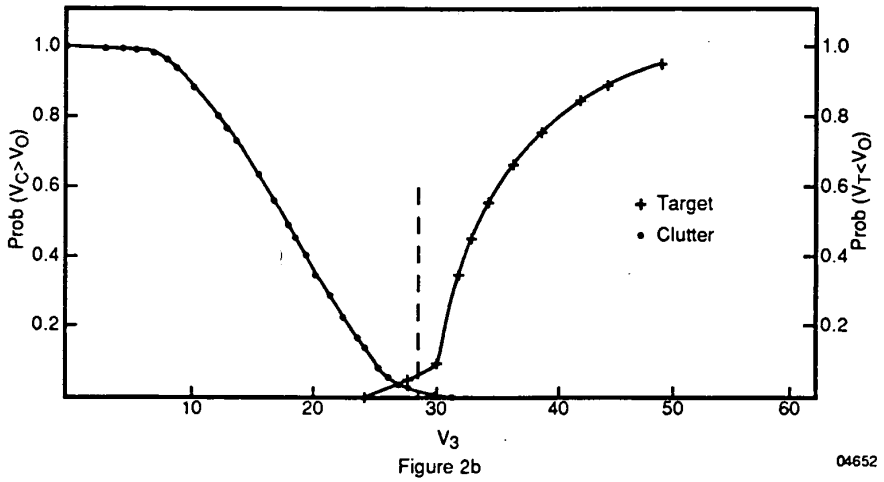
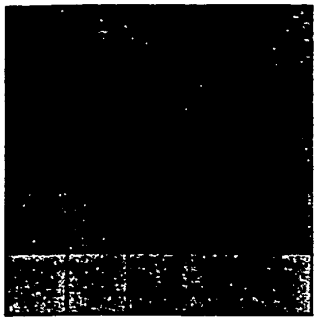
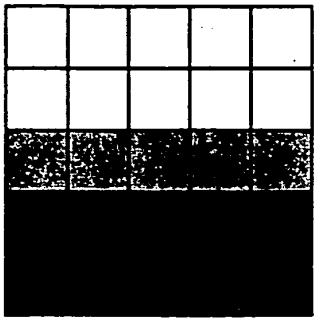


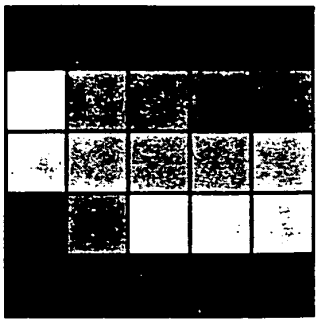
Figure 2b



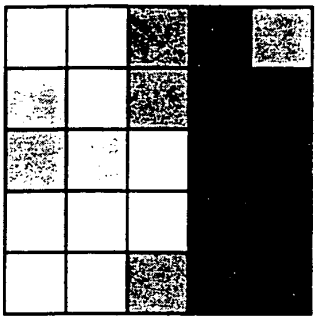
Filter 1 s/n = 1



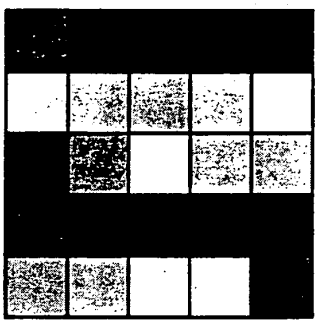
Filter 2 s/n = 7



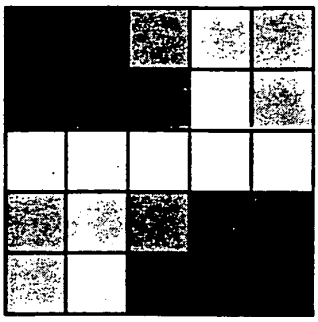
Filter 3 s/n = 7



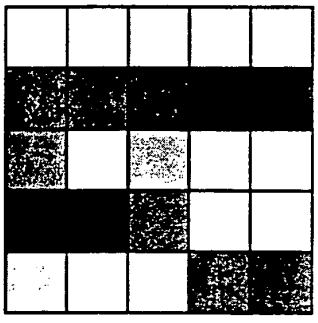
Filter 4 s/n = 5



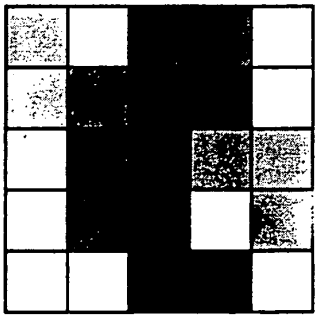
Filter 5 s/n = 23



Filter 6 s/n = 8



Filter 7 s/n = 13



Filter 8 s/n = 9

Figure 3

04651

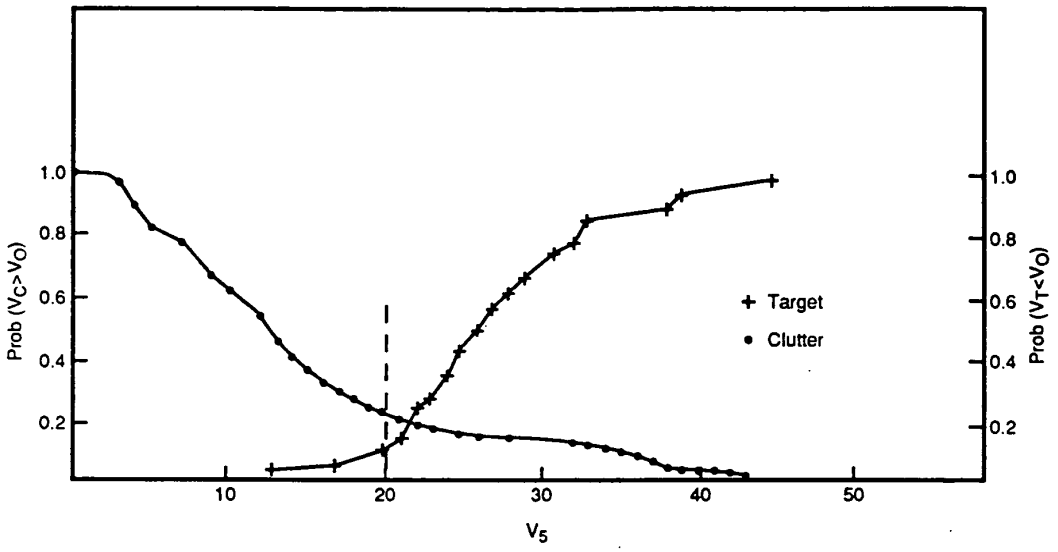


Figure 4

04653

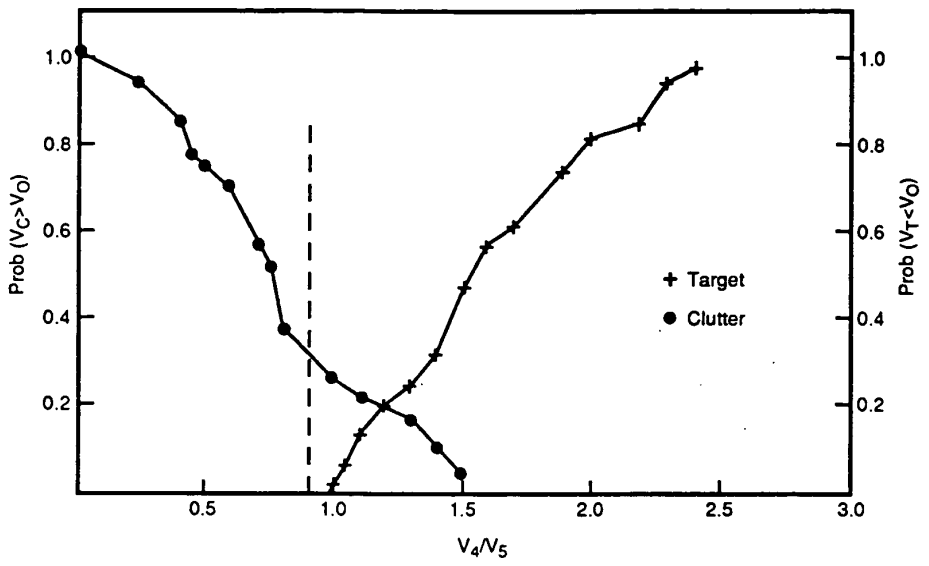


Figure 5a

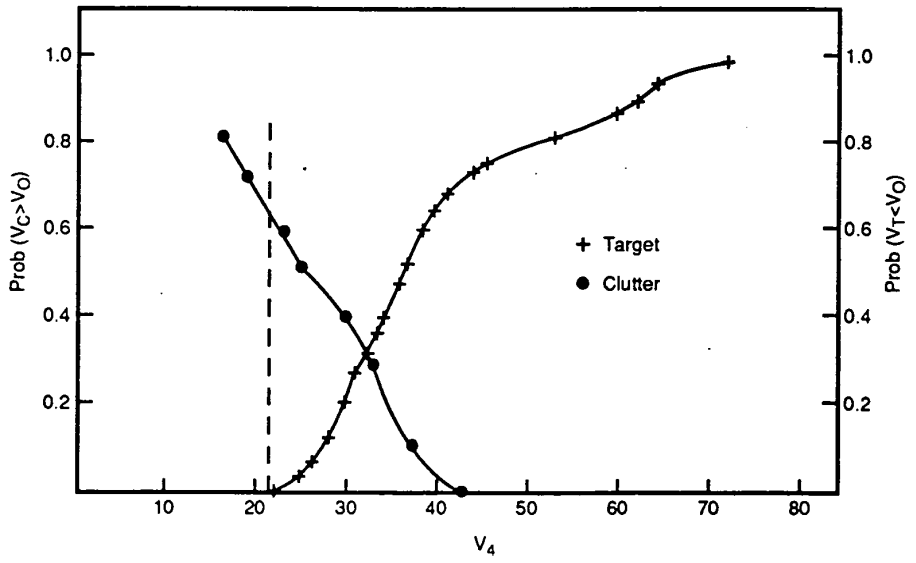


Figure 5b

04655

II

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office

Address : COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	INVENTOR	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ A	TI-16314

EXAMINER	
CAIN, D	/

ART UNIT	PAPER NUMBER
2202	5

DATE MAILED: 07/08/92

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

☒ This application has been examined ☐ Responsive to communication filed on _____ ☐ This action is made final.

A shortened statutory period for response to this action is set to expire 6 month(s), _____ days from the date of this letter.
Failure to respond within the period for response will cause the application to become abandoned. 35 U.S.C. 133

Part I THE FOLLOWING ATTACHMENT(S) ARE PART OF THIS ACTION:

1. ☐ Notice of References Cited by Examiner, PTO-892.
2. ☒ Notice re Patent Drawing, PTO-948.
3. ☐ Notice of Art Cited by Applicant, PTO-1449.
4. ☐ Notice of Informal Patent Application, Form PTO-152
5. ☐ Information on How to Effect Drawing Changes, PTO-1474.
6. ☐ _____.

Part II SUMMARY OF ACTION

1. ☒ Claims 1-19 are pending in the application.

   Of the above, claims _____ are withdrawn from consideration.

2. ☐ Claims _____ have been cancelled.
3. ☐ Claims _____ are allowed.
4. ☒ Claims 1-19 are rejected.
5. ☐ Claims _____ are objected to.
6. ☐ Claims _____ are subject to restriction or election requirement.
7. ☒ This application has been filed with informal drawings under 37 C.F.R. 1.85 which are acceptable for examination purposes.
8. ☐ Formal drawings are required in response to this Office action.
9. ☐ The corrected or substitute drawings have been received on _____. Under 37 C.F.R. 1.84 these drawings are ☐ acceptable; ☐ not acceptable (see explanation or Notice re Patent Drawing, PTO-948).
10. ☐ The proposed additional or substitute sheet(s) of drawings, filed on _____. has (have) been ☐ approved by the examiner; ☐ disapproved by the examiner (see explanation).
11. ☐ The proposed drawing correction, filed _____, has been ☐ approved; ☐ disapproved (see explanation).
12. ☐ Acknowledgement is made of the claim for priority under U.S.C. 119. The certified copy has ☐ been received ☐ not been received ☐ been filed in parent application, serial no. _____ ; filed on _____.
13. ☐ Since this application apppears to be 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.
14. ☐ Other

DECLASSIFIED By License Review
This document contains information under SECRECY ORDER, as defined in 35USC 181-188. Unauthorized Disclosure subject to Civil and Criminal Sanctions.
DECLASSIFIED By License Review
DECLASSIFIED By License Review

EXAMINER'S ACTION

PTOL-326 (Rev.9-89)

1. This application has been filed with informal drawings which are acceptable for examination purposes only. Formal drawings will be required when the application is allowed.

