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(71) Applicant *(for US only)*: **ROCHE DIAGNOSTICS OPERATIONS, INC.** [US/US]; 9115 Hague Road, Indianapolis, 46250 (US).

(71) Applicant *(for DE only)*: **ROCHE DIAGNOSTICS GMBH** [DE/DE]; Sandhofer Straße 116, 68305 Mannheim (DE).

(71) Applicant *(for all designated States except DE, US)*: **F. HOFFMANN-LA ROCHE AG** [CH/CH]; Grenzacherstraße 124, 4070 Basel (CH).

(72) Inventors: **REIN, Michael**; c/o Roche Diagnostics Automation Solutions GmbH, Albert-Ruprecht-Straße 2, 71636 Ludwigsburg (DE). **WIEGAND, Friederike**; c/o Roche Diagnostics Automation Solutions GmbH, Albrecht-Ruprecht-Strasse 2, 71636 Ludwigsburg (DE).

(74) Agent: **PATENTANWÄLTE RUFF, WILHELM, BEIER, DAUSTER & PARTNER MBB**; Kronenstraße 30, 70174 Stuttgart (DE).

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(54) **Title:** METHOD AND LABORATORY SYSTEM FOR DETERMINING AT LEAST ONE CONTAINER INFORMATION ABOUT A LABORATORY SAMPLE CONTAINER

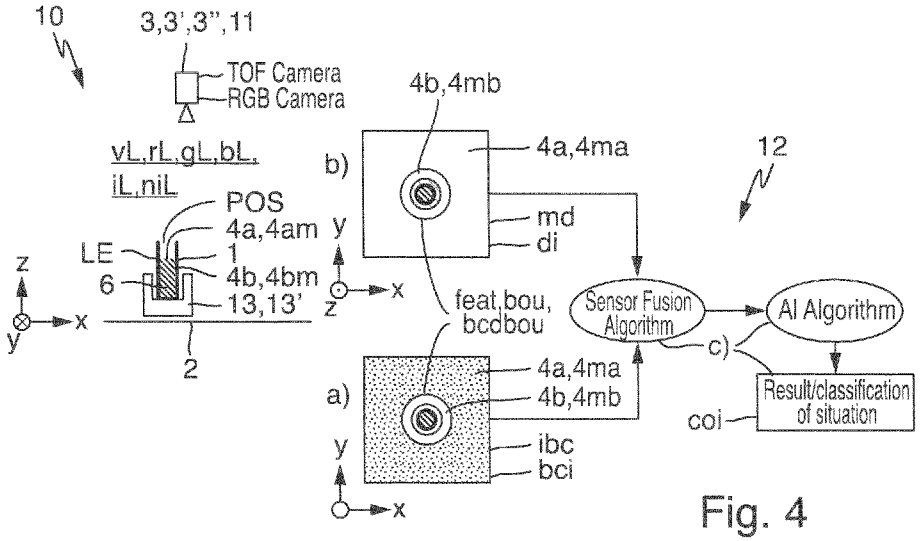

Fig. 4

(57) **Abstract:** The invention relates to a method for determining at least one container information (coi) about a laboratory sample container (1), wherein the method comprises the steps: a) acquiring an image (ibc) comprising a brightness and/or color information (bci) of a possible region (2) of the container (1), b) acquiring a map (md) comprising a depth information (di) of the region (2), and c) determining the container information (coi) by fusing the brightness and/or color information (bci) and the depth information (di).

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Method and laboratory system for determining at least one container information about a laboratory sample container

TECHNICAL FIELD AND PRIOR ART

The invention relates to a method and a laboratory system, in particular each, for determining at least one container information about a laboratory sample container.

SUMMARY OF THE INVENTION

It is the object of the invention to provide a method and a laboratory system, in particular each, for determining at least one container information about a laboratory sample container, in particular having improved properties.

This object is solved by a method and a laboratory system as defined in the independent claims. Preferred embodiments are defined in the dependent claims.

The invention relates to a method for determining at least one container information about a laboratory sample container, wherein the method comprises the steps:

a) acquiring an image comprising a brightness and/or color information of a possible or potential, respectively, region of the container,

b) acquiring a map comprising a depth information of the, in particular same or identical, respectively, region, and

c) determining the container information by fusing the brightness and/or color information and the depth information, in particular with each other.

This, in particular the fusing the brightness and/or color information and the depth information, enables determining the container information, in particular and thus inspecting the container, accurately and/or completely and/or reliably and/or with less uncertainty, in particular than would be possible when only one such information was used individually.

In particular the method, the determining, the acquiring and/or the fusing may be automatically.

The phrase "container property of" may be used synonymously for the phrase "container information about". In particular the property may be a physical property.

The, in particular respective, information may comprise a content and/or a value.

The term "having" may be used synonymously for the term "comprising".

The container may be made of glass or, in particular transparent and/or colorless, plastic or any other, in particular somewhat, solid material. Additionally or alternatively the container may be configured as a tube.

The term "capturing" may be used synonymously for the term "acquiring".

The image and the map may be acquired from a, in particular same or identical, viewpoint. Additionally or alternatively the image and/or the map may be digital.

The image may be a brightness and/or color image. Additionally or alternatively the image may be two-dimensional.

The term "representing" or "containing" may be used synonymously for the term "comprising".

The brightness information may be a brightness information of a, in particular given, color/s.

The term "data" may be used synonymously for the term "information".

The container may be present in the possible region. Additionally or alternatively a container carrier for carrying, in particular for transporting, the container may be present in the possible region. In particular, an empty carrier may be present in the possible region in which the container could also be expected. Additionally or alternatively the carrier may have a white color.

The map may be a depth map. In particular the phrase "depth profile" may be used synonymously for the term "depth map". Additionally or alternatively the map may be three-dimensional or have two dimensions and one additional, third dimension, wherein the third dimension may relate to a height over a plane defined by the other two dimensions, or indicate how an upper surface of a specific region changes height in two dimensions, respectively.

The depth information may relate to a, in particular perpendicular, distance of at least one surface of at least one, in particular scene, object from a, in particular the, viewpoint.

