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(54) Benævnelse: **A ROBOT AND A METHOD OF CONTROLLING A ROBOT**

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(57) Sammendrag:
The present invention relates to a robot comprising a horizontal or horizontally slanted transparent experiment layer being adapted to support items at arbitrary positions on the experiment layer, and a moveable sensor arranged below the transparent experimental layer said sensor being configured for providing a sensor signal indicative of item(s)' location on the experiment layer, an actuator arranged for being moved into different positions above the horizontal transparent layer a display device being configured for visually representing located item(s) a user input device configured for receiving information as to operation of the actuator.

Fortsættes ...

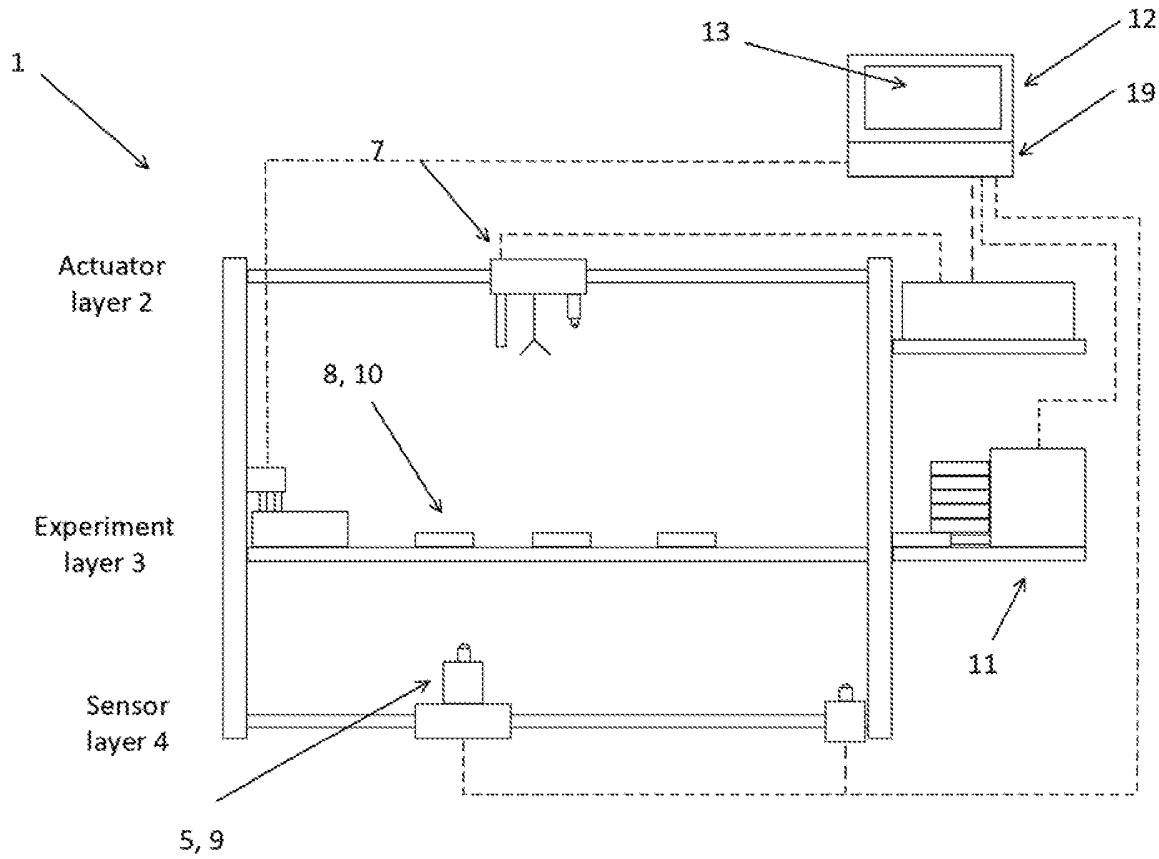

1
13
12
19
7
Actuator
layer 2
8, 10
Experiment
layer 3
11
Sensor
layer 4
5, 9

Fig. 1

A ROBOT AND A METHOD OF CONTROLLING A ROBOT

FIELD OF THE INVENTION

The present invention relates to a robot comprising a horizontal or horizontally slanted transparent experiment layer being adapted to support items at arbitrary positions on the experiment layer, and a moveable sensor arranged below the transparent experimental layer said sensor being configured for providing a sensor signal indicative of item(s)' location on the experiment layer, an actuator arranged for being moved into different positions above the horizontal transparent layer a display device being configured for visually representing located item(s) a user input device configured for receiving information as to operation of the actuator.

The invention also relates to a method of controlling such a robot and to the use of such a robot.

BACKGROUND OF THE INVENTION

Robots are known for manipulating contents in e.g. containers see US 6353774. Such robots reside in the concept of pre-informing the controller of the robot with a set of instructions to be carried out in order to manipulate the content of containers and the prior knowledge of the location of the containers in the robots. The prior knowledge of the locations of the containers in the robots are defined by trays having a plurality of receptacle for receiving a container, thus a container needs to fit into a receptacle with a fixed location in the tray.

While the robot disclosed in US 6353744 is well suited for repeated and automated operations, the robot residence in an automation of repeated operations makes it less versatile to handling e.g. one-of-kind operations.

Hence, an improved robot and use of such a robot would be advantageous.

