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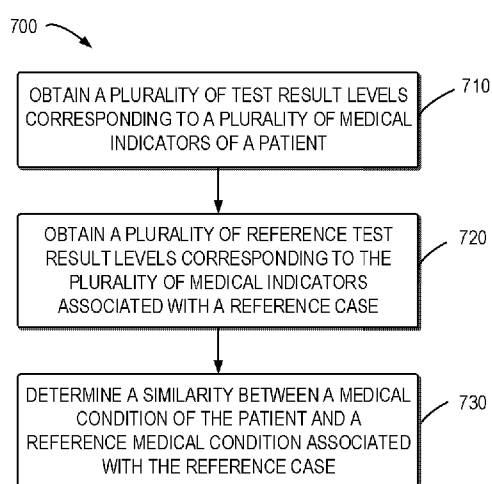


Fig. 7

(57) **Abstract:** Embodiments of the present disclosure relate to test result level based analysis. Some embodiments of the present disclosure provide a computer-implemented method. The method comprises obtaining a plurality of test result levels corresponding to a plurality of medical indicators of a patient, each test result level indicating that a quantitative test result of a corresponding medical indicator falls within one of a plurality of predetermined quantitative ranges; obtaining a plurality of reference test result levels corresponding to the plurality of medical indicators associated with a reference case, each reference test result level indicating that a quantitative reference test result of a corresponding medical indicator falls within one of the plurality of predetermined quantitative ranges; and determining a similarity between a medical condition of the patient and a reference medical condition associated with the reference case at least based on the plurality of test result levels and the plurality of reference test result levels. Through the solution, by means of test result level based analysis, it can protect the patient's privacy and obtain an accurate interpretation for the patient.

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TEST RESULT LEVEL BASED ANALYSIS

FIELD

- 5 **[0001]** Embodiments of the present disclosure generally relate to the field of computer science and in particular, to method, device, and computer program product for test result level based analysis.

BACKGROUND

- 10 **[0002]** In the medical field, a patient usually needs to undertake a variety of medical tests to obtain quantitative test results. Physicians or doctors will refer to the quantitative test results of the patient to analyze a medical condition of the patient and make a diagnosis for the patient. To make an accurate diagnosis and prepare an appropriate treatment for the patient, the physicians or doctors need to refer to massive information including the
15 quantitative test results, medical knowledge, reference books and knowledge from reference cases.

- [0003]** Such quantitative test results-based analysis is time consuming and unsatisfying. Thus, it is expected to apply automated tools to perform the analysis, for example, to find out reference cases that have similar medical conditions to the patient, or to provide
20 potential interpretation for the patient based on medical knowledge. However, considering data privacy and security, an authorization from the patient may be needed to use his or her quantitative test results, which is inconvenient and/or not practical for many cases.

25 SUMMARY

- [0004]** In general, example embodiments of the present disclosure provide a solution for test result level based analysis.

- [0005]** In a first aspect, there is provided a computer-implemented method. The method comprises obtaining a plurality of test result levels corresponding to a plurality of medical
30 indicators of a patient, each test result level indicating that a quantitative test result of a corresponding medical indicator falls within one of a plurality of predetermined quantitative ranges; obtaining a plurality of reference test result levels corresponding to the

plurality of medical indicators associated with a reference case, each reference test result level indicating that a quantitative reference test result of a corresponding medical indicator falls within one of the plurality of predetermined quantitative ranges; and determining a similarity between a medical condition of the patient and a reference medical condition associated with the reference case at least based on the plurality of test result levels and the plurality of reference test result levels.

[0006] In a second aspect, there is provided an electronic device. The electronic device comprises at least one processor; and at least one memory comprising computer readable instructions which, when executed by the at least one processor of the electronic device, cause the electronic device to perform the steps of the method in the first aspect described above.

[0007] In a third aspect, there is provided a computer program product. The computer program product comprises instructions which, when executed by a processor of an apparatus, cause the apparatus to perform the steps of any one of the methods in the first aspect described above.

[0008] In a fourth aspect, there is provided a computer readable medium. The computer readable medium has program instructions stored thereon, which, when executed by a device, cause the device to perform the steps of any one of the methods in the first aspect described above.

[0009] It is to be understood that the summary section is not intended to identify key or essential features of embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The following detailed description of the embodiments of the present disclosure can be best understood when read in conjunction with the following drawings, where:

[0011] Fig. 1 illustrates an example environment in which embodiments of the present disclosure may be implemented;

[0012] Fig. 2A illustrates example medical test information for a patient according to some embodiments of the present disclosure;

[0013] Fig. 2B illustrates example medical test information with test result levels for a patient according to some embodiments of the present disclosure;

[0014] Fig. 3 illustrates a block diagram of example architecture for reference case similarities analysis based on test result levels according to some embodiments of the present disclosure;

[0015] Fig. 4 illustrates a block diagram of example architecture for interpretation determination based on test result levels according to some embodiments of the present disclosure;

[0016] Fig. 5 illustrates an example decision tree for interpretation determination according to some embodiments of the present disclosure;

[0017] Fig. 6A illustrates an example user interface according to some embodiments of the present disclosure;

[0018] Fig. 6B illustrates another example user interface according to some embodiments of the present disclosure;

[0019] Fig. 7 illustrates a flowchart of an example process for reference case similarity analysis based on test result levels according to some embodiments of the present disclosure; and

[0020] Fig. 8 illustrates a block diagram of an example computing system/device suitable for implementing example embodiments of the present disclosure.

[0021] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0022] Principle of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below.

[0023] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of

ordinary skills in the art to which this disclosure belongs.

[0024] References in the present disclosure to “one embodiment,” “an embodiment,” “an example embodiment,” and the like indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an example embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0025] It shall be understood that although the terms “first” and “second” etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms.

[0026] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “has,” “having,” “includes” and/or “including”, when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0027] As briefly mentioned above, in medical field, to analyze a medical condition of the patient, make a diagnosis and prepare an appropriate treatment for the patient, the physicians need to analyze massive information including the quantitative test results of the patient, medical knowledge, reference books and knowledge from reference cases. Such quantitative test results-based analysis takes the physicians a lot of time and sometimes leads to an unsatisfying result. In addition, considering the data privacy and security, an authorization from the patient to use his or her quantitative test results may be needed,

which is inconvenient and/or not practical for many cases.

[0028] According to example embodiments of the present disclosure, there is proposed a solution for test result level based analysis. In this solution, a similarity between a medical condition of a patient and a reference medical condition associated with a reference case is determined based on a plurality of test result levels of the patient and a plurality of reference test result levels of the reference case. Each test result level indicates that a quantitative test result of a corresponding medical indicator of the patient falls within one of a plurality of predetermined quantitative ranges. Likewise, each reference test result level indicates that a quantitative reference test result of a corresponding medical indicator of the reference case falls within one of a plurality of predetermined quantitative ranges.

[0029] As such, the similarity between the patient's medical condition and the reference case's medical condition can be determined using test result levels instead of the specific quantitative test results. Such test result level based analysis is an efficient way to help the physicians to search for reference cases having similar medical conditions to the patient and provide an appropriate interpretation for the patient based on the reference cases. In addition, through the solution, by using the test result levels instead of quantitative test results, it also addresses the data security and privacy concerns.

Example Environment

[0030] Example embodiments of the present disclosure will be discussed in detail below with reference to Figs. 1-8. Fig. 1 illustrates an example environment 100 in which various embodiments for test result level based analysis of the present disclosure can be implemented. It is to be understood that the environment 100 shown in Fig. 1 is only for the purpose of illustration, without suggesting any limitation to functions and the scope of the embodiments of the present disclosure.

[0031] In the environment 100, a data processing system 110 is configured to perform various processes relating to medical analysis. For example, the data processing system 110 may perform test result level based similarity analysis for a patient with a reference case.

[0032] As illustrated in Fig. 1, the data processing system 110 may comprise a level determination module 120 and a similarity determination module 140. The level determination module 120 is configured to obtain a plurality of test result levels 125 corresponding to a plurality of medical indicators of a patient 102. The level

determination module 120 is also configured to obtain a plurality of reference test result levels 135 corresponding to the plurality of medical indicators associated with a reference case 112.

[0033] As used herein, the term of “test result level” indicates that a quantitative test result of a corresponding medical indicator falls within one of a plurality of predetermined quantitative ranges. For example, the test result level may indicate that the quantitative test result falls within a standard quantitative range for the corresponding medical indicator, a quantitative range higher than the standard quantitative range, or a quantitative range below the standard range. As used herein, the term of “medical indicator” refers to an item of medical test. The term of “standard quantitative range” refers to a standard or reference quantitative range for the medical indicator, within which the quantitative test result is considered as normal. It is to be understood that the above mentioned predetermined quantitative ranges are for the purpose of illustration, without suggesting any limitations. There may be fewer or more predetermined quantitative ranges.