2. Claims 1-19 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

The difference between "selecting", "generating" and "extracting" target specific information needs to be clearly defined in the context of the claims.

3. An inquiry concerning this communication should be directed to David Cain at telephone number 703-308-0463.

Cain/06-26-92

David Cain

THOMAS H. TARCZA
SUPERVISORY PRIMARY EXAMINER
GROUP ART UNIT 222

PTO FORM 948
(Rev 5-91)

U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

ATTACHMENT TO PAPER NUMBER 5

APPLICATION NUMBER 810005

GROUP

NOTICE OF DRAFTSMAN'S PATENT DRAWING REVIEW

The PTO Draftsmen review all originally filed drawings regardless of whether they were designated as informal or formal.

The drawings filed 12/18/91.

A. ☐ are approved.

B. ☒ are objected to under 37 CFR 1.84 for reason(s) checked below. The examiner will require submission of new, corrected drawings at the appropriate time. Corrected drawings must be submitted according to the instructions listed on the back of this Notice.

1. Paper and ink. 37 CFR 1.84(a)
   - ☐ Poor Quality Paper. Must Be White. Transparent Paper Not Allowed. Sheet(s) _____
2. Size of Sheet and Margins. 37 CFR 1.84(b)
   Acceptable Paper Sizes and Margins

Margin	Paper Size: 8 1/2 by 14 inches	8 1/2 by 13 inches	DIN size A4 21 by 29.7 cm.
Top	2 inches	1 inch	2.5 cm.
Left	1/4 inch	1/4 inch	2.5 cm.
Right	1/4 inch	1/4 inch	1.5 cm.
Bottom	1/4 inch	1/4 inch	1.0 cm.

   - ☐ Proper Size Paper Required. All Sheets Must be Same Size. Sheet(s) _____
   - ☐ Proper Margins Required. Sheet(s) _____
     ☐ Top ☐ Right ☐ Left ☐ Bottom
3. Character of Lines. 37 CFR 1.84(c)
   - ☒ Lines Pale, Rough and Blurred, or Jagged. Fig(s) 1-10
   - ☒ Solid Black Shading Not Allowed. Fig(s) 12A, 13A, 13B, 13H.
4. ☐ Photographs Not Approved. _____
5. Hatching and Shading. 37 CFR 1.84(d)
   - ☐ Shade Lines are Required. Fig(s) _____
   - ☐ Criss-Cross Hatching Not Allowed. Fig(s) _____
   - ☐ Double Line Hatching Not Allowed. Fig(s) _____
   - ☐ Parts in Section Must be Hatched Properly. Fig(s) _____
6. Reference Characters. 37 CFR 1.84(f)
   - ☒ Reference Characters, Poor or Rough and Blurred. Fig(s) 1-10, 12B
   - ☐ Minimum 1/8 inch (3.2 mm.) in height is required. Fig(s) _____
   - ☒ Figure Legends Poor ~~or Placed Incorrectly~~. Fig(s) 1-15B
7. Views. 37 CFR 1.84(i) & (j)
   - ☒ Figures Must be Numbered ~~Separately~~. As Fig. 1-17 (Table I, II not Allowed).
   - ☐ Figures Must Not be Connected Fig(s) _____
8. Identification of Drawings. 37 CFR 1.84(l)
   - ☒ ~~Extraneous Matter or~~ Copy Machine Marks Not Allowed. Fig(s) 1-10.
9. ☐ Changes Not Completed from Prior PTO-948 dated _____

☒ Comments:

- Full time photographs on photographic sheets reqd. Fig. 11
- Stippings obj. Fig. 12A, 13A-13H

Telephone inquires concerning this review should be directed to the Chief Draftsman at telephone number (703) 557-6404.

AD
Reviewing Draftsman

1/29/92
Date

PTO Copy

#4

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
07/810,005	12/18/91	KATZ	A TI-16314

EXAMINER
ZANELLI, M

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

ART UNIT	PAPER NO.
2304	

DATE MAILED: 05/12/92

SECRECY ORDER
AND PERMIT FOR FOREIGN FILING IN CERTAIN COUNTRIES
(Title 35, United States Code, §§ 181-188)

Sponsoring Agency & Address: Mr. Donald Singer
Department of Air Force, AF/JACP
1900 Half Street, S.W.
Washington, DC 20324
(202) 475-1386

Notice: To the patent applicant(s); his, her, or their heirs; and any and all of the assignees, licensees, attorneys and agents (hereinafter designated principals):

The sponsoring agency listed above has determined that this patent application discloses critical technology with military or space application, the unauthorized disclosure of which would be detrimental to the national security and which is subject to export control under:

ECCN[1] Reference: 1565A

Goods Accompanied by Sophisticated Know-How	Keystone Equipment or Materials

ITAR[2] Reference:

Goods Accompanied by Sophisticated Know-How

YOU ARE ORDERED TO KEEP THE SUBJECT MATTER SECRET (as required by 35 U.S.C. §181) and YOU ARE FURTHER ORDERED NOT TO PUBLISH OR DISCLOSE THE SUBJECT MATTER TO ANY PERSON EXCEPT AS SPECIFICALLY AUTHORIZED HEREIN.

---

[1] Export Commodity Control Number (ECCN) on the Commodity Control List, Export Administration Regulations, U.S. Department of Commerce; Supplement No. 1 to 15 CFR §399.1.

[2] International Traffic in Arms Regulations (ITAR), Office of Defense Trade Controls, U.S. Department of State; 22 CFR §§120-130.

Any other patent application already filed or hereafter filed in the U.S. or any foreign country which contains any significant part of the subject matter of the above-identified application falls within the scope of this Order. If such other patent application is not under a Secrecy Order imposed by the U.S. Patent and Trademark Office, it and the common subject matter must be brought to the attention of the Director, Group 220, Attention: Licensing and Review, U.S. Patent and Trademark Office, Washington, D.C. 20231 as soon as possible.

Publication or disclosure of the subject matter of the above-identified patent application, except as authorized herein or subsequently by the Commissioner of Patents and Trademarks, may subject the person publishing or disclosing the subject matter to the penalties of 35 U.S.C. 182, 185 and 186 (1952).

This Order should not be construed in any way to mean that the Government has adopted or contemplates adoption of the invention disclosed in this application and it is not any indication of the value of such invention.

The principals may disclose, for legitimate business purposes[3], the subject matter of the above-identified application to a U.S. citizen or to a person who is both admitted lawfully into the United States for permanent residence and is located in the United States provided the U.S. citizen or person is furnished with a copy of this Secrecy Order and is informed that this Secrecy Order is applicable to the subject matter disclosed.

Legitimate business purposes include selling or producing products for the commercial domestic marketplace, or for the commercial foreign marketplace providing that any required export license is obtained. Legitimate business purposes also include selling or otherwise disclosing technical data to foreign contractors or foreign governments after receiving the required export license or approval by the U.S. Government.

The principals shall notify the Commissioner of Patents and Trademarks if a validated license is obtained from the Office of Export Administration, U.S. Department of Commerce, or a license is obtained from the Director, Office of Defense Trade Controls, U.S. Department of State, under regulations governing the export of technical data (15 CFR §379 of the Export Administration Regulations or 22 CFR §125 of the International Traffic in Arms Regulations).

The subject matter of the above-identified application has been determined not to be encompassed by Executive Order 10865, entitled "Safeguarding of Classified Information Within Industry" or Executive Order 12356, entitled "National Security Information" and thus is not subject to the "Industrial Security Manual for Safeguarding Classified Information." However, since the disclosure of the subject matter would be detrimental to the national security, the subject matter must be safeguarded under conditions that will provide adequate protection and prevent access by unauthorized persons. When copies of the subject matter are no longer needed, they should be destroyed by any method that will prevent disclosure of the contents or reconstruction of the document.

---

[3] The term "legitimate business purposes" is to be interpreted consistent with 32 CFR Part 250 (49 FR 484040, December 10, 1984), originally published as DOD Directive 5230.25, November, 1984, entitled "Withholding of Unclassified Technical Data From Public Disclosure."

The principals are permitted, subject to the conditions stated hereinafter, to file and prosecute a corresponding application for patent in each of the following countries: Australia, Belgium, Canada, Denmark, France, Federal Republic of Germany, Greece, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Turkey and the United Kingdom. The papers for each foreign application and its prosecution shall be transmitted to the sponsoring agency, identified herein, for forwarding through diplomatic channels for filing in the foreign country either directly by the principals or through the principals' foreign patent attorney or agent if authorized by the foreign government. Correspondence exclusively relating to payments of taxes and fees need not be sent through the sponsoring agency and diplomatic channels — provided that such correspondence contains no information pertaining to the subject matter of the above-identified application.

International reciprocal agreements providing for the filing of patent applications under a Secrecy Order in the above-identified countries require the principals to furnish to the sponsoring agency identified herein (in addition to the papers to be filed in the foreign patent office) a copy of the specification (including any drawings annexed thereto, any resume and the claims included in the patent application) filed in the patent office of the foreign country. This copy will be furnished to the appropriate defense agency of the foreign government for information only and without prejudice to any rights of the principals. The filing date and serial number of the patent application should also be furnished to the sponsoring agency.

The principals shall request the foreign patent office to place in secrecy the foreign patent applications corresponding to the above-identified application and shall furnish a copy of this Secrecy Order and permit with the first papers to be filed in the foreign patent office.

The use of this permit to file in a foreign country shall constitute a waiver, unless otherwise required by international agreements, of any claim to compensation for loss or damage due solely to the imposition of secrecy or similar treatment of the invention. Belgium, France, the Federal Republic of Germany, the Netherlands, Norway, Turkey and the United Kingdom normally require a separate document confirming such a waiver.

In the case of Japan, the applicant shall ensure in its contract with its patent attorney that the patent attorney shall submit to the Japanese Patent Office a certified copy of this Secrecy Order and Permit. The submission of this permit to the Japanese Patent Office is considered notification to the Government of Japan of the Secrecy Order status of the above-mentioned application and a corresponding Japanese application will be considered an Agreement Application referred to in paragraph 3(a) of the Protocol to the 1956 United States-Japan Agreement.

Please contact the above sponsoring agency for information concerning the imposition or status of the Secrecy Order. Contact the Licensing and Review Branch of the Patent and Trademark Office (703/308-1718) for information regarding the examination of this patent application.

Charles T. Jordan
for Robert E. Garrett
Director, Special Laws Administration

ALAN JERRY KATZ
4334 MELISSA LANE,
DALLAS, TX 40100

23C1
CP4-8 M

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC 20324-1000

1 May 1992

RECEIVED
MAY 0 8 1992
LICENSING & REVIEW

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Attn: Security Group, Licensing and Review
Washington, D.C. 20231

Dear Sir:

The following identified application has been examined by Air Force, a member of the Armed Services Patent Advisory Board, under the provisions of 35 U.S.C. 181.

U.S. Patent Application Serial No. 07/810,005
Filed: 18 December 1991
Inventor(s): Alan J. Katz
Title: Generalized Hebbian Learning For Principal Component Analysis and Automatic Target Recognition Systems and Methods
Prosecuted by: ( ) Government, ( ) Contractor, (x) Unknown Party

This is to notify you in accordance with the above examination that the publication or disclosure of the invention by the granting of a patent therefor would be detrimental to the national security. It is accordingly requested that you order that the invention be kept secret and withhold the grant of a patent for such period as the national interest requires.

It is further requested that the following Secrecy order issue

(X) Secrecy Order and Permit for Foreign Filing in Certain Countries

ECCN Reference 1565A
ITAR Reference _____

( ) Secrecy Order and Permit for Disclosing Classified Information

Level of Classification _____

( ) Secrecy Order - It is further requested that this Secrecy Order issue with

( ) Permit A (PTO 229)
( ) No Permit

Sincerely,

Donald J. Singer

DONALD J. SINGER, USAF
Sponsor (ASPAB (Member)
Organization _____

MAIL ROOM
MAR
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1992
PATENT & TRADEMARK OFFICE

#3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RECEIVED
MAR 19 1992
GROUP 230

In re the Application of Alan Jerry Katz
Serial No.: 07/810,005
Filed: 12/18/91
For: OBJECT SCREENER FOR AUTOMATIC TARGET RECOGNITION BASED ON PRINCIPAL COMPONENT FEATURES

TI-16314
Examiner ---
Art Unit 2301

Additional Filing Fee

MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(A)
I hereby certify that the above correspondence is being deposited with the U.S. Postal Service as First Class Mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on February 28, 1992.

Donna J. Otto

Donna J. Otto

Honorable Commissioner of Patents and Trademarks
Washington, D. C. 20231

We are in receipt of your office action for "Notice of Additional Filing Fee Due Within One Month" dated 01/30/92 requesting an additional filing fee of $2.00.