The phrase "distance information" may be used synonymously for the phrase "depth information".

The depth information may be different and/or independent and/or complementary and/or correlated to the brightness and/or color information.

The term "combining" may be used synonymously for the term "fusing".

Step b) may be performed before, simultaneously with and/or after step a).

Step c) may be performed after step a) and step b).

The method, in particular step a), step b) and/or step c), may be performed again and/or repeatedly, in particular multiple times.

In particular step b) may comprise non-contact measuring of the region. In particular the non-contact measuring may use ultrasound.

According to an embodiment of the invention, step a) comprises: acquiring the image comprising the brightness and/or color information by detecting visible light, in particular red light, green light and blue light. Additionally or alternatively step b) comprises: acquiring the map comprising the depth information by detecting infrared light, in particular near-infrared light. Such a light enables to have interacted with an, in particular the, object in the region, in particular to be reflected by the object. Additionally or alternatively the visible light and the infrared light enable to not disturb each other's detecting. In particular the term "sensing" or "receiving" may be used synonymously for the term "detecting". Additionally or alternatively the, in particular respective, detecting may be automatically or a detecting of a, in particular respective, intensity of the light. Further additionally or alternatively, the visible light may have a wavelength in the range of 400 to 700 nm (nanometers). Further additionally or alternatively, the infrared light may have a wavelength longer than those of the visible light and/or in the range of 700 nm to 1 mm (millimeter), in particular to 1.4 µm (micrometer).

In particular step c), in particular the method, may not or does not have to be, in particular performed, by photogrammetry.

According to an embodiment of the invention, step b) comprises: acquiring the map comprising the depth information by a time-of-flight measurement. This enables a very quick and/or simple acquiring and/or an easy, in particular low computational load, processing of the acquired map.

In particular the image and the map may be acquired by separate devices, in particular cameras.

According to an embodiment of the invention, the image and the map are acquired by a, in particular same or identical, respectively, 3D camera, in particular a range camera, in particular a time-of-flight camera. This enables acquiring the image and the map from a, in particular the, same or identical viewpoint and/or, in particular thus, an easy, in particular low computational load, processing of the acquired image and the acquired map. In particular the 3D camera may be electric, in particular electronic. Additionally or alternatively the image and/or the map may not or does not have to be acquired by a stereo camera. Further additionally or alternatively the depth information may relate to or represent a, in particular perpendicular, distance of at least one surface of at least one, in particular scene, object and a plane of the, in particular scene, 3D camera.

According to an embodiment of the invention, the image and the map are acquired in top view or from a top or upper, respectively, side or above, respectively. In other words: the light may be received from below. This enables acquiring the image comprising meaningful brightness and/or color information and/or the map comprising meaningful depth information, in particular and thus determining meaningful container information. In particular the term “important” or “relevant” may be used synonymously for the term “meaningful”.

According to an embodiment of the invention, step c) comprises: extracting the brightness and/or color information from the image and/or the depth information from the map in form of features. Additionally or alternatively step c) comprises: classifying the, in particular extracted, brightness and/or color information and/or the, in particular extracted, depth information and fusing the classified brightness and/or color information and/or the classified depth information. This enables generating small information spaces or amount, respectively, and/or, in particular thus, a low computational load fusing. In particular the extracting and/or the classifying may be automatically. Additionally or alternatively the term “extrapolating” or “detecting” may be used synonymously for the term “extracting”.

According to an embodiment of the invention, step c) is, in particular the extracting, the classifying and/or the fusing are/is, performed by an artificial neural network, rule-based decisions and/or machine learning. This enables a very good performing.

According to an embodiment of the invention, the brightness and/or color information and/or the depth information are/is about at least one boundary, in particular a brightness, color and/or depth boundary, between two spatial regions occupied by different matter. This enables the extracting the brightness and/or color information from the image and/or the depth information from the map in form of the features formed by the at least one boundary. In particular the term "edge" may be used synonymously for the term "boundary". Additionally or alternatively the phrase "spatial phases" may be used synonymously for the phrase "spatial regions". Further additionally or alternatively the term "material" may be used synonymously for the term "matter".

According to an embodiment of the invention, the container information is about, in particular is, an absence or a presence of the container in the region, a position of the container, in particular in the region, a presence or an absence of a cap on, in particular top of, the container, an absence or a presence of a laboratory sample in or contained by, respectively, the container, and/or a level of the sample in the container. This enables handling the container. In particular step a) may comprise: acquiring the image of the carrier, if present, the container, if present, the cap, if present, and/or the sample, if present. Additionally or alternatively step b) may comprise: acquiring the map of the carrier, if present, the container, if present, the cap, if present, and/or the sample, if present. Further additionally or alternatively the term "location" or "place" may be used synonymously for the term "position". Further additionally or alternatively the container may have an opening, in particular at a top or upper, respectively, end. In particular the opening may be defined by an end of a wall and/or a circumference of the container. Additionally or alternatively the container or its opening, respectively, may be open or closed, in particular by the cap. Further additionally or alternatively the cap may comprise rubber and/or plastic or may completely consist of rubber and/or plastic. Further additionally or alternatively the cap may have a blue color. Further additionally or alternatively the cap may be embodied as a lid, in particular as a rigid lid, or as a foil, in particular a flexible foil. Further additionally or alternatively the sample may be a liquid sample and/or a blood sample or a urine sample. In particular the blood sample may have a red color and/or the urine sample may have a yellow color. Further additionally or alternatively typically the sample may not fill the container completely, in particular up to the opening. Further additionally or alternatively the map may have two dimensions and one additional, third dimension, wherein the third dimension may relate to a height parallel to a longitudinal axis of the container over two directions, which may be perpendicular to the axis and/or parallel to a plane defined by the opening. In particular the term "vertical" may be used synonymously for the term "longitudinal". Further additionally or alternatively for the different cases the image and the map, in particular each, may be distinctly different.

According to an embodiment of the invention, the method comprises the step:

d) handling the container based on or in dependence of, respectively, the determined container information, in particular transporting or moving, respectively, gripping, decapping, capping, filling and/or defilling the container.