[0034] For example, as illustrated in Fig. 1, the level determination module 120 may receive a plurality of quantitative test results 105 of the plurality of medical indicators of the patient 102. The level determination module 120 may determine a plurality of test result levels 125 based on the plurality of quantitative test results 105. The level determination module 120 may send the determined plurality of test result levels 125 to the similarity determination module 140 for further analysis.

[0035] Similarly, the level determination module 120 may receive a plurality of quantitative reference test results 115 of the plurality of medical indicators associated with the reference case 112. The level determination module 120 may determine a plurality of reference test result levels 135 based on the plurality of quantitative reference test results 115. The level determination module 120 may send the determined plurality of reference test result levels 135 to the similarity determination module 140 for further analysis.

[0036] The plurality of medical indicators may relate to one or more aspects of a medical condition of a patient. In some example embodiments, the plurality of medical indicators is associated with medical tests relating to thyroid serum. For example, the plurality of medical indicators may comprise at least one of: thyroid stimulating hormone (TSH), free triiodothyronine (FT3), free thyroxine (FT4), total triiodothyronine (TT3), total thyroxine (TT4), anti-thyroid peroxidase (Anti-TPO), antithyroglobulin (Anti-Tg), antibody against

TSH receptor (Anti-TSHR), thyroglobulin (Tg) and Calcitonin. The quantitative test results of those medical indicators may be produced by running a medical test on the patient.

5 [0037] In some example embodiments, the plurality of medical indicators may be associated with medical tests relating to hormone. In this case, the plurality of medical indicators may comprise several medical test items regarding the hormone. It is to be understood that the example medical indicators are only for the purpose of illustration, without suggesting any limitations.

10 [0038] Fig. 2A illustrates example medical test information 200 for a patient according to some embodiments of the present disclosure. The medical test information 200 may be stored as an electronic report for the patient in a database. As illustrated in Fig. 2A, the medical test information 200 comprises clinical background information 210 and test result information 220. The clinical background information 210 may comprise case ID, age, gender and other personal information of the patient. The test result information 220 may
15 comprise a plurality of quantitative test results of the medical indicators related to thyroid serum of the patient. The plurality of quantitative test results 105 may be obtained from the test result information 220.

[0039] In some example embodiments, for each quantitative test result in the test result information 220, a test result level may be determined by the level determination module
20 120. The level determination module 120 may map a quantitative test result to one of a plurality of predetermined test result levels, each of the predetermined test result levels indicating a plurality of predetermined quantitative ranges for a corresponding medical indicator.

[0040] For example, each medical indicator may have first, second and third
25 predetermined quantitative ranges. When determining a test result level for a given one of the medical indicators, the level determination module 120 may compare a quantitative test result of the given medical indicator with its first, second and third predetermined quantitative ranges. In accordance with a determination that the quantitative test result falls within one of the first, second and third quantitative ranges, the level determination
30 module 120 may determine a test result level indicating that the corresponding quantitative test result falls within this predetermined quantitative range.

[0041] In some example embodiments, for a given medical indicator, there may be a

standard quantitative range, also referred to as a reference quantitative range. This standard quantitative range shows a range within which the quantitative test result for the given medical indicator is normal for the patient. The plurality of predetermined quantitative ranges for this medical indicator may be divided according to the standard
5 quantitative range.

[0042] Taking FT3 as shown in Fig. 2A as an example, it is assumed that this medical indicator has a standard quantitative range of 3.78-5.97 pmol/L. For FT3, the three predetermined quantitative ranges may be set as a first range above the standard quantitative range, a second range equal to the standard quantitative range, and a third
10 range below the standard quantitative range, respectively. In such example, if the quantitative test result of FT3 is above the upper limit of the standard quantitative range (e.g., 5.97 pmol/L), the test result level may indicate the first predetermined quantitative range or also referred to as a high quantitative range or a high range. If the quantitative test result of FT3 is below the lower limit of the standard quantitative range (e.g., 3.78
15 pmol/L), the test result level may indicate the third predetermined quantitative range or also referred to as a low quantitative range or a low range. If the quantitative test result of FT3 is within the standard quantitative range, the test result level may indicate the second predetermined quantitative range or also referred to as a normal quantitative range or a normal range. In the example of Fig. 2A where FT3 has a quantitative test result of 4.25
20 pmol/L, it is determined that this quantitative test result falls within the standard quantitative range of 3.78-5.97 pmol/L and thus the test result level of FT3 may indicate the second predetermined quantitative range (i.e., the normal range).

[0043] It is to be understood that the example standard quantitative range is only for the purpose of illustration, without suggesting any limitations.

25 [0044] The level determination module 120 may determine a test result level for each quantitative test result. Fig. 2B illustrates example medical test information 250 with test result level indications for the patient according to some embodiments of the present disclosure. As illustrated in Fig. 2B, the medical test information 250 comprises the clinical background information 210 and test result information 260. The test result level
30 information 260 shows the quantitative test result along with a respective test result level indication for each medical indicator. As illustrated in Fig. 2B, a circle sign 272 or also referred to as the normal range indication represents that the test result level indicates a normal quantitative range, an upward arrow sign 276 or also referred to as the high range

indication indicates a high quantitative range, and a downward arrow sign 274 or also referred to as the low range indication indicates a low quantitative range. The test result level information 260 may be determined by the level determination module 120 based on the test result information 220 as shown in Fig. 2A. Taking FT3 as shown in Fig. 2A and
5 Fig. 2B as an example, the quantitative test result of FT3 is equal to 4.25 which falls within the standard or normal quantitative range of FT3. The test result level information 260 in Fig. 2B shows that the test result level of FT3 indicates that the quantitative test result of FT3 is normal. That is, the quantitative test result of FT3 is within the standard quantitative range. It is to be understood that in some example embodiments, the test
10 result level can be inputted to the data processing system 110 by a qualified user instead of by determining by the level determination module 120.

[0045] In some example embodiments, the medical test information 200 and the medical test information 250 may be stored in a database. The database may be a MySQL database, or Oracle database or other suitable database. When an authorized user, for
15 example the patient, gets access to the database to search for the medical test information of the patient in person, he or she may see the test result information 220 and/or the test result level information 260. When a user with limited authorization gets access to the medical test information of the patient, for example a physician who intends to search for a similar case, the physician may only see the test result level indications in the test result level
20 information 260 without knowing the quantitative test results of the patients. By storing the medical test information 250 in the database, future case cohort analysis and other extended functions can be supported.

[0046] In this way, the privacy of the patient can be protected, avoiding a risk of leaking the specific quantitative test results. In addition, the physicians can search for similar
25 reference cases for further analysis and study without a risk of leaking the specific quantitative test results.

[0047] It is to be understood that although in the example of Fig. 2B, there are three predetermined quantitative ranges, there may be less or more predetermined quantitative ranges. For example, in some example embodiments, two predetermined quantitative
30 ranges may be set. In the example of two predetermined quantitative ranges, the two predetermined quantitative ranges may respectively indicate that the quantitative test result is higher than a threshold quantitative test result (also referred to as a negative range), or the quantitative test result is below the threshold quantitative test result (also referred to as a

positive range).

[0048] As another example, five predetermined quantitative ranges may be set. In the example of five predetermined quantitative ranges, the five predetermined quantitative ranges may respectively indicate that the quantitative test result is within a range greatly
5 higher than the standard quantitative range, a range a little higher than the standard quantitative range, a range equal to the standard quantitative range, a range a little lower than the standard quantitative range, and a range greatly lower than the standard quantitative range.

[0049] Examples of patient test result level determination have been described with
10 respect to Figs. 1, 2A and 2B. It is to be understood that for the reference case, the level determination module 120 may perform a similar process to determine the reference test result levels 135 based on the quantitative reference test results. For the purpose of brevity, the reference case test result level determination process will not be repeated here.

[0050] Still referring to Fig. 1, the similarity determination module 140 is configured to
15 determine a similarity 150 between a medical condition of the patient 102 and a reference medical condition associated with the reference case 112. For example, the similarity determination module 140 is configured to determine the similarity 150 based on the plurality of test result levels 125 and the plurality of reference test result levels 135. As used herein, the term of “medical condition” refers to a health condition or a prevalence
20 situation of the patient. For example, the medical condition may be associated with thyroid serum. In this situation, the medical condition may refer to a thyroid health condition. As another example, the medical condition may be associated with hormone. It is to be understood that the example medical conditions are only for the purpose of illustration, without suggesting any limitations.

[0051] In some example embodiments, the similarity determination module 140 may
25 determine the similarity 150 based on a group of pairs of test result level and reference test result level. Each pair comprises one of the plurality of test result levels and one of the plurality of reference test result levels that correspond to a same medical indicator among the plurality of medical indicators. For example, one pair may comprise a FT3 test result
30 level and a FT3 reference test result level.

