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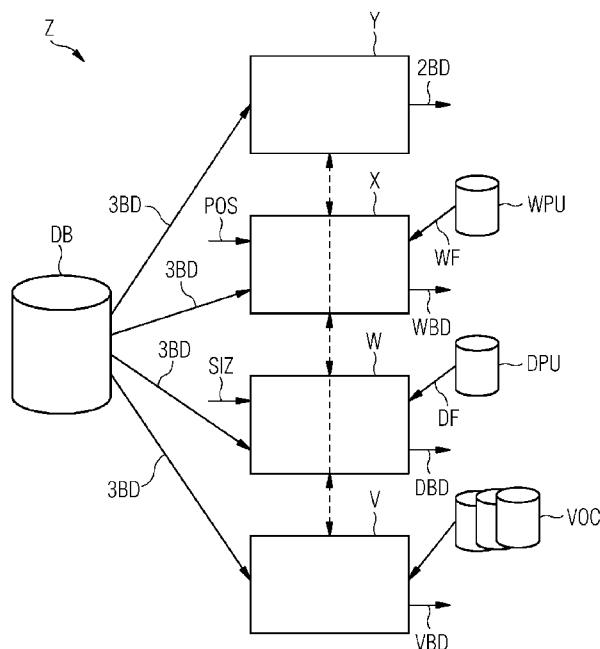
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(54) Title: ASSIGNMENT OF ANNOTATIONS

FIG 1



(57) Abstract: The present invention concerns a method (Z) of assigning a number of annotations to medical image data (3BD, 3BD') of a patient wherein an annotation represents a feature linked to a particular local candidate location (LF₁, LF₂, LF₃, LF₄) within the image data (3BD, 3BD'), whereby the method comprises the following steps: conversion (Y) of the image data from three-dimensional image data (3BD, 3BD') into a number of two-dimensional image data (2BD, 2BD₁, 2BD₂, 2BD₃) in which the assignment is performed, association (X) of the local candidate location (LF₁(LF₂, LF₃, LF₄) with a weighting factor (WF, WF₁, WF₂, WF₃, WF₄) which weighting factor (WF, WF₁, WF₂, WF₃, WF₄) represents a significance value of the local candidate location (LF₁(LF₂, LF₃, LF₄) in the context of the image data (3BD, 3BD'), determination (W) of a distance between a number of local candidate locations (LF₁, LF₂, LF₃, LF₄) to which annotations are assigned based on an extension (SIZ) of a volume or area of the image data (3BD, 3BD'), based on a predefined distance factor (DF), derivation (V) of the feature based on a plurality of annotation vocabularies (VOC). The invention also concerns an assignment system (5) for that purpose.

Description

Assignment of Annotations

- 5 The present invention concerns a method of assigning a number of annotations to medical image data of a patient wherein an annotation represents a feature linked to a particular local candidate location within the image data. The invention also concerns an assignment system for the same purpose.
- 10 Despite their pivotal importance, very relevant findings such as those referring to malignant tissue lesions are often at risk of being missed by practitioners in three-dimensional (3D) medical images, even of the most commonly used modalities.
- 15 Not only the detection of abnormalities but also their characterization, a treatment choice and risk assessment and risk prognostics are difficult, in particular when it comes to smaller findings. This hinders a prompt and personalized patient management.
- 20 Several computer-based techniques have been proposed to assist practitioners in such search for abnormalities in 3D medical image data. The key element of these techniques is a reliable representation (i.e. assignment) of each candidate
- 25 location (also called findings) with a set of variables which are called "features" (or synonymously "descriptors"). In other words, the candidate location is annotated with an annotation in the above-mentioned manner.
- 30 One approach thereby is the bag-of-visual words (or bag-of-words - BoW) approach, which has recently been successfully applied to the field of image and video analysis. For an overview over this approach and its medical application cf. Tsai, C.-F.: Bag-of-words representation in image annotation:
- 35 a review. ISRN Artificial Intelligence Vol 2012, 2012 and Yang W. et al: Content-based retrieval of focal liver lesions using bag-of-visual-words representations of single and multi-phase contrast-enhanced CT images. Journal of Digital Imaging

25(6) 2012, pp. 708-719, the teachings of both of which are considered to be an integral part of this description.

In the medical imaging field a BoW feature vector for an image can be generated by using the following steps:

First, local features over each candidate region and/or points of interest within that candidate region are computed. For instance, if medical image data of a liver are to be annotated with the bag-of-words approach, the candidate region would be the region within the image data in which the liver is situated. The liver can then be subdivided into so-called patches, i.e. points of interest, to which patches a feature is assigned. Such feature may for instance comprise a vector description.

Second, the features can be clustered into groups, which are also considered "words" and which form a visual vocabulary of the candidate region. The centres of such clusters are then used as the vocabulary words (i.e. a dictionary) of that candidate region.

Thirdly, a BoW feature histogram of word frequencies can be computed based on the previously constructed vocabulary. This means that a frequency of occurrence of each vocabulary word is computed in a histogram.

To sum up, with the BoW approach, a visual vocabulary is generated in which a medical image data with a candidate location can be represented as a histogram of visual word occurrences. Such histogram can then be used to generate a discrete representation of the medical image data (in particular of the candidate location) with (binary) information regarding most frequently occurring visual words or a likelihood of distribution of these visual words.

Although this BoW approach is getting increasingly popular also in the field of medical imaging, it still has its lim-

its. Thereunder count the computational complexity of dictionary learning and in particular of clustering. In 3D images the amount of candidates may easily amount to 1000 or even more. Another issue is precision of the results of such BoW approach.

It is the object of the present invention to provide an improved possibility of annotation of medical image data. This includes for instance a reduction of computational effort and/or an increase in precision of the results.

This object is met by the method according to claim 1 and the assignment system according to claim 13.

According to the invention, the above-mentioned method is further improved by comprising (generally in any arbitrary order - with a preferred order given below) at least one of the following steps:

a) conversion of the image data from three-dimensional image data into a number of two-dimensional (2D) image data in which the assignment is performed. "2D" image data thereby may comprise image data referring to a plane, but also referring to a curved surface which can - by point-to-point projection be projected onto a planar surface. This implies an enormous reduction of computational power necessary, because instead of 3D image data, a 2D image data representing the 3D image data are generated and used for annotation. While the computational expenses are reduced, such use of representative 2D image data can still lead to very accurate results or even to an improvement of accuracy of results as possibly more candidates along one plane of the image data can be annotated than would be possible when operating in the 3D image data. In other words, the distances between candidates can be reduced because less computational power is needed due to the projection from 3D image data to 2D image data.

b) association of the local candidate location with a weighting factor which weighting factor represents a significance value of the local candidate location in the context of the image data and/or of a particular object of interest of the image data. Such weighting factor serves to prioritize candidate locations in comparison with other candidate locations. For instance, a candidate location which is closer to a particular point of interest within the medical image data may be prioritized over a candidate location which is further away. This measure serves for instance to increase effectiveness on the one hand and accuracy of the overall annotations on the other hand.

c) determination of a distance between a number of local candidate locations to which annotations are assigned based on an extension of a volume and/or area of the image data and/or of an object of interest (such as an organ of interest and/or a particular affected region therein - for instance a lesion or the like) within the image data, based on a predefined distance factor. This implies that for instance if the volume of the medical image data and/or the volume of the object of interest is larger, the distance between local candidate locations can also be increased to get a clear overall picture whilst at the same time reducing computational effort to a necessary minimum.

d) derivement of the feature based on a plurality of annotation vocabularies. That implies that not only one method of annotation (namely only one vocabulary behind the annotation method) is used but several ones. Such measure leads for instance to a more differentiated and thus more accurate overall result of the annotation process.