This, in particular the fusing the brightness and/or color information and the depth information, enables handling the container accurately and/or reliably and/or with less uncertainty, in particular than would be possible when only one such information was used individually.

In particular the handling may be automatically.

The invention further relates to a laboratory system for determining, in particular the, at least one container information about a, in particular the, laboratory sample container, in particular for performing the method according to the invention, wherein the system comprises an acquiring device and a determining device. The acquiring device is configured for acquiring an, in particular the, image comprising a, in particular the, brightness and/or color information of a, in particular the, possible region of the container and a, in particular the, map comprising a, in particular the, depth information of the region. The determining device is configured for determining the container information by fusing the brightness and/or color information and the depth information.

By this system, the same advantages as discussed above with regard to the method may be achieved.

In particular the system, the acquiring device and/or the determining device may be electric, in particular electronic.

The acquiring device may comprise or be a detector or sensor, respectively, in particular at least two detectors.

The determining device may comprise or be a processor and/or a memory.

The term “adapted” or “designed” may be used synonymously for the term “configured”.

The carrier may be configured for carrying the container aligned with respect or in relation, respectively, to the acquiring device.

According to an embodiment of the invention, the laboratory system comprises a handling device. The handling device is configured for handling the container based on the determined container

information. In particular the handling device may be electric. Additionally or alternatively the handling device may comprise or be a transporter or mover, respectively, in particular the carrier, a gripper, a decapper, a capper, a filler and/or a defiller. In particular the mover may be configured for moving the container with respect or in relation, respectively, to the acquiring device. Additionally or alternatively the mover may comprise or be a conveyor belt or band and/or a laboratory sample distribution system as described in EP 2 995 958 A1.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, embodiments of the invention will be described in detail with reference to the drawings. Throughout the drawings, the same elements will be denoted by the same reference numerals.

Fig. 1 shows a method and a laboratory system for determining at least one container information about a laboratory sample container, wherein the container is absent and a carrier for carrying the container is absent,

Fig. 2 shows the method and the system of Fig. 1, wherein the carrier is present and the container is absent,

Fig. 3 shows the method and the system of Fig. 1, wherein the carrier is present, the container is present, a cap is absent and a laboratory sample is absent,

Fig. 4 shows the method and the system of Fig. 1, wherein the carrier is present, the container is present, the cap is absent and the sample is present,

Fig. 5 shows the method and the system of Fig. 1, wherein the carrier is present, the container is present and the cap is present, and

Fig. 6 shows details of the method and the system of Fig. 1.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Fig. 1 to 6 show a laboratory system 10 and a method for determining at least one container information coi about a laboratory sample container 1.

The system 10 comprises an acquiring device 11 and a determining device 12. The acquiring device 11 is configured for acquiring an image ibc comprising a brightness and/or color information bci of a possible region 2 of the container 1 and a map md comprising a depth information di of the region 2, in particular acquires. The determining device 12 is configured for determining the container information coi by fusing the brightness and/or color information bci and the depth information di, in particular determines.

The method comprises the steps:

a) acquiring the image ibc comprising the brightness and/or color information bci of the possible region 2 of the container 1, in particular by the acquiring device 11,

b) acquiring the map md comprising the depth information di of the region 2, in particular by the acquiring device 11, and

c) determining the container information coi by fusing the brightness and/or color information bci and the depth information di, in particular by the determining device 12.

In detail step a) comprises: acquiring the image ibc comprising the brightness and/or color information bci by detecting visible light vL, in particular red light rL, green light gL and blue light bL. Additionally or alternatively step b) comprises: acquiring the map md comprising the depth information di by detecting infrared light iL, in particular near-infrared light niL.

Furthermore, step b) comprises: acquiring the map md comprising the depth information di by a time-of-flight measurement TOF.

Moreover, the image ibc and the map md are acquired by a 3D camera 3, in particular a range camera 3', in particular a time-of-flight camera 3'', in particular of the system 10, in particular the acquiring device 11.

In particular the system 10, in particular the acquiring device 11, comprises a RGB camera (red, green and blue). In the shown embodiment the 3D camera and the RGB camera are included into only one camera. In alternative embodiments the 3D camera and the RGB camera may be two cameras on one position or multiple positions.

Further, the image ibc and the map md are acquired in top view.

Furthermore, step c) comprises: extracting the brightness and/or color information bci from the image ibc and/or the depth information di from the map md in form of features feat, in particular by the determining device 12. Additionally or alternatively step c) comprises: classifying the, in particular extracted, brightness and/or color information bci and/or the, in particular extracted, depth information di and fusing the classified brightness and/or color information bci and/or the classified depth information di, in particular by the determining device 12.

Moreover, step c) is, in particular the extracting, the classifying and/or the fusing are/is, performed by an artificial neural network AI, rule-based decisions and/or machine learning, in particular by the determining device 12.

Further, the brightness and/or color information bci and/or the depth information di are/is about at least one boundary bou, in particular a brightness, color and/or depth boundary bcdbou, in particular forming the features feat, between two spatial regions 4a, 4b occupied by different matter 4ma, 4mb.

In the shown embodiment the acquiring device 11 and/or the 3D camera 2 is above the region 2. The region 2 extends in an x-y-plane. A height is given along a z-axis, in particular perpendicular to the x-y-plane.

In Fig. 1 nothing is present, in particular on a black and flat underground. Thus, the image ibc shows nothing and the map md shows a homogenous depth or height, respectively. Thus, the container information coi is about an absence of a part of a handling device 13 comprising a container carrier 13' for carrying the container 1 and an absence of the container 1 in the region 2.

In Fig. 2 the carrier 13', in particular in form of an empty tube holder, is present, in particular on the underground. Thus, the image ibc shows an inner, in particular white, circle being surrounded by a, in particular white, ring, in particular which corresponds to the cross-section of the carrier 13' shown in the left of Fig. 2. The map md shows a lower inner part, in particular corresponding to the inner circle, and a higher surrounding elevated part, in particular corresponding to the surrounding ring.