[0052] In some example embodiments, the similarity determination module 140 may determine the similarity 150 further based on a second group of pairs of condition levels for

the patient and reference condition levels for the reference case. Each pair corresponds to an influence factor related to the medical condition. Examples of influence factor may comprise but are not limited to a disease condition, a history of surgery, a medication history, an Iodine treatment, a pregnancy condition, an age, and a gender.

5 [0053] In some example embodiments, the similarity determination module 140 may determine the similarity 150 further based on a third group of pairs of test result level and reference test result level. Each pair corresponds to different special medical indicators among the plurality of medical indicators. In the case that the medical condition is associated with thyroid serum, different special medical indicators may comprise at least
10 two of the following: FT3, TT3, FT4 and TT4.

[0054] In some example embodiments, the similarity determination module 140 may determine the similarity 150 based on a first similarity score to indicate respective first differences between each of the first groups of pairs. The respective first difference may be determined by calculating a Euclidean distance between each pair. The similarity
15 determination module 140 may further determine a second similarity score to indicate respective second differences between each of the second groups of pairs. The respective second difference may be determined by calculating a Euclidean distance between each pair. The similarity determination module 140 may still further determine a third similarity score to indicate respective third differences between each of the third group of pairs. The
20 respective third difference may be determined by calculating a Euclidean distance between each pair.

[0055] In some example embodiments, the similarity determination module 140 may determine the similarity 150 by adding the first and second similarity scores multiplied respectively by first and second predetermined weights, and subtracting the third similarity score multiplied by a third predetermined weight to obtain the similarity. For example, the
25 first predetermined weight may be larger than the second predetermined weight. In addition, the second predetermined weight may be larger than the third predetermined weight.

[0056] In some example embodiments, in the case that the medical condition is associated
30 with thyroid serum, the similarity determination module 140 may use a similarity function as below to determine the similarity 150:

$$\begin{aligned}
& \text{simi_score}(P, P^0) \\
& = 1 \\
& * [(TSH - TSH^0)^2 + (FT_3 - FT_3^0)^2 + (FT_4 - FT_4^0)^2 + (TT_3 - TT_3^0)^2 \\
& + (TT_4 - TT_4^0)^2] + 1 \\
& * [(TgAb - TgAb^0)^2 + (TPOAb - TPOAb^0)^2 + (TRAb - TRAb^0)^2 \\
& + (Tg - Tg^0)^2 + (CT - CT^0)^2] - 0.215 \\
& * [f(FT_3, TT_3^0) + f(FT_4, TT_4^0) + f(TT_3, FT_3^0) + f(TT_4, FT_4^0)] - 0.205 \\
& * [f(FT_3, FT_4^0) + f(FT_4, FT_3^0)] + 0.95 \\
& * [(Disease - Disease^0)^2 \\
& + (History_of_surgery - History_of_surgery^0)^2 + (Medication \\
& - Medication^0)^2 + (Iodine_treatment - Iodine_treatment^0)^2] + 0.95 \\
& * [(Pregnancy - Pregnancy^0)^2 \\
& + (Generation - Generation^0)^2 + (Gender - Gender^0)^2] \tag{1}
\end{aligned}$$

wherein P and P^0 denote the plurality of reference test result levels 135 and the plurality of test result levels 125 respectively. TSH , FT_3 , FT_4 , TT_3 , TT_4 , $TgAb$, $TPOAb$, $TRAb$, Tg , and CT denote TSH, FT3, FT4, TT3, TT4, Anti-Tg, Anti-TPO, Anti-TSHR, Tg and Calcitonin reference test result levels for the reference, respectively. TSH^0 , FT_3^0 , FT_4^0 , TT_3^0 , TT_4^0 , $TgAb^0$, $TPOAb^0$, $TRAb^0$, Tg^0 , and CT^0 denote TSH, FT3, FT4, TT3, TT4, Anti-Tg, Anti-TPO, Anti-TSHR, Tg and Calcitonin test result levels for the patient, respectively. $Disease$, $History_of_surgery$, $Medication$, $Iodine_treatment$, $Pregnancy$, $Generation$ and $Gender$ denote a disease condition, a history of surgery, a medication history, an Iodine treatment, a pregnancy condition, a generation of age, and a gender reference condition levels for the reference case, respectively. $Disease^0$, $History_of_surgery^0$, $Medication^0$, $Iodine_treatment^0$, $Pregnancy^0$, $Generation^0$ and $Gender^0$ denote a disease condition, a history of surgery, a medication history, an Iodine treatment, a pregnancy condition, an age, and a gender condition levels for the patient, respectively.

[0057] In some example embodiments, the function $f(x, y)$ used in the above similarity function (1) may be illustrated as below:

$$f(x, y) = \begin{cases} 0, & \text{Others} \\ 1, & x == y \text{ and } x \neq 0 \end{cases} \tag{2}$$

[0058] It is to be understood that the above described similarity function (1) is only for the purpose of illustration, without suggesting any limitations. The similarity determination module 140 may use a different similarity function which uses test result levels and reference test results levels of different set of medical indicators. The different set of

medical indicators may comprise less or more medical indicators than the similarity function (1).

[0059] In some example embodiments, the weights of different parameters in the similarity function (1) may be predetermined based on medical knowledge base and medical reference information. For example, as the medical knowledge base shows that the medical indicators are of more importance in making a diagnosis for the patient than the influence factors, the weights associated with the medical indicators may be larger than the weights of the influence factors. By doing so, it may obtain a more accurate similarity 150.

10 [0060] In some cases, several medical indicators may be correlated with each other. For example, there is a strong correlation between FT3 and TTS, FT4 and TT4. That is, FT3 and TT3 tend to have a similar trend of change. Likewise, FT4 and TT4 may have a similar trend of change. By configuring an appropriate weight (for example, 0.215 as shown in (1)) to subtract the correlations between FT3 and TT3 and between FT4 and TT4, 15 it may be possible to calculate a more accurate similarity 150. In addition, there is a certain correlation between FT3 and FT4. By reducing the certain correlation between FT3 and FT4 with a corresponding weight, for example, 0.205 as shown in (1), it may determine a more accurate similarity 150.

[0061] Alternatively, or in addition, the weights for the plurality of parameters in the similarity function defined in Equation (1) may be dynamically adjusted. For example, if the similarity 150 is calculated to be a relatively high value, for example, close to 1, then the similarity indicates that the medical condition of the patient and the reference medical condition of the reference case is quite close. However, after the patient undertakes additional medical tests and gets a final diagnosis which shows that the patient has a different disease with the reference case, the weights of the similarity function in Equation 25 (1) may be adjusted in order to get a reduced similarity between the patient and the reference case.

[0062] In some example embodiments, some qualified users such as specialists may give a feedback to the similarity 150. For example, if a specialist opines that the similarity 150 is not accurate, he or she may give a feedback indicating that the similarity 150 is too high or too low. The similarity function may be adjusted according to this feedback. It is to be understood that the similarity function may be adjusted according to massive feedback 30

information and massive diagnosis information for the patient. By adjusting the similarity function, it may obtain a more accurate similarity between the patient and the reference case. With the accurate similarity, the physician may find a more similar reference case for the patient, which will thus help the physician to provide appropriate diagnosis and treatment for the patient.

Example Test Result Level based Similarity Determination

[0063] Examples of test result level based determination of the similarity between the patient and the reference case have been described with respect to Fig. 1. In some example embodiments, such test result level based analysis can be applied to a group of reference cases. Fig. 3 illustrates a block diagram of example architecture 300 for reference case similarities analysis based on test result levels according to some embodiments of the present disclosure. It is to be understood that the architecture 300 as shown in Fig. 3 is only for the purpose of illustration, without suggesting any limitation to functions and the scope of the embodiments of the present disclosure. The test result level based determination of the similarity shown in the architecture 300 may be performed by the data processing system 110 in the Fig. 1 or any other suitable device. For the purpose of discussion, the architecture 300 will be described with reference to Fig. 1.

[0064] In the example of Fig. 3, the data processing system 110 may get access to a reference case database 310. The reference case database 310 may be a local database in the data processing system 110, or a remote database that may be accessed by the data processing system 110. The reference case database 310 may be a MySQL database, or Oracle database or other suitable database. For example, a group of reference cases 312 may be obtained from the reference case database 310. As illustrated in Fig. 3, a group of a plurality of quantitative reference test results 320 for the group of reference case 312 may be obtained from the reference case database 310 and transmitted to the level determination module 120. The level determination module 120 may determine a group of a plurality of reference test result levels 330 based on the group of plurality of quantitative reference test results 320. The level determination process is similar to the process described with respect to Fig. 1, which will not be repeated here.

