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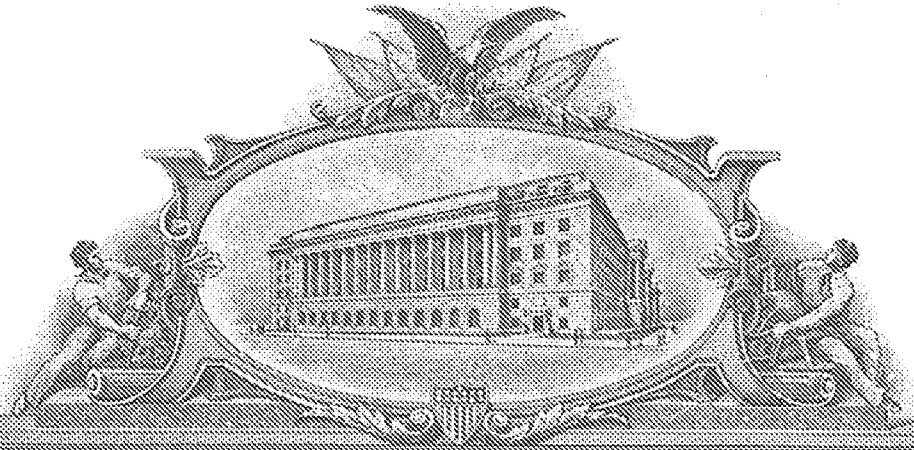
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APPLICATION NUMBER: 62/442,691
FILING DATE: *January 05, 2017*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/442,691*



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Title:

Ultrasound Image Formation and Tissue Characterization
Using a Deep Learning Architecture

Abstract:

detailed description to be provided on
next page

We propose an ultrasound system that uses a deep learning neural network to calculate the characteristics of the displayed images from the acquired radio frequency (RF) Echo signals. By presenting appropriate input and output data to a neural network training algorithm, this system can be trained to produce images of selected tissue characteristics without the need for a physically-derived model to guide system operation. By changing the weights of the neural network, this system can be dynamically reprogrammed to produce images of a wide variety of different characteristics.

Detailed description of the invention

Please describe the invention using the headings below.

Background of the invention

There has recently been an explosion of activity in the field of Deep Learning and deep neural networks (DNNs). Much of the attention has been focused on image recognition and classification. In particular, so called convolutional deep learning neural networks have made remarkable advances in being able to learn functional mappings between arrays of input data (e.g. images) and one or more output sets (e.g. `is_a_human_face`, `is_a_chair`, `is_none_of_the_above...`) or values. To train a neural network, training sets containing multiple instances of input arrays and output classifications, $\{X_i, Y_n\}$, are presented to appropriate deep learning training algorithms, such as AlexNet (Krizhevsky, A., Sutskever, I. and Hinton, G. E. ImageNet Classification with Deep Convolutional Neural Networks NIPS 2012) or its descendants. The output of this training is a set of weights that are used by the neural network during operation. The neural network then operates on any input array, X_k to produce one or more output values that can be interpreted loosely as a probability or confidence estimate that X_k is a member of the output set Y_n (e.g. that the image X_i represents a human face). The output sets, Y_n , can also represent numerical value ranges. In a refinement of this approach, Deep Convolutional Neural Networks (CNNs) or so called Fully Convolutional Networks (FCN) can be used to localize objects within an image on a pixel by pixel basis using. Here, the input training arrays, X_i , are formed from the image data surrounding each point in the image. Each training array is classified into one or more output sets or values based on the set membership of the output point or pixel in question. For instance, one output set might be the set of all points within an image that represent a part of a human face (https://people.eecs.berkeley.edu/~jonlong/long_shelhamer_fcn.pdf). Similarly, a value-based output of the CNN could represent the approximate distance from the camera to each pixel in a photograph (http://www.cv-foundation.org/openaccess/content_cvpr_2015/papers/Liu_Deep_Convolutional_Neural_2015_CVPR_paper.pdf).

The main element(s) of the invention

We propose an ultrasound system that uses a deep convolutional neural network (DNN, CNN or FCN) to calculate the characteristics of the displayed images from the acquired radio frequency (RF) Echo signals. By presenting appropriate input and output data to a neural network training algorithm, this system can be trained to produce images of selected tissue characteristics without the need for a physically-derived model to guide system operation. By changing the weights of the neural network, this system can be dynamically reprogrammed to produce images of a wide variety of different characteristics.