OBJECT OF THE INVENTION

It is a further object of the present invention to provide an alternative to the prior art.

In particular, it may be seen as an object of the present invention to provide a robot, control of a robot and a use of a robot that solves the above mentioned problems of the prior art.

SUMMARY OF THE INVENTION

Thus, the above described object and several other objects are intended to be obtained in a first aspect of the invention by providing a robot (1) preferably comprising

- a horizontal or horizontally slanted transparent experiment layer preferably being adapted to support items at arbitrary positions on the experiment layer;
- a moveable sensor arranged below the transparent experimental layer, said sensor being configured for providing a sensor signal indicative of item(s)' location on the experiment layer;
- an actuator arranged for being moved into different positions above the horizontal transparent layer;
- a display device being configured for visually representing located item(s);
- a user input device.

A robot according to the present invention preferably further comprises a processor configured to

- on the basis of the sensor signal locate an item on the transparent experiment layer;
- display the located item(s) or a graphical presentation thereof on the display device;
- receive a manipulation input through the user input device; , and
- in response to said manipulation input, control the actuator to manipulate the content of the displayed item(s).

By horizontal or horizontally slanted transparent experiment layer is preferably meant that the surface of the experiment layer is horizontal or is angled (slanted horizontal experimental layer) with respect to horizontal in an amount less than 45 degrees, such as less than 30degress, preferably less than 15 degrees, such as less than 5 degrees.

The manipulation may comprise a number of different types of manipulation, such as substance exchange, such as liquid addition and/or removal , movement of one or more item, stacking of the items or the like.

By arranging the sensor below the experimental layer and the actuator above the experimental layer, the present invention provides the advantage that the sensor and actuator can be operated independently of each other, such as being operated in parallel. This has, inter alia, the effect that the sensor can be used to monitor an experiment carried out on the experiment layer and can thereby signal if something moves, such as moves unintentionally, in the experimental set-up (e.g. by an operator pushes to the robot or the actuator pushes to a container on the experimental layer). Further, mistakes where for instances an operator relocate an item on the experimental layer without informing the robot can be avoided as the sensor may keep track of such movements.

In the present context terms are used in a manner being ordinary to skilled person and some of the terms used are detailed below:

Actuator layer is preferably used to mean the space section of a robot being bordered by the extreme positions of one or more actuators of the robot.

Experimental layer is preferably used to mean the space section of a robot defined by the space at which experiments and/or analysis is carried out.

Sensor layer is preferably used to mean the space section of a robot being bordered by the

Field of view is preferably used to mean that the position within the robot of image obtained by a camera is known.

Support items at arbitrary positions on the experiment layer is preferably used to mean that an item's weight repose on the experimental layer and that the no cavities are provided in the experiment layer to receive the items. Typically and preferably the upper surface of the experiment layer on which the items repose is an even surface.

In a second aspect, the invention relates to a method of controlling the robot according the first aspect of the invention.

The individual aspects of the present invention may each be combined with any of the other aspects. These and other aspects of the invention will be apparent from the following description with reference to the described embodiments.

BRIEF DESCRIPTION OF THE FIGURES

The present invention and in particular preferred embodiments thereof will now be described in more detail with regard to the accompanying figures. The figures show ways of implementing the present invention and are not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim set.

Figure 1 is a schematic side view of a gantry robot according to a first embodiment of the invention,

Figure 2 is a schematic top view of a the gantry robot of fig. 1,

Figure 3 is a schematic view of a combined display device and input device (touch sensitive device) according to a preferred embodiment of the invention.

Figure 4 is a schematic system-chart representing an out-line of/in detail the operations of the controlling of the gantry robot according to a preferred embodiment of the invention, and

Fig. 5 is a schematic illustration of a receptacle according to a preferred embodiment of the invention.

DETAILED DESCRIPTION OF AN EMBODIMENT

Reference is made to fig. 1 which schematically illustrates a robot according to a first embodiment of the invention. It is noted that the embodiment of fig. 1 illustrates the robot as being a gantry robot, but the invention is not limited to

such gantry robots as will be elucidated below. In the following x,y refers to horizontal coordinates and z refers to vertical coordinates.

As illustrated in fig. 1, the robot 1 comprises a horizontal transparent experiment layer 3 being adapted to support items 8 at arbitrary positions at the experiment layer 3. In many practical embodiments, the transparent experiment layer 3 is a plate made from a transparent material such glass, plastic or the like allowing light to pass through the transparent layer 3 to allow items 8 located on the layer 3 to be imaged (or in general sensed) from below through the layer 3. In many preferred embodiments, the term "at arbitrary position" refers to that the transparent layer 3 is a straight plate with no cavities, indentations or the like for receiving the items 5.

The robot further comprising a moveable sensor 5 arranged below the transparent experimental layer 3. The sensor 5 is typically arranged so that it can be moved horizontally in an x,y-plane and the sensor 5 is preferably configured for providing a sensor signal indicative of item(s)' 8 location, e.g. the x,y position, at the experiment layer 3.

The robot further comprising an actuator 7 arranged for being moved into different positions above the horizontal transparent layer 3. Typically, the actuator is moveable in all three directions x,y,z of the robot, so as to allow the actuator to e.g. extract a sample from one item 8, and deliver the sample to another item 8 both items being located on the transparent layer 3.