Any of the steps a) to d) can generally be used on its own without a combination with the other mentioned steps.

However, the inventors have found out that a combination of at least two of these steps makes the annotation process con-

siderably more effective as any combinations of these steps lead to synergetic effects:

5 As for the combination of steps a) and b), the effectivity (i.e. the reduction in use of computational power) is enriched with an increase of accuracy of the results of the annotation process.

10 As for the combination of steps a) and c), these constitute two steps which increase the overall effectivity of the process whilst still (at least) maintaining the accuracy of the process.

15 As for the combination of steps a) and d), again, the effectivity is enriched with an increase of accuracy of the results of the annotation process.

20 As for the combination of steps b) and c) this constitutes an adaption of the resolution of the annotations combined with a weighting factor of each candidate candidate location. In this case, again, computational power is reduced to a necessary minimum whilst potentially increasing the accuracy of the results nevertheless.

25 The same applies mutatis mutandis for the combination of steps c) and d), whilst the combination of steps b) and d) provides for a particularly high accuracy of the results of the annotation process.

30 A combination of three of the above-mentioned steps a) to d) increases the above-named effects further, and it is most preferred that all steps a) to d) are taken. Whenever step a) is taken, it is further preferred that it is performed before any of the other steps as it reduces the amount of potential
35 candidates beforehand considerably so that all succeeding steps can be performed already for a very reduced number of potential candidates.

The above-mentioned assignment system is enhanced according to the invention by comprising at least one of the following units:

- 5 a) a conversion unit realized to convert the image data from three-dimensional image data into a number of two-dimensional image data in which the assignment is performed. Such conversion unit thus performs step a) of the method according to the invention.
- 10 b) an association unit realized to associate the local candidate location with a weighting factor which weighting factor represents a significance value of the local candidate location in the context of the image data and/or of a particular
- 15 object of interest of the image data. Such association unit thus performs step b) of the method according to the invention.
- c) a determination unit realized to determine a distance between a number of local candidate locations to which annotations are assigned based on an extension of a volume and/or area of the image data and/or of an object of interest within the image data, based on a predefined distance factor. Such determination unit thus performs step c) of the method according to the invention.
- 25 d) a derivement unit realized to derive the feature based on a plurality of annotation vocabularies. Such derivement unit thus performs step d) of the method according to the invention.
- 30

As the method according to the invention preferably comprises several of the above-mentioned steps a) to d), the assignment system is realized accordingly with the corresponding number of units a) to d) as well.

35

The invention further concerns a medical image processing system comprising a provision unit for medical image data of

a patient and an assignment system according to the invention. Thereby, the provision unit can for instance be a memory (and/or image database) in which the medical image data are stored and provided, it may also comprise an acquisition
5 unit which in operation acquires such medical image data or the provision unit may also be realized as an input interface from other modalities, databases or memories (or the like) via which interface the medical image data are simply fed into the medical image processing system.

10

Any of the components of the assignment system, in particular conversion unit, the association unit, the determination unit, and the derivement unit, may each and possibly all of them be realized as software components on a processor, but
15 also as hardware components or as a combination thereof.

Therefore, the invention also concerns a computer programme product directly loadable into a processor of a programmable assignment system comprising programme code means to conduct
20 all steps of the method according to the invention when the computer programme product is executed on the assignment system.

Particularly advantageous embodiments and features of the invention are given by the dependent claims, as revealed in the
25 following description. Features of different claim categories may be combined as appropriate to give further embodiments not described herein.

30 In the context of the invention, it is most preferred that the annotations are based on the bag-of-words methodology. As outlined above, this method is particularly accurate at the one hand and involves a large computational resource at the same time. Therefore, the invention has a particularly strong
35 effect in this context, providing its advantages to its full extent.

According to a first embodiment referring to step a) the two-dimensional image data comprise a number of surfaces derived from a round object within the image data. A "surface" in the context of this embodiment refers to such 2D geometric object which describes the outer limits of the round object or parts thereof. Such round object can be for instance an object of interest such as an organ. "Round" in this context is used as a generalisation for any curved object, in particular also a spherical or elliptical or oval object and also a curved object with irregular shape. The surfaces derived from such object can also be transferred into projections of the surface or of parts thereof onto a planar surface as described above. For instance, if one uses a ball-like, i.e. completely round object, one can divide this into a number of longitudinal-latitudinal surface parts (as on a globe) each of which can then be projected onto such planar surface. Analogously, an elliptical, oval or irregularly curved surface can also be subdivided and projected. This embodiment has the advantage that the complete outer surface of an object of interest can be annotated.

According to a second embodiment, which can be used alternatively to the first embodiment or additionally, in step a) the two-dimensional image data comprise a number, preferably a plurality of non-parallel planes from the image data. Such planes thus pass through an object of interest so that they also represent the inner part of that object. For instance, such planes can be orientated such that they essentially pass a centre of an abnormality of an organ such as a lesion.

In this context, it is particularly preferred that at least two non-parallel planes are aligned orthogonally with respect to each other, most preferred that at least three non-parallel planes are aligned orthogonally with respect to one another. Such three non-parallel planes can advantageously represent a coronal, and an axial, and a sagittal orientation of the patient.

Generally, any number of planes with arbitrary orientation can be used. Using two orthogonal planes means that the 3D medical image data are represented by at least two 2D planes which are aligned such that they represent the three-

5 dimensionality of the object of interest. This is even more so if three planes all aligned orthogonally to one another are generated. If such three planes are orientated in the above-mentioned fashion (i.e. to represent a coronal, and an axial, and a sagittal orientation of the patient) this pro-
10 vides for a clear and well-established coordinate system of the 2D medical image data which can thus be even better used for comparison with other medical datasets.

Thus, a solution with planes representing an axial, and a
15 sagittal orientation of the patient is motivated by the fact that radiologists in their search for malignancies and in their decision making regarding finding characterization and treatment choice usually rely on these three commonly used 2D projections of 3D data. Therefore, if the planes represent
20 these three orientations, the results provide for a better understanding of radiologists.

It is further preferred that the assignment of annotations is performed learning different annotation dictionaries for at
25 least two of the above-mentioned planes, preferably for more than two planes and most preferred for all planes. In the last-mentioned case, the assignment in each plane is thus based on an annotation dictionary of its own. Thus, for each 2D plane, an independent dictionary is learnt (thus, for the
30 case with the three classical orthogonal planes or projections, three independent dictionaries are learnt, one for images of each projection). In an empirical study, the inventors observed that while a representation with three independent dictionaries corresponding to the three planes, coronal, axial, and sagittal, clearly outperforms any pure 2D
35 solution.

As for step b), it is preferred that the weighting factor is assigned based on a position of the local candidate location, in particular with respect to the object of interest. For instance, the object of interest such as an organ or a particular abnormality (e.g. a lesion) within an organ, may comprise positions or locations to which a higher importance is given than to other positions. Such position may for instance refer to an abnormality within an organ, but also to a centre location of an organ and/or of an abnormality.

The idea behind this approach is that some sub-regions within a given region of interest might be more relevant than others, with a varying importance for decision making. To this end, the inventors devised a weighting scheme for the contributing image points, i.e. the local candidate locations. For instance a Gaussian weighting scheme (although any other function can be applied) can be used that prioritizes the information contained towards the center or the outside along for instance 2D planes. A 3D weighting scheme could also be devised and applied to a 3D region (i.e. 3D medical image data or parts thereof) as a whole.