Detailed description of how to build and use the invention

Figure 1 shows an embodiment of the proposed invention, with the following features:

- 1) A transmit receive processor controls the transmission of ultrasound signals by an transducer and reception of ultrasound echo signals from individual elements or groups of elements (as in microbeamformed transducers);
- 2) The transducer can be any form of single element, array or micro-beamformed ultrasonic transducer;
- 3) The received per-element/group echoes are stored in channel memory and may be accumulated over multiple transmit/receive cycles;
- 4) Optionally, an ultrasound beamformer may be employed to form beamformed RF signals representing one or more lines of sight in the body. This beamformer may be based upon

any of the principles listed in the preceding section entitled “Ultrasonic Beamforming”. The beamformer can operate on per element/group echo signals corresponding to one or more transmit events.

- 5) In one embodiment, the beamformer delays the individual ultrasonic echo signals in accordance with the nominal ultrasonic time of flight as in a delay and sum beamformer (i.e. delaying and aligning per element echo data together corresponding to a specific depth region on a scanline), but does not perform the final summing step. In this embodiment, the delays can be calculated to form so-called scanlines emanating from the transducer or, optionally, echoes representing individual pixels in the final image can be aligned and grouped together, without the intervening step of arranging the pixels into scanlines.
- 6) In the key inventive step, per element / group echo or beamformed echo signals corresponding to a localized region of tissue are selected by the data selector and presented as input data to a deep learning neural network (DNN). In one preferred embodiment, this network is a convolutional or fully convolutional deep learning neural network (CNN or FCN – see for instance http://www.cv-foundation.org/openaccess/content_cvpr_2015/papers/Liu_Deep_Convolutional_Neural_2015_CVPR_paper.pdf). Auxiliary data, for instance information about the desired spatial location of the point in the image, other imaging parameters, transducer parameters, and / or information about the clinical context may also be fed into the DNN. In response the input data, the neural network calculates one or more output parameters in accordance with the standard operation of such a network. By appropriate input data selection and training as outlined in the examples below, the neural network can be made to generate one or more concurrent output parameters related to spatially localized properties of the tissue and/ or the interaction of sound with tissue.
- 7) The output data from the DNN corresponding to each output parameter are then processed by a data conditioner which has a principle function of spatially or temporally processing the data to highlight desired spatial or temporal characteristics. In one embodiment, this data conditioner performs multi-resolution image processing such as Cosmix processing.
- 8) The conditioned data from each output parameter are then scan-converted to generate image data which are combined in a display processor to form the final output image. This combination may constitute displaying different tissue characteristics as overlays, segmenting or blending the data on the basis of one or more characteristics. Data may be displayed as 2-dimensional images, as a function of depth and time, or as 3-dimensional or 4-dimensional loops in accordance with common ultrasonic image display formats.
- 9) Output data may be processed in the same manner as image data on a conventional ultrasound system. For instance, it may be sent to an imaging display, to cineloop memory, or exported to an external storage or printing system. It may also be processed further to extract quantitative and/or qualitative information about the anatomy and/or physiology of the tissues being scanned.
- 10) An embodiment of this invention is a self-contained transducer unit that not only transmits and receives signals, but also applies deep learning framework to yield a clinical usable output. The output may simply be a LED flashing green (for normal) or red (for abnormal) but could also be an automatically annotated ultrasound image or volume.

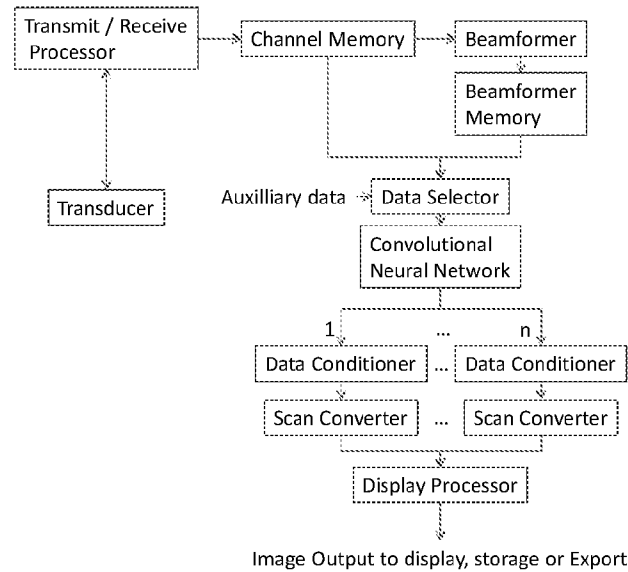


Figure 1: Block Diagram of the proposed invention

Data Selection and Training Examples

Tissue Characterization with Beamforming

To perform beamforming with the proposed architecture, the data selector should be programmed to select, for each point of interest in the imaging field of view, an array of m echo signal samples from each element, where the samples from each echo signal have been selected so that the center sample corresponds approximately to the round trip time delay to the depth of interest as shown in Figure 2 below (where the e_i represent per-channel echo data). As long as the data segment lengths m , are long enough to include the information from each echo surrounding the depth of interest, it may not be not strictly necessary to center the depth of interest within the echo segments. In this latter case, all beamforming including time delays would be performed implicitly by the neural network itself. Auxiliary data could include information about the beamformer programming, the transducer properties, the anatomy being imaged and the spatial location of the point of interest. The desired output of this system would be an estimate of the tissue properties of the region of interest.