[0065] In some embodiments, the similarity determination module 140 may determine a plurality of similarities 350 between the medical condition of the patient 102 and a plurality of medical conditions of the group of reference cases 312 based on the test result levels 125

and the group of plurality of reference test result levels 330. The data processing system 110 may sort the group of reference cases 312 according to the plurality of similarities 350. The data processing system 110 may choose a target reference case 360 with a highest similarity. It is to be understood that the data processing system 110 may choose more than one target reference cases with higher similarities.

[0066] In some example embodiments, the data processing system 110 may comprise a user interface 370. Information about the target reference case 360 may be displayed on the user interface 370. For example, a recorded interpretation for a reference medical condition of the target reference case 360 will be presented via the user interface 370. Additional information associated with the target reference case 360, such as the treatment plan will optionally be presented via the user interface 370.

[0067] In some example embodiments, a user 380 may provide a feedback 390 to the user interface 370 regarding the target reference case 360. For example, if the user such as a physician opines that the reference medical condition of the target reference case 360 is quite similar with the medical condition of the patient, the user may provide a positive feedback showing that the similarity is correct. On the other hand, if the physician opines that the reference medical condition of the target reference case 360 is quite different from the medical condition of the patient, the user may provide a negative feedback showing that the similarity is not accurate. By collecting the feedback 390 from the user 380, the similarity determination module 140 will be improved. For example, the similarity function used by the similarity determination module 140 will be updated. In this way, it may provide more accurate target reference cases for further analysis.

[0068] Examples of test result level based similarity determination have been described with respect to Figs. 1 to 3. In some example embodiments, the test result levels may also be applied to determine an appropriate interpretation for the patient.

Example Test Result Level based Interpretation Determination

[0069] Fig. 4 illustrates a block diagram of example architecture 400 for interpretation determination based on test result levels according to some embodiments of the present disclosure. It is to be understood that the architecture 400 as shown in Fig. 4 is only for the purpose of illustration, without suggesting any limitation to functions and the scope of the embodiments of the present disclosure. The test result level based interpretation determination shown in the architecture 400 may be performed by the data processing

system 110 in the Fig. 1 or any other suitable device. For the purpose of discussion, the architecture 400 will be described with reference to Fig. 1.

[0070] As illustrated in Fig. 4, the data processing system 110 may comprise a decision tree module 410. The decision tree module 410 is configured to determine an interpretation 420 based on the test result levels 125.

[0071] For example, the decision tree module 410 may obtain a decision tree comprising a plurality of decision conditions for a plurality of candidate interpretations related to a medical condition. Examples of decision tree will be described with respect to Fig. 5 below. The decision tree module 410 will select an interpretation 420 for the medical condition of the patient from the plurality of candidate interpretations by determining whether the plurality of test result levels meet the plurality of decision conditions. In addition, the data processing system 110 may present the interpretation 420 for the medical condition of the patient via the user interface 370.

[0072] By determining the interpretation based on the test result level, the privacy of the patient can be protected, avoiding a risk of leaking the specific quantitative test results. In addition, the physicians can refer to the interpretation for further analysis and study without a risk of leaking the specific quantitative test results.

[0073] In some example embodiments, a user 430 may provide a feedback 440 to the user interface 370 regarding the interpretation 420. For example, if the user such as a physician opines that the interpretation 420 is quite suitable for the medical condition of the patient, the user may provide a positive feedback showing that the interpretation 420 is appropriate. On the other hand, if the physician opines that the interpretation 420 cannot be applied to the medical condition of the patient, the user may provide a negative feedback showing that the interpretation 420 is not accurate. By collecting the feedback 440 from the user 430, the decision tree module 410 will be improved. In this way, it may provide more accurate interpretation for the patient.

[0074] Fig. 5 illustrates an example decision tree 500 for interpretation determination according to some embodiments of the present disclosure. In the decision tree 500, a first decision condition is related to TSH 510. If the test result level of TSH 510 indicates that the quantitative test result of TSH 510 falls within a normal range 514 (i.e., the standard quantitative test result range), it will lead to a first interpretation 560-1. For example, the first interpretation 560-1 may state that if the test result level of TT4 is high, or the test

result level of TT3 is low or normal, then it indicates that there may be SBP2 gene disease.

[0075] If the test result level of TSH 510 indicates that the quantitative test result of TSH 510 falls within a low range 512, it needs to refer to the test result level of FT4 or TT4 520. If the test result level of FT4 or TT4 520 indicates a low range 522, then it needs to further refer to the test result level of FT3 or TT3 530. If the test result level of FT3 or TT3 530 indicates a low range 532, it will lead to a second interpretation 560-2. For example, the second interpretation 560-2 may state that the patient may have a central hypothyroidism, a euthyroid sick syndrome, a low T3 syndrome, or a decreased TBG.

[0076] If the test result level of FT4 or TT4 520 indicates a normal range 524, then it needs to further refer to the test result level of FT3 or TT3 530. If the test result level of FT3 or TT3 530 indicates a normal range 534, it will lead to a third interpretation 560-3. For example, the third interpretation 560-3 may state that the patient may have a subclinical hyperthyroidism, or a euthyroid sick syndrome, and this may be caused by medication or TSH β mutation. If the test result level of FT3 or TT3 530 indicates a high range 536, it will lead to a fourth interpretation 560-4. For example, the fourth interpretation 560-4 may state that the patient may have a T3 hyperthyroidism.

[0077] If the test result level of FT4 or TT4 520 indicates a high range 526, then it needs to further refer to the test result level of FT3 or TT3 530. If the test result level of FT3 or TT3 530 indicates a normal range 534, it will lead to a fifth interpretation 560-5. For example, the fifth interpretation 560-5 may state that that the patient may have a T4 hyperthyroidism. If the test result level of FT3 or TT3 530 indicates a high range 536, it will lead to a sixth interpretation 560-6. For example, the sixth interpretation 560-6 may state that the patient may have a hyperthyroidism, an occult hyperthyroidism or a thyroiditis. In the case of the sixth interpretation 560-6, it may further refer to the test result level of Anti-TSHR 540. If the test result level of Anti-TSHR 540 indicates a positive range 542, then it may lead to a seventh interpretation 560-7. For example, the seventh interpretation 560-7 may state that the patient may have an autoimmune thyroid disease.

[0078] If the test result level of TSH 510 indicates that the quantitative test result of TSH 510 falls within a high range 516, it needs to refer to the test result level of FT4 or TT4 520. If the test result level of FT4 or TT4 520 indicates a low range 522, then it needs to further refer to the test result level of FT3 or TT3 530. If the test result level of FT3 or TT3 530 indicates a low range 532, it will lead to an eighth interpretation 560-8. For example, the

eighth interpretation 560-8 may state that the patient may have a hypothyroidism. In the case of the eighth interpretation 560-8, it may further refer to the test result level of Anti-TPO or Anti-Tg 550. If the test result level of Anti-TPO or Anti-Tg 550 indicates a positive range 552, then it may lead to a ninth interpretation 560-9. For example, the
5 ninth interpretation 560-9 may state that the patient may have an autoimmune thyroid disease.

[0079] If the test result level of FT4 or TT4 520 indicates a normal range 524, then it needs to further refer to the test result level of FT3 or TT3 530. If the test result level of FT3 or TT3 530 indicates a normal range 534, it will lead to a tenth interpretation 560-10.
10 For example, the tenth interpretation 560-10 may state that the patient may have a subclinical hypothyroidism, thyroid hormone resistance syndrome. If the test result level of FT3 or TT3 530 indicates a high range 536, it will lead to an eleventh interpretation 560-11. For example, the eleventh interpretation 560-11 may state that the patient may have an α thyroid hormone resistance syndrome, or an Alian-Herndon-Dudley syndrome

15 [0080] If the test result level of FT4 or TT4 520 indicates a high range 526, then it needs to further refer to the test result level of FT3 or TT3 530. If the test result level of FT3 or TT3 530 indicates a high range 536, it will lead to a twelfth interpretation 560-12. For example, the twelfth interpretation 560-12 may state that the patient may have a thyroid hormone resistance, a thyroid hormone resistance syndrome (a pituitary selection type or a
20 peripheral tissue selection type), a TSH tumor, an increased TBG, a genetic abnormality of transport binding protein, a synthetic protein genetic abnormalities.

[0081] Examples of decision tree 500 have been described with respect to Fig. 5. It is to be understood that the decision tree 500 is only for the purpose of illustration without suggesting any limitations. The decision tree module 410 can use other possible decision
25 trees. The decision tree 500 may be obtained from medical knowledge base or other medical reference information. In some example embodiments, the decision tree 500 may be updated by collecting and analyzing the user feedback. Alternatively, or in addition, other medical indicators can be added into the decision tree 500 to obtain more interpretations for the patient.

30 [0082] By determining an interpretation for the patient, it can help the physician to make a diagnosis for the patient and to determine an appropriate treatment for the patient. In addition, the interpretation may also provide some explanations and possible causes for the

possible disease the patient may have.