According to a first embodiment of such step b), a centre location of the object of interest is assigned a higher weighting factor and locations away from the centre location are assigned decreasing weighting factors, depending on their distance from the centre location. In this embodiment, the centre location is thus also a kind of centre of attention of the annotation process. In particular, it is preferred in that context that the centre location of the object of interest is assigned the highest weighting factor of all weighting factors.

According to a second embodiment of such step b) a centre location of the object of interest is assigned a lower weighting factor and locations away from the centre location are assigned increasing weighting factors, depending on their distance from the centre location. Such embodiment thus fo-

cusses more on the limiting borders and/or on the periphery of the object of interest. Then, it is particularly preferred that the centre location of the object of interest is assigned the lowest weighting factor.

5

As for step c), the motivation for this step is that if a similar sampling scheme is applied, with dense grid sampling, to both small and large regions and/or objects of interest (such as lesions), the number of features that can be extracted from large objects/regions of interest can significantly outnumber those extracted from smaller (e.g. sub-centimeter) ones. Consequently, for instance large lesions will dominate in the clustering process and in the ultimate dictionary, while small lesions will be under-represented, which can be an undesirable effect. In order to more equally represent both large and small objects and/or regions of interest, an adaptive sampling step (relying for instance on a lesion's size) has been devised. For large lesions, features are extracted in a sparse pattern, while for small lesions the sampling pattern is more dense.

Further, the distance between the local candidate locations is preferably determined in a stepwise, i.e. in a non-gradual assignment based on a plurality of different extension categories so that each extension category is linked to a specific distance between local candidate locations and assigned to a corresponding predefined distance factor. Thus, instead of smoothly increasing or decreasing the distance between local candidate locations in linear dependence of the extension of the volume and/or area, i.e. region and/or object of the image data, a step-wise, non-gradual approach is chosen, whereby the steps of scaling the distance between the local candidate locations are assigned to specific extension categories, such as for instance "small" = distance factor 0,5; "medium" = distance factor 0,75 and "large" = distance factor 1. These are just arbitrary categorisations which serve the purpose of illustration. The results clearly outperform an

approach with equally-distant patch sampling, in particular for smaller lesions.

As for step d) the approach of this step extends the classical histogram representation with a single dictionary. Instead, multiple vocabularies are created to represent 3D image regions, including, except already mentioned above vocabularies for different 2D projections, vocabularies of different size, and vocabularies obtained with different generation algorithms (e.g. regions of interest of different size, sampling patterns, and even clustering techniques), and construct the ultimate (BoW) feature histogram as a combination of the component feature histograms for the lesion in question, generated from all the component vocabularies. The representation with a combination of multiple, potentially simpler dictionaries, is better than the generation of a single complex dictionary, both in terms of predictive performance and computational complexity. In an empirical study by the inventors, the results of such vocabulary combination, and its associated combined histogram for objects of interest, have clearly outperformed the results obtained with the representations with just one vocabulary histogram.

The use of multiple simple dictionaries is thus more computationally efficient than using a single complex dictionary. Not only has this step improved the representational power for the (BoW) features, but it is also applicable to a wide variety of tasks, including detection, segmentation and/or characterization of any structure in 2D and 3D images.

Other objects and features of the present invention will become apparent from the following detailed descriptions considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for the purposes of illustration and not as a definition of the limits of the invention. They are not necessarily drawn to scale.

Fig. 1 shows a schematic block diagramme of an embodiment of the method according to the invention,

Fig. 2 shows a first example of two-dimensional image data
5 which can be used in step Y (corresponding to step a) in the claims) of the method of Fig. 1,

Fig. 3 shows a second example of two-dimensional image data
10 which can be used in step Y of the method of Fig. 1,

Fig. 4 shows a third example of two-dimensional image data
which can be used in step Y of the method of Fig. 1,

Fig. 5 shows a fourth example of two-dimensional image data
15 which can be used in step Y of the method of Fig. 1,

Fig. 6 shows an example of a weighting scheme which can be
applied in step X (corresponding to step b) of the claims) of
the method of Fig. 1,
20

Fig. 7 shows schematically an example of a procedure of step
V (corresponding to step d) in the claims) of the method of
Fig. 1,

25 Fig. 8 shows a schematic block diagramme of an assignment
system according to an embodiment of the invention.

Fig. 1 shows a schematic block diagramme of an embodiment of
the method Z according to the invention. The method comprises
30 four steps Y, X, W, V only one of which is principally neces-
sary, but which are preferably combined in combinations of
two, three or even all of the mentioned steps Y, X, W, V.

From a memory DB (alternatively directly from an acquisition
35 unit of a medical imaging system) medical image data 3BD are
supplied. In this example, the medical image data 3BD com-
prise three-dimensional image data 3BD, i.e. volume image
data 3BD.

In the first step Y these three-dimensional image data 3BD are converted into a number of two-dimensional image data 2BD. These can then be used to perform an assignment of annotations therein, for instance based on the bag-of-words approach. The assignment of annotations is part of the method Z but not shown for reasons of clarity.

In the second step X which can be used alternatively to step Y or in addition to the latter, a local candidate location is associated with a weighting factor WF which is supplied from a weighting factor provision unit WPU. This is preferably based on a position POS of that local candidate location within the image data 3BD and/or within a particular object of interest therein. The result from this step is weighted data WBD.

In the third step W which can again be used as an alternative to any of the above-named steps Y, X or in addition to any (possibly also both) of them, a distance between a number of local candidate locations to which annotations are assigned is determined. This determination is based on an extension SIZ and on a predefined distance factor DF from a distance factor provision unit DPU. The extension SIZ refers to a volume and/or area of the image data 3BD and/or of an object of interest within the image data 3BD. From this step W there result distance-adjusted data DBD.

The fourth step V comprises a derivement V of a number of features of the annotations based on a plurality of annotation vocabularies VOC. The result of that step are multi-vocabulary data VBD.

As is shown by the double arrows from each of the steps Y, X, W, V to one another, the resulting data 2BD, WBD, DBD, VBD can be used in order to perform any of the other steps next. In particular, if step Y is performed, it is preferred that it be performed before any of the other steps so that the

next steps are not based in the three-dimensional image data 3BD but rather on the two-dimensional ones 2BD in order to safe computational power.

5 Figs. 2 to 5 show four different examples of two-dimensional image data $2BD_1$, $2BD_2$, $2BD_3$, $2BD_4$ which can be used in step Y of the method of Fig. 1.

Fig. 2 shows 2D image data $2BD_1$ comprising three image planes P_1 , P_2 , P_3 aligned with respect to each other at angles α , β , γ which angles α , β , γ are all 90° . In other words, the three planes P_1 , P_2 , P_3 are orthogonal to one another. They are preferably aligned such that they represent the coronal, axial, and sagittal orientation of the patient whose image data $2BD_1$ are shown.

Fig. 3 shows 2D image data $2BD_2$ which differ from the 2D image data $2BD_1$ of Fig. 2 in that there is not just a single one, but rather two parallel planes P_{1a}/P_{1b} , P_{2a}/P_{2b} , P_{3a}/P_{3b} for each of the above-named orientations (coronal, axial, and sagittal).

Fig. 4 shows 2D image data $2BD_3$ which differ from the two preceding examples by comprising three or even four planes $P_{1a}'/P_{1b}'/P_{1c}$, $P_{2a}'/P_{2b}'/P_{2c}/P_{2d}$, $P_{3a}'/P_{3b}'/P_{3c}/P_{3d}$.