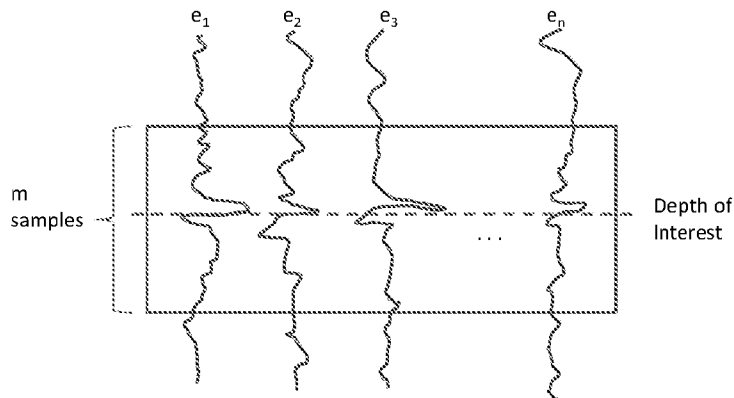


Figure 2: illustration of possible input data for a neural network beamformer (see text for details)

One possible means of training such a neural network beamformer would be to scan tissue with known characteristics. The tissues would be scanned with a transducer attached to a spatial localization system, such as that employed by the Philips EPIQ/Affiniti fusion navigation system, and per channel RF data and transducer localization information would be acquired. For each point of interest in the ultrasound image, a training set $[x_i, y_i]$ could be generated with:

- **input data $[x_i]$** consisting of the per channel echo data as illustrated in Figure 2, together with any desired auxiliary data; and
- **output data $[y_i]$** consisting of any of the known properties of the tissue corresponding to the point of interest. For instance, if (living or cadaver) human tissue is scanned, then the output data might consist of fusion navigation localized MRI or CT data from the same tissue.

By presenting thousands or even millions of such data sets to the neural network training algorithm, it should be possible to train a neural network to directly estimate the tissue properties based upon the measured data, without relying on any explicit physical model of the input $\Leftrightarrow$ output relationship. The ultrasound system as described here would not explicitly perform any of the conventional steps of RF filtering, demodulation, or compression and (in some cases) beamforming. Rather, these processes would be accomplished implicitly within the neural network. Tissue properties might include fat content, histological classification, or any other physical property of the tissue that influences the ultrasonic echoes including fat content. If the tissue consists of one or more ultrasonic phantoms of known properties, then the properties might include ultrasound characteristics such as backscatter coefficient or attenuation.

An alternative means of training such a neural network beamformer would be to first perform standard beamforming and image formation on the per-channel echo data with a conventional ultrasound beamformer and imaging system and to use the images thus formed as output data (y_i), and the corresponding per channel echo signals as input data (x_i) for training the neural network. In

this manner, it should be possible to train a neural network to mimic a conventional ultrasound beamformer and imaging system.

Another alternative means of training such a neural network beamformer would be to use ultrasound simulations such as the Field II program (J.A. Jensen: *A Model for the Propagation and Scattering of Ultrasound in Tissue*, J. Acoust. Soc. Am. 89, pp. 182-191, 1991). This program takes as input a spatial distribution of points representing scatterers in an image field together with data about the geometry of the ultrasound transducer and the transmitted pulse. The output of this program consists of computed ultrasonic data representing the per-element echo signals. To use these data for training purposes, the simulated echoes and auxiliary data about the transducer etc. for each point in space would be presented to the neural network as input training data, $[x_i]$, and the corresponding output data, $[y_i]$ would be the scatterer densities from the simulation.

Cardiac Chamber Identification

In a manner similar to the beamforming example described above, human hearts from multiple test subjects could be scanned using 1-D or 2D array transducers and the resulting images and/or 3D volumes could be segmented (for instance, manually) into regions that are either

A: Within a cardiac chamber; or

B: myocardial tissue

Here, the input data, $[x_i]$, would be per channel echo data and auxiliary information as described above, but the output data would be a semantic classifier (A or B). This resulting trained network could be used to segment and identify cardiac chambers directly. This segmentation information could be used to suppress imaging artifacts, or it could be fed directly into algorithms to quantify ejection fraction or other clinical parameters. The inventive system could be similarly trained to identify other tissue types.