Thus, from the image ibc and from the map md, in particular each, a boundary bou between the inner circle or the lower inner part, respectively, and the surrounding ring or the higher surrounding elevated part, respectively, and another boundary bou between the surrounding ring and the background are extracted.

Thus, the container information coi is about the presence of the carrier 13' and the absence of the container 1 in the region 2.

In Fig. 3 the carrier 13' and the container 1, in particular in form of an empty tube, are present, in particular the container 1 in the carrier 13'. Thus, the image ibc shows a narrower inner, in particular colorless, circle being surrounded by a narrower, in particular colorless, ring being surrounded by another, in particular white, ring, in particular which corresponds to the cross-section of the container 1 and the carrier 13' shown in the left of Fig. 3. The map md shows a narrower lower inner part, in particular corresponding to the inner circle, a narrower higher surrounding elevated part, in particular corresponding to the surrounding ring, and a lower surrounding elevated part, in particular corresponding to the another surrounding ring.

Thus, from the image ibc and from the map md, in particular each, a boundary bou between the inner circle or the lower inner part, respectively, and the surrounding ring or the higher surrounding elevated part, respectively, another boundary bou between the surrounding ring and the another surrounding ring or the lower surrounding elevated part, respectively, and another boundary bou between the another surrounding ring and the background are extracted.

Thus, the container information coi is about the presence of the carrier 13', the presence of the container 1 in the region 2, the position POS of the container 1, the absence of a cap 5 on the container 1 and the absence of a laboratory sample 6 in the container 1.

In Fig. 4 the carrier 13', the container 1, in particular in form of a filled tube, and the sample 6 are present, in particular the sample 6 in the container 1. Thus, the image ibc shows an inner, in particular red or yellow, circle being surrounded by a, in particular colorless, ring being surrounded by another, in particular white, ring, in particular which corresponds to the cross-section of the sample 6, the container 1 and the carrier 13' shown in the left of Fig. 4. The map md shows a less lower inner part, in particular corresponding to the inner circle, a higher surrounding elevated part, in particular corresponding to the surrounding ring, and a lower surrounding elevated part, in particular corresponding to the another surrounding ring.

Thus, from the image ibc and from the map md, in particular each, a boundary bou between the inner circle or the less lower inner part, respectively, and the surrounding ring or the higher surrounding elevated part, respectively, another boundary bou between the surrounding ring and the another surrounding ring or the lower surrounding elevated part, respectively, and another boundary bou between the another surrounding ring and the background are extracted.

Thus, the container information coi is about the presence of the carrier 13', the presence of the container 1 in the region 2, the position POS of the container 1, the absence of the cap 5 on the container 1, the presence of the sample 6 in the container 1 and the level LE of the sample 6 in the container 1.

In Fig. 5 the carrier 13', the container 1, in particular in form of a capped tube, the sample 6 and the cap 5 are present, in particular the cap 5 on the container 1.Thus, the image ibc shows a wider inner, in particular blue, circle being surrounded by a, in particular white, ring, in particular which corresponds to the cross-section of the cap 5 on the container 1 and the carrier 13' shown in the left of Fig. 5. The map md shows a wider higher inner part, in particular corresponding to the inner circle, and a lower surrounding elevated part, in particular corresponding to the surrounding ring.

Thus, from the image ibc and from the map md, in particular each, a boundary bou between the inner circle or the higher inner part, respectively, and the surrounding ring or the lower surrounding elevated part, respectively, and another boundary bou between the surrounding ring and the background are extracted.

Thus, the container information coi is about the presence of the carrier 13', the presence of the container 1 in the region 2, the position POS of the container 1 and the presence of the cap 5 on the container 1.

Furthermore, the laboratory system 10 comprises the handling device 13. The handling device 13 is configured for handling the container 1 based on the determined container information coi, in particular handles.

Moreover, the method comprises the step: d) handling the container 1 based on the determined container information coi, in particular transporting or moving, respectively, gripping, decapping, capping, filling and/or defilling the container 1, in particular by the handling device 13.

In the shown embodiment the handling device 13 comprises the carrier 13. Such a handling device 13 is used in order to transport the container 1 on the underground or a transport plane, respectively. In particular the carrier 13' may be only a part, in particular of the handling device, that is movable by external means. For example the carrier 13' may comprise a magnet and electromagnetic actuators may be positioned below the transport plane in order to drive the carrier 13'. Thus, the combination of the electromagnetic actuators and the carrier 13' can be regarded as the handling device 13.

Fig. 6 shows further details of the relevant information or signal, respectively processing. The image ibc comprises three sub-images corresponding to the three colors red (R), green (G), and blue (B). In principle, also other colors may be used. This information, in particular the brightness and/or color information bci, and the depth information di is delivered to a sensor fusion algorithm, which preprocesses, normalizes and/or merges this information. A confidence map is obtained, in which each point in space has a confidence and/or a probability. Furthermore, an AI matching algorithm produces the container information coi, which comprises a scene classification. For example, the following may be output: open tube with liquid - a height of the liquid, for example 55 mm, and/or a height of the tube, for example 100 mm; underground or underground plate, respectively – a height of the surface, for example 3 mm; closed tube- a height of the closed tube, for example 110 mm; and/or carrier – a height of a surface of the carrier, for example 22 mm.

This enables the system to know, whether the tube is overfilled or not, in particular to avoid spilling. Additionally or alternatively this enables to ensure, that the cap really has been removed, in particular for successful aliquoting. Further additionally or alternatively this enables to ensure, that the cap is present, in particular for storage and/or centrifugation. Further additionally or alternatively this enables to ensure a precise enough placement of the tube by the carrier, in particular to allow a gripper to take the tube.

As the shown and above discussed embodiments reveal, the invention provides a method and a laboratory system, in particular each, for determining at least one container information about a laboratory sample container, in particular having improved properties.

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Claims

1. Method for determining at least one container information (coi) about a laboratory sample container (1), wherein the method comprises the steps:

a) acquiring an image (ibc) comprising a brightness and/or color information (bci) of a possible region (2) of the container (1),

b) acquiring a map (md) comprising a depth information (di) of the region (2), and

c) determining the container information (coi) by fusing the brightness and/or color information (bci) and the depth information (di).