We hereby authorize you to charge deposit account No. 20-0668 in the amount of $2.00. The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to said deposit account. A duplicate copy of this sheet is enclosed.

Respectfully submitted,

Stanton C. Braden
Attorney for the Applicant
Reg. No. 32,556

SCB:DJO

Stanton C. Braden
Texas Instruments Incorporated
P.O. Box 655474, M/S 219
Dallas, Texas 75265
(214)995-1358
Fax: (214) 995-3170

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1992
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UNITED S[illegible]S DEPARTMENT OF COMMERCE
Patent and [illegible]demark Office
ASSISTANT SECRETARY AND COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

KDB

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO.
07/810,005	12/18/91	KATZ	A TI-16314

RECEIVED
MAR 19 1992

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

ART UNIT: GROUP 230
2301

DATE MAILED: 01/30/92

Fee 2-29-92

NOTICE OF ADDITIONAL FILING FEE DUE WITHIN ONE MONTH

A shortened statutory period for response is set to expire ONE MONTH from the date of this letter. The time period set in this letter may not be extended under 37 CFR 1.136(a). Failure to pay the additional filing fee within the time set will result in the application becoming abandoned.

An application for patent was filed on or after December 16, 1991, accompanied by payment of a fee in the amount of $ 760.00. An additional filing fee specified below must be submitted:

$ 2.00

New Patent and Trademark Office fees became effective December 16, 1991. A copy of the new fee schedule is enclosed.

Unless expressly notified to the contrary, this procedure is effective for the above-identified application only.

RECEIVED
FEB 05 1992
TI PATENTS

Application Processing Division

This notice should be completed and returned with the required additional fee.

C514161 03/17/92 07810005 20-0668 140 102 2.00CH

CERTIFICATE OF MAILING

I hereby certify that this notice and the required additional fee are being deposited with the U. S. Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on (date) 1/29/92

Print Name: Kim Duncan Signature: Kim J Duncan

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO.
07/810,005	12/18/91	KATZ A	TI-16314

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

ART UNIT: 2301

DATE MAILED: 01/30/92

NOTICE OF ADDITIONAL FILING FEE DUE WITHIN ONE MONTH

A shortened statutory period for response is set to expire ONE MONTH from the date of this letter. The time period set in this letter may not be extended under 37 CFR 1.136(a). Failure to pay the additional filing fee within the time set will result in the application becoming abandoned.

An application for patent was filed on or after December 16, 1991, accompanied by payment of a fee in the amount of $760.00. An additional filing fee specified below must be submitted:

$2.00

New Patent and Trademark Office fees became effective December 16, 1991. A copy of the new fee schedule is enclosed.

Unless expressly notified to the contrary, this procedure is effective for the above-identified application only.

Application Processing Division

This notice should be completed and returned with the required additional fee.

CERTIFICATE OF MAILING

I hereby certify that this notice and the required additional fee are being deposited with the U. S. Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on (date) 1/29/92.

Print Name: Kim Duncan Signature: Kim J Duncan

SERIAL NUMBER	PATENT DATE	PATENT NUMBER
07/810005		

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/810,005	12/18/91	~~395~~ 382 ~~364~~	546	~~2301~~ 3602	~~Gorin~~ Hayes

APPLICANTS

ALAN J. KATZ, DALLAS, TX.

CONTINUING DATA********
VERIFIED

JCY NONE

FOREIGN/PCT APPLICATIONS********
VERIFIED

JCY NONE

BEST AVAILABLE COPY

Foreign priority claimed 35 USC 119 conditions met	Verified and Acknowledged	Examiner's initials	AS FILED	STATE OR COUNTRY	SHEETS DRWGS.	TOTAL CLAIMS	INDEP. CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☒ no / ☐ yes ☒ no		JCY		TX	14	19	4	$760.00	TI-16314

ADDRESS

RICHARD A. STOLTZ
TEXAS INSTRUMENTS, PATENT DEPT.,
MAIL STATION 219,
P. O. BOX 655474
DALLAS, TX 75265

TITLE

GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHOD

U.S. DEPT. of COMM.-Pat. & TM Office—PTO-436L (rev. 10-78)

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED	PREPARED FOR ISSUE		CLAIMS ALLOWED	
	Assistant Examiner	Docket Clerk	Total Claims	Print Claim
ISSUE FEE			DRAWING	
Amount Due / Date Paid	Primary Examiner		Sheets Drwg. / Figs. Drwg.	Print Fig.
	ISSUE CLASSIFICATION		ISSUE BATCH NUMBER	
	Class	Subclass		

WARNING: The information disclosed herein may be restricted. Unauthorized disclosure may be prohibited by the United States Code Title 35, Sections 122, 181 and 368. Possession outside the U.S. Patent & Trademark Office is restricted to authorized employees and contractors only.

Entered or Counted

SEARCHED

Class	Sub	Date	Exmr
342	27,28,61, 62-81, 89-103, 159-164, 175,192, 193-197	2/23/04	DEY
	EAST		
342	22		
367	87,93-98, 135,136		
704	200,231, 232-257		
706	15-44	2/25/04	DEY
382	103		
	EAST		

45

SEARCH NOTES

	Date	Exmr.
WEST DATABASE WORDSEARCH	2/23/04	DEY

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.

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FORMAT NO. 2 ATTORNEY

Staple Issue Slip Here

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POSITION		INIT.	DATE
CLASSIFIER			1/6/92
EXAMINER		215	1-22-92
TYPIST			
VERIFIER		315	1-24-92
CORPS CORR.			
SPEC. HAND			
FILE MAINT.			

INDEX OF CLAIMS

Claim Final	Claim Original	Date
	1	7/8/92
	2	2/25/94
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SYMBOLS

- ✓ ..... Rejected
- = ... Allowed
- - (Through numeral) Canceled
- + ... Restricted
- N ..... Non-elected
- I ..... Interference
- A ..... Appeal
- O ..... Objected

Claim Final	Claim Original	Date
	51	
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MAIL ROOM
DEC 18 1991
32
PAT. & TRADE MARK OFF.

07/810005

APPLICATION FOR U.S. PATENT
TRANSMITTAL FORM

Attorney Docket: TI-16314

December 18, 1991

Commissioner of Patents and Trademarks
Washington, D.C. 20231
Dear Sir:

"EXPRESS MAIL"
Express Mailing Label Number RB101289562
Date of Deposit December 18, 1991
I hereby certify that this paper or fee 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 and Trademarks, Washington, D. C. 20231.
Donna J. Otto

Transmitted herewith for filing is the patent application of:

Inventor(s): Alan Jerry Katz

For: Object Screener For Automatic Target Recognition Based On Principal Component Features

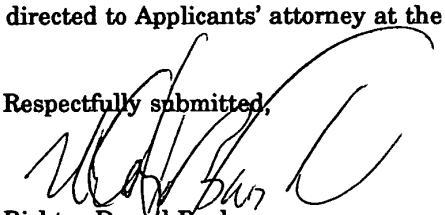
Enclosed are 14 sheets of informal drawing and assignment of the invention to TEXAS INSTRUMENTS, INCORPORATED.

FEE CALCULATION					FEE
				Basic Fee	$690
	Number	Allowed	Extra	Rate	
Total Claims	19	20	0	20	0
Independent Claims	4	3	1	72	72
				Total Filing Fee	760
				Assignment Recording Fee	20
				TOTAL FEES	$780

Please charge deposit account No. 20-0668 in the amount of the Total Fees set forth above. The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to said deposit account. A duplicate copy of this sheet is enclosed.

All correspondence regarding this application may be directed to Applicants' attorney at the below listed telephone number and address.

Respectfully submitted,



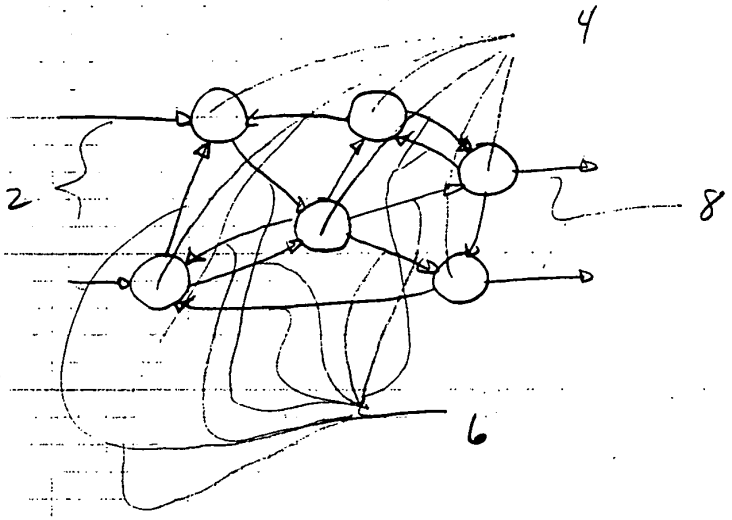
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Attorney for the Applicant
Reg. No. P-35,464

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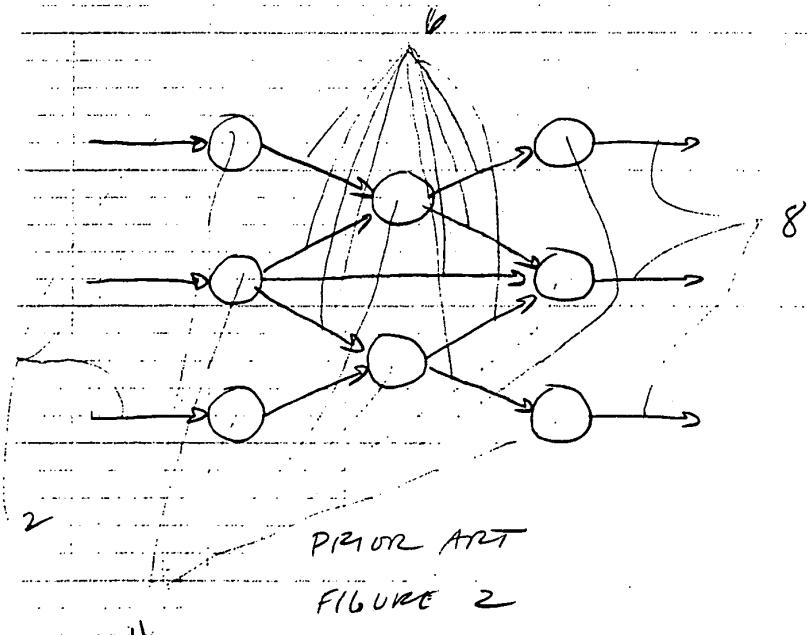
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Sheet No 1 Of 14