Thus, a characteristic of a robot according to the present invention is that the actuator 7 is located above the transparent layer 3 and the sensor 5 is located below the transparent layer 3.

The sensor 5 is disclosed above as being configured for determining the position of an item 8; however, the sensor 5 may also be configured for determining a content in an item. For instance the sensor 5 may be configured – assisted by suitable software and hardware – to determining e.g. a bacteria colony count in an item 10.

Further, the robot has a display device 12 being configured for visually representing located item(s) 8. This typically means that the sensor 5 determines the position of an item 8 and an image is shown on the display device 12 illustrating the position of the item 8 on the transparent layer 3 and/or the items relative position to another item 8 located on the transparent layer 3 (see also fig. 3).

In fig. 1 data connections used e.g. for instructing elements of the robot and/or receiving data from such elements are illustrated by dotted lines. It is noted that the processor(s) 19 used in the control of the robot and the display device is(are) in the embodiment shown in fig. 1 built into the display device 12 but may be arranged differently.

Instruction of the robot to carry out a manipulation of items 8 and/or content in the items 5 is typically carried out by use of a user input device 13. Preferably, and as illustrated in fig. 1, the user input is a touch sensitive screen of the display device and the instruction to be carried out by the robot is typically provided by a drag-and-drop (see fig. 3) action. Alternatively or in combination thereto the input device may be a computer mouse (not shown).

The control of the various functions of the robot is carried out by a processor 19 included in the robot or in a computer connected to the robot, e.g. built into the display device 12 as disclosed above. Such a processor – or computer in general – is typically configured to on the basis of the sensor signal(s) to locate an item 8 on the transparent experiment layer 3, to provide e.g. the x,y-coordinates of an item 8.

After the item is located, the processor 19 produces a graphical representation of the located item(s) on the display device 12.

The processor 19 then receives a manipulation input through the user input device 13, and in response to said manipulation input, controls the actuator 7 to manipulate the content of the displayed item(s) 8.

It is noted that although focus in the above have been put in disclosing the system as being user driven, the robot may operate in a fully automated manner if so desired. This could for instance be implemented by the user input being pre-input as a general instruction to perform a given manipulation with a pre-selected set of items 8 such as containers.

An item's 8 location may be described in different reference systems, and it is generally preferred that the location of an item 8 comprising determining the relative position in the robot. This means for instance the an x-y-coordinate system is assigned with a fixed origo on surface of the transparent experimental layer 3 and a position of an item 8 is referenced within this coordinate system. Further, as an item 8 typically has a horizontal extension, the position of the item may be selected either as a projection of the horizontal extension on the experimental layer 3 (whereby the position may be a set of x,y coordinates parametric representation of the projection) and/or a geometrical centre of the item 8.

As disclosed above the sensor 5 may further be adapted to determine the content of an item 8. This means that the sensor 5 may be comprised by a composite sensor having a number of different sensors 5' for sensing different characteristics and being assembled to form the composite sensor 5. Such different sensors 5' may be thermographic sensors, magnetism sensors, microscope, full view camera, laser scanners, web-cam and/or the like.

Although the invention is not limited to a transparent experiment layer 3 extending in one horizontal plane, this is generally preferred e.g. as items 8 can be moved around on the horizontal plane by a simple push-pull operation. However, if for instance a slanted transparent layer 3 is preferred, the items 8 can be maintained a position on the layer e.g. by use of magnetic force. If the items 8 is not magnetisable, a magnetisable element, such as a sheet of metal, may be applied to the item. If a receptacle 17 is used, this receptacle can be made of metal or other magnetisable material or a magnetisable element, such as a sheet of metal may be applied to the receptacle 17.

The manipulation may comprise a number of different actions and in a preferred embodiment, the manipulation comprising exchange content between items 8 supported by the experiment layer 3. In such embodiments, the actuator 7 may preferably comprising a pump such as an actuated syringe for sucking up liquid from an item 8, and deliver the liquid into another item 8 (if the item is a well plate, the actuator may also deliver to another well in the same item).

In a preferred embodiments as illustrated in fig. 1, the robot 1 comprising rails 14 (extending horizontally) and slides 15 arranged on the rails 14 to provide an x-y-movement; the sensor 5 is arranged on one of the slide 15 and this arrangement is arranged below the transparent experiment layer 3 so as to move the sensor 5 horizontally in a plane parallel-displaced to the experimental layer 3.

In many preferred embodiments, the sensor 5 comprises or is formed by a camera 9, such as a standard web camera, with a field of view covering at least a section of the experimental layer 3. As will be elucidated further below, locating of an item by a camera included determining the position of the item 8 in the field of view of the camera and determining the position of the camera, the latter being determined e.g. by keeping track of the movement of the camera or by a calibration step that provides the position of the camera.

In embodiments where the robot 1 is in the form of a gantry robot, the robot has rails 14 and slides 15 arranged above the transparent experiment layer 3 as illustrated in fig. 2. The actuator 5 is arranged on a slide so as to move the actuator 5 horizontally in a plane parallel-displaced to the experimental layer 3 and vertically.

Alternatively to the gantry robot – or in combination thereto - the robot has a robotic arm 6 on which the actuator 7 is arranged. Such a robotic arm 6 is typically a multi axis robotic arm with a pivot position arranged away from the plane defined by the transparent layer 3; that is typically beside extremities of the sensor layer 4 and at the same vertical level as the sensor layer 4.