2. Method according to the preceding claim,

- wherein step a) comprises: acquiring the image (ibc) comprising the brightness and/or color information (bci) by detecting visible light (vL), in particular red light (rL), green light (gL) and blue light (bL), and/or
- wherein step b) comprises: acquiring the map (md) comprising the depth information (di) by detecting infrared light (iL), in particular near-infrared light (niL).

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

- wherein step b) comprises: acquiring the map (md) comprising the depth information (di) by a time-of-flight-measurement (TOF).

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

- wherein the image (ibc) and the map (md) are acquired by a 3D camera (3), in particular a range camera (3'), in particular a time-of-flight-camera (3'').

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

- wherein the image (ibc) and the map (md) are acquired in top view.

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

- wherein step c) comprises: extracting the brightness and/or color information (bci) from the image (ibc) and/or the depth information (di) from the map (md) in form of features (feat), and/or
- wherein step c) comprises: classifying the, in particular extracted, brightness and/or color information (bci) and/or the, in particular extracted, depth information (di) and fusing the

classified brightness and/or color information (bci) and/or the classified depth information (di).

7. Method according to any one of the preceding claims, in particular the preceding claim,
- wherein step c) is, in particular the extracting, the classifying and/or the fusing are/is, performed by an artificial neural network (AI), rule-based decisions and/or machine learning.

8. Method according to any one of the preceding claims,
- wherein the brightness and/or color information (bci) and/or the depth information (di) are/is about at least one boundary (bou), in particular a brightness, color and/or depth boundary (bcdbou), between two spatial regions (4a, 4b) occupied by different matter (4ma, 4mb).

9. Method according to any one of the preceding claims,
- wherein the container information (coi) is about an absence or a presence of the container (1) in the region (2), a position (POS) of the container (1), a presence or an absence of a cap (5) on the container (1), an absence or a presence of a laboratory sample (6) in the container (1), and/or a level (LE) of the sample (6) in the container (1).

10. Method according to any one of the preceding claims, wherein the method comprises the step:

d) handling the container (1) based on the determined container information (coi), in particular transporting, gripping, decapping, capping, filling and/or defilling the container (1).

11. Laboratory system (10) for determining at least one container information (coi) about a laboratory sample container (1), in particular for performing a method according to any one of the preceding claims, wherein the system (10) comprises:
- an acquiring device (11), wherein the acquiring device (11) is configured for acquiring an image (ibc) comprising a brightness and/or color information (bci) of a possible region (2)

of the container (1) and a map (md) comprising a depth information (di) of the region (2), and

- a determining device (12), wherein the determining device (12) is configured for determining the container information (coi) by fusing the brightness and/or color information (bci) and the depth information (di).

12. Laboratory system (10) according to the preceding claim, wherein the system (10) comprises:

- a handling device (13), wherein the handling device (13) is configured for handling the container (1) based on the determined container information (coi).

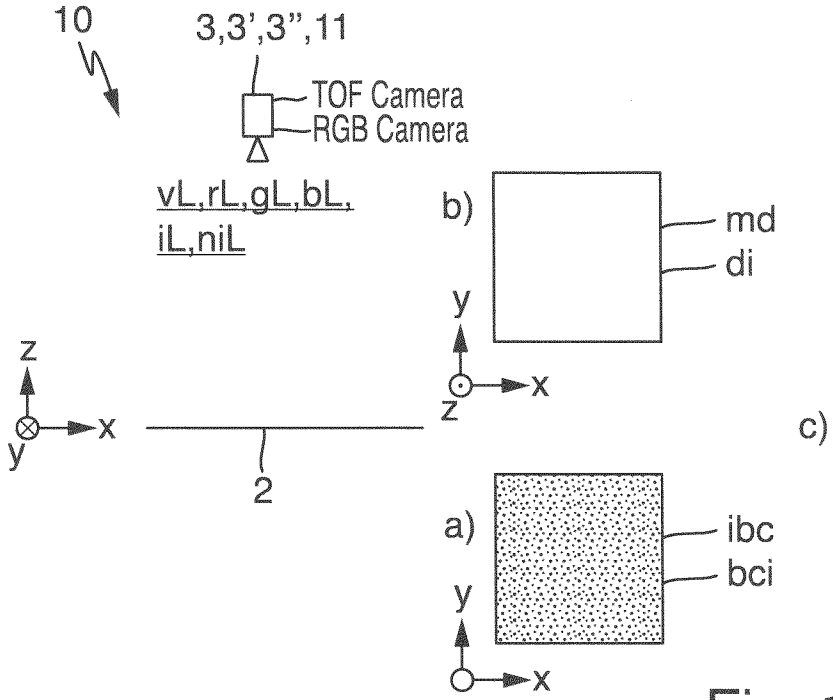
10
3,3',3",11
TOF Camera
RGB Camera
vL,rL,gL,bL,
iL,niL
b)
md
di
y
x
z
z
x
y
2
c)
a)
ibc
bci
y
x