PATENT SKETCH FORM

Attorney RDB



PRIOR ART
FIGURE 1

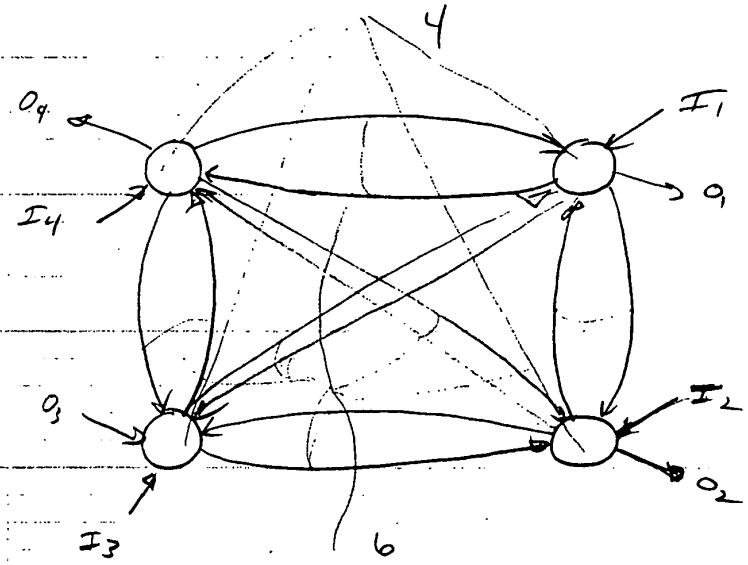


PRIOR ART
FIGURE 2

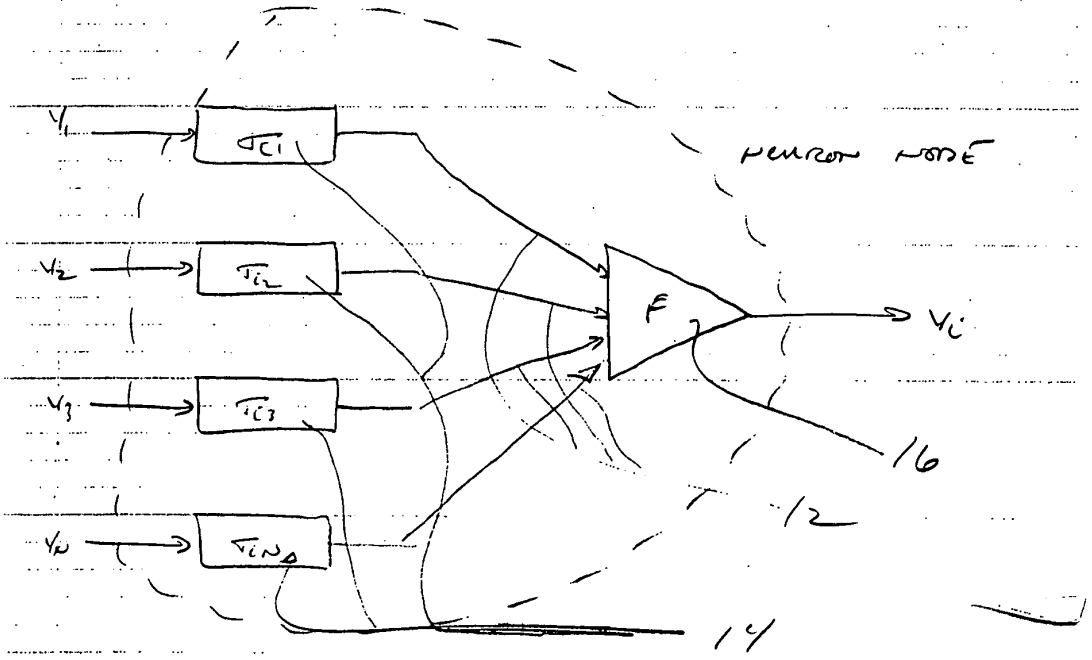
TI Nº 16314
Sheet Nº 2 Of 14

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Attorney MDB



PRIOR ART
FIGURE 3

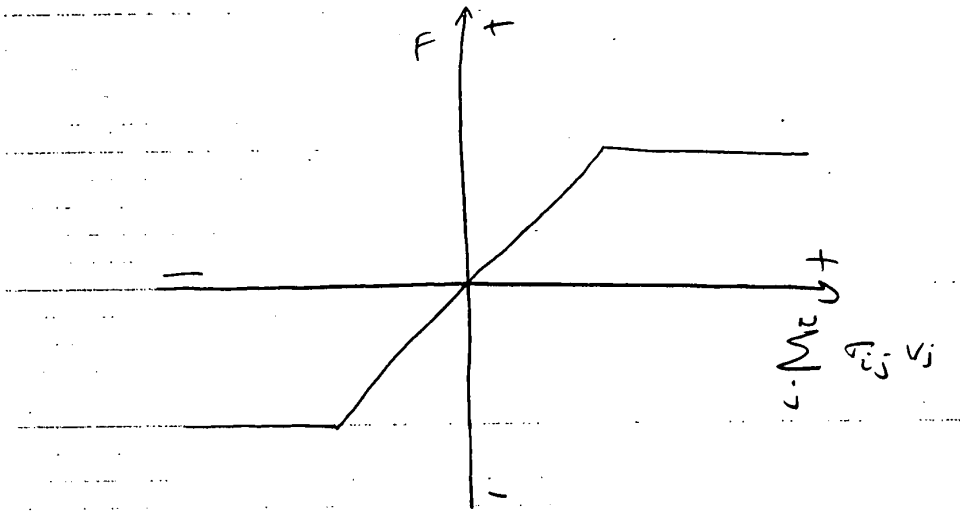


PRIOR ART
FIGURE

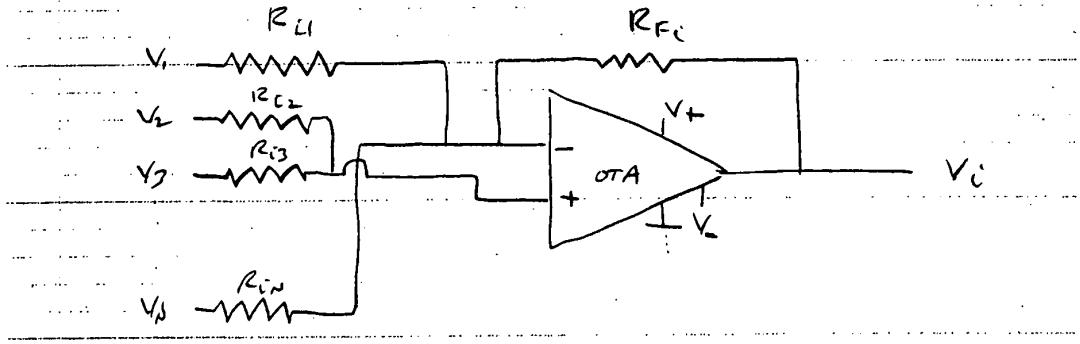
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Sheet No 10 of 14

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PRIOR ART
FIGURE 5

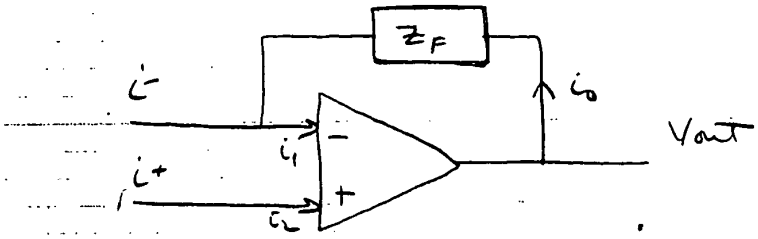


PRIOR ART
FIGURE 6

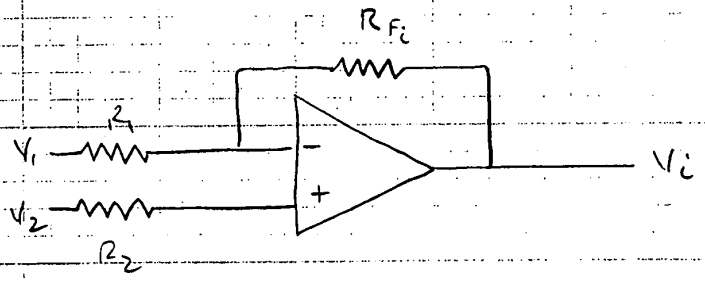
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Sheet No 7 of 14

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FIGURE 7

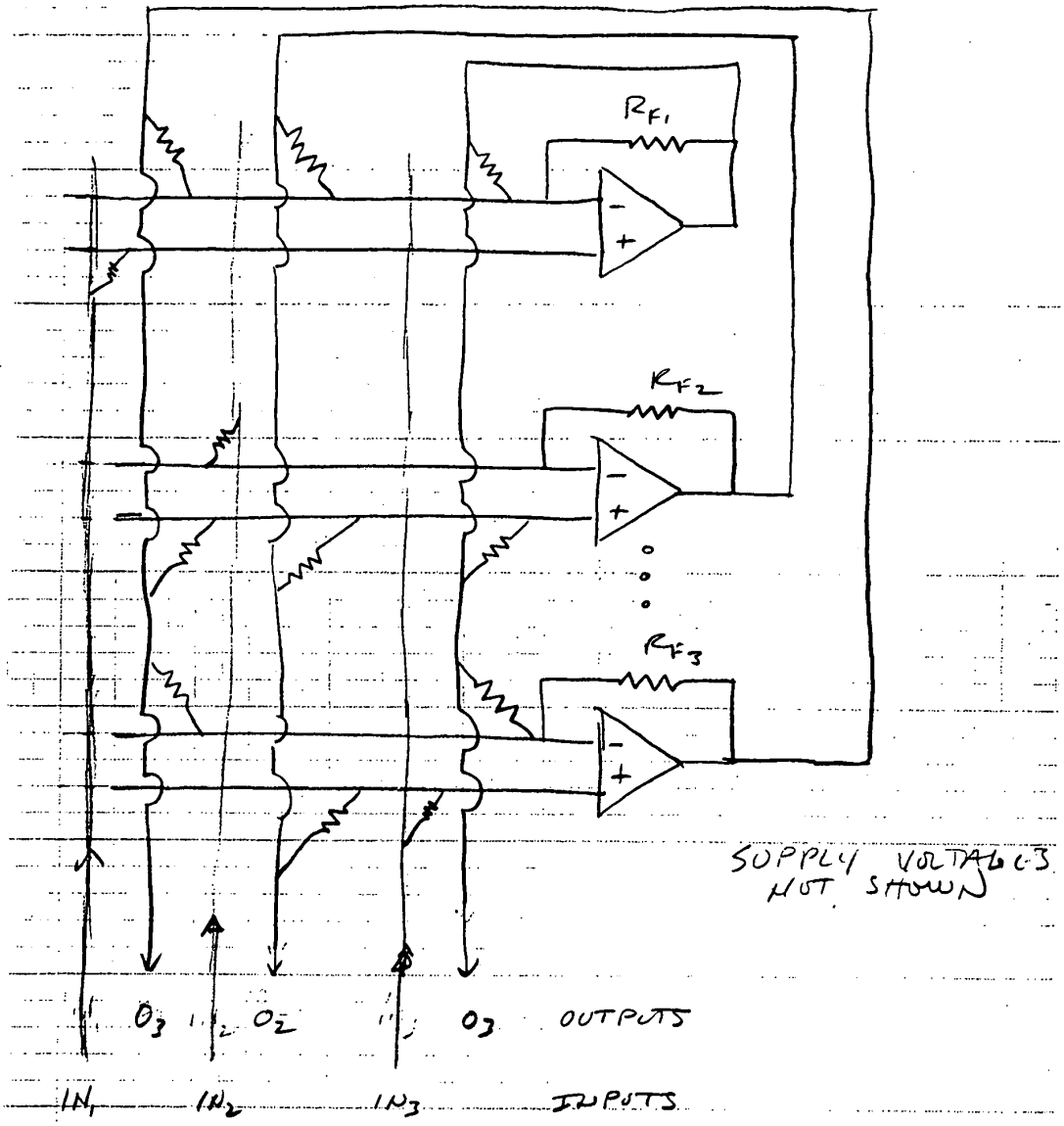


PRIOR ART
FIGURE 8

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Sheet Nº 5 Of

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PRIOR ART

FIGURE 9

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Sheet No 6 Of 14

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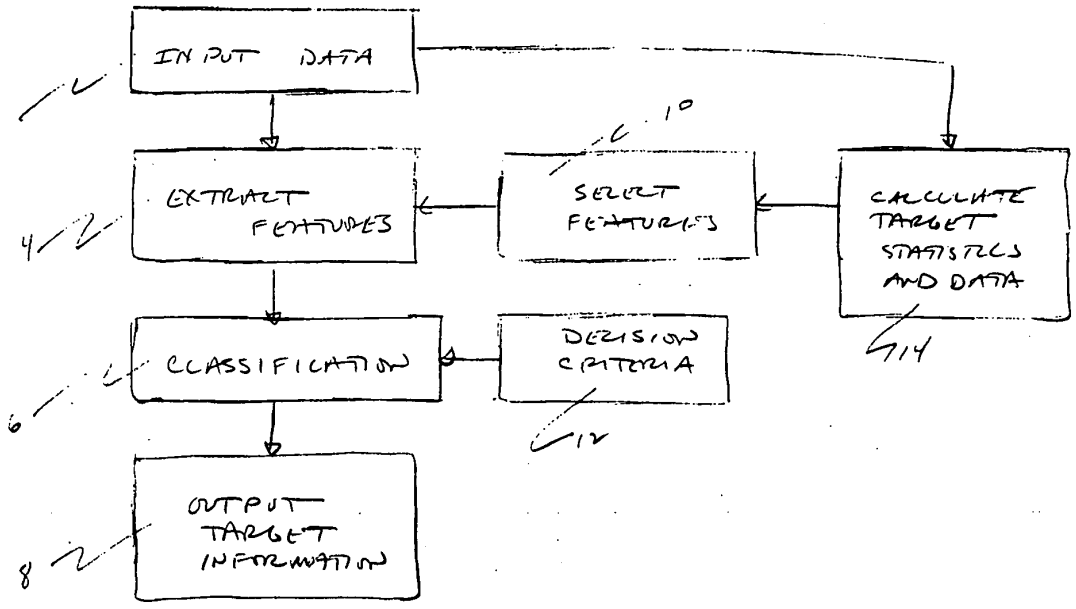