Blood flow / Contrast Imaging

If the ultrasonic echoes, e_i , shown in Figure 2 are selected to include data acquired over multiple ultrasonic transmit receive cycles, then a training process similar to the one described above could be used to distinguish different tissue types on the basis of the spatial and temporal characteristics of the echoes from multiple transmit events. In, such a manner, it should be possible in principle to train the proposed system to image moving (and perhaps even stationary) blood or contrast media. Li et al (Coherent flow Power Doppler (CFPD): Flow Detection Using Spatial Coherence Beamforming UFFC 62 (6), June 2015) have recently shown that time-varying per-channel echo data may be processed to provide enhanced detection of blood flow compared with conventional methods that rely only on beam-formed RF data. For array IVUS imaging devices such as the Philips Volcano Eagle Eye catheter, it may be possible to identify and localize flowing blood from the 2D echo image data by training the proposed ultrasonic imaging system using the per-channel echo data from multiple frames as training input (x_i) and the corresponding manually segmented image data (tissue / blood) as training output (y_i).

Tissue Classification from Beamformed RF Data

Notwithstanding the benefits of operating on the raw per channel echo data as described above, it may be practical in many instances to apply the inventive method directly to beamformed RF data as shown in Figure 1. In this case, the e_i in Figure 2 would represent beamformed RF scanlines from the region of interest and neighbouring lines of sight, or they could equally well represent beamformed RF scanlines generated from successive transmit events. Such processing could be used to perform a wide range of tissue characterization tasks.

For instance, since current liver fat quantification estimation techniques operate on beamformed RF data, it follows that a neural network trained in the manner described above but using beamformed

RF echoes surrounding the region of interest should be capable of estimating the attenuation coefficient and back-scattering properties of liver, and also the fat content of the liver directly. Beamformed radio frequency scanline data and corresponding pathology data similar to those used to develop the Philips Volcano VH algorithm (Nair et al. Euro Intervention (2007);3: 113-120) could be used to train the proposed ultrasonic imaging system to estimate vascular tissue composition directly from the detected RF echoes, without the need for Fourier transforms and the heuristic techniques used with the current VH processing. Since many blood flow detection and imaging algorithms operate on beamformed RF data acquired over multiple transmit / receive cycles, it follows that the present system could be trained using beamformed RF data to perform these tasks.

Electronic Acknowledgement Receipt

EFS ID:	27982851
Application Number:	62442691
International Application Number:	
Confirmation Number:	9005
Title of Invention:	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE
First Named Inventor/Applicant Name:	David Hope Simpson
Customer Number:	24737
Filer:	Christopher L. Kuyper/Jacqueline Andreu
Filer Authorized By:	Christopher L. Kuyper
Attorney Docket Number:	2017P01487US
Receipt Date:	05-JAN-2017
Filing Date:	
Time Stamp:	16:03:51
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 260
RAM confirmation Number	010617INTEFSW00003079141270
Deposit Account	
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File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	2017PF01487_ADS.pdf	1823176	no	9
			3929daf92b46fcbfdd40db1ccdd4421d651959c		
Warnings:					
Information:					
2	Auth or Resc of Auth to Access Appl by DAS/PDX Office	2017PF01487_Authorization.pdf	176900	no	2
			972e1d5943b54742d2417a2f0ca91d3888fc25a5		
Warnings:					
Information:					
3	Specification	2017PF01487_Specification.pdf	178774	no	7
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Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30224	no	2
			7f073a6143c0c8b85c356c316b768e1a73dc63f2		
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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.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	2017P01487US
		Application Number	
Title of Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
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Inventor Information:

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	2017P01487US	
		Application Number		
Title of Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE			

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Postal Code	5656 AE	Country ⁱ	NL		
Inventor	4				Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Vijay	Thakur	Shamdasani	

Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service

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Postal Code	5656 AE	Country ⁱ	NL		

 All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.
Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	24737		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE		
Attorney Docket Number	2017P01487US	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	2017P01487US
		Application Number	
Title of Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE		

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not be** the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	24737		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	2017P01487US
		Application Number	
Title of Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE		

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	2017P01487US
		Application Number	
Title of Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	2017P01487US
		Application Number	
Title of Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant	1	Remove
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If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

[Clear](#)

Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	KONINKLIJKE PHILIPS N.V.		
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Mailing Address Information For Applicant:

Address 1	HIGH TECH CAMPUS 5		
Address 2			
City	EINDHOVEN	State/Province	
Country	NL	Postal Code	5656 AE
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. [Add](#)

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Assignee	1
-----------------	---

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1				
Address 2				
City		State/Province		
Country i		Postal Code		
Phone Number		Fax Number		
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Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

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Signature:

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NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the **INITIAL** filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Christopher L. Kuyper/		Date (YYYY-MM-DD)	2017-01-05
First Name	Christopher	Last Name	Kuyper	Registration Number
				59611

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	2017P01487US
		Application Number	
Title of Invention	ULTRASOUND IMAGE FORMATION AND TISSUE CHARACTERIZATION USING A DEEP LEARNING ARCHITECTURE		

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

- 1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
- 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.
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- 5 A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
- 6 A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
- 7 A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
- 8 A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
- 9 A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.