Fig. 1

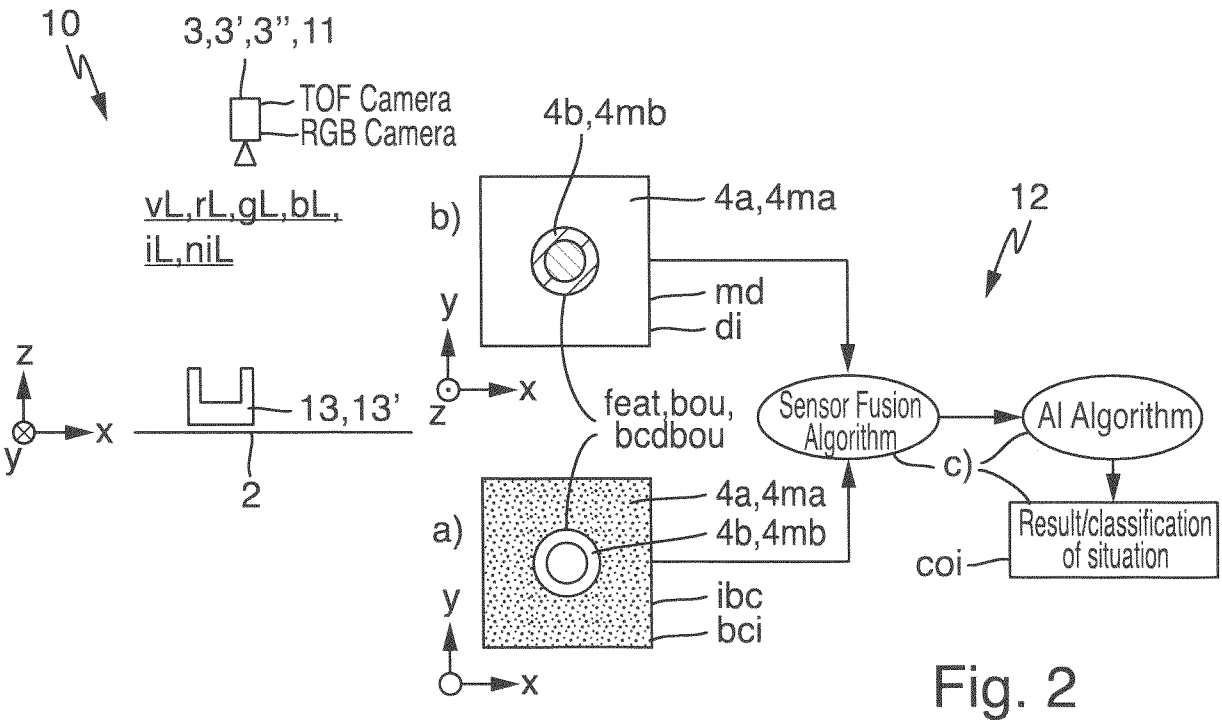
10
3,3',3",11
TOF Camera
RGB Camera
4b,4mb
vL,rL,gL,bL,
iL,niL
b)
4a,4ma
12
md
di
y
x
z
z
x
y
13,13'
2
feat,bou,
bcdbou
Sensor Fusion
Algorithm
AI Algorithm
c)
4a,4ma
a)
4b,4mb
Result/classification
of situation
coi
ibc
bci
y
x

Fig. 2

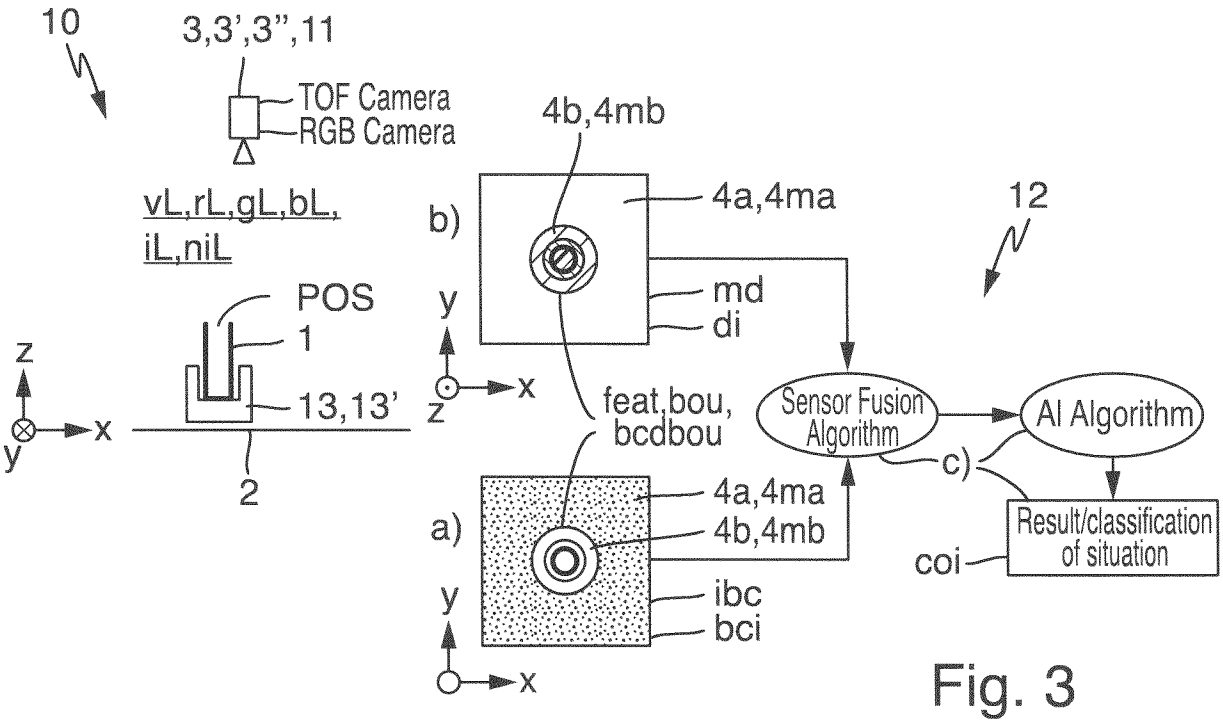
10
3,3',3'',11
TOF Camera
RGB Camera
vL,rL,gL,bL,
iL,niL
POS
1
13,13'
2
z
x
y
b)
4b,4mb
4a,4ma
md
di
y
x
z
feat,bou,
bcdbou
a)
4a,4ma
4b,4mb
ibc
bci
y
x
12
Sensor Fusion
Algorithm
AI Algorithm
c)
Result/classification
of situation
coi