Common for both the gantry robot and the robotic arm – or a robot in general – is typically, that the actuator 5 may comprise an electronically operated suction or dispensing device, such as a syringe, pipette or the like.

A robot according to the present invention is considered highly versatile as it may handle and manipulate content of item 8 of many different types, and it is has proven to be specially useful for robotic handling of item being containers, such as petri dish, well-plate or the like.

While many such items 8 can be characterised as containers having an at least partially transparent bottom and/or a non-transparent marker 16. Such non-transparent marker 16 may be applied to the item 8 in order to solve visibility issues stemming from a camera having difficulties in locating transparent items and/or may be applied to identify a certain item 8. Such a marker 16 may be in the form of e.g. a bar code or another unique identifier, e.g. a physical element arranged inside and/or outside the item 8.

As illustrated in fig.s 1 and 2, a robot 1 according to the present invention may further comprise an item dispenser 11 configured for dispensing items onto the experimental layer 3. As illustrated in fig. 1 and 2 the item dispenser has a storage for storing a stack of item and a pusher configured to push an item 8 from the stack (typically the lowest item in the stack) and onto the experimental layer 3. If further positioning of an item 8 on the experimental layer is desired, the actuator 8 may be equipped with a device configured for moving the item 8 along around on the experimental layer 3.

In some preferred embodiment, the items 8 (or in general container 10) are received in a receptacle 17. Such a receptacle 17 is adapted to receive e.g. a container and has an open or transparent bottom and/or a non-transparent marker 16. This concept is illustrated in fig. 5. which illustrates in a schematically manner a receptacle 17 having an open bottom 18 – or an at least partially transparent bottom part 18. In the upper part of fig. 5, the receptacle 17 is shown as seen from above and in the lower part of fig. 5, the receptacle 17 is shown in a cross sectional view along line A-A in the upper part of fig. 5. The receptacle may be applied with a non-transparent marker 16 as illustrated in right hand side of

fig. 5 illustrating the receptacle as seen from below. In the embodiment shown in fig. 5, the non-transparent marker is a 4-point star which may be used to indicate the receptacle type or identify the receptacle, which in the latter case often requires that the non-transparent marker is unique for a given receptacle. Other graphical presentations of the non-transparent marker 16, such as bar-codes or the like, can be applied and the actual position on the bottom of the receptacle 17 of the non-transparent marker may be different from what is shown in fig. 5 – for instance the non-transparent marker may be arranged on a transparent bottom of a receptacle.

The invention also relates to a method for controlling a robot 1 according to the present invention. Such a method may typically comprise the steps of:

- obtaining by use of the sensor 5 the location of one or more items 8, if any present, at the experiment layer 3,
- displaying on the display device 12, an image representing the one or more located items 8,
- receiving manipulation input through the user input device 13 indicative of desired exchange of content between the displayed items 8,
- controlling the actuator 7 in accordance with the received manipulation input.

The displaying and manipulation input is schematically illustrated in fig. 1. This figure illustrates a display device imaging two items, a petri dish and a well plate. The manipulation input is illustrated by the "drag and drop" operation where a user e.g points at the petri dish and drags the petri dish onto the well plate. This is translated by the processor 19 of the robot to a manipulation where content of the petri dish is transferred to one of the wells of the well plate.

The sensor is preferably a camera providing a digital image and the step of obtaining the location of one or more items 8 typically comprises

- obtaining the field of view used for providing the digital image;
- for at least one item 8, recognising in the digital image a pre-defined pattern representing the item 8 and the pattern's position in the field of view.

Typically, the pre-defined pattern is a projected contour of an item on the experimental layer 3. Alternatively, or in combination thereto, the pre-defined pattern is or includes an object, preferably not resembling the shape of the item 8, such as bar-code, a QR-code, a polygon, a circle, an ellipse.

In some situation, the manipulation or other externally influences may shift the position of an item during the manipulation and the step of obtaining the location of one or more items 8 may be repeated a number of time during the time at which a manipulation is carried out and the thereby obtained locations for each item 8 are compared to identify movements of the items during manipulation. This can be used to generate an error signal if a movement of an item is identified as being larger than a predefined threshold. If such an error signal is generated, the manipulation may be changed or aborted so as e.g. to assure that the manipulation is carried out as instructed.

While the above disclosure of the method according to the invention focus of the locating of items the method may advantageously also comprise the step of obtaining by use of the sensor 5 for an item 8 a signal representing the content of the item 8, such as a number of bacteria colonies in a petri dish. Thereby the robot can be used both as a manipulation device and as a measuring device in broad terms.

The obtaining by use of the sensor 5 for an item 8 a signal representing the content of the item 8 is repeated a plurality of time so as to obtain a plurality of consecutive signals each representing the content of the item 8 at different time instances. Thereby time series may be obtained representing e.g. a process occurring in an item 8.

Also the actuator 7 may be devised with a sensor for sensing one or more properties in or of items 8 arranged on the experimental layer 3.

The invention can be implemented by means of hardware, software, firmware or any combination of these. The invention or some of the features thereof can also be implemented as software running on one or more data processors and/or digital signal processors.

The individual elements of an embodiment of the invention may be physically, functionally and logically implemented in any suitable way such as in a single unit, in a plurality of units or as part of separate functional units. The invention may be implemented in a single unit, or be both physically and functionally distributed between different units and processors.