[0083] Fig. 6A illustrates an example user interface 370 according to some embodiments of the present disclosure. In the user interface 370 of Fig. 6A, example case 610, case 620 and case 630 are illustrated. The case 610 is of the similarity 615 equal to 90%. The case 620 is of the similarity 625 equal to 90%. The case 630 is of the similarity 635 equal to 80%. These similarities may be determined by the similarity determination module 140. In the example shown in Fig. 6A, the case 610 and the case 620 have the higher similarities, thus can be selected as the target reference cases for further study. The user interface 370 also shows relevant information regarding each case, which can help the physician to analyze the similar cases.

[0084] Fig. 6B illustrates another example user interface 370 according to some other embodiments of the present disclosure. In the user interface 370 of Fig. 6B, general medical information 660 of the patient is presented. For example, the general medical information 660 comprises a general diagnosis for the patient. The general medical information 660 may comprise basis test result level information of several medical indicators of the patient. The general medical information 660 may further comprise some suggestions for the next step.

[0085] In some example embodiments, an explanation 670 may also be presented via the user interface 370. For example, the explanation 670 may comprise influence information regarding the medical condition of the patient.

[0086] As shown in Fig. 6B, an interpretation 680 is also presented via the user interface 370. The interpretation 680 may be determined by the decision tree module 410 as shown in Fig. 4. The interpretation 680 shows several possible diagnoses for the patient. In addition, customer optimal interpretation 685 and case study notes 690 can be inputted by the user, for example the physician, to provide feedback.

[0087] By using the example user interfaces 370, information comprising the similar cases, the interpretations, the explanations and other possible information may be presented for the user's further analysis. In addition, the user may provide feedback through the user interface 370 which will in turn improve the system performance.

30 Example Processes

[0088] Fig. 7 illustrates a flowchart of an example process for reference case similarity analysis based on test result levels according to some embodiments of the present

disclosure. The process 700 can be implemented by the data processing system 110 in Fig. 1. For the purpose of discussion, the process 700 will be described with reference to Fig. 1.

[0089] At block 710, the data processing system 110 obtains a plurality of test result levels corresponding to a plurality of medical indicators of a patient. Each test result level indicates that a quantitative test result of a corresponding medical indicator falls within one of a plurality of predetermined quantitative ranges. At block 720, the data processing system 110 obtains a plurality of reference test result levels corresponding to the plurality of medical indicators associated with a reference case. Each reference test result level indicates that a quantitative reference test result of a corresponding medical indicator falls within one of the plurality of predetermined quantitative ranges. At block 730, the data processing system 110 determines a similarity between a medical condition of the patient and a reference medical condition associated with the reference case at least based on the plurality of test result levels and the plurality of reference test result levels.

[0090] In some embodiments, to obtain the plurality of test result levels, for a given one of the plurality of medical indicators having first, second and third predetermined quantitative ranges, the data processing system 110 may compare a quantitative test result of the given medical indicator with the first, second and third predetermined quantitative ranges; and determine a test result level indicating that the quantitative test result falls within one of the first, second and third predetermined quantitative ranges.

[0091] In some embodiments, to obtain the plurality of reference test result levels, for a given one of the plurality of medical indicators having first, second and third predetermined quantitative ranges, the data processing system 110 may compare a quantitative reference test result of the given medical indicator with the first, second and third predetermined quantitative ranges; and determine a reference test result level indicating that the quantitative reference test result falls within one of the first, second and third predetermined quantitative ranges.

[0092] In some embodiments, the medical condition is associated with thyroid serum. In some embodiments, the plurality of medical indicators comprises at least one of: thyroid stimulating hormone (TSH), free triiodothyronine (FT3), free thyroxine (FT4), total triiodothyronine (TT3), total thyroxine (TT4), anti-thyroid peroxidase (Anti-TPO), antithyroglobulin (Anti-Tg), antibody against TSH receptor (Anti-TSHR), thyroglobulin

(Tg) and Calcitonin.

[0093] In some embodiments, to determine the similarity, the data processing system 110 may determine the similarity based on a first group of pairs of test result level and reference test result level. Each pair comprises one of the plurality of test result levels and one of the plurality of reference test result levels that correspond to a same medical indicator among the plurality of medical indicators. In some embodiments, to determine the similarity, the data processing system 110 may determine the similarity further based on at least one of the following: a second group of pairs of condition levels for the patient and reference condition levels for the reference case that each pair corresponds to an influence factor related to the medical condition, and a third group of pairs of test result level and reference test result level that each pair corresponds to different special medical indicators among the plurality of medical indicators. In some embodiments, the similarity is determined based on a first similarity score to indicate respective first differences between each of the first group of pairs, and further based on at least one of the following: a second similarity score to indicate respective second differences between each of the second group of pairs, and a third similarity score to indicate respective third differences between each of the third group of pairs. In some embodiments, the similarity is calculated by the following: adding the first and second similarity scores multiplied respectively by first and second predetermined weights; and subtracting the third similarity score multiplied by a third predetermined weight to obtain the similarity. In some embodiments, the first predetermined weight is larger than the second predetermined weight and the second predetermined weight is larger than the third predetermined weight.

[0094] In some embodiments, the influence factor comprises at least one of the following: a disease condition, a history of surgery, a medication history, an Iodine treatment, a pregnancy condition, an age, and a gender. In some embodiments, in the case that the medical condition is associated with thyroid serum, the different special medical indicators comprise at least two of the following: free triiodothyronine (FT3), total triiodothyronine (TT3), free throxine (FT4) and total thyroxine (TT4).

[0095] In some embodiments, the data processing system 110 may further determine a plurality of similarities between the medical condition of the patient and a plurality of medical conditions of a group of reference cases. The group of reference cases comprises the reference cases. The data processing system 110 may further sort the group of reference cases according to the plurality of similarities; and present, via a user interface, a

recorded interpretation for a reference medical condition of at least one target reference case with a highest similarity.

[0096] In some embodiments, the data processing system 110 may further obtain a decision tree comprising a plurality of decision conditions for a plurality of candidate interpretations related to a medical condition; select an interpretation for the medical condition of the patient from the plurality of candidate interpretations by determining whether the plurality of test result levels meet the plurality of decision conditions; and present, via a user interface, the interpretation for the medical condition of the patient.

Example System/Device

10 [0097] Fig. 8 illustrates a block diagram of an example computing system/device 800 suitable for implementing example embodiments of the present disclosure. The system/device 800 can be implemented as or implemented in the data processing system 110 in Fig. 1. The system/device 800 may be a general-purpose computer, a physical computing device, or a portable electronic device, or may be practiced in distributed cloud
15 computing environments where tasks are performed by remote processing devices that are linked through a communication network. The system/device 800 can be used to implement the process 700 of Fig. 7.

[0098] As depicted, the system/device 800 includes a processor 801 which is capable of performing various processes according to a program stored in a read only memory (ROM) 802 or a program loaded from a storage unit 808 to a random access memory (RAM) 803.
20 In the RAM 803, data required when the processor 801 performs the various processes or the like is also stored as required. The processor 801, the ROM 802 and the RAM 803 are connected to one another via a bus 804. An input/output (I/O) interface 805 is also connected to the bus 804.

25 [0099] The processor 801 may be of any type suitable to the local technical network and may include one or more of the following: general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), graphic processing unit (GPU), co-processors, and processors based on multicore processor architecture, as non-limiting examples. The system/device 800 may have multiple processors, such as an
30 application-specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[00100] A plurality of components in the system/device 800 are connected to the I/O

interface 805, including an input unit 808, such as keyboard, a mouse, or the like; an output unit 807 including a display such as a cathode ray tube (CRT), a liquid crystal display (LCD), or the like, and a loudspeaker or the like; the storage unit 808, such as disk and optical disk, and the like; and a communication unit 809, such as a network card, a modem, a wireless transceiver, or the like. The communication unit 809 allows the system/device 800 to exchange information/data with other devices via a communication network, such as the Internet, various telecommunication networks, and/or the like.

[00101] The methods and processes described above, such as the process 700, can also be performed by the processor 801. In some embodiments, the process 700 can be implemented as a computer software program or a computer program product tangibly included in the computer readable medium, e.g., storage unit 808. In some embodiments, the computer program can be partially or fully loaded and/or embodied to the system/device 800 via ROM 802 and/or communication unit 809. The computer program includes computer executable instructions that are executed by the associated processor 801. When the computer program is loaded to RAM 803 and executed by the processor 801, one or more acts of the process 700 described above can be implemented. Alternatively, processor 801 can be configured via any other suitable manners (e.g., by means of firmware) to execute the process 700 in other embodiments.

Enumerated Example Embodiments

[00102] The embodiments of the present disclosure may be embodied in any of the forms described herein. For example, the following enumerated example embodiments describe some structures, features, and functionalities of some aspects of the present disclosure disclosed herein.