Fig. 5 shows a slightly different approach to the three preceding figures: it shows 2D image data $2BD_4$ which are comprised of a plurality of 2D surfaces P_a , P_b , P_c , P_a' , P_b' , P_c' of the outer surface of a round object of interest OI. The longitudinal and latitudinal lines of the round object of interest OI divide it into such 2D surfaces P_a , P_b , P_c , P_a' , P_b' , P_c' which can also be considered to be 2D image data $2BD_4$ in the context of the invention.

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Fig. 6 serves to further illustrate step X of Fig. 1: it shows an example of weighted data WBD with a number of local candidate locations LF_1 , LF_2 , LF_3 , LF_4 . The weighted data WBD

are based on medical image data - here 2D medical image data, which implies that the image data have previously been processed through step Y or that they have been provided right from the start as 2D data rather than 3D data. The weighted data WBD are thus planar and reach from a centre location C to a periphery. Each of the local candidate locations LF_1 , LF_2 , LF_3 , LF_4 is associated with a corresponding weighting factor WF_1 , WF_2 , WF_3 , WF_4 . The weighting factor WF_4 associated with the local candidate location LF_4 at the centre location C is the highest weighting factor, whilst the weighting factors WF_1 , WF_2 , WF_3 associated with the more peripheral local candidate locations LF_1 , LF_2 , LF_3 are lower the further these local candidate locations LF_1 , LF_2 , LF_3 are away from the centre location C. Alternatively, the logic could also be reverse, with the weighting factor WF_4 associated with the local candidate location LF_4 at the centre location C being the lowest weighting factor, whilst the weighting factors WF_1 , WF_2 , WF_3 associated with the more peripheral local candidate locations LF_1 , LF_2 , LF_3 being higher the further these local candidate locations LF_1 , LF_2 , LF_3 are away from the centre location C. Such choice of weighting logic depends on the application of the annotations derived with the step X. If one wants to focus mainly on a centre of an object of interest such as a lesion, one may choose the first variant whilst if it is more necessary to specifically look at the boundaries of such object of interest, the second variant may be chosen.

Fig. 7 shows schematically a representation of step V: medical image data, in this exemplary case the 2D image data of Fig. 2, are processed through two different dictionary vocabularies VOC_1 , VOC_2 , wherefrom there result two different annotations AN_1 , AN_2 . These annotations AN_1 , AN_2 can be processed further into one common and thus refined annotation $AN_{1/2}$.

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Fig. 8 shows a schematic block view of a medical image processing system 1 according to an embodiment of the invention. It comprises a provision unit 3 for medical image data 3BD of

a patient and an assignment system 5 according to an embodiment of the invention. The assignment system 5 comprises an input interface 7 for the medical image data 3BD and an output interface 9 for results RES and at least one of the following units: a conversion unit 11, an association unit 13, a determination unit 15 and a derivement unit 17. With reference to Fig. 1, the conversion unit is realized to perform step Y, the association unit 13 is realized to perform step X, the determination unit 15 is realized to perform step W, and the derivement unit 17 is realized to perform step V.

Although the present invention has been disclosed in the form of preferred embodiments and variations thereon, it will be understood that numerous additional modifications and variations could be made thereto without departing from the scope of the invention.

For the sake of clarity, it is to be understood that the use of 'a' or 'an' throughout this application does not exclude a plurality, and 'comprising' does not exclude other steps or elements.

Claims

1. Method (Z) of assigning a number of annotations to medical image data (3BD, 3BD') of a patient wherein an annotation
5 represents a feature linked to a particular local candidate location (LF_1 , LF_2 , LF_3 , LF_4) within the image data (3BD, 3BD'), whereby the method comprises at least one of the following steps:
- a) conversion (Y) of the image data from three-dimensional
10 image data (3BD, 3BD') into a number of two-dimensional image data ($2BD$, $2BD_1$, $2BD_2$, $2BD_3$) in which the assignment is performed,
- b) association (X) of the local candidate location (LF_1 , LF_2 , LF_3 , LF_4) with a weighting factor (WF , WF_1 , WF_2 , WF_3 , WF_4)
15 which weighting factor (WF , WF_1 , WF_2 , WF_3 , WF_4) represents a significance value of the local candidate location (LF_1 , LF_2 , LF_3 , LF_4) in the context of the image data (3BD, 3BD') and/or of a particular object of interest of the image data (3BD, 3BD'),
- 20 c) determination (W) of a distance between a number of local candidate locations (LF_1 , LF_2 , LF_3 , LF_4) to which annotations are assigned based on an extension (SIZ) of a volume and/or area of the image data (3BD, 3BD') and/or of an object of interest within the image data (3BD, 3BD'), based on a prede-
25 fined distance factor (DF),
- d) derivement (V) of the feature based on a plurality of annotation vocabularies (VOC).
2. Method according to claim 1, comprising at least two of
30 steps a) to d), preferably three of steps a) to d) and most preferred all steps a) to d).
3. Method according to claim 1 or 2, whereby the annotations are based on the bag-of-words methodology.
- 35 4. Method according to any one of the preceding claims, whereby in step a) the two-dimensional image data comprise a

number of surface planes derived from a round object within the image data (3BD, 3BD').

5. Method according to any one of the preceding claims,

5 whereby in step a) the two-dimensional image data (2BD, 2BD₁, 2BD₂, 2BD₃) comprise a number of non-parallel planes (P₁, P₂, P₃, P_{1a}, P_{1b}, P_{2a}, P_{2b}, P_{3a}, P_{3b}, P_{1a}', P_{1b}', P_{1c}, P_{2a}', P_{2b}', P_{2c}, P_{2d}, P_{3a}', P_{3b}', P_{3c}, P_{3d}) from the image data (3BD, 3BD').

10 6. Method according to claim 5, whereby at least two non-parallel planes (P₁, P₂, P₃, P_{1a}, P_{1b}, P_{2a}, P_{2b}, P_{3a}, P_{3b}, P_{1a}', P_{1b}', P_{1c}, P_{2a}', P_{2b}', P_{2c}, P_{2d}, P_{3a}', P_{3b}', P_{3c}, P_{3d}) are aligned orthogonally with respect to each other.

15 7. Method according to claim 6, whereby at least three non-parallel planes (P₁, P₂, P₃, P_{1a}, P_{1b}, P_{2a}, P_{2b}, P_{3a}, P_{3b}, P_{1a}', P_{1b}', P_{1c}, P_{2a}', P_{2b}', P_{2c}, P_{2d}, P_{3a}', P_{3b}', P_{3c}, P_{3d}) are aligned orthogonally with respect to one another, the three non-parallel planes (P₁, P₂, P₃, P_{1a}, P_{1b}, P_{2a}, P_{2b}, P_{3a}, P_{3b}, P_{1a}',
20 P_{1b}', P_{1c}, P_{2a}', P_{2b}', P_{2c}, P_{2d}, P_{3a}', P_{3b}', P_{3c}, P_{3d}) preferably representing a coronal, and an axial, and a sagittal orientation of the patient.

8. Method according to any one of claims 3 to 7, whereby the
25 assignment of annotation in at least two different planes, preferably more than two planes, most preferred all planes, is performed learning a different annotation dictionary.

9. Method according to any one of the preceding claims,
30 wherein in step b) the weighting factor (WF, WF₁, WF₂, WF₃, WF₄) is assigned based on a position (POS) of the local candidate location (LF₁, LF₂, LF₃, LF₄), in particular with respect to the object of interest.

35 10. Method according to claim 9, whereby a centre location (C) of the object of interest is assigned a higher weighting factor (WF₄) and locations away from the centre location are assigned decreasing weighting factors (WF₁, WF₂, WF₃), depend-

ing on their distance from the centre location (C), and whereby preferably the centre location (C) of the object of interest is assigned the highest weighting factor (WF₄).