Reference is made fig. 4 being a flow chart schematically illustrating preferred steps carried out in connection with the present invention. As illustrated in fig. 4, the sensor 5, provides the location of items – in the embodiment of fig. 4, the items are containers – on the experimental layer 3. The location is send to the input device and to the actuator.

On the input device, the user is presented with the information provided by or related to the information provided by the sensor, that is typically an image showing the item identified and the items position relative to another item. It is noted if for instance a digital image is obtained, the image shown on the input device may be the digital image but may alternatively be another graphical presentation of the item.

The input device is typically as disclosed above, a touch sensitive screen and the user may instruct the robot to carry out operations on the items by a drag-and-drop operation as illustrated in fig. 3.

Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is to be interpreted in the light of the accompanying claim set. In the context of the claims, the terms "comprising" or "comprises" do not exclude other possible elements or steps. Also, the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. The use of reference signs in the claims with respect to elements indicated in the figures shall also not be construed as limiting the scope of the invention. Furthermore, individual features mentioned in different claims, may possibly be advantageously combined, and the mentioning of these features

in different claims does not exclude that a combination of features is not possible and advantageous.

List of reference symbols used:

1	Robot
2	Actuator layer
3	Experimental layer
4	Sensor layer
5	Sensor
6	Robotic arm
7	Actuator
8	Item
9	Camera
10	Container
11	Item dispenser
12	Display device
13	User input device
14	Rail
15	slide
16	Non-transparent marker
17	Receptacle
18	Opening in receptacle
19	Processor

CLAIMS

1. A robot (1) comprising

- a horizontal or horizontally slanted transparent experiment layer (3) being adapted to support items (8) at arbitrary positions on the experiment layer (3);
- a moveable sensor (5) arranged below the transparent experimental layer (3) said sensor being configured for providing a sensor signal indicative of item(s)' (8) location on the experiment layer (3);
- an actuator (7) arranged for being moved into different positions above the horizontal transparent layer (3);
- a display device (12) being configured for visually representing located item(s) (8);
- a user input device (13);

wherein the robot further comprising a processor (19) configured to

- on the basis of the sensor signal locate an item (8) on the transparent experiment layer (3);
- display the located item(s) or a graphical presentation thereof on the display device (12);
- receive a manipulation input through the user input device (13), and
- in response to said manipulation input, control the actuator (7) to manipulate the content of the displayed item(s) (8).

2. A robot (1) according to claim 1, wherein the location of an item (8) comprising determining the relative position in the robot of the item (8).

3. A robot (1) according to claim 1 or 2, wherein the sensor (5) further being adapted to determine the content of an item (8).

4. A robot (1) according to any of the preceding claims, wherein the transparent experiment layer (3) extends in one horizontal plane.

5. A robot (1) according to any of the preceding claims, wherein the manipulation comprising exchange content between items (8) supported by the experiment layer (3)

4. A robot (1) according to any of the preceding claims, wherein the robot comprising rails (14) and slides (15) arranged below the transparent experiment layer (3) and on which the sensor (5) is arranged so to move the sensor (5) horizontally in a plane parallel-displaced to the experimental layer (3).

5. A robot (1) according to any of the preceding claims, wherein the sensor (5) comprising a camera (9), such as an digital camera, such as an optical coherence tomography camera, with a field of view covering at least a section of the experimental layer (3).

6. A robot (1) according to any of the preceding claims, wherein the robot comprising rails (14) and slides (15) arranged above the transparent experiment layer (3) and on which the actuator (5) is arranged so to move the actuator (5) horizontally in a plane parallel-displaced to the experimental layer (3) and vertically.

7. A robot (1) according to any of the preceding claims 1-5, wherein the robot comprising a robotic arm (6) on which the actuator (7) is arranged.

8. A robot (1) according to any of the preceding claims, wherein the actuator (5) comprising an electronically operated suction and dispensing device, such as a syringe, pipette or the like.

9. A robot (1) according to any of the preceding claims, wherein one or more of the items are containers (8), such as petri dish, well-plate or the like.

10. A robot (1) according to any of the preceding claims 1-8, wherein one or more of the items are receptacles (17) having an at least partially transparent bottom and/or a non-transparent marker (16).

11. A robot (1) according to any of the preceding claims, further comprising an item dispenser (11) configured for dispensing items onto the experimental layer (3).

12. A robot (1) according to any of the preceding claims, wherein the display device (12) and input device (13) together is a touch sensitive display device.

13. A receptacle (17) for use in a robot (1) according to any of the preceding claims, the receptacle (17) being adapted to receive a container and having an open or transparent bottom and/or a non-transparent marker.

14. A method for controlling a robot (1) according to any of the preceding claims, the method comprising the steps of:

- obtaining by use of the sensor (5) the location of one or more items (8), if any present, at the experiment layer (3),
- displaying on the display device (12), an image representing the one or more located items (8),
- receiving manipulation input through the user input device (13) indicative of desired exchange of content between the displayed items (8),
- controlling the actuator (7) in accordance with the received manipulation input.

15. A method according to claim 14, wherein the sensor is a camera providing a digital image and the step of obtaining the location of one or more items (8) comprising

- obtaining the field of view used for providing the digital image;
- for at least one item (8), recognising in the digital image a pre-defined pattern representing the item (8) and the pattern's position in the field of view.

