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(54) Title: MEDICAL IMAGING DEVICES, METHODS, AND SYSTEMS
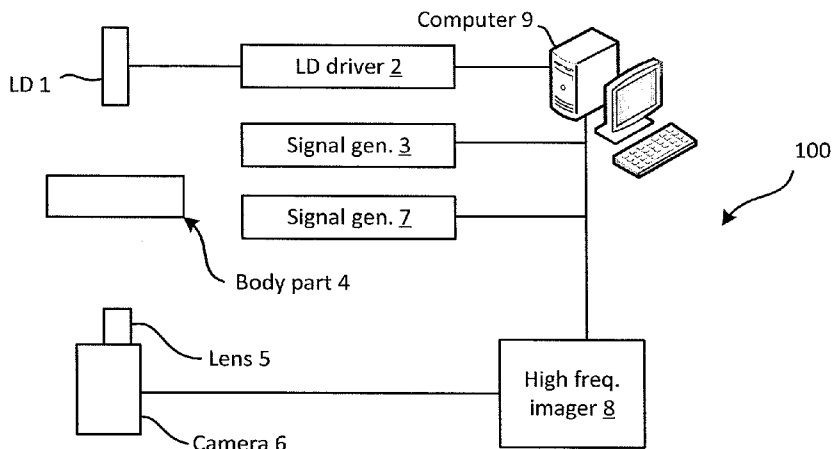
Fig. 1

(57) Abstract: Devices, methods, and systems for providing optical imaging to detect and characterize anatomical and/or physiological indicators, such as, rheumatoid arthritis, and devices, methods and systems for computer aided detection and diagnosis of tomographic images. Embodiments for optimizing machine classification of tissue samples are described. Embodiments for using machine classification techniques to classify indicators present in optical tomographic images are described.

INTERNATIONAL SEARCH REPORT

	International application No.
	PCT/US2011/064723

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 8/13 (2012.01)
USPC - 600/425
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - A61B 8/13, 15; G01J 5/02 ; G06K 9/40, 42, 46, 60; G06T 11/00, 15/00, 19/00 (2012.01)
USPC - 250/341.1, 363.04, 370.08; 378/21; 382/154, 294; 600/425

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, ProQuest

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KLOSE et al. Multiparameter classifications of optical tomographic images. Journal of Biomedical Optics, September/October 2008, Vol. 13(5) retrieved from SPIE Digital Library. retreived on [23.05.2012] <URL: http://spiedigitallibrary.org/jbo/resource/1/jbopfo/v13/i5/p050503_s1?bypassSSO=1> entire document	1-19,22-24,34-36,38,39
Y	HILTUNEN et al. A combined reconstruction-classification method for diffuse optical tomography. Institute of Physics and Engineering in medicine, 2009 retreived from the internet. retreived on [23.05.2012] <URL: http://www.cs.ucl.ac.uk/staff/s.prince/Papers/PrincePMB2009.pdf> entire document	1-19,22-24
Y	US 2004/0052328 A1 (SABOL et al) 18 March 2004 (18.03.2004) entire document	34-36,38,39
Y	BOUKTIF et al. Improving Rule Set Based Software Quality Prediction: A genetic algorithm-based approach. Journal of Object Technology, vol. 3, no. 4, April 2004, Special issue: TOOLS USA 2003, retreived from the internet. retreived on [23.05.2012] <URL: http://www.jot.fm/issues/issue_2004_04/article13.pdf > Pages 227, 241	2, 3/2, 4/3/2, 5/4/3/2, 6/4/3/2, 7/4/3/2, 8/4/3/2, 9/4/3/2, 10/6/4/3/1, 11/6/4/3/2, 12/11/6/4/3/2, 13/12/11/6/4/3/2, 14/13/11/6/4/3/2, 15/3/2, 16/15/3/2, 17/16/15/3/2, 18/17/16/15/3/2, 19/3/2

☒ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"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
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 May 2012	**0 5 JUN 2012**
Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450	Blaine R. Copenheaver
Facsimile No. 571-273-3201	PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	YALAVARTHY. A generalized least-squares minimization method for near infrared diffuse optical tomography. Dartmouth College 2007. retreived from ProQuest Dissertations and Theses. retreived on [23.05.2012] <URL: http://search.proquest.com/docview/304868521?accountid=142944> entire document	4/3/1, 5/4/3/1, 6/4/3/1, 7/4/3/1, 8/4/3/1, 9/8/4/3/1, 10/6/4/3/1, 11/6/4/3/1, 12/11/6/4/3/1, 13/12/11/6/4/3/1, 14/13/12/11/6/4/3/1, 15/3/1, 16/15/3/1, 17/16/15/3/1, 18/17/16/15/3/1
Y	US 7,272,264 B2 (ELSHISHINY et al) 18 September 2007 (18.09.2007) entire document	19
Y	US 7,034,303 B2 (SCHOTLAND et al) 25 April 2006 (25.04.2006) entire document	24
A	US 7,148,887 B2 (KAUFMAN et al) 12 December 2006 (12.12.2006) figures 14, 15, 17; column 15, line 30 to column 15, line 10; column 17, line 25 to column 20, line 17.	1-19,22-24,34-36,38,39