FIGURE 1Φ

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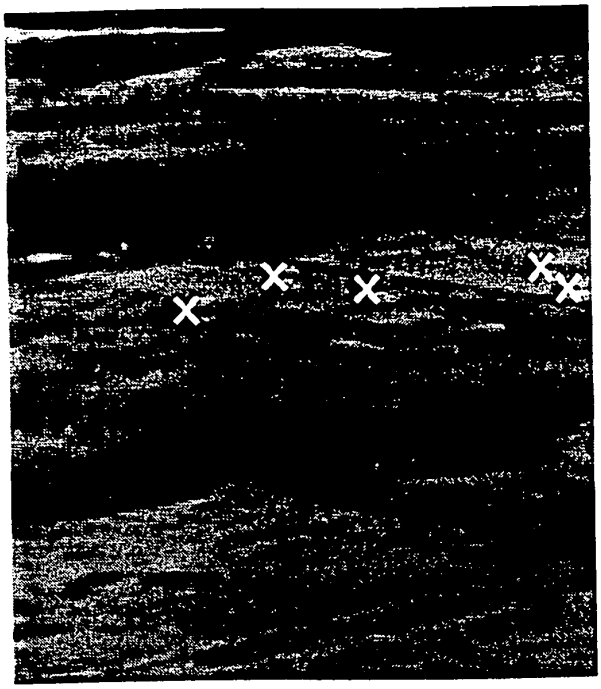


Fig. 11

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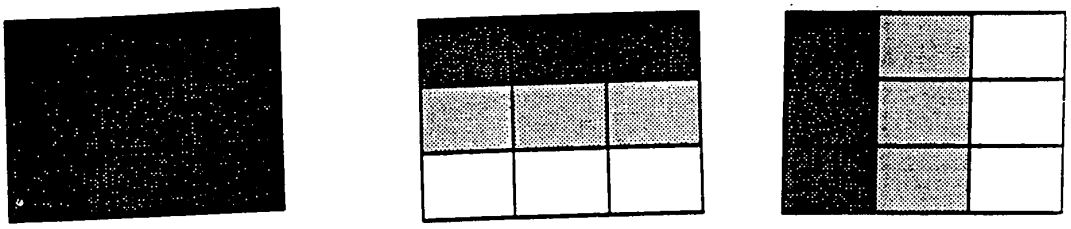


Fig 12a

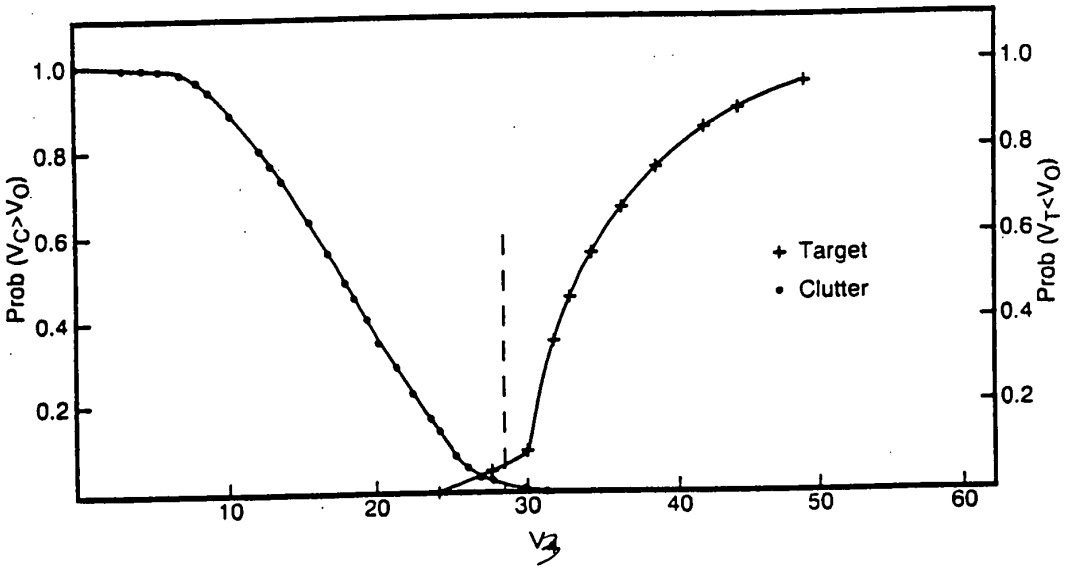
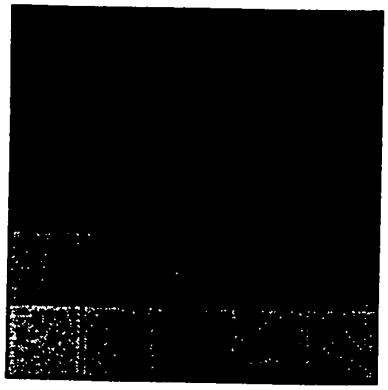


Fig 12b

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Sheet No 9 Of 14

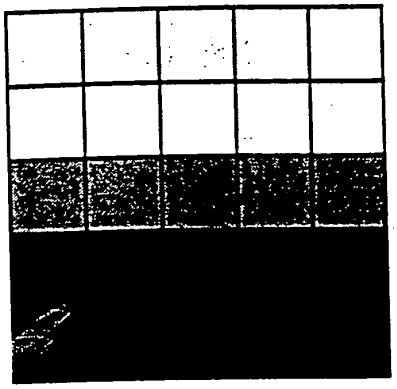
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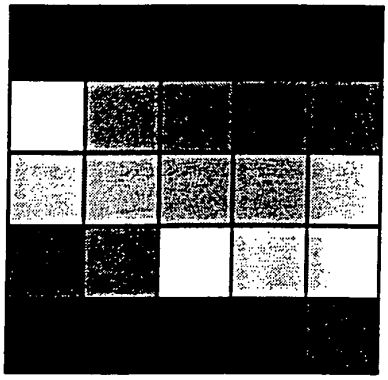
Filter 1 s/n = 1

Fig 13a



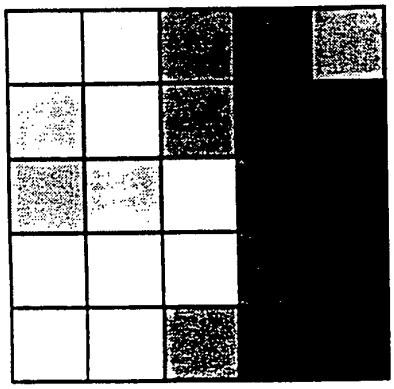
Filter 2 s/n = 7

Fig 13b



Filter 3 s/n = 7

Fig 13c



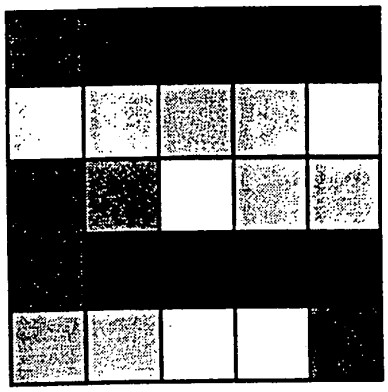
Filter 4 s/n = 5

Fig 13d

TI No. _____
Sheet No. 12 of 14

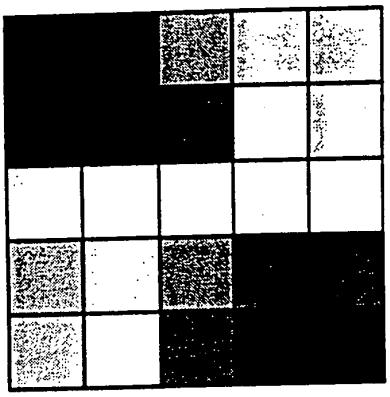
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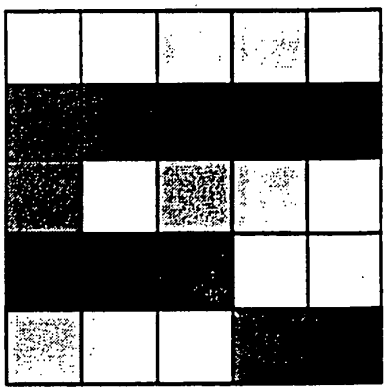
Filter 5 s/n = 23

FIG 13E



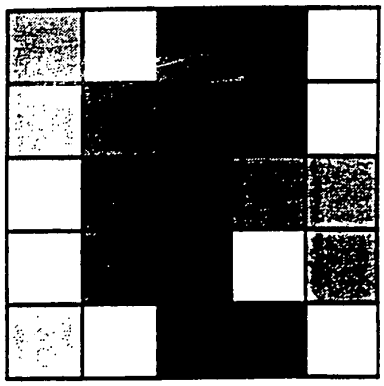
Filter 6 s/n = 8

FIG 13F



Filter 7 s/n = 13

Fig 13G



Filter 8 s/n = 9

FIG 13H

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Sheet No 11 Of 14

PATENT SKETCH FORM

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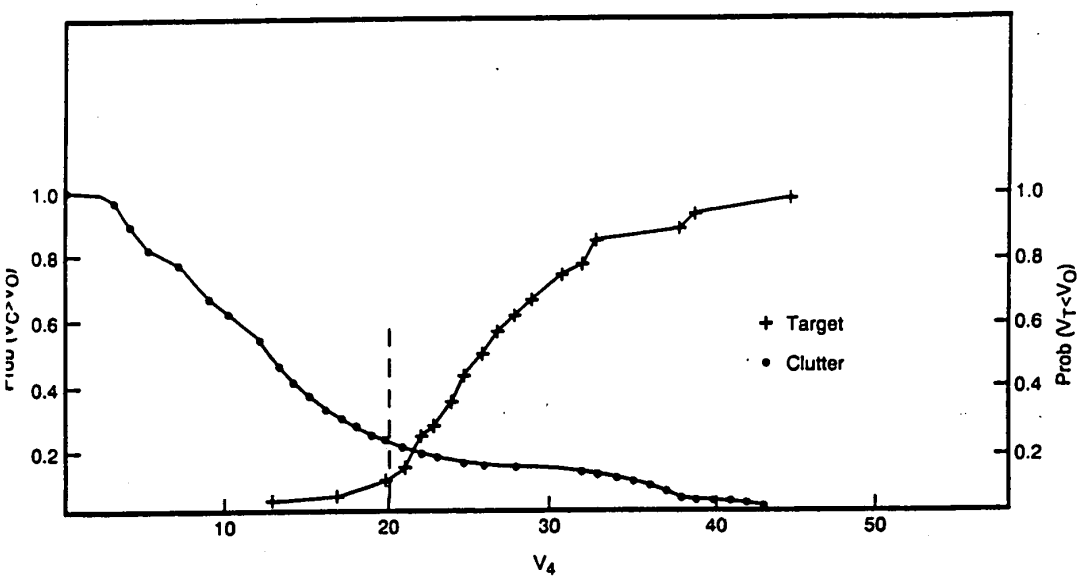


Fig 14

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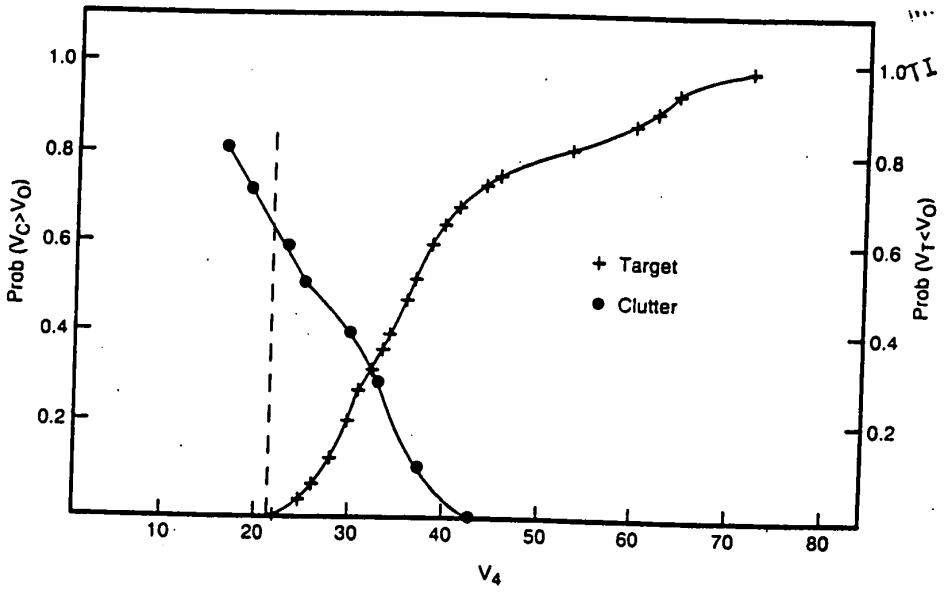