Fig. 3

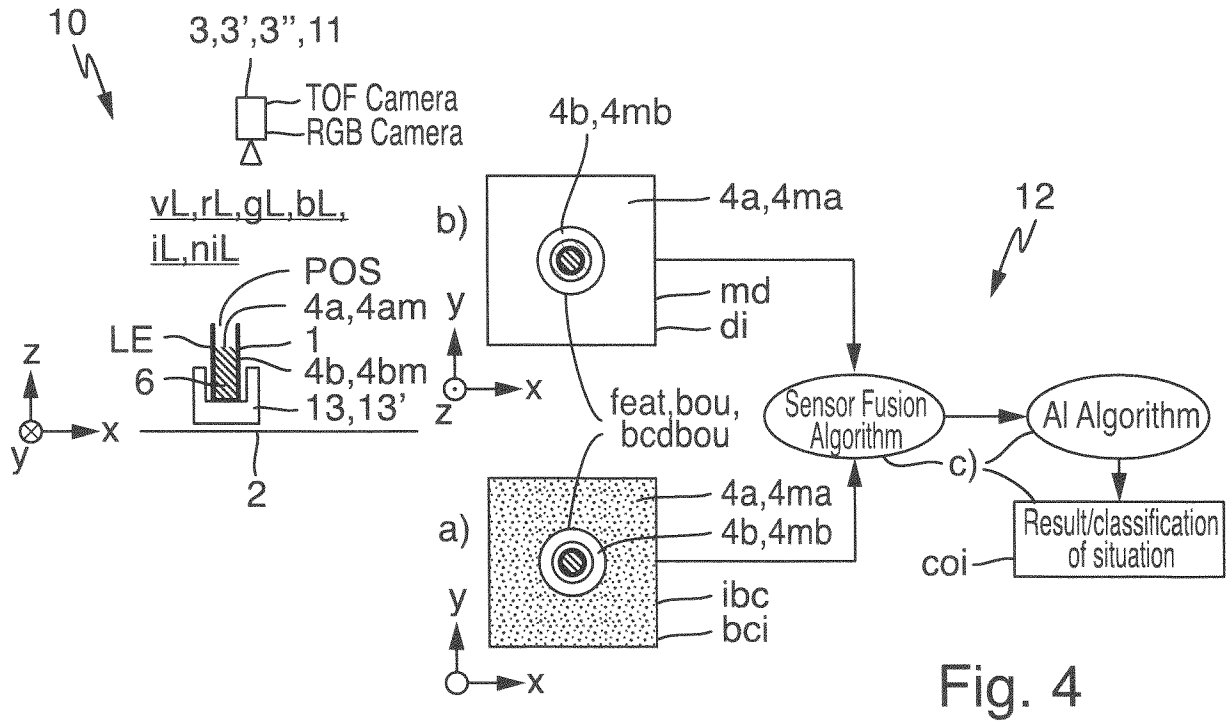
10
3,3',3'',11
TOF Camera
RGB Camera
vL,rL,gL,bL,
iL,niL
POS
4a,4am
LE
1
6
4b,4bm
13,13'
2
z
x
y
b)
4b,4mb
4a,4ma
md
di
y
x
z
feat,bou,
bcdbou
a)
4a,4ma
4b,4mb
ibc
bci
y
x
12
Sensor Fusion
Algorithm
AI Algorithm
c)
Result/classification
of situation
coi

Fig. 4

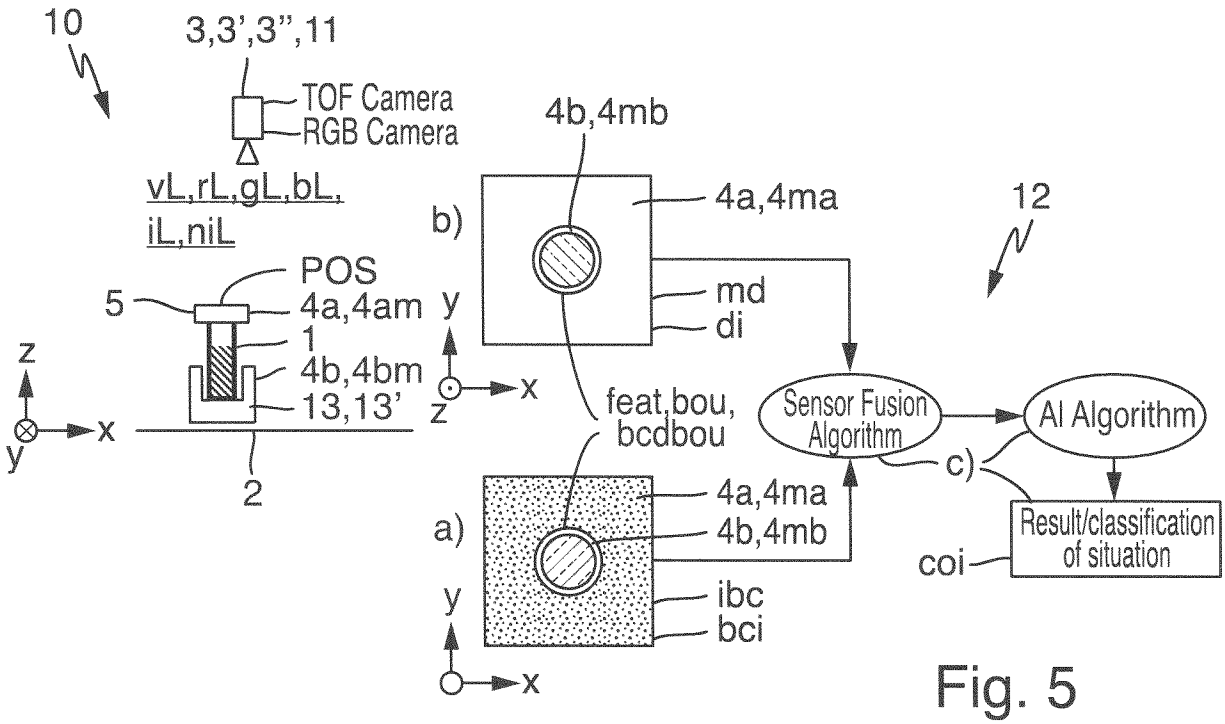
10
3,3',3'',11
TOF Camera
RGB Camera
vL,rL,gL,bL,
iL,niL
POS
5
4a,4am
1
4b,4bm
13,13'
2
z
x
y
4b,4mb
b)
4a,4ma
md
di
y
x
z
feat,bou,
bcdbou
a)
4a,4ma
4b,4mb
ibc
bci
y
x
12
Sensor Fusion Algorithm
AI Algorithm
c)
Result/classification of situation
coi