16. A method according to claim 15, wherein the pre-defined pattern is a projected contour of an item on the experimental layer (3).

17. A method according to claim 15, wherein the pre-defined pattern is an object, preferably not resembling the shape of the item (8), such as bar-code, a QR-code, a polygon, a circle, an ellipse.

18. A method according to any of the preceding claims 15-17, wherein the manipulation input comprising:

- selecting one or more items (8) to obtain a manipulated content
- instructing the robot to provide the manipulated content.

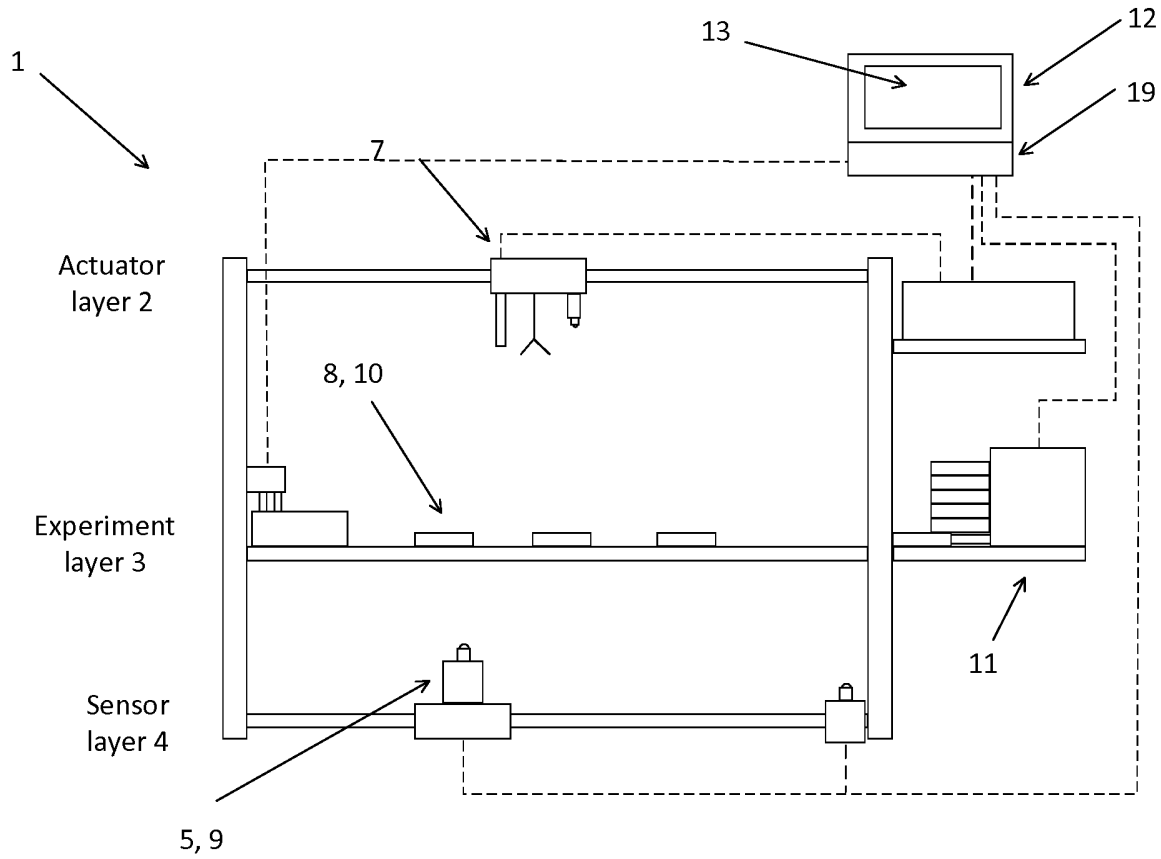
19. A method for controlling a gantry robot according to any of the claims 15-19, wherein step of obtaining the location of one or more items (8) is repeated a number of time during the time at which a manipulation is carried out and the thereby obtained locations for each item (8) are compared to identify movements of the items during manipulation.

20. A method according to claim 19, further comprising generating an error signal if a movement of an item is identified as being larger than a predefined threshold.

21. A method according to any of the claims 15-20, the method comprising

- obtaining by use of the sensor (5) for an item (8) a signal representing the content of the item (8), such as a number of bacteria colonies in a petri dish.

22. A method according to claim 21, wherein the obtaining by use of the sensor (5) for an item (8) a signal representing the content of the item (8) is repeated a plurality of time so as to obtain a plurality of consecutive signals each representing the content of the item (8) at different time instances.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Actuator layer 2
8, 10
Experiment layer 3
11
Sensor layer 4
5, 9