Fig 15b

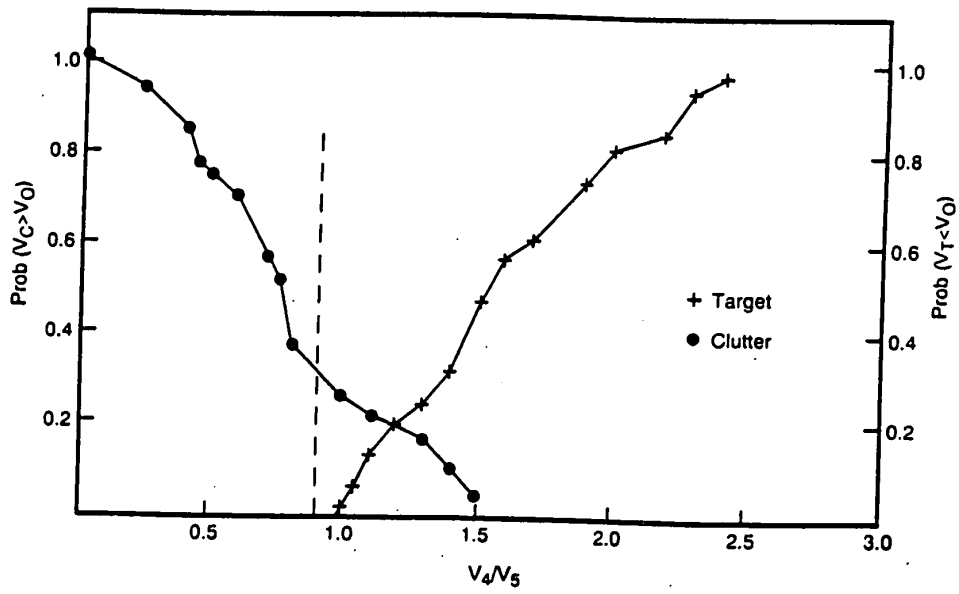


Fig 15a

```
#define N  128      /* number of neurons in simulated network   */
#define C  100      /* number of simulated time steps           */
#define POSITIVE_RAIL  15.0   /* Simulated power supply limits */
#define NEGATIVE_RAIL -15.0
#define Rf             0.001  /* Feedback resistance common to */
                              /* all neurons                   */

main()
{
 double R[N][];
 double Vinitial[N];
 double Vnow[N];
 double sum;
 int c,i,j;

/* Get synapse list and copy initial neuron states into
   relaxation vector */

load_synapse_matrix(R,N);
copy_first_vector_into_second(Vinitial,Vnow,N);

 for(c=0;c<C;c++)                 /* for C time steps        */
  {
    for(i=0;i<N;i)                /* for all neurons         */
     {
      sum = 0.0;
      for(j=0;j<N;j++)            /* get sum of products     */
       sum += (Rf/R[i][j])*Vnow[j];

      if(sum > POSITIVE_RAIL)     /* simulate ramp-threshold */
        Vnow[i] = POSITIVE_RAIL;
      else
      if(sum < NEGATIVE_RAIL)
        Vnow[i] = NEGATIVE_RAIL;
      else
        Vnow[i] = sum;
     }
  }

print(Vnow);    /* output final state of neurons */

}  /* end of simulation program */
```

TABLE 1

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Image Set	Number of Images	Location	Scene Description
1	4	G	a
2	2	G	b
3	1	S	c
4	1	S	d
5	2	N	e

a. Fields and Trees; Urban Clutter; Open and Partially Occluded Targets
b. Fields; Urban Clutter; Targets in Open
c. Fields; Urban Clutter; Targets in Open
d. Heavy Forests; Partially Occluded Targets
e. Fields and Heavy Forests; Partially Occluded Targets

Image Set	Number of Images	Location	Scene Description
1	21	S	Fields With Clusters of Trees; Urban Clutter; Open and Partially Occluded Targets.
2	3	N	Heavy Vegetation; Rural Clutter; Open targets.

Data Set II

TABLE II

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GENERALIZED HEBBIAN LEARNING FOR PRINCIPAL COMPONENT ANALYSIS AND AUTOMATIC TARGET RECOGNITION, SYSTEMS AND METHODS

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FIELD OF THE INVENTION

The present invention relates generally to products and methods pertaining to pattern recognition and classification procedures, parallel computer architectures, learning techniques, and neural networks.

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BACKGROUND OF THE INVENTION

Target recognition and pattern classification involves the evaluation of new observations on the basis of past observations to distinguish targets or desired patterns from background clutter. This task is complicated by the complex nature of real world environments. Moreover, the computational overhead of many practical classification problems strain serial computer resources.

With respect to the complexity of pattern recognition and pattern classification techniques, many of these techniques rely on feature information to differentiate preferred targets from background clutter. Coordination and selection of this feature information is an ongoing problem, as the desired feature information itself (e.g., contrast-based and texture-based) often varies from target to target (e.g., size, stationary, make-up, composition, orientation), target to background (e.g. location of target), data set to data set (e.g., lighting, time-of-day, ambient temperature, and context of scene, sensor characteristics), and data source to data source (e.g., one-dimensional or multi-dimensional data, such as digitized infrared imagery, digitized TV imagery, digitized Infra-red imagery, speech samples, or radar samples).

Recently, researchers have focused on the perception of features in the visual field by biological visual systems and the organization of these biological visual systems. In short, this research has focused on what features are perceived and how are the receptive fields (e.g. neurons sensitive to particular features) organized. This work contributes to the understanding of biological vision systems and lays the groundwork for artificial vision systems in such areas as robotics and automatic

target recognition.

In particular, D.J. Hubel and T.N. Wiesel in their article Hubel, D.J. and Wiesel, T.N, "Receptive Fields, Binocular Interaction, and Functional Architecture in The Cat's Visual Cortex." Journal of Physiology, vol. 160, pp.106-154 (1962) and D. Marr in his book Marr, D. Vision W.H. Freeman and co. San Francisco 1982 are credited with initiating research in this field. Recent work, however, in artificial neural networks suggests mechanisms and optimization strategies that explain the formation of receptive fields and their organization in mammalian vision systems. This work includes Miller, K.d., Keller, J.B. and Stryker, M.P. "Ocular Dominance Column Development: Analysis and Simulation." Science, vol. 245, pp. 605-615 (1989), Durbin, R. and Michison, G. "A Dimension Reduction Framework For Understanding Cortical Maps." Nature, vol. 343, pp. 644-647 (1990), Linsker, R. "Self Self-organization In a Perceptual Network." Computer, vol. 21, pp. 105-117 (1988), and Kammen, D.M. and Yuille, A.L. "Spontaneous Symmetry-breaking Energy Function." Biological Cybernetics, vol. 59, pp. 23-31 (1988). Linsker demonstrated how Hebbian learning algorithms, which change synaptic connections according to the degree of correlation between neuronal inputs and outputs, give rise to layers of center-surround and orientation-selective cell, even if the input to the initial layer is random white Gaussian noise. Kammen and Yuille show that orientation-selective receptive fields can also develop from a symmetry-breaking mechanism. Under certain conditions, the receptive fields perform a principal component analysis of the input data, as was shown in Oja, E.J. "A Simplified Neuron Model As A Principal

Component Analyzer." Mathematics and Biology, vol. 15, pp. 267-273 (1982). Similarly, the article by Brown, T.H., Kairiss, E.W., and Keenan, C.L., "Hebbian synapses: Biophysical mechanisms and algorithms," Annual Review of Neuroscience, vol. 13, pp. 475-511 (1990) suggested Hebbian learning occurs in nature.

With respect to the computational requirements, neural networks provide parallel computational implementations. These networks embody an approach to pattern recognition and classification based on learning. Example patterns are used to train these networks to isolate distinctions between the particular patterns and background clutter for proper classification.

With respect to neural networks, the architecture of a neural network can be simply represented by a data-dependency graph, such as that shown in Figure 1. As shown, this data-dependency graph includes a set of active nodes 4 and a set of passive communicative links 6. The graph nodes 4 represent artificial neurons and the passive communication links 6 define unidirectional communication paths between the artificial neurons 4 (graph nodes 4). Additional links 2 are used as network inputs, which indicate which neurons will receive input signals from outside the network. Similarly, additional links 8 are used as network outputs, which indicate which neurons will transmit output signals to outside the network. A communication link 6 effectively makes the output state of one neuron at the tail of the link available to the neuron at the head of the link. For example, if the neuron states were made available as electrical voltages or currents, the communication links could be provided as simple conductive wires.

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Referring to Figure 2, some architectures are feed-forward, wherein signals are inputed through communication links 2 which direct the input signals, flow through the communication links 6 to the neurons 4 in the neural network in a layer-by-layer fashion, and outputted through the communications links 8 which direct the output signals. No circular path of feedback exists within this type of network. Other networks are fully interconnected, wherein all neurons are connected to all other neurons. Figure 3 shows an example of this type of network, wherein all neurons 4 are connected to all other neurons 4 through corresponding communication links 6 with input and output communication links as shown. In general, each neuron in a neural network architecture has a high fan-in and a high fan-out.

With respect to the neuron function itself, neuron states are generally defined by non-linear local functions. The output value of a neuron is defined by a transfer function, which depends only upon the neurons' current internal state, a set of local parameters called synapses, and the value of signals received from other neurons. Figure 4 shows a simplified schematic of a neuron, along with its network links 12, synaptic parameters 14, and typical input-output transfer function 16. Input voltages V_1, V_2, V_3, ..V_N are received from other neurons and output voltage V_i is outputed to other neurons. The neuron transfer function 16 is usually described as a non-linear function of the sum-of-products of the synapse parameters 14 with their associated input signal values. Figure 5 shows a typical non-linear function that must be

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provided by each neuron that operates according to equation 1, which is defined as follows

$$V_i = F\left(\sum_{j=1}^{N} \sigma_{ij} V_j\right)$$

In defining the transfer function described by equation 1, V_i is the output value (or state) of neuron i, $\sum$ ij is the value of the synapse parameter that modifies the effect of the output of neuron j on the state of neuron i, and F is a function of the sum-of-products of the synapses with neuron states. With respect to Figure 5, F is a linear function of the sum-of-products input near the zero sum region, while saturating to positive and negative values when the sum exceeds a preset positive or negative value.

With respect to training and using the neural network, the synapses affect the transfer function by modulating the strength of signals received from other neurons in the network. In virtually all models, the behavior of the network as a whole is changed by altering the values of the synaptic parameters. Once the parameters are altered, inputs can be applied to the network, and the processed output taken from the designated set of neurons. The time during which the synapse parameter values are altered is generally called the Training Phase. The time during which input signals flow through the network while the synapse parameters remain fixed is called the Recall or Relaxation Phase.

With respect to neuron circuit embodiments, Figure 6 shows the schematic

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diagram of an artificial neuron implemented using resistors and an operational transconductance amplifier. The resistors R_{ij} are associated primarily with the synapses in equation 1, while the operational transconductance amplifier (OTA) and its feedback component R_{fi} is used to provide the desired transfer function F_i.

With respect to the operation of an OTA, as shown in Figure 6, an ideal OTA generates an output voltage proportional to the difference of the currents entering its inputs, multiplied by a very large gain factor. Figure 7 shows an ideal OTA. The defining equation 7 for this circuit may be derived by the analysis, as follows

$$V_{OUT} = A\ (i_2 - i_1) \quad A>>>1$$

$$i_1 = i^- + i_0$$

$$V_{out} = A\ (i^+ - i^- - i_o)$$

$$i_o = \frac{V_{out}}{Z_F}$$

Thus,

$$V_{out} = \frac{Z_F\ A}{A + Z_F}\ (i^+ - i^-)$$

If $A >> Z_F$,

$$V_{out} = Z_F \ (i^+ - i^-)$$

The gain factor A is infinite in the idea case, and very large values of A (Over 1 million) can be obtained in practice using off-the-shelf OTA components. An ideal OTA will have a zero input resistance at its inputs, so that the operation of the circuit may be understood by assuming equation 7, and by assuming that the voltage at either input referenced to ground is always zero. Electrical components placed between the output of an OTA and its negative input induce negative current feedback in the circuit while components placed between the OTA output and its positive input induce positive current feedback. Simple resistive feedback causes the OTA to generate an output voltage proportional to the net current difference at its' positive and negative input terminals, as shown in figure 8 and the corresponding equations 8, 9 and 10, which are as follows

$$V_i = R_{Fi} \ \frac{V_2}{R_2} - \frac{V_1}{R_1}$$

$$V_i = \sum_{j=1}^{2} \sigma_{ij} V_j$$

$$\sigma_{ij} = \frac{R_{Fi}}{R_j}$$

Using these assumptions, the operation of the neuron circuit can be explained. The resistors attached to the input of the amplifier shown in Figure 6 serve to produce input currents proportional to the product of the input voltages V_j and the conductances of the resistors R_{ij}. The input resistors thus act as the synaptic parameters in Figure 4, while the neuron state values are represented as the output voltages of the OTAs that implement each neuron function. In general, synapse parameters can be bipolar. That is, these parameters can take on positive and negative values. However, it is not simple in general to implement negative conductances that physically represent mathematically negative synaptic parameters. Fortunately, the differencing nature of the OTA can be used to provide the effect of negative conductances using positive conductance elements. This is accomplished by attaching resistors that provide the absolute (positive) value of the desired conductance to the negative input of the OTA. Since the subtraction of a positive current in the OTA is equivalent to the addition of a negative current, negative synapse parameters can be equally well implemented using standard resistive elements. The feedback resistor R_{fi} defines the slope of the OTA transfer function in the linear region, while the power supply voltages determine the limiting values of the transfer function in regions of strong negative and positive bias. The circuit shown in Figure 6 provides the basic functional requirements for a typical neural

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network neuron. Using a more complex feedback impedance in place of R_{fi} can provide more complex transfer functions when necessary.