[00103] In a first aspect, example embodiments of the present disclosure provide a computer-implemented method. The method comprises obtaining a plurality of test result levels corresponding to a plurality of medical indicators of a patient, each test result level indicating that a quantitative test result of a corresponding medical indicator falls within one of a plurality of predetermined quantitative ranges; obtaining a plurality of reference test result levels corresponding to the plurality of medical indicators associated with a reference case, each reference test result level indicating that a quantitative reference test result of a corresponding medical indicator falls within one of the plurality of predetermined quantitative ranges; and determining a similarity between a medical

condition of the patient and a reference medical condition associated with the reference case at least based on the plurality of test result levels and the plurality of reference test result levels.

5 [00104] In some embodiments, obtaining the plurality of test result levels comprises: for a given one of the plurality of medical indicators having first, second and third predetermined quantitative ranges, comparing a quantitative test result of the given medical indicator with the first, second and third predetermined quantitative ranges; and determining a test result level indicating that the quantitative test result falls within one of the first, second and third predetermined quantitative ranges.

10 [00105] In some embodiments, obtaining the plurality of reference test result levels comprises: for a given one of the plurality of medical indicators having first, second and third predetermined quantitative ranges, comparing a quantitative reference test result of the given medical indicator with the first, second and third predetermined quantitative ranges; and determining a reference test result level indicating that the quantitative reference test
15 result falls within one of the first, second and third predetermined quantitative ranges.

[00106] In some embodiments, the medical condition is associated with thyroid serum. In some embodiments, the plurality of medical indicators comprises at least one of: thyroid stimulating hormone (TSH), free triiodothyronine (FT3), free thyroxine (FT4), total triiodothyronine (TT3), total thyroxine (TT4), anti-thyroid peroxidase (Anti-TPO),
20 antithyroglobulin (Anti-Tg), antibody against TSH receptor (Anti-TSHR), thyroglobulin (Tg) and Calcitonin.

[00107] In some embodiments, determining the similarity comprises: determining the similarity based on a first group of pairs of test result level and reference test result level, each pair comprising one of the plurality of test result levels and one of the plurality of
25 reference test result levels that correspond to a same medical indicator among the plurality of medical indicators.

[00108] In some embodiments, determining the similarity comprises: determining the similarity further based on at least one of the following: a second group of pairs of condition levels for the patient and reference condition levels for the reference case that
30 each pair corresponds to an influence factor related to the medical condition, and a third group of pairs of test result level and reference test result level that each pair corresponds to different special medical indicators among the plurality of medical indicators.

[00109] In some embodiments, the similarity is determined based on a first similarity score to indicate respective first differences between each of the first group of pairs, and further based on at least one of the following: a second similarity score to indicate respective second differences between each of the second group of pairs, and a third similarity score to indicate respective third differences between each of the third group of pairs.

[00110] In some embodiments, the similarity is calculated by the following: adding the first and second similarity scores multiplied respectively by first and second predetermined weights; and subtracting the third similarity score multiplied by a third predetermined weight to obtain the similarity. In some embodiments, the first predetermined weight is larger than the second predetermined weight and the second predetermined weight is larger than the third predetermined weight.

[00111] In some embodiments, the influence factor comprises at least one of the following: a disease condition, a history of surgery, a medication history, an Iodine treatment, a pregnancy condition, an age, and a gender. In some embodiments, in the case that the medical condition is associated with thyroid serum, the different special medical indicators comprise at least two of the following: free triiodothyronine (FT3), total triiodothyronine (TT3), free thyroxine (FT4) and total thyroxine (TT4).

[00112] In some embodiments, the method further comprises: determining a plurality of similarities between the medical condition of the patient and a plurality of medical conditions of a group of reference cases, the group of reference cases comprising the reference case; sorting the group of reference cases according to the plurality of similarities; and presenting, via a user interface, a recorded interpretation for a reference medical condition of at least one target reference case with a highest similarity.

[00113] In some embodiments, the method further comprises: obtaining a decision tree comprising a plurality of decision conditions for a plurality of candidate interpretations related to a medical condition; selecting an interpretation for the medical condition of the patient from the plurality of candidate interpretations by determining whether the plurality of test result levels meet the plurality of decision conditions; and presenting, via a user interface, the interpretation for the medical condition of the patient.

[00114] In a second aspect, example embodiments of the present disclosure provide an electronic device. The electronic device comprises at least one processor; and at least one memory comprising computer readable instructions which, when executed by the at least

one processor of the electronic device, cause the electronic device to perform the steps of the method in the first aspect described above.

[00115] In a third aspect, example embodiments of the present disclosure provide a computer program product comprising instructions which, when executed by a processor of an apparatus, cause the apparatus to perform the steps of any one of the methods in the first aspect described above.

[00116] In a fourth aspect, example embodiments of the present disclosure provide a computer readable medium comprising program instructions for causing an apparatus to perform at least the method in the first aspect described above. The computer readable medium may be a non-transitory computer readable medium in some embodiments.

[00117] Generally, various example embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of the example embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representations, it will be appreciated that the blocks, apparatuses, systems, techniques, or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00118] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry out the methods/processes as described above. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined or split between program modules as desired in various embodiments. Computer-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[00119] The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable medium may include but is not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific
5 examples of the computer readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable
10 combination of the foregoing.

[00120] Computer program code for carrying out methods disclosed herein may be written in any combination of one or more programming languages. The program code may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes,
15 when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a computer, partly on the computer, as a stand-alone software package, partly on the computer and partly on a remote computer or entirely on the remote computer or server. The program code may be distributed on specially-programmed devices which may be
20 generally referred to herein as “modules”. Software component portions of the modules may be written in any computer language and may be a portion of a monolithic code base, or may be developed in more discrete code portions, such as is typical in object-oriented computer languages. In addition, the modules may be distributed across a plurality of computer platforms, servers, terminals, mobile devices and the like. A given module may
25 even be implemented such that the described functions are performed by separate processors and/or computing hardware platforms.

[00121] While operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In
30 certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular

embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

- 5 [00122] Although the present disclosure has been described in languages specific to structural features and/or methodological acts, it is to be understood that the present disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

WHAT IS CLAIMED IS:

1. A computer-implemented method, comprising:

5 obtaining a plurality of test result levels corresponding to a plurality of medical indicators of a patient, each test result level indicating that a quantitative test result of a corresponding medical indicator falls within one of a plurality of predetermined quantitative ranges;

10 obtaining a plurality of reference test result levels corresponding to the plurality of medical indicators associated with a reference case, each reference test result level indicating that a quantitative reference test result of a corresponding medical indicator falls within one of the plurality of predetermined quantitative ranges; and

15 determining a similarity between a medical condition of the patient and a reference medical condition associated with the reference case at least based on the plurality of test result levels and the plurality of reference test result levels.

2. The method of claim 1, wherein obtaining the plurality of test result levels comprises: for a given one of the plurality of medical indicators having first, second and third predetermined quantitative ranges,

20 comparing a quantitative test result of the given medical indicator with the first, second and third predetermined quantitative ranges; and

determining a test result level indicating that the quantitative test result falls within one of the first, second and third predetermined quantitative ranges.

25 3. The method of any of claims 1 and 2, wherein obtaining the plurality of reference test result levels comprises: for a given one of the plurality of medical indicators having first, second and third predetermined quantitative ranges,

comparing a quantitative reference test result of the given medical indicator with the first, second and third predetermined quantitative ranges; and

30 determining a reference test result level indicating that the quantitative reference test result falls within one of the first, second and third predetermined quantitative ranges.

4. The method of any of claims 1 to 3, wherein the medical condition is associated with thyroid serum; and

wherein the plurality of medical indicators comprises at least one of: thyroid stimulating hormone (TSH), free triiodothyronine (FT3), free throxine (FT4), total triiodothyronine (TT3), total thyroxine (TT4), anti-thyroid peroxidase (Anti-TPO), antithyroglobulin (Anti-Tg), antibody against TSH receptor (Anti-TSHR), thyroglobulin (Tg) and Calcitonin.

5. The method of any of claims 1 to 4, wherein determining the similarity comprises:

determining the similarity based on a first group of pairs of test result level and reference test result level, each pair comprising one of the plurality of test result levels and one of the plurality of reference test result levels that correspond to a same medical indicator among the plurality of medical indicators.

6. The method of claim 5, wherein determining the similarity comprises:

determining the similarity further based on at least one of the following:

a second group of pairs of condition levels for the patient and reference condition levels for the reference case that each pair corresponds to an influence factor related to the medical condition, and

a third group of pairs of test result level and reference test result level that each pair corresponds to different special medical indicators among the plurality of medical indicators.

7. The method of claim 6, wherein the similarity is determined based on a first similarity score to indicate respective first differences between each of the first group of pairs, and further based on at least one of the following:

a second similarity score to indicate respective second differences between each of the second group of pairs, and

a third similarity score to indicate respective third differences between each of the third group of pairs.

