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(54) Title: MACHINE LEARNING METHODS AND RELATED ASPECTS FOR PROCESSING MEDICAL IMAGES

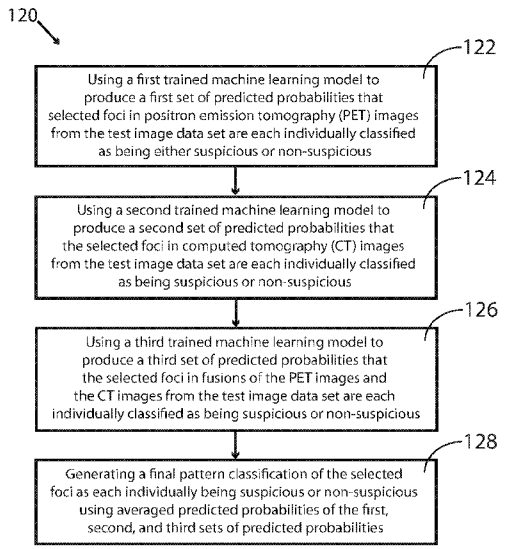

FIG. 1C

(57) Abstract: Examples may provide a method of segmenting test image data sets obtained from a test subject. The method includes using a first trained machine learning model to segment non-suspicious foci in the test image data set to produce segmented non- suspicious foci data. The test image data set comprises positron emission tomography (PET) images and/or computed tomography (CT) images. The method also includes applying a mask to the non-suspicious foci in the test image data set using the segmented non-suspicious foci data to produce masked and unmasked portions of the test image data set. In addition, the method also includes using a second trained machine learning model and the unmasked portions of the test image data set to segment suspicious foci in the test image data to produce segmented suspicious foci data. Related methods, systems, and computer readable media are also provided.

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[Continued on next page]

GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 24/32342

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. G06T 7/10, G06T 7/00, A61B 6/03, G16H 30/40, G16H 50/20, G16H 50/30 (2024.01)
ADD. A61B 5/00 (2024.01)

CPC - INV. G06T 7/10, G06T 7/0012, A61B 6/03, G16H 30/40, G16H 50/20, G16H 50/30
ADD. A61B 5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2020/0202532 A1 (Siemens Healthcare GmbH et al.), 25 June 2020 (25.06.2020), entire document	1-32, 35-37, 39-41
Y	US 2022/0005586 A1 (EXINI Diagnostics AB), 06 January 2022 (06.01.2022), entire document	1-32, 35-37, 39-41
Y	US 2023/0142747 A1 (Cleerly Inc), 11 May 2023 (11.05.2023), entire document	14-15 and 29-30
A	US 2011/0268338 A1 (Collins et al.), 03 November 2011 (03.11.2011), entire document	1-32, 35-37, 39-41
A	US 2017/0337687 A1 (SHANGHAI UNITED IMAGING HEALTHCARE CO., LTD), 23 November 2017 (23.11.2017), entire document	1-32, 35-37, 39-41

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"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)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 October 2024	NOV 0 6 2024
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 24/32342

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.:
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:
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.

Group I - Claims 1-32, 35-37, and 39-41 are directed to a method of segmenting a test image data set obtained from a test subject using a computer.

Group II - Claims 33-34 and 38, 42 are directed to a method of classifying a test image data set obtained from a test subject using a computer.

--- (See Continuation in Supplemental Box) ---

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.:
1-32, 35-37, and 39-41

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.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/32342

Continuation of Box No. III, Observations where unity of invention is lacking:

The inventions listed as Groups I-II 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:

Special Technical Features:

The invention of Group I included the features of applying, by the computer, a mask to the non-suspicious foci in the test image data set using the segmented non-suspicious foci data to produce masked and unmasked portions of the test image data set; and using, by the computer, a second trained machine learning model and the unmasked portions of the test image data set to segment one or more suspicious foci in the test image data to produce segmented suspicious foci data, wherein the suspicious foci are suspicious for the presence of the disease state in the test subject, not required by group II.

The invention of Group II included the features of using, by the computer, a second trained machine learning model to produce a second set of predicted probabilities that the selected foci in one or more computed tomography (CT) images from the test image data set are each individually classified as being suspicious or non-suspicious; using, by the computer, a third trained machine learning model to produce a third set of predicted probabilities that the selected foci in one or more fusions of the one or more PET images and the one or more CT images from the test image data set are each individually classified as being suspicious or non-suspicious; and, generating, by the computer, a final pattern classification of the selected foci as each individually being suspicious or non-suspicious using averaged predicted probabilities of the first, second, and third sets of predicted probabilities, not required by group I.

Common Technical Features

Groups I and II share the features of a processor; and a memory communicatively coupled to the processor, the memory storing instructions which, when executed on the processor, perform operations comprising: produce a selected foci in one or more positron emission tomography (PET) images from the test image data set are each individually classified as being either suspicious or non-suspicious; test image data set comprises one or more positron emission tomography (PET) images and/or one or more computed tomography (CT) images.

However, the shared technical features do not represent a contribution over prior art as being obvious over US 2011/0268338 A1 (Collins et al.) (hereinafter Collins), 03 November 2011 (03.11.2011) in view of US 2017/0337687 A1 (SHANGHAI UNITED IMAGING HEALTHCARE CO., LTD), 23 November 2017 (23.11.2017).

Collins teaches produce a selected foci in one or more positron emission tomography (PET) images from the test image data set are each individually classified as being either suspicious or non-suspicious (para [0015], [0068]- the results from the analysis of one mode (for example, kinetics) are indeterminate or suggest benign lesion; discriminating between benign and malignant lesions.); test image data set comprises one or more positron emission tomography (PET) images and/or one or more computed tomography (CT) images (para [0043]- Computed Tomography (CT) images, Positron Emission Tomography (PET) images, PET/CT, nuclear, MRS or any images or data from a suitable image or data acquisition device).

SHANGHAI UNITED IMAGING HEALTHCARE CO., LTD teaches a processor (para [0074]); and a memory communicatively coupled to the processor, the memory storing instructions which, when executed on the processor, perform operations (para [0075]-[0076]).

As the common features were known in the art at the time of the invention, this cannot be considered a common technical feature that would otherwise unify the groups. Therefore, Groups I-II lack unity under PCT Rule 13.