Fig. 5

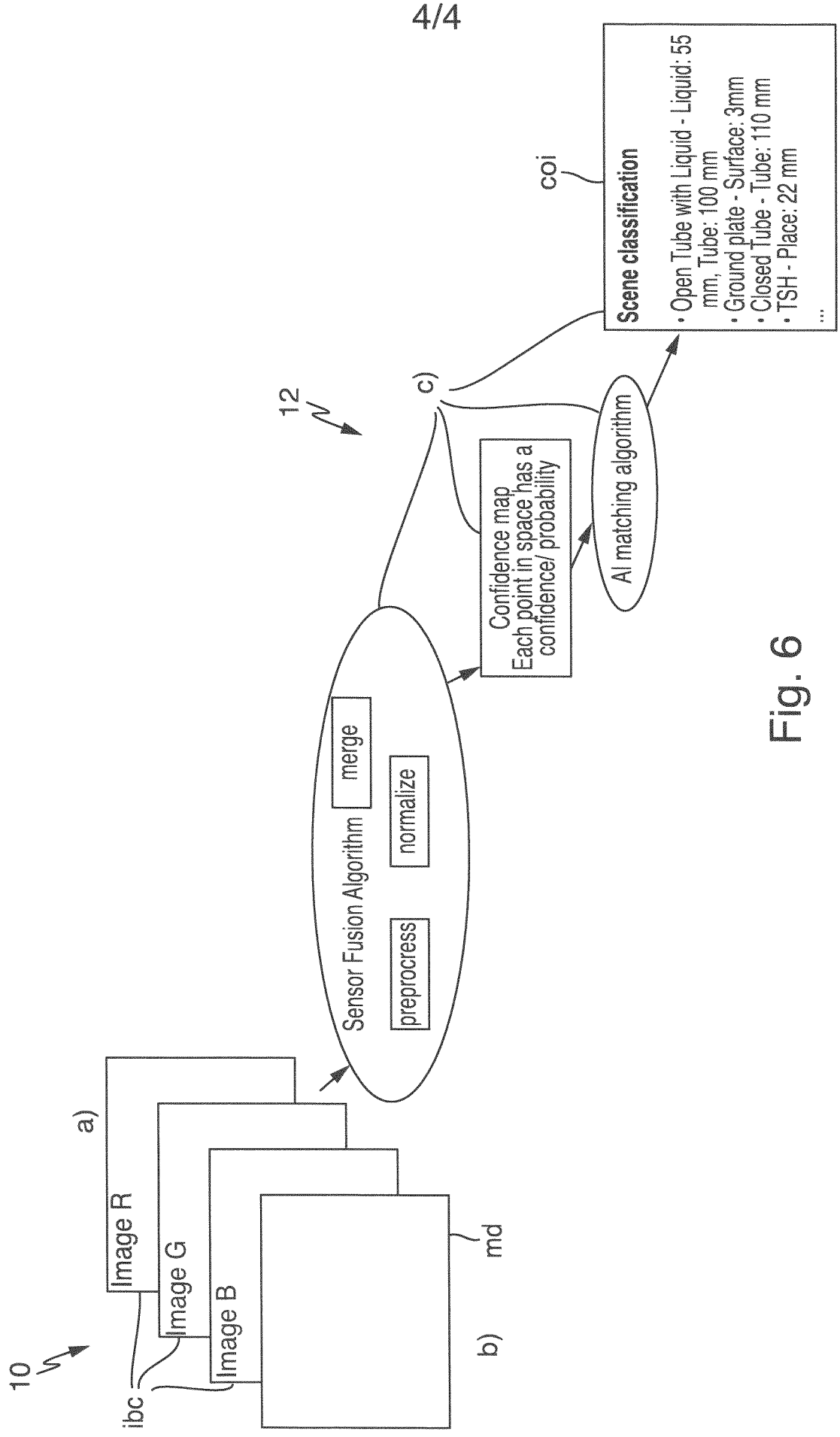
10
ibc
Image R
Image G
Image B
a)
b)
md
12
Sensor Fusion Algorithm
preprocress
normalize
merge
c)
Confidence map
Each point in space has a confidence/ probability
AI matching algorithm
coi
Scene classification
• Open Tube with Liquid - Liquid: 55 mm, Tube: 100 mm
• Ground plate - Surface: 3mm
• Closed Tube - Tube: 110 mm
• TSH - Place: 22 mm
...

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/061331

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06V10/80
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)
H04N G06K G06T G01N G06V

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2019/108396 A1 (DAL MUTTO CARLO [US] ET AL) 11 April 2019 (2019-04-11) abstract; figure all paragraphs [0004], [0073], [0083], [0005], [0007], [0181], [0131] - [0156]	1,6,7,11 2-5, 8-10,12
Y	US 2019/306489 A1 (CHENG CHAO-CHUNG [TW] ET AL) 3 October 2019 (2019-10-03) abstract; figure all paragraphs [0027] - [0029]	2-4
Y	US 2016/018427 A1 (STREIBL SEBASTIAN [DE] ET AL) 21 January 2016 (2016-01-21) abstract; figure all paragraph [0066]	5

-/--

[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 June 2023	07/07/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Winne, Dominique

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/061331

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2019 504997 A (SIEMENS HEALTHCARE DIAGNOSTICS INC) 21 February 2019 (2019-02-21) abstract; figure all paragraph [0012] -----	8
Y	US 2021/287370 A1 (SAROFIM EMAD [CH]) 16 September 2021 (2021-09-16) abstract; figure all paragraph [0049] -----	9,10,12

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2023/061331

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		HK 1255411 A1	16-08-2019
		JP 6870826 B2	12-05-2021
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		US 2019033209 A1	31-01-2019
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		JP 2021148793 A	27-09-2021
		US 2021287370 A1	16-09-2021