5 11. Method according to claim 9, whereby a centre location (C) of the object of interest is assigned a lower weighting factor (WF₄) and locations away from the centre location (C) are assigned increasing weighting factors (WF₁, WF₂, WF₃), depending on their distance from the centre location (C) and
10 whereby preferably the centre location (C) of the object of interest is assigned the lowest weighting factor (WF₄).

12. Method according to any one of the preceding claims, whereby in step c) the distance between the local candidate
15 locations (LF₁, LF₂, LF₃, LF₄) is determined in a stepwise assignment based on a plurality of different extension categories so that each extension category is linked to a specific distance between local candidate locations (LF₁, LF₂, LF₃, LF₄) and assigned to a corresponding predefined distance factor (DF).
20

13. Assignment system (5) for assigning a number of annotations to medical image data (3BD, 3BD') of a patient wherein an annotation represents a feature linked to a particular local candidate location (LF₁, LF₂, LF₃, LF₄) within the image
25 data (3BD, 3BD'), whereby the assignment system comprises at least one of the following units:

a) a conversion unit (11) realized to convert the image data from three-dimensional image data (3BD, 3BD') into a number
30 of two-dimensional image data (2BD, 2BD₁, 2BD₂, 2BD₃) in which the assignment is performed,

b) an association unit (13) realized to associate the local candidate location (LF₁, LF₂, LF₃, LF₄) with a weighting factor (WF, WF₁, WF₂, WF₃, WF₄) which weighting factor (WF, WF₁,
35 WF₂, WF₃, WF₄) represents a significance value of the local candidate location (LF₁, LF₂, LF₃, LF₄) in the context of the image data (3BD, 3BD') and/or of a particular object of interest of the image data (3BD, 3BD'),

c) a determination unit (15) realized to determine a distance between a number of local candidate locations (LF_1 , LF_2 , LF_3 , LF_4) to which annotations are assigned based on an extension (SIZ) of a volume and/or area of the image data (3BD, 3BD') and/or of an object of interest within the image data (3BD, 3BD'), based on a predefined distance factor (DF),
d) a derivement unit (17) realized to derive the feature based on a plurality of annotation vocabularies (VOC).

10 14. Medical image processing system (1) comprising a provision unit (3) for medical image data (3BD, 3BD') of a patient and an assignment system (5) according to claim 13.

15 15. Computer programme product directly loadable into a processor of a programmable assignment system (5) comprising programme code means to conduct all steps of a method according to any one of claims 1 to 12 when the computer programme product is executed on the assignment system (5).