Fig. 1

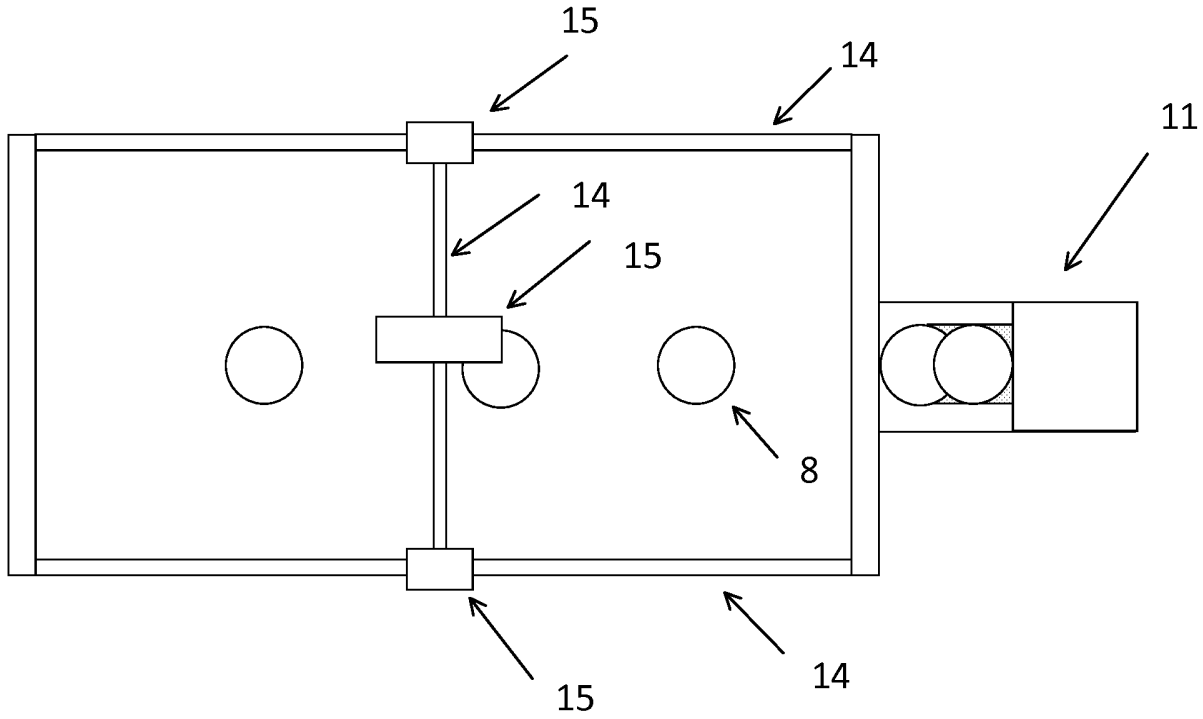
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Fig. 2