Figure 9 shows a schematic of a general neural network based on the use of resistor elements for the synapse parameters and OTAs for the neurons. A non-intersecting grid of wires is used to allow synapse resistors to be connected from OTA outputs to OTA inputs. Pairs of grid lines are used to allow each synapse resistor to be connected from an OTA output to either a positive or negative OTA input terminal. This functionality may be implemented in a software domain as well. For instance, the software algorithm shown in Table 1 produces a dynamic change in neuron state similar to the dynamic changes expected from the OTA array shown in Figure 9. The synaptic parameters (Resistor values) are assumed to be fixed and pre-stored in a two dimensional matrix R. The OTA feedback resistors are assumed to be the same for all neurons. The neuron states are assumed to be initially preset to certain values and are initially defined by a one dimensional matrix V. All parameters are assumed to be double precision floating point. While only the relaxation model is shown, other models exist and are well known in the art. The training algorithm varies according to the specific neural network type.

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SUMMARY OF THE INVENTION

This application discloses a method for distinguishing targets from background clutter, comprising the steps of inputting data (e.g., one-dimensional or multi-dimensional data, such as digitized infrared imagery, digitized TV imagery, speech samples, or radar samples), calculating data statistics from the data and using said data statistics to select target specific feature information (e.g., contrast-based and texture-based) to distinguish specific targets from background clutter, generating the target specific feature information from the data statistics, extracting the target specific feature information from the data, using the target specific feature information to distinguish specific targets from background clutter (e.g., parametric and non-parametric techniques and one-class, two-class, or multi-class classification procedures), and outputting target and background clutter information. In particular, this method uses the Hebbian Learning to distinguish and take advantage of second order correlation information.

The invention may also be incorporated into a classification system, comprising a data input (e.g., one-dimensional or multi-dimensional data, such as digitized infrared imagery, digitized TV imagery, speech samples, or radar samples), a calculator to calculate data statistics from the data input, a selector to use the data statistics to select target specific feature information (e.g., contrast-based and texture-based) to distinguish specific targets from background clutter, a generator to generate the target specific feature information from the data statistics, a feature extractor to extract target specific feature information from the data input, and a classifier to use

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the target specific feature information to distinguish targets from background clutter and output target and background clutter data (e.g., parametric and non-parametric techniques and one-class, two-class, or multi-class classification procedures).

The advantages of this method and system and the corresponding hardware and software embodiments are that they generate and select the target specific feature information for the classification of preferred targets in the context of particular backgrounds, and thereby increases the robustness of the overall classification process. In particular, this method and system uses a variation of the Hebbian learning algorithm and recently discovered relationships between neural network Hebbian learning algorithms and statistically-based principal component analysis to generate a set of distinguishing target characteristics pertinent to the classification and separation of targets from background clutter in automatic target recognition applications.

In addition, advantages also include the tailoring the features (in the form of principal component filters) to reflect the characteristics of a specific target or target class which leads to separability of the targets based on a relatively small number of features, which reduces the size of the feature space and the corresponding size of the training set required for adequate generalization. Similarly, using only target training examples for feature generation removes biases that arise from nonrepresentative clutter training sets and signal-to-noise ratios aid in identifying features that are more robust over the training data. Likewise, hierarchies of feature filters covering relevant length scales in the image set provide further discrimination

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of the object classes and indicate any scale invariant properties of the objects. Finally, carrying out filter convolutions is a local operation and can be parallel over the image to yield fast implementation times.

Although our focus is on automatic target recognition, the described learning and classification methods extend to a variety of pattern recognition domains. The invention may be implemented in software and hardware configurations as well. Parallel computer archetectures, such as neural networks, are used extensively.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages will become apparent from the following and more particular description of the various embodiments of the invention, as illustrated in the accompanying drawing, wherein:

Figure 1 shows a data-dependency graph of a typical neural neural network.

Figure 2 shows an example of a feed-forward neural network.

Figure 3 shows an example of a fully connected neural network.

Figure 4 shows a simplified schematic of a neuron, along with its network links, synaptic parameters, and typical input-output transfer function.

Figure 5 shows a typical non-linear function provided by each neuron operating according to defining equations.

Figure 6 shows the schematic diagram of an artificial neuron implemented using resistors and an operational transconductance amplifier.

Figure 7 shows an ideal operational transconductance amplifier.

Figure 8 is a 2-input operational transconductance amplifier, which shows how equation 1 is provided.

Figure 9 shows a schematic of a general neural network based on the use of resistor elements for the synapse parameters and OTAs for the neurons.

Figure 10 shows a preferred system configuration.

Figure 11 is a TV image from data set I, which contains the five targets (marked with an "x"). that were used for training.

Figure 12a shows 3 x 3 pixel filters determined by learning with the

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generalized Hebbian algorithm, which are the first three principal components for the training target regions from data set I.

Figure 12b is a graph showing the separability of target and clutter objects based on variance values derived from the third filter in Figure 12a.

Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h show the 5 x 5 pixel filters derived from training data set II, which represent top eight principal components ordered by decreasing eigenvalue.

Figure 14 is a graph showing variances derived from Filter 5 in Figure 13e in conjunction with the probability of detection and the false alarm rate.

Figure 15a is a graph showing the ratio of variances derived from Filters 4 and 5 in Figures 13d and 13e.

Figure 15b is a graph showing the variance derived from Filter 4 in a second set of 5 x 5 pixel filters described in the detailed description in conjunction with the probability of detection and the false alarm rate.

Table 1 shows a software algorithm that produces a dynamic change in neuron state similar to the dynamic changes expected from the OTA array shown in Figure 9.

Table 2 is a description of the two data sets discussed in text.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 10 shows a preferred classification system configuration. As shown in Figure 10, the classification system inputs the data in module 2, extracts feature information from the inputted data in module 4 and inputs the feature information into the classification module 6 which uses decision criteria 12 to classify the target from background clutter and outputs this information in module 8. The feature selection module 10 uses target statistics and data which are extracted from the input data in module 14 to select and generate features specific to a given target class and inputs this information into module 4 that extracts features. These distinguishing target characteristics help the classifier separate targets from background clutter, which makes the classification system more robust.

In particular, the preferred system shown in Figure 10 accepts primarily long-wavelength infrared (IR) and television (TV) imagery to be analyzed. As discussed, infra, the data inputs are primarily derived from two data sets that characterize two target scenarios: targets that are partially occluded (e.g., targets along tree lines) and targets that resemble background clutter. Various procedures are used to extract feature information, which will be discussed infra in conjunction with the feature selection process. The preferred system shown in Figure 10 uses binary tree structure to classify inputted feature information, wherein the parameters defined by the eigenvalues associated with the principal components, discussed infra in conjunction with the feature selection process, constitute the decision criteria.

With respect to the feature selection process, the preferred embodiment uses

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target statistics and a neural network that implements a generalized Hebbian learning algorithm to select and generate features specific to a given target class. The generalized Hebbian learning algorithm employed, which was discussed in the Sanger, T.D. "Optimal Unsupervised Learning." Neural Networks vol. 2, pp. 459-473 (1989), selects features for automatic target recognition from the inputted imagery. The generalized Hebbian Learning algorithm generates principal components or receptive features that resemble those found in Linsker's work, discussed supra. Inter alia, Sanger shows that the GHA determines the principal components of the data set in order of decreasing eigenvalue, which is important because the higher eigenvalue components are generally the most important or prominent features.

The generalized Hebbian learning algorithm trains a one-layer neural network, where the input nodes define arrays of pixel intensity values from image data and the output nodes index the principal components. Sanger describes the procedure with the following equation:

$$c_{ij}(T+1)=c_{ij}(T)+\gamma(T)\left[Y_i(T)x_j(T)-Y_i(T)\sum_{k<i} c_{kj}(T)y_k(T)\right]$$

where c_{ij} is the weight or connection strength between the j^{th} input neuron and the i^{th} output neuron, x_j is the j^{th} component of the input vector, y_i is the i^{th} component of the output vector, and Y(T) is a learning parameter that decreases with time such that

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$$\lim_{T\to\infty} \gamma(T)=0 \text{ and } \sum_{T=0}^{T=\infty} \gamma(T)=\infty$$

The second term on the rhs of equation 1 is the Hebbian term and the third term ensures that the algorithm learns successive eigenvectors (which are the principal components) of the co-variance matrix of the input vectors ordered by decreasing eigenvalue. This decomposition of the co-variance matrix in terms of eigenvectors is the well-known Karhunen-Loeve transform. Local operations affect equation 1, which distinguishes the relationship described in equation 1 from other relationships characterized by the Karhunen-Loeve transform and underscores the importance of equation 1 for training neural networks. Whereas Sanger applies equation 1 to image coding, texture segmentation, and the generation of receptive fields, principal components have been used to characterize image texture, as discussed in Ade, F. "Characterization Of Textures By Eigenfilters." Signal Processing,vol. 5, pp. 451-457 (1983) and are used in the preferred embodiment.

The preferred embodiment uses equation 1 to develop receptive fields for identifying a specific target object. The extracted characteristics of the target object are embedded in the second-order image statistics. Inputs to the network are r x s arrays of pixel values, which are rastered into r x s component vectors, from image subregions that contain the target of interest. The resulting principal components are directions in the r x s dimensional input space with maximum variance. Projections of input vectors along the principal component directions are

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maximally distinguishable. Eigenvalues corresponding to the principal components determined from equation 1 provide a measure of the variance in the principal component directions. Since vectors in the input space are made up of pixel intensities, the principal components generally correspond to prominent intensity patterns or features in the object of interest. The preferred embodiment trains on several examples of the target object to smooth out noise present in individual examples and to generate principal components that signify features common to different occurrences of the object.

The generated principal components are arrayed in r x s matrices to produce receptive fields or filters that are convolved with the original image data during classification. The preferred embodiment convolves these filters such that the spatial sampling of pixel intensities used to construct the input vectors is preserved. Next, every r x s array of pixels contained in the image subregion of interest is multiplied by the generated filters and then compute the variances of the resulting convolutions. Variances (these are related to the eigenvalues of the principal components) or ratios of the variances (these provide a measure of the relative content of two patterns) compose the parameter sets used for classification. The preferred embodiment uses range information, if available, to scan the image to properly adjust the size of the

box or window circumscribing the subregion of interest to reflect the target size.

The spatial sampling density entering into the construction of the input vectors is an important parameter in the generation of the receptive fields. This parameter

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corresponds to the synaptic connection density in Linsker's Hebbian algorithm, discussed supra, which only yields principal components if the connection density is held fixed. The preferred embodiment uses the spatial sampling density to determine the scale of the feature. Please note that the spatial sampling density must be appropriately scaled to ensure that the same feature scale is measured in all cases, if the target object occurs at different ranges in the image data, as in the inputted data reviewed in the preferred embodiment. As the spatial sampling density for targets at nearer ranges are reduced, the preferred embodiment averages over the shorter length scales to avoid aliasing effects. Thus, the preferred embodiment assumes that the target at the longest range fits into a u x v pixel box. Input vectors for this case are formed from intensity values of r x s blocks of pixels (where these blocks are smaller than the box size) extracted from the box circumscribing the target object. The preferred embodiment composes input vectors from 2r x 2 s blocks of pixels for targets at half the initial range and extracts the intensity value from every second pixel. The preferred embodiment continues in this fashion in closer ranges.

The preferred embodiment also scales the spatial sampling density for a given target sample to generate a hierarchy of receptive fields at different scales. The relevant scales are set by the smallest scale detectable (effectively the resolution) for the target seen at longest range and the size of the target object. This hierarchy characterizes the target object in terms of what features become relevant at different length scales. For example, self-similar objects, which are objects that look the same at any scale, are expected to have an invariant feature set as a function of scale.