FIG 1

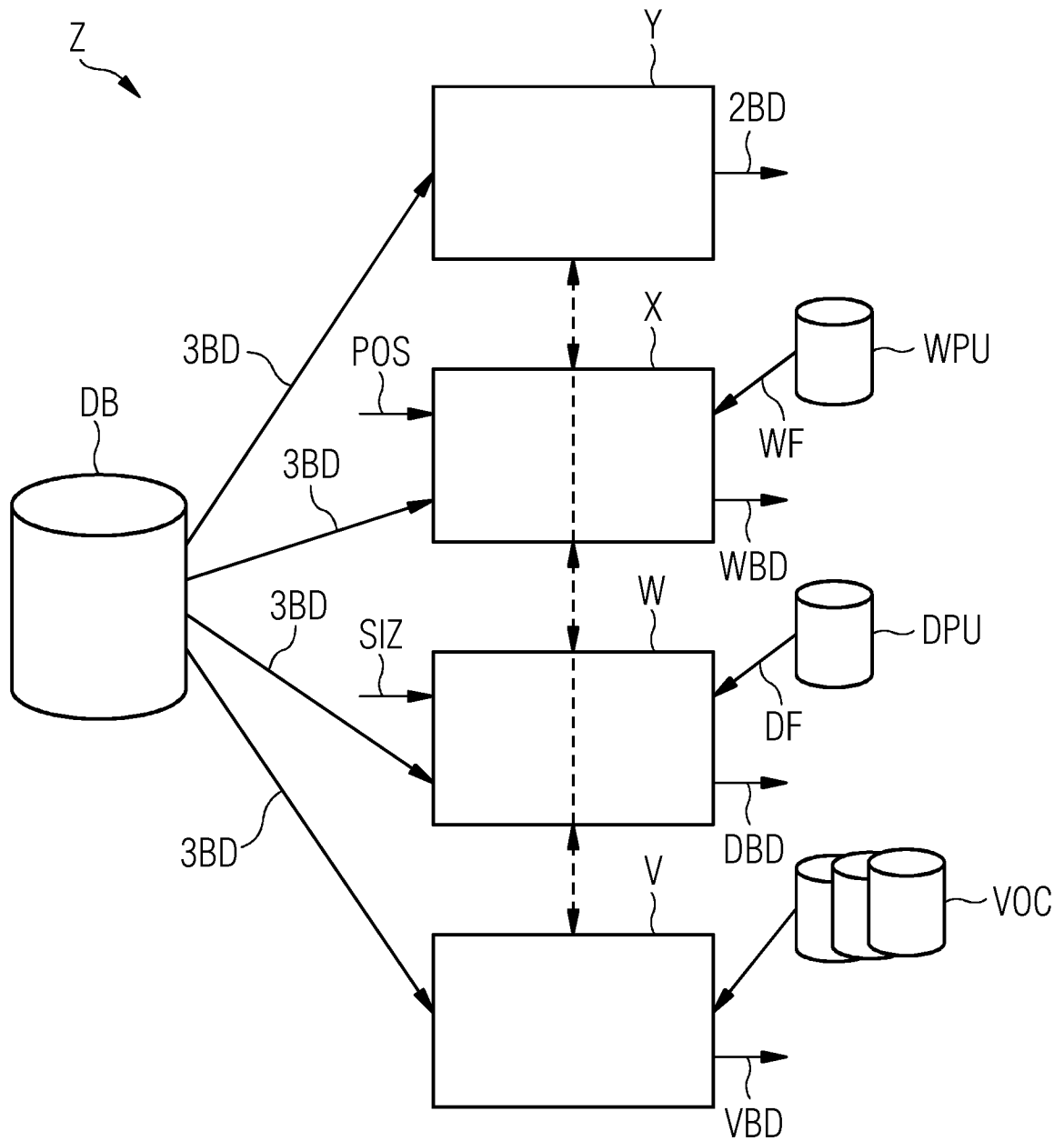


FIG 2

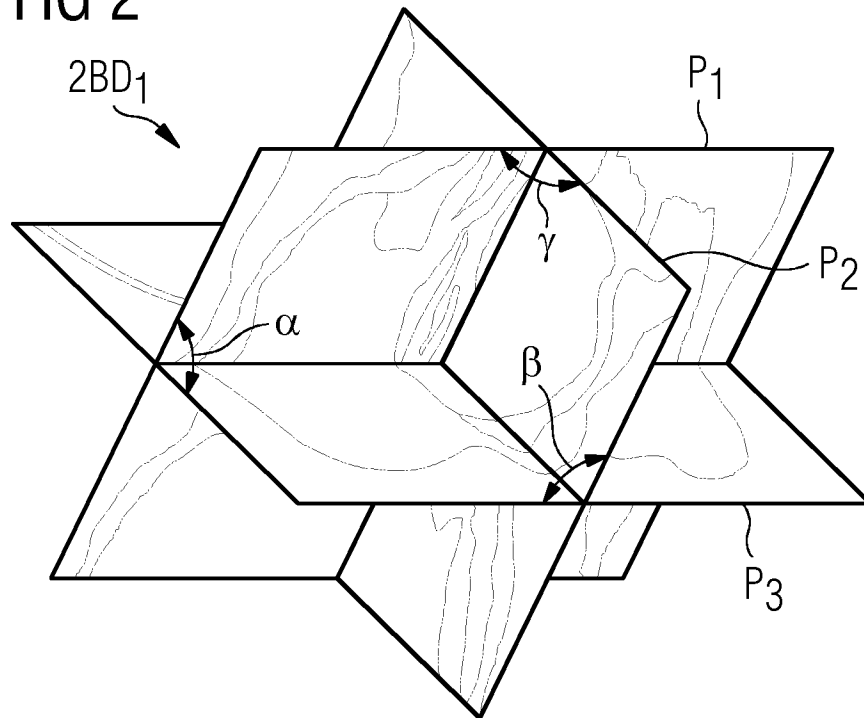


FIG 3

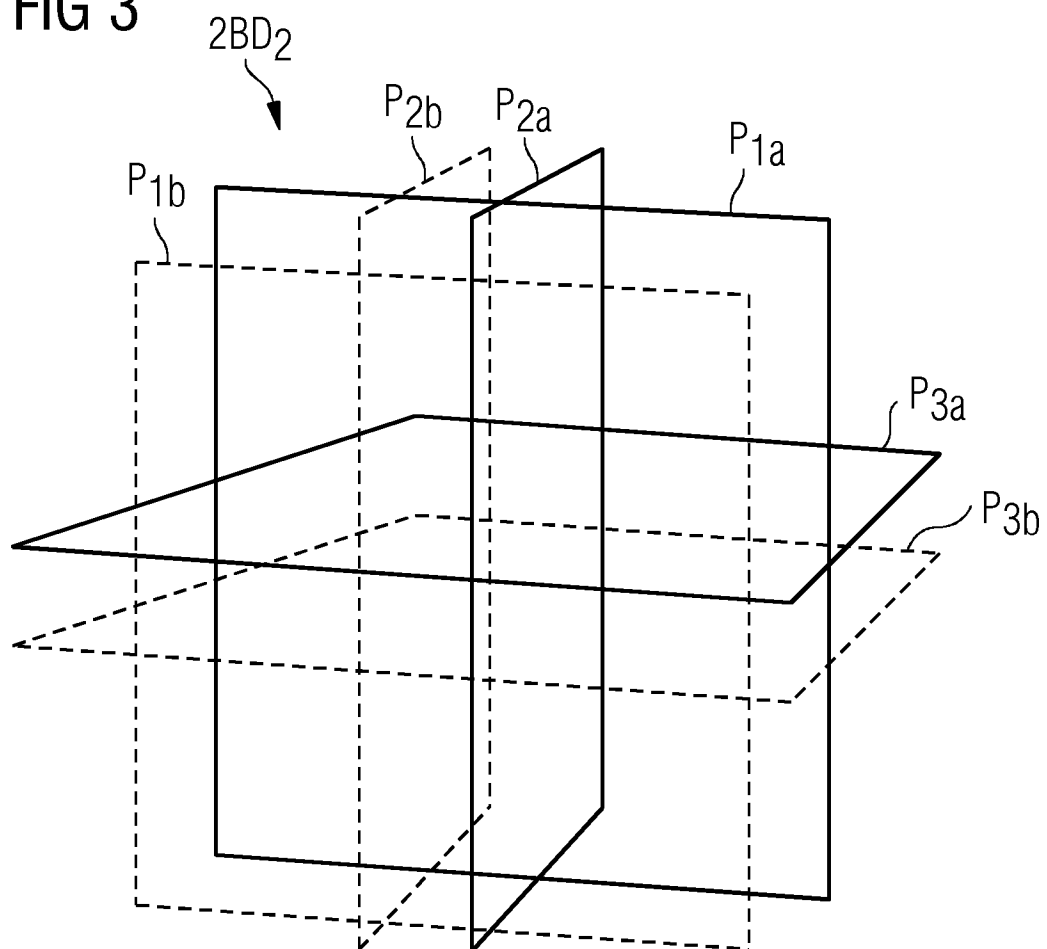


FIG 4

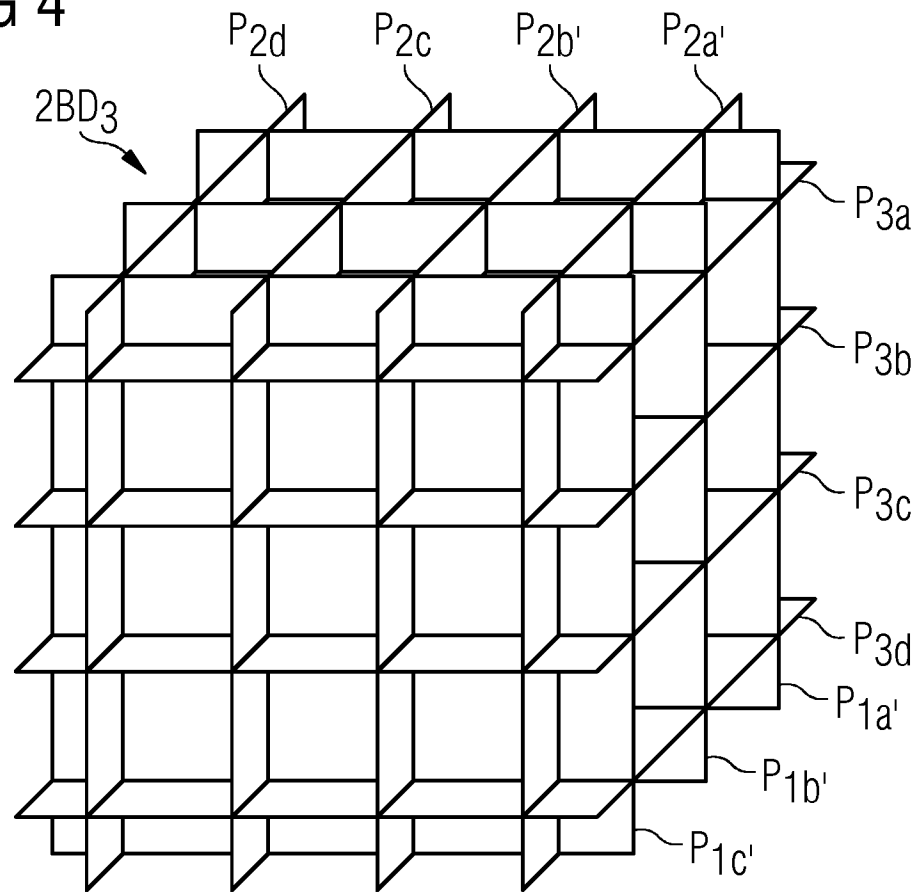