Box No. II   Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
    because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
    because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 20-21, 25-30, 31-32, 40, 45-54, 59-62, 63, 73-76
    because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III   Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Se extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
    1-19, 22-24, 34-36, 38, 39

Remark on Protest   ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

Continuation of Box III.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-19, 22-24, 34-36, 38, 39, drawn to a method of classifying optical tomographic images of tissue samples, comprising extracting a plurality of features representing optical properties of the tissue, statistically analyzing the features and selecting a subset of features providing greater predictive accuracy as to the presence of disease.
Group II, claims 33, drawn to a method for providing automated classification for medical imaging, comprising fitting a smooth function to a planar projection of the images; applying parameters characterizing the smooth function to a classifier.
Group III, claims 37, drawn to an automated algorithm to search through a plurality of features for features that yield an optimum cross-validation classification accuracy for a tomographic image.
Group IV, claims 41-44, 55-58, 64, drawn to a method and computer readable medium for obtaining information from tissue, comprising generating at least one image which includes first data regarding absorption and scattering coefficients of a tissue based on electro-magnetic radiation exiting from the tissue; obtaining second data based on the absorption and scattering coefficients of the image; and analyzing the second data to determine an indicator associated with the tissue.
Group V, claims 65-68, drawn to a method , tissue imaging apparatus and computer readable medium comprising providing first electromagnetic frequency modulated radiation to a tissue at a frequency selected to target certain material of the tissue which have at least one characteristic indicative of rheumatoid arthritis or disease; receiving at least one second electromagnetic radiation from the tissue; generating data regarding the material indicative of rheumatoid arthritis or disease.
Group VI, claims 69-72, 78-92, drawn to a method, system and non-transitory computer readable medium comprising generating a model of three dimensional structure within at least one tissue and deriving spectral features from the model.
Group VII, claims 77, 96-97, drawn to a method comprising acquiring volumetric data representing a property distribution in a tissue sample; rendering a two dimensional representation of a feature and the property distribution of the tissue sample on a digital display; accessing a data store containing rules and automatically selecting a region of interest in the tissue sample and excluding another region; receiving user input regarding the selection; generating an interface on the display providing selectable controls for selecting features to be derived from the volumetric data; receiving user input indicating selected ones of the feature.
Group VIII, claims 93-95, drawn to a system comprising a holding device configured to securely hold a target subject therewithin, the holding device being further configured to be adjustably positioned between a radiation source and detector.
The inventions listed as Groups I-VIII do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: selecting a subset of features providing greater predictive accuracy as claimed therein is not present in the invention of Groups II-VIII. The special technical feature of the Group II invention: fitting a smooth function to a planar projection of the images as claimed therein is not present in the invention of Groups I, III-VIII. The special technical feature of the Group III invention: an automated algorithm to search through a plurality of features for features that yield an optimum cross-validation classification accuracy as claimed therein is not present in the invention of Groups I, II, IV-VIII. The special technical feature of the Group IV invention: generating at least one image which includes first data regarding absorption and scattering coefficients of a tissue based on electro-magnetic radiation exiting from the tissue; obtaining second data based on the absorption and scattering coefficients of the image; and analyzing the second data to determine an indicator as claimed therein is not present in the invention of Groups I, II, III or V-VIII. The special technical feature of the Group V invention: providing first electromagnetic frequency modulated radiation to a tissue at a frequency selected to target certain material of the tissue which have at least one characteristic indicative of rheumatoid arthritis or disease; receiving at least one second electromagnetic radiation from the tissue; generating data regarding the material indicative of rheumatoid arthritis or disease as claimed therein is not present in the invention of Groups I-IV, VI-VIII. The special technical feature of the Group VI invention: generating a model of three dimensional structure within at least one tissue and deriving spectral features from the model as claimed therein is not present in the invention of Groups I-V, VII-VIII. The special technical feature of the Group VII invention: acquiring volumetric data representing a property distribution in a tissue sample; rendering a two dimensional representation of a feature and the property distribution of the tissue sample on a digital display; accessing a data store containing rules and automatically selecting a region of interest in the tissue sample and excluding another region; receiving user input regarding the selection; generating an interface on the display providing selectable controls for selecting features to be derived from the volumetric data; receiving user input indicating selected ones of the feature as claimed therein is not present in the invention of Groups I-VI or VIII. The special technical feature of the Group VIII invention: a holding device configured to securely hold a target subject therewithin, the holding device being further configured to be adjustably positioned between a radiation source and detector as claimed therein is not present in the invention of Groups I-VII.

Groups I, II, III, IV, V, VI, VII and VIII lack unity of invention because even though the inventions of these groups require the technical feature of imaging with computed tomography and analzying the imaging data to extract features, statistically analyzing the features to determine the prescence of disease; an image processing device which generates a three dimensional model of the target area, the model including two dimensional projections in two dimensional domains, deriving information from the model and data to aid in classifying diseased tissue, this technical feature is not a special technical feature as it does not make a contribution over the prior art in view of US 7,148,887 B2 (KAUFMAN et al) 12 December 2006 (12.12.2006) figures 14, 15, 17; column 15, line 30 to column 15, line 10; column 17, line 25 to column 20, line 17.

Since none of the special technical features of the Group I, II, III, IV, V, VI, VII or VIII inventions are found in more than one of the inventions, unity of invention is lacking.