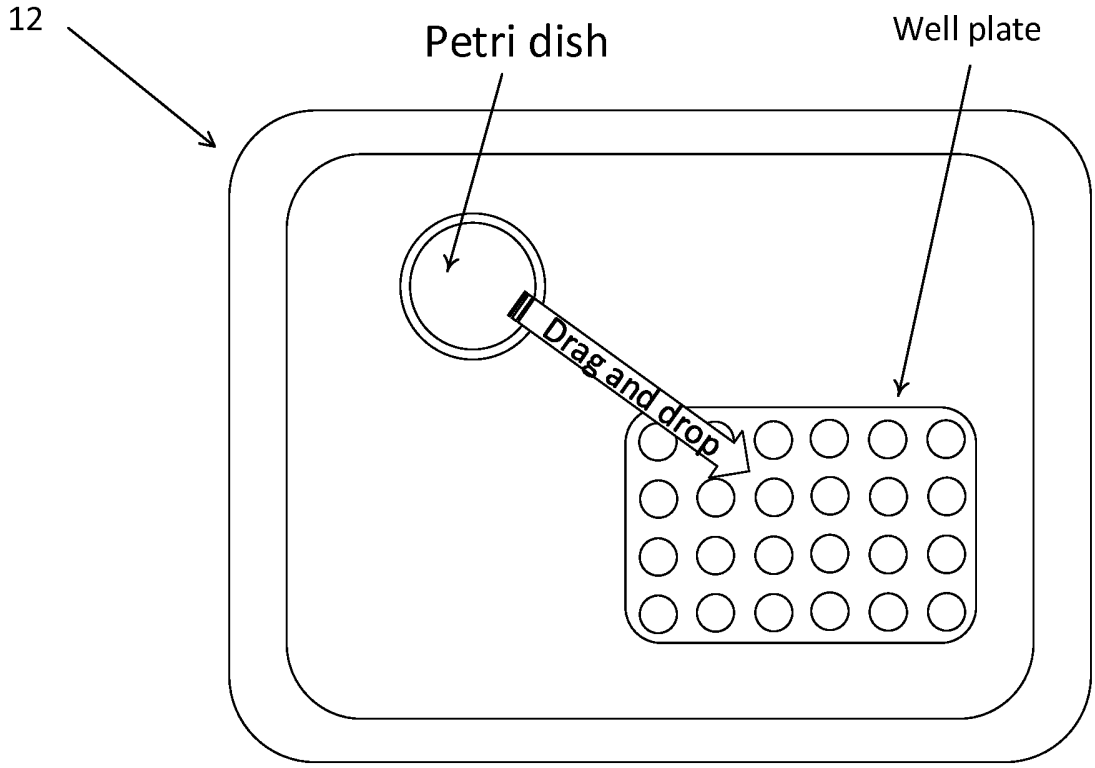

Fig. 3

Actuator

Fig. 4

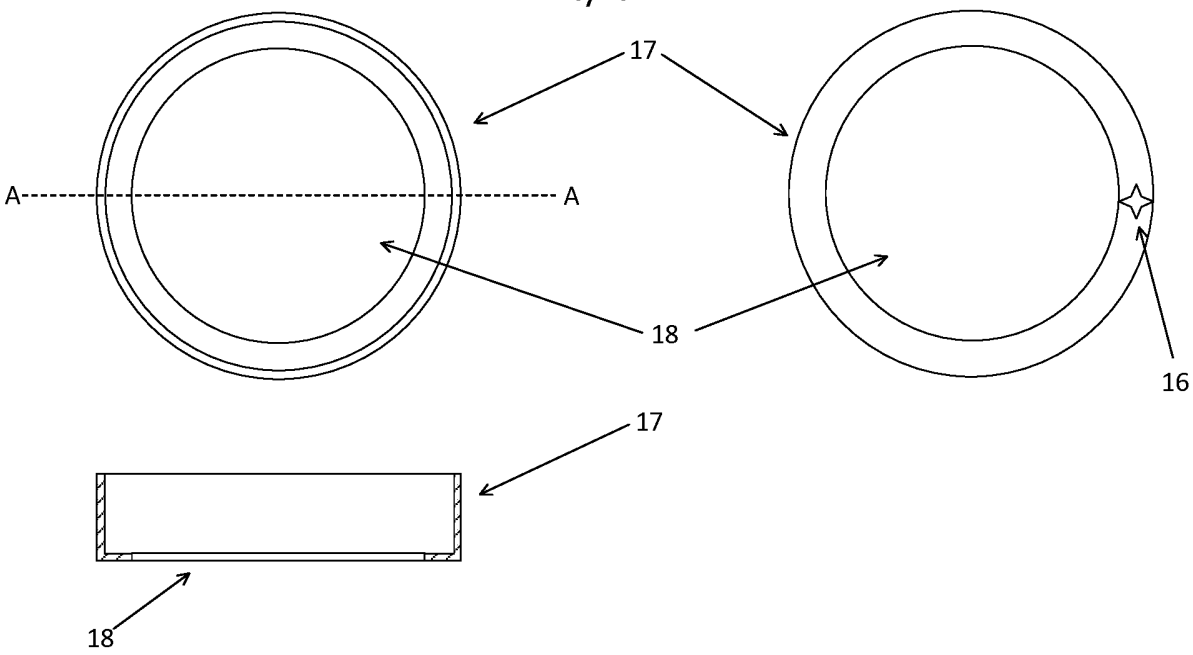

Fig. 5

DANISH PATENT AND TRADEMARK OFFICE

SEARCH REPORT - PATENT	Application No. PA 2016 70155

1. ☐ Certain claims were found unsearchable (See Box No. I).

2. ☐ Unity of invention is lacking prior to search (See Box No. II).

A. CLASSIFICATION OF SUBJECT MATTER

B25J 9/16 (2006.01); B25J 21/00 (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC&CPC&FICLA: B25J, G01N, G05B

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

DK, NO, SE, FI: IPC-classes as above.

Electronic database consulted during the search (name of database and, where practicable, search terms used)

EPODOC, WPI, FULL TEXT: ENGLISH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
A	US 6353774 B1 (GOLDENBERG et al.) 05 March 2002. See abstract, description col. 1, lin. 32 - 46, col. 5, lin. 16 - 61, col. 6, lin. 23 - 51, col. 7, lin. 47 - col. 8, lin. 35, claims 1, 2, 9, 13, 17 and figs. 1 , 2, 6, 8, 11, 12 and 14.	1 - 22
A	EP 0980523 A1 (NEUROSEARCH AS) 23 February 2000. See claim 1, sections [0139], [0141] and fig. 1.	1 - 22
A	EP 2745997 A1 (YASKAWA DENKI SEISAKUSHO KK) 25 June 2014. See abstract, section [0073] and fig. 1A.	1 - 22

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

* Special categories of cited documents:	
"A" Document defining the general state of the art which is not considered to be of particular relevance.	
"D" Document cited in the application.	
"E" Earlier application or patent but published on or after the filing date.	
"L" Document which may throw doubt 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 filing date but later than the priority date claimed.
	"T" Document 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.

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Date of completion of the search report
3 January 2017

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SEARCH REPORT - PATENT		Application No. PA 2016 70155
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
A	US 2013/0065797 A1 (SILBERT, ROLF) 14 March 2013. See abstract, sections [0010], [0101], [0104], [0217] figs. 1, 8, 9, and 12 - 14.	1 - 22
A	US 2014/0071580 A1 (HIGGINSON et al.) 13 March 2014. See abstract, section [0062] and fig. 1.	1 - 22
A	US 2009/0080611 A1 (GANZ et al.) 26 March 2009. See abstract, section [0066], figs. 1, 7, 8, and 26 - 30.	1 - 22
A	WO 2013/070744 A2 (BECKMAN COULTER INC) 16 May 2013. See abstract, sections [0035], [0065], [0075] - [0084], [0087] - [0107] and figs. 1 and 5a.	1 - 22

SEARCH REPORT - PATENT	Application No. PA 2016 70155

Box No. I Observations where certain claims were found unsearchable

This search report has not been established in respect of certain claims for the following reasons:

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

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

3. ☐ Claims Nos.:
because of other matters.

Box No. II Observations where unity of invention is lacking prior to the search

The Danish Patent and Trademark Office found multiple inventions in this patent application, as follows:