FIG 5

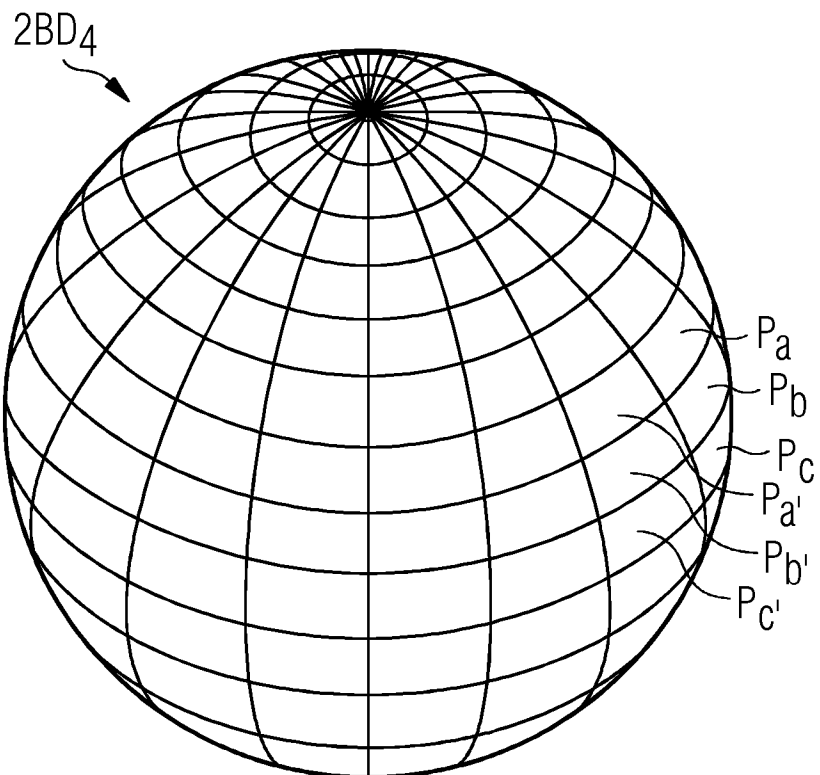


FIG 6

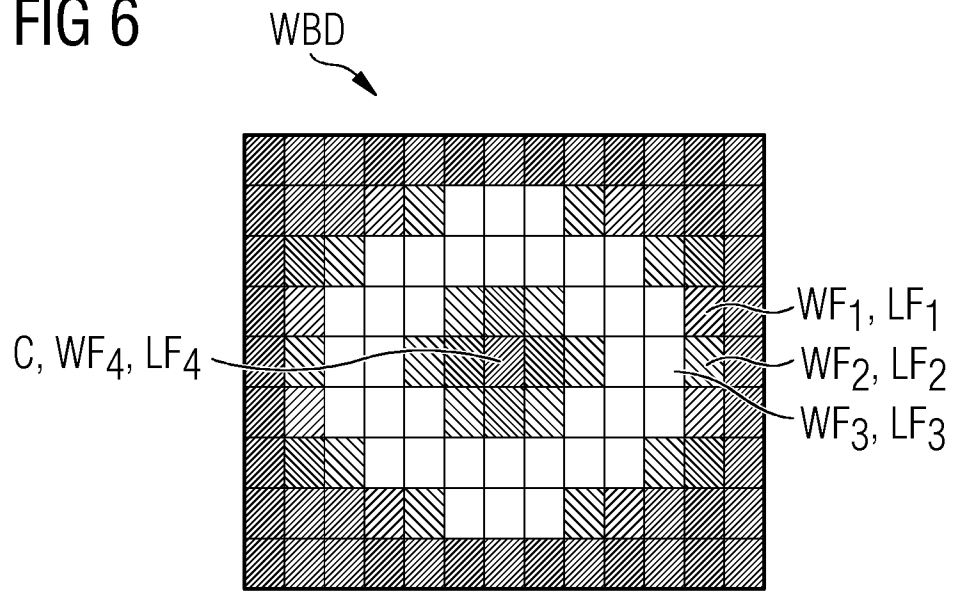


FIG 7

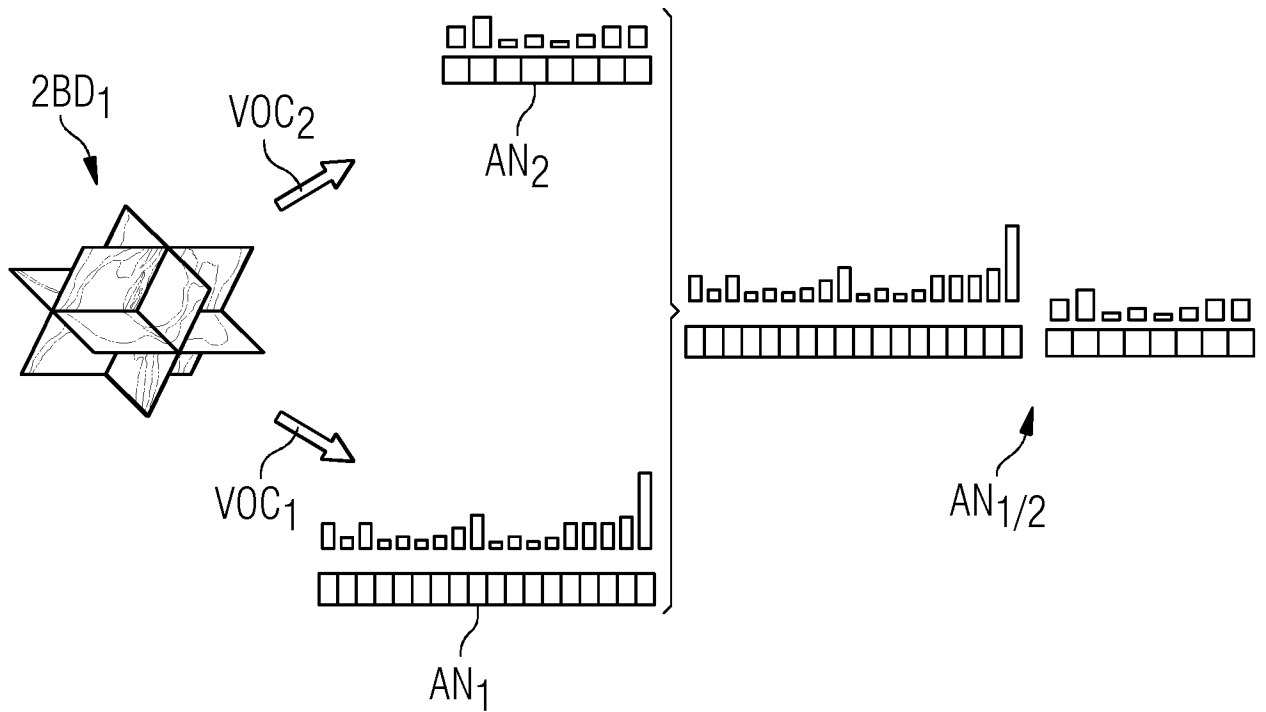
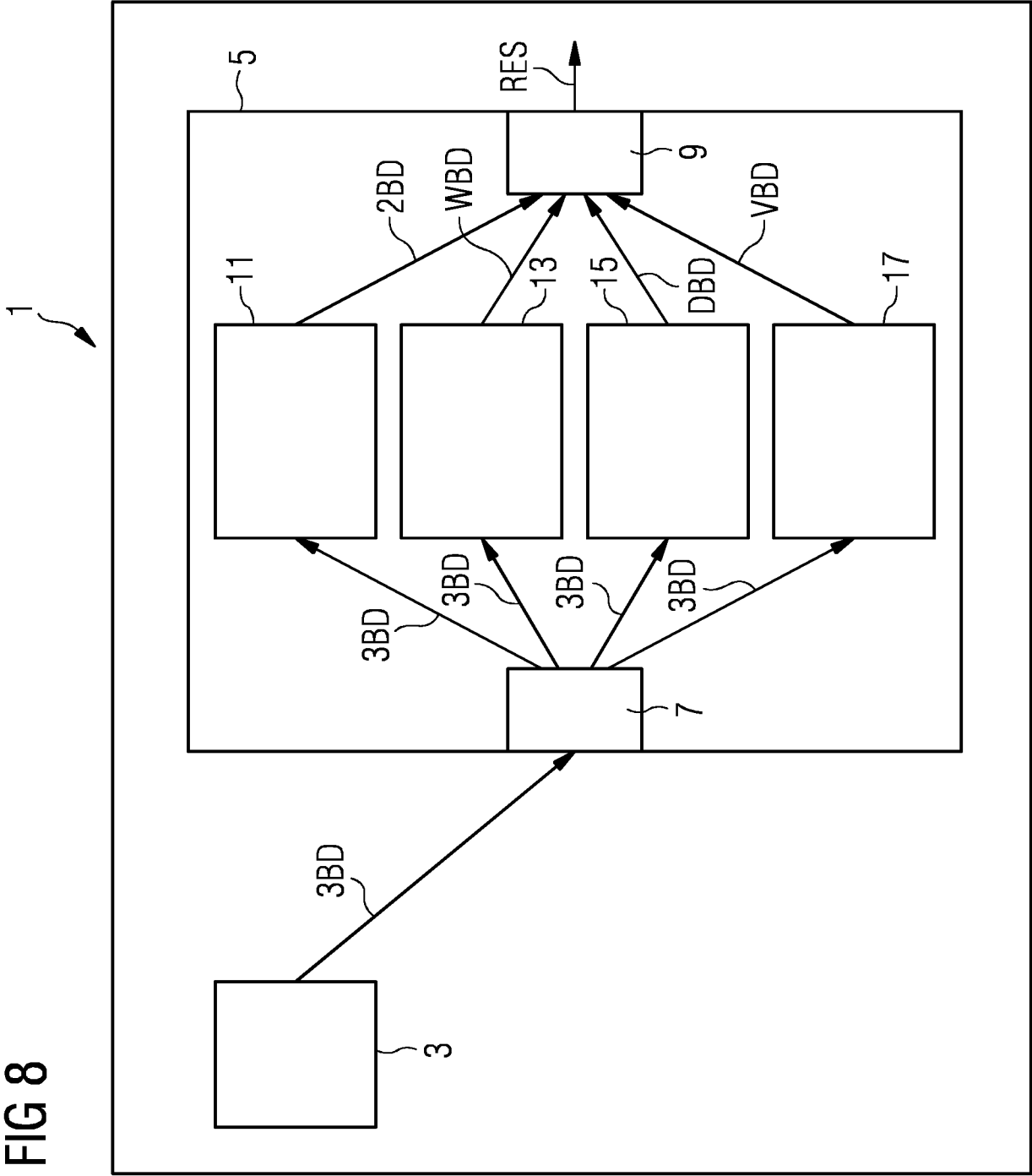


FIG 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2013/074062

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.: 2(completely); 1, 3-15(partially)
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:
see FURTHER INFORMATION sheet PCT/ISA/210
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:

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 an 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.:

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/EP2013/074062

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T7/00
ADD.

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)
G06T G06F

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)

EPO-Internal, COMPENDEX, INSPEC, WPI Data, EMBASE, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MEIYAN HUANG ET AL: "Retrieval of Brain Tumors with Region-Specific Bag-of-Visual-Words Representations in Contrast-Enhanced MRI Images", COMPUTATIONAL AND MATHEMATICAL METHODS IN MEDICINE, vol. 18, no. 8, 1 January 2012 (2012-01-01), pages 1-17, XP055134727, ISSN: 1748-670X, DOI: 10.1155/2012/280538 abstract sections "1. Introduction", "3.1. Image Data", "3.4.1. BoW Model", "3.4.2. Construction of the Region-Specific BoW Model", "4.2.2. Different Patch Sizes and Vocabulary Sizes", "4.3. Region-Specific BoW Representation" figures 2, 4(b), 9(b) ----- -/--	1,3-15



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

"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

19 August 2014

Date of mailing of the international search report

02/09/2014

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2013/074062

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	TATIANA TOMMASI ET AL: "Cue Integration for Medical Image Annotation", 19 September 2007 (2007-09-19), ADVANCES IN MULTILINGUAL AND MULTIMODAL INFORMATION RETRIEVAL; [LECTURE NOTES IN COMPUTER SCIENCE], SPRINGER BERLIN HEIDELBERG, BERLIN, HEIDELBERG, PAGE(S) 577 - 584, XP019104056, ISBN: 978-3-540-85759-4 sections "1 Introduction", "2.1 Feature Extraction" -----	1,3-15
A	HOO-CHANG SHIN ET AL: "Stacked Autoencoders for Unsupervised Feature Learning and Multiple Organ Detection in a Pilot Study Using 4D Patient Data", IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, IEEE COMPUTER SOCIETY, USA, vol. 35, no. 8, 1 August 2013 (2013-08-01), pages 1930-1943, XP011515334, ISSN: 0162-8828, DOI: 10.1109/TPAMI.2012.277 abstract sections "3 Dataset", "4.2 Application of Single-Layer Sparse Autoencoders to Visual Feature Learning", "5.1 Part-Based Model with Spatial Feature Matching" -----	1,3-15

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 2(completely); 1, 3-15(partially)

1 Independent method claim 1 defines an undue number of non-concise alternatives which obscure the subject matter for which protection is sought (Art. 6 PCT).

1.1 Claim 1 defines a method of assigning a number of annotations to medical image data comprising "at least one of" four steps a, b, c and d.

1.2 Step b comprises an "and/or" combination leading to step b representing in fact 3 different features, since "A and/or B" equals A, B or A and B (i.e. three alternatives).

1.3 Similarly, step c comprises two "and/or" combinations and thus seven alternatives.

1.4 Regarding the very annotation of medical image data (i.e. 1. 3 - 4 of claim 1) as a further step in itself, the claim comprises this step plus a (1 step) plus b (3 steps) plus c (7 steps) plus d (1 step), hence 13 different possible steps. Choosing "at least one" of these features leads to any of the single steps plus any possible pair of steps plus any possible triple of steps - and so forth - until the combination of all 13 possible steps. Even when restricting to the case that the sequence of steps does not matter, this leads to $2^{13} - 1 = 8191$ different alternatives in claim 1 alone.

2 The same holds true for corresponding independent claims 13 (system) and 15 (computer program product).

3 As a result, the alternatives defined in the independent claims as a whole violate the requirement of conciseness (Art. 6 PCT) and cannot be clearly distinguished one from another. It would be very cumbersome for the skilled person to determine the scope for which protection is sought.

4 In view of the massive lack of conciseness (see point VIII below), with submission of 30 July 2014, the applicant has filed an amended set of claims to clarify the desired scope of the search. As the applicant may not amend the claims before the international search report has been drawn up (Art. 19(1) PCT), said amended claims cannot formally form the basis of this report and to this extent, the request to base the search on these claims is refused. However, the applicant's indications have certainly been taken into account, leading to restriction of the searched subject matter as follows and as requested by the applicant:

4.1 Independent claims 1 (method), 13 (system) and by reference 15 (computer program product) have been interpreted as "comprising the steps of" (cl. 1, l. 7), "comprises the following units" (cl. 13, p. 20, l. 26 - 27) and using the same restriction in claim 15 by reference, respectively.

4.2 Furthermore, steps/units b and c have been interpreted as no longer referring to an object of interest (cl. 1, l. 17 - 19 and 23 - 24 / cl. 13, p. 20, l. 37 - 38 and p. 21, l. 5 - 6).

4.3 Finally, step/unit b have been interpreted as now referring to an extension of a volume or area (cl. 1, l. 22 / cl. 13, p. 21, l. 4).

4.4 Dependent claim 2 has been disregarded and hence not

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

searched.

4.5 The optional features "preferably more than two planes, most preferred all planes" in claim 8 (l. 26) have been disregarded.

4.6 Dependent claims 3 - 7, 9 - 12 and 14 have been searched as filed under the provision of the above restrictions of the antecedent claims.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.