8. The method of claim 7, wherein the similarity is calculated by the following:

adding the first and second similarity scores multiplied respectively by first and second predetermined weights; and

subtracting the third similarity score multiplied by a third predetermined weight to

obtain the similarity.

9. The method of claim 8, wherein the first predetermined weight is larger than the second predetermined weight and the second predetermined weight is larger than the third predetermined weight.

10. The method of any of claims 6 to 9, wherein the influence factor comprises at least one of the following: a disease condition, a history of surgery, a medication history, an Iodine treatment, a pregnancy condition, an age, and a gender; and
wherein in the case that the medical condition is associated with thyroid serum, the different special medical indicators comprise at least two of the following: free triiodothyronine (FT3), free throxine (FT4), total triiodothyronine (TT3), and total thyroxine (TT4).

11. The method of any of claims 1 to 10, further comprising:
determining a plurality of similarities between the medical condition of the patient and a plurality of medical conditions of a group of reference cases, the group of reference cases comprising the reference case;
sorting the group of reference cases according to the plurality of similarities; and
presenting, via a user interface, a recorded interpretation for a reference medical condition of at least one target reference case with a highest similarity.

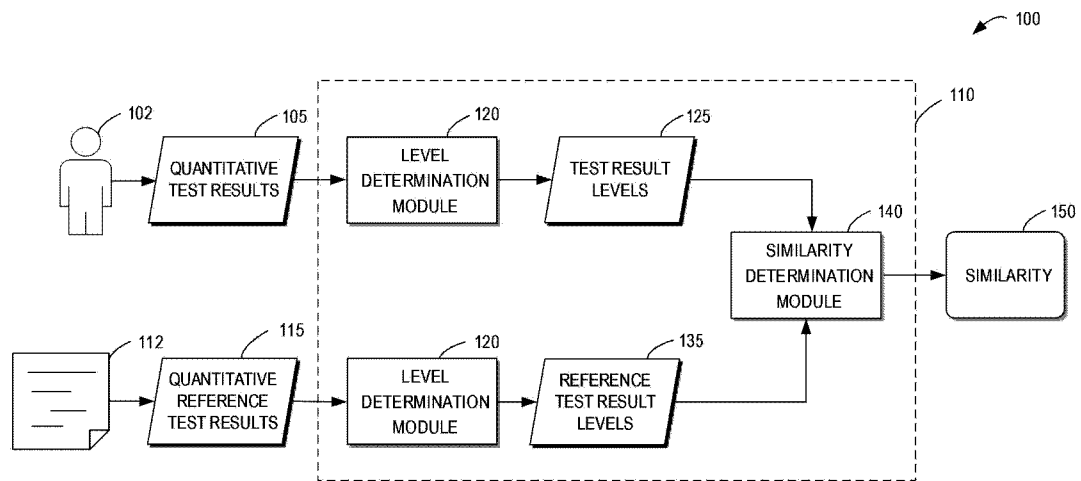
12. The method of any of claims 1 to 11, further comprising:
obtaining a decision tree comprising a plurality of decision conditions for a plurality of candidate interpretations related to a medical condition;
selecting an interpretation for the medical condition of the patient from the plurality of candidate interpretations by determining whether the plurality of test result levels meet the plurality of decision conditions; and
presenting, via a user interface, the interpretation for the medical condition of the patient.

13. An electronic device comprising:
at least one processor; and
at least one memory storing program instructions which, when executed by the at

least one processor of the electronic device, cause the electronic device to perform the steps of the method according to any of claims 1 to 12.

5 14. A computer program product comprising instructions which, when executed by a processor of an apparatus, cause the apparatus to perform the steps of the method according to any of claims 1 to 12.

10 15. A computer readable medium having program instructions stored thereon, which, when executed by a device, cause the device to perform the steps of the method according to any of claims 1 to 12.

**Fig. 1**

200

CASE ID 35678	AGE 35	GENDER FEMALE	PREGNANCY EARLY	IODINE TREATMENT NO
MEDICATION NO	DISEASE NO	OPERATION HISTORY NO	REGION HEBEI PROVINCE	OTHER
* TSH 0.273 μ U/mL	* FT3 4.25 pmol/L	* FT4 12.74 pmol/L	TT3 1.89 nmol/L	TT4 197 nmol/L
Anti-Tg 400 IU/mL	Anti-TPO 56 IU/mL	Anti-TSHR 0.98 IU/L	Tg 67 ng/mL	Calcitonin 6.9 pg/mL

210

220

Fig. 2A

250

CASE ID 35678	AGE 35	GENDER FEMALE	PREGNANCY EARLY	IODINE TREATMENT NO
MEDICATION NO	DISEASE NO	OPERATION HISTORY NO	REGION HEBEI PROVINCE	OTHER
* TSH 0.273 μ U/mL	* FT3 4.25 pmol/L	* FT4 12.74 pmol/L	TT3 1.89 nmol/L	TT4 197 nmol/L
Anti-Tg 400 IU/mL	Anti-TPO 56 IU/mL	Anti-TSHR 0.98 IU/L	Tg 67 ng/mL	Calcitonin 6.9 pg/mL