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Scaling of the spatial sampling density resembles renormalization group analysis that assumes system behavior is governed by how the physical operators scale, discussed in Wilson, K.G. "The Renormalization Group: Critical Phenomena And The Kondo Problem." Review of Modern Physics vol. 47, PP. 773-840 (1975).

The inventor used test data sets with military targets to evaluate the effectiveness of the preferred system implementation, described supra. Table 2 shows a description of the two data sets used. Images in data set I were TV whereas those in data set II were long-wavelength IR. Target objects for both data sets were of several different types, so the preferred embodiment needed to find receptive fields common to all types. Different orientations of the target objects in these data sets did not appear to generate problems. Apparently, targets from data set I were positioned in the field-of-view at long enough range that there was little sensitivity to orientation, and targets from data set II were sufficiently spherically symmetric to neutralize orientation effects. Preprocessing procedures were used to normalize linearly the pixel intensities so they fell in the range from 0 to 255.

The inventor defined clutter objects for both data sets as any region in the image passed by the screener and not a target fell into the clutter class, which is consistent with conventional screeners. The inventor then used this definition to measure the capability of the principal component features to distinguish targets from objects similar in appearance.

Figure 11 is a TV image from data set I, which contains the five targets (marked with an "x") that were used for training. For data set I, the experiments

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used 3 x 3 pixel filters using five targets contained in a single image and tested filter performance on 9 additional images. Targets in the training image represented different types of the target class. Target heights in data set I ranged from 4 pixels to 32 pixels.

Figure 12a displays the 3 x 3 pixel filters determined by learning with the generalized Hebbian algorithm, which are the first three principal components for the training target regions from data set I. The first filter emphasizes regions that have strong grayshade contrast with the background environment; most of the targets show strong contrast with background. The second and third features highlight regions with strong horizontal and vertical grayshade gradients, respectively; target regions all have sharp transitions in grayshade, from pixels within the targets to pixels outside the targets.

Figure 12b shows the separability of target and clutter objects based on variance values derived from the third filter in Figure 12a. Abscissa values V_3 are the variances derived from Filter 3 in Figure 12a. The left-hand curve is the probability for a clutter region to have a variance V_c larger than variance V_o; the right-hand curve is the probability for a target region to have a variance V_t smaller than variance V_o. The dotted line indicates the lower-bound on V_t determined from the training data. Please note the dotted line lies close to the point where the two probability curves cross, which marks the demarcation point in a Bayes classification approach. In particular, Figure 12b indicates that most of the background clutter has a much smaller vertical gradient content than the targets; tree lines and roads and

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horizons in the image set extend mostly parallel to the horizontal edges of the image and provide little vertical gradient content. The inventor also examined the same images with a feature set based on contrast and edge measures and found that between 8 and 16 of these features were required to achieve the same level of separability found in Figure 12b and that the discriminant surface, which divided targets and clutter, was highly nonlinear.

The experiments generated eight 5 x 5 pixel filters, which are shown in Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h for target set II from four examples in a single image and tested filter performance on 23 images. The 5 x 5 pixel filters were derived from training data for data set II. The filters shown represent the top eight principal components and are ordered by decreasing eigenvalue. Only filters 4 and 5 were used for classification. S/N denotes the signal to noise ratio defined infra. In addition, the 5 x 5 pixel filters shown in Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h represent top eight principal components ordered by decreasing eigenvalue. Target heights ranged from 15 pixels in the far range to 175 pixels in the near range. Data set II was in several ways more challenging than the first data set because the noise level was higher and the target texture was very similar to the texture of the clutter. The filters were ranked by a signal-to-noise ratio (S/N), as shown in Figures 13a, 13b, 13c, 13d, 13e, 13f, 13g, and 13h, where S is the mean of the variances from the four examples in the training set and N is the variance of the variances from the same training examples. S/N is a natural criterion, since the target characteristics sought are both prominent and invariant over the data set, which leads to large

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values of S/N.

Figure 14 is a graph showing variances derived from Filter 5 in Figure 13e in conjunction with the probability of detection and the false alarm rate. V_5 denotes variances derived from Filter 5 in Figures 13e. The dotted line is the lower bound on V_t determined from the training data. With the lower bound, the probability of detection, P_d, is 0.89 and the false alarm rate, P_{fa}, is 0.27. As shown in Figure 14, filter 5 had the largest S/N ratio among the eight generated and alone provides considerable separation of targets and clutter. Figure 14 also shows a lower cutoff for the target region, as the training examples establish a lower bound on the target region in the feature space due to the higher degree of noise and corresponding smaller variance values associated with these examples. The use of noisy examples, (and, hence, examples more easily confused with clutter) helps estimate the true position (as determined from an infinitely large data set) of the classification discriminant surface from examples that lie close to the boundary between target and clutter than from examples that lie further away.

To achieve further separability of targets from clutter, the inventor also examined ratios of the variance values from the filters and found the ratios of the variance outputs from filters 4 and 5 in Figures 13d and 13e further distinguish targets and clutter, as shown in Figure 15a. In particular, Figure 15a is a graph showing the ratio of variances derived from Filters 4 and 5 in Figures 13d and 13e. V_c, V_t, and V_o indicate the ratio of variances from Filters 4 and 5. The dotted line is determined from training data. The clutter curve uses only false alarms from the

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results in Figure 14, whereas the target curve uses all the target points. Using the dotted line to discriminate targets and clutter (together with results from Figure 14), the detection probability is defined to be 0.89 and the false alarm rate is defined to be 0.10, which is a significant improvement over 0.27.

In addition, the experiments used the training image to generate a second set of eight 5 x 5 pixel filters at a larger length scale by halving the spatial sampling density of the input vectors to the neural network. The filter with the second largest S/N ratio was the same as filter 5 in Figure 13. This same filter further reduces the number of clutter points mistakenly identified as targets, as shown in Figure 15b, which suggests some self-similarity in the target characteristics and indicates the persistence of a particular feature over a factor of two in length scales. In particular, Figure 15b is a graph showing the variance derived from Filter 4 in a second set of 5 x 5 pixel filters described in the detailed description in conjunction with the probability of detection and the false alarm rate. V_4 is the variance derived from Filter 4 in a second set of 5 x 5 pixel filters, described infra. The clutter curve uses only false alarms from the results in Figure 15a. All target points, however, are used. The dotted line is the discriminator between targets and clutter set by the training data. If the results shown in Figures 14, 15a, and 15b are used in sequence, the detection probability is determined to be 0.89 and the false alarm rate is determined to be 0.07, which is another significant improvement in performance. As a group, the three filters and their corresponding variance outputs establish a binary classification tree for distinguishing targets from background clutter. The final

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probability of detection (ratio of the number of targets detected to total number of targets) was 0.89, whereas the false alarm rate (ratio of the number of clutter points mistakenly classified as targets to total number of clutter points) was 0.07.

The values and ranges disclosed herein are given for a preferred embodiment of the present invention, of course these values may vary as the parameters are changed. Therefore it is to be understood that many changes in detail may be made as a matter of engineering choices without departing from the spirit and scope of the invention, as defined by the appended claims. In particular, alternate procedures that share the same functionally as the procedures discussed, supra, such as alternate classification techniques or data inputs, are plainly within the scope of the invention.

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CLAIMS

I claim:

1. A method for distinguishing targets from background clutter, comprising the steps of

(a) inputting data;

(b) calculating data statistics from said data and using said data statistics to select target specific feature information to distinguish specific targets from background clutter;

(c) generating said target specific feature information from said data statistics;

(d) extracting said target specific feature information from said data;

(e) using said target specific feature information to distinguish specific targets from background clutter; and

(f) outputting target and background clutter information.

2. The method of claim 1, wherein said data is one-dimensional, two-dimensional, or multi-dimensional.

3. The method of claim 1, wherein said data is digitized imagery, speech signals, or radar signals.

4. The method of claim 1, wherein parallel hardware architectures are employed to use said feature information to distinguish particular targets from background clutter.

5. The method of claim 4, wherein said parallel hardware architectures

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comprise neural networks.

6. The method of claim 1, wherein said feature information is contrast-based or texture-based.

7. The method of claim 1, wherein said feature information is further used to distinguish two target classes or a plurality of target classes from one another.

8. The method of claim 1, wherein Hebbian learning techniques are used to select said target specific feature information.

9. A classification system, comprising

(a) a calculator to calculate data statistics from a data input;

(b) a selector to use said data statistics outputted from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) a generator to generate said target specific feature information from said data statistics outputted from said calculator;

(d) a feature extractor to extract target specific feature information from said data input; and

(e) a classifier to use said target specific feature information extracted from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

10. The classification system of claim 9, wherein said data input is one-dimensional, two-dimensional, or multidimensional.

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11. The classification system of claim 9, wherein said data input is digitized imagery, speech signals or radar signals.

12. The classification system of claim 9, wherein parallel hardware architectures are employed in the classifier to use said feature information to distinguish particular targets from background clutter.

13. The classification system of claim 12, wherein said parallel hardware architectures comprise neural networks.

14. The classification system of claim 9, wherein said feature information is contrast-based or texture-based.

15. The classification system of claim 9, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

16. A classification hardware system, comprising

(a) a calculator to calculate data statistics from a data input;

(b) a selector to use said data statistics outputed from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) a generator to generate said target specific feature information from said data statistics outputed from said calculator;

(d) a feature extractor to extract target specific feature information from said data input; and

(e) a classifier to use said target specific feature information extracted

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from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

17. The classification hardware system of claim 16, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

18. A classification software system, comprising

(a) calculation software to calculate data statistics from a data input;

(b) selection software to use said data statistics outputed from said calculator to select target specific feature information to distinguish specific targets from background clutter, wherein said target specific feature information uniquely describes a target for recognition purposes;

(c) generator software to generate said target specific feature information from said data statistics outputed from said calculator;

(d) feature extraction software to extract target specific feature information from said data input; and

(e) classification software to use said target specific feature information extracted from said data input by said feature extractor to distinguish targets from background clutter and output target and background clutter data.

19. The classification software system of claim 18, wherein said selector employs Hebbian learning techniques to select said target specific feature information.

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ABSTRACT

This application discloses a method for distinguishing targets from clutter, comprising the steps inputting data, calculating data statistics from said data and using said data statistics to select target specific feature information to distinguish specific targets from background clutter, generating said target specific feature information from said data statistics, extracting said target specific feature information from said data, using said target specific feature information to distinguish specific targets from background clutter, and outputting target and background clutter information. Classification systems, including hardware and software embodiments, are also disclosed.

8/10005

COMBINED DECLARATION AND POWER OF ATTORNEY

TI-16314

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe that I am the original, first and sole inventor or an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: **Object Screener For Automatic Target Recognition Based On Principal Component Features**, the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations §1.56(a).

As a named inventor, I hereby appoint the following attorneys to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Richter Darryl Burke, Reg. No. P-35,464
Richard L. Donaldson, Reg No. 25,673
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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 §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

TI-16314 TITLE: Object screener For Automatic Target Recognition Based On Principal Component Features

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Country of Citizenship: U.S.A.

Inventor's signature: Alan Jerry Katz **Date:** 12/16/91

07/810005

PATENT APPLICATION SERIAL NO._____

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

LA10866 12/27/91 07809005 20-0668 010 101 760.00CH TI-16314

PTO-1556
(5/87)

PATENT APPLICATION FEE DETERMINATION RECORD

Effective December 16, 1991

Application or Docket Number: 8/0005

CLAIMS AS FILED - PART I

	(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				$ 345.00	OR		$ 690.00
TOTAL CLAIMS	19 minus 20 =	*	x $10 =		OR	x $20 =	
INDEPENDENT CLAIMS	4 minus 3 =	* 1	x 36 =		OR	x 72 =	72
MULTIPLE DEPENDENT CLAIM PRESENT			+ 110 =		OR	+ 220 =	
			TOTAL		OR	TOTAL	76.2

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

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	* 20	Minus	** 20	= —
Independent	* 5	Minus	*** 4	= 1
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				

SMALL ENTITY RATE	SMALL ENTITY ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDITIONAL FEE
x $10 =		OR	x $20 =	
x 36 =		OR	x ~~72~~ =	74.00
+ 110 =		OR	+ 220 =	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	74.00

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				

SMALL ENTITY RATE	SMALL ENTITY ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDITIONAL FEE
x $10 =		OR	x $20 =	
x 36 =		OR	x 72 =	
+ 110 =		OR	+ 220 =	
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				

SMALL ENTITY RATE	SMALL ENTITY ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDITIONAL FEE
x $10 =		OR	x $20 =	
x 36 =		OR	x 72 =	
+ 110 =		OR	+ 220 =	
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".
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