260

272 NORMAL

274 LOW

276 HIGH

Fig. 2B

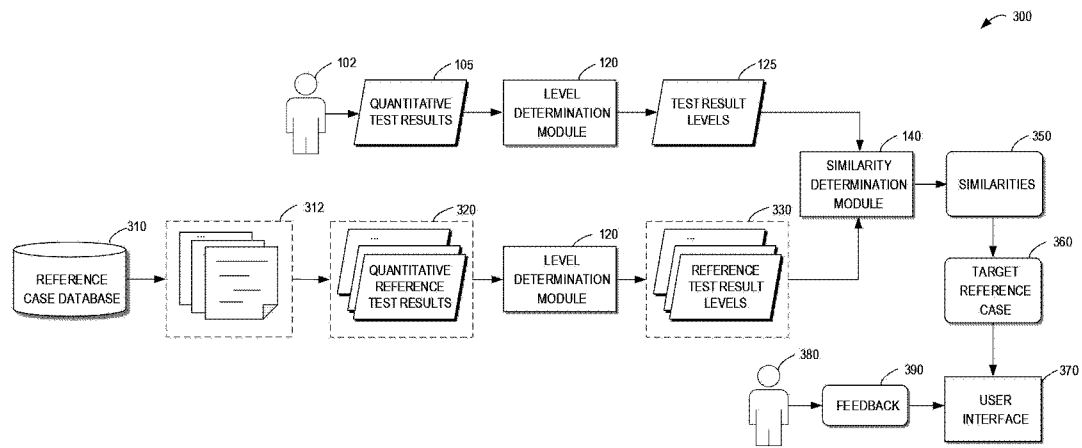


Fig. 3

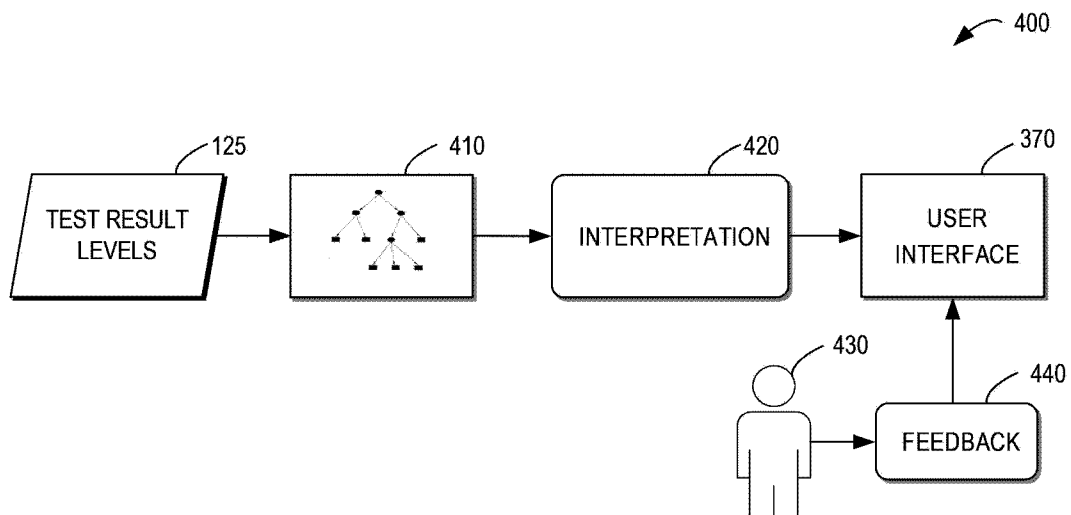


Fig. 4

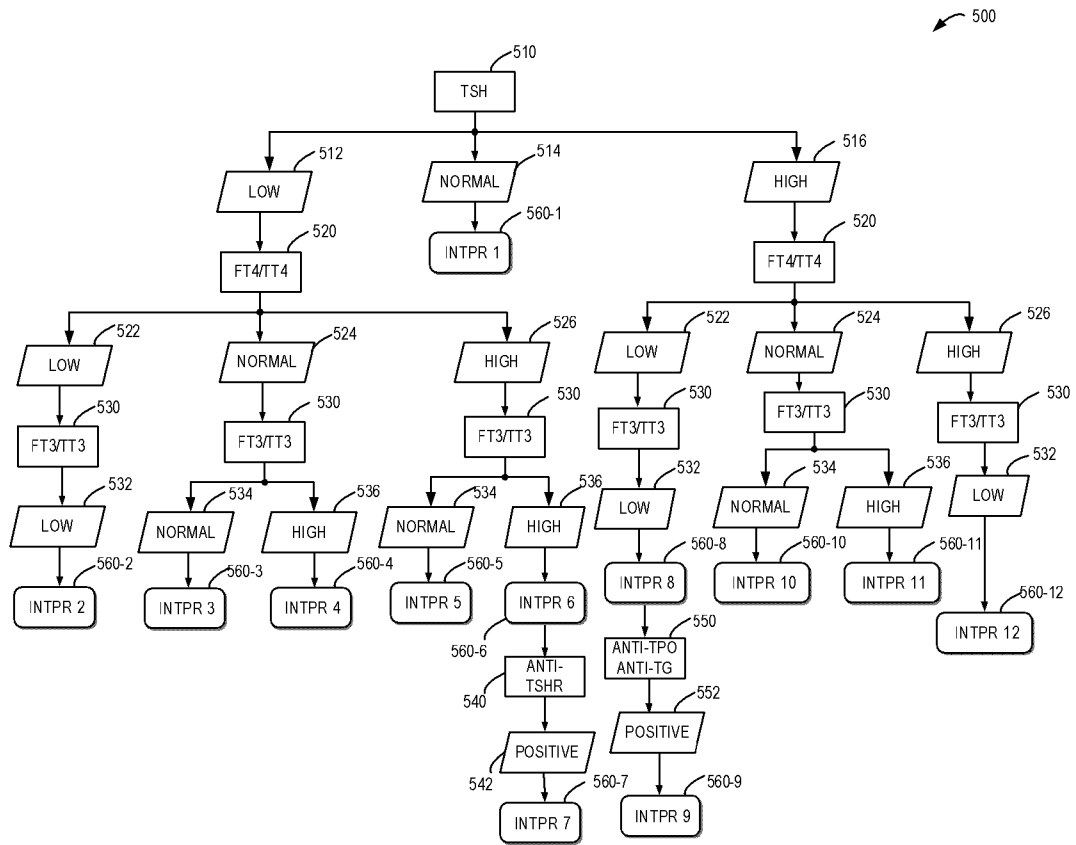


Fig. 5

Case	Similarity	Details
Case 1	Similarity 90%	40 years old; female; not pregnant; Heilongjiang Province; disease is not special; medication is not special; TSH is elevated; TT3 is elevated; TT4 is elevated. Optimal explanation: Age Factor
Case 2	Similarity 90%	42 years old; female; not pregnant; Heilongjiang Province; disease is not special; medication is not special; TSH is elevated; TT3 is elevated; TT4 is elevated. Optimal explanation: Thyroid hormone resistance
Case 3	Similarity 80%	46 years old; female; not pregnant; menstrual period; Heilongjiang Province; disease is not special; medication is not special; TSH is elevated; T3 is elevated; T4 is elevated Optimal explanation: Thyroid Stimulating Hormone Secreting Pituitary Adenoma

Fig. 6A

Hyperthyroidism

Basis: Low TSH combined with elevated FT3, FT4 (and/or TT3 and TT4) is a typical hyperthyroidism (referred to as hyperthyroidism), among which the most common are primary hyperthyroidism (Graves hyperthyroidism), toxic goiter and variant Types of hyperthyroidism of thyroiditis.

Suggestions for the next step.

Human influence:

Improper collection.

Specific interference:

Effect of medication.

Best interpretation of the case

1. Hyperthyroidism
2. Effect of medication
3. Anti-reagent component antibody interference

Customer interpretation optimal

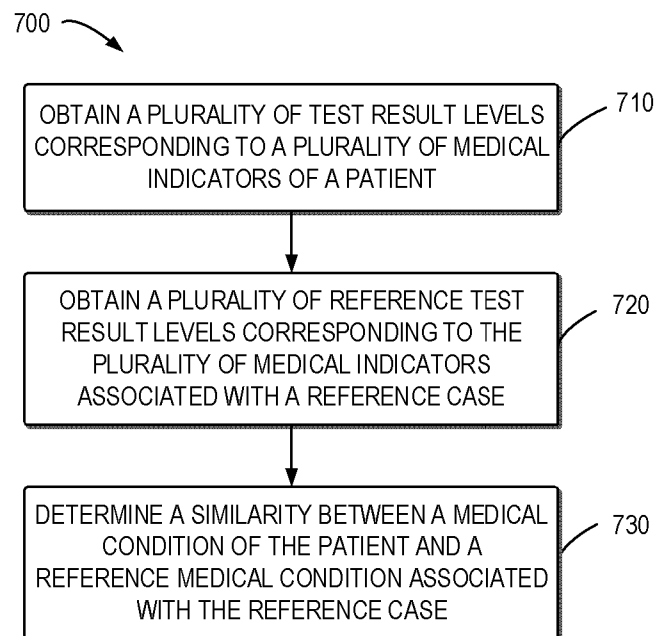
Please enter your custom best explanation...

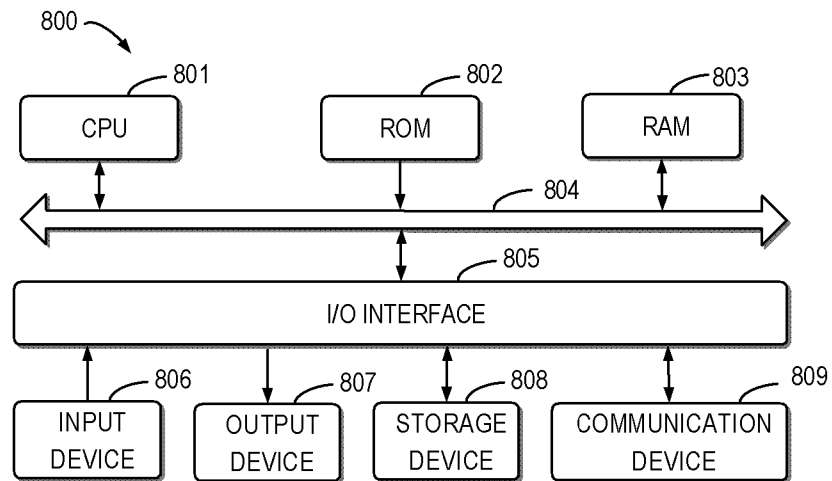
Case study notes

Please enter your case study notes...

SAVE

Fig. 6B

**Fig. 7**

**Fig. 8**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/136426

A. CLASSIFICATION OF SUBJECT MATTER

G16H 10/60(2018.01)i; G16H 50/70(2018.01)i

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)

G16H,G01N,C12Q

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)

CNPAT,CNKI,WPI,EPODOC,IEEE,INTERNET: similarity, test result, reference, case, medical, indicator, level, range, thyroid, serum

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 113241136 A (HARBIN INSTITUTE OF TECHNOLOGY, SHENZHEN) 10 August 2021 (2021-08-10) description, paragraphs 0038-0049 and 0073	1-15
A	CN 108827947 A (ANGZHOU MEDICAL COLLEGE) 16 November 2018 (2018-11-16) the whole document	1-15
A	CN 102095869 A (SHANGHAI YULONG BIOTECHNOLOGY CO., LTD.) 15 June 2011 (2011-06-15) the whole document	1-15
A	US 2001008217 A1 (WATKINS, Michael I. et al.) 19 July 2001 (2001-07-19) the whole document	1-15



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

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“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

23 August 2022

Date of mailing of the international search report

07 September 2022

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2021/136426

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	113241136	A	10 August 2021	None			
CN	108827947	A	16 November 2018	None			
CN	102095869	A	15 June 2011	None			
US	2001008217	A1	19 July 2001	US	2006269962	A1	30 November 2006
				CA	2260991	A1	18 May 1999
				DE	69812329	D1	24 April 2003
				EP	0965044	A1	22 December 1999
				US	2005260686	A1	24 November 2005
				JP	2000516345	A	05 December 2000
				US	2004126904	A1	01 July 2004
				AU	1203199	A	07 June 1999
				US	2006275820	A1	07 December 2006
				WO	9926067	A1	27 May 1999
				US	2001054580	A1	27 December 2001
				EP	1248110	A2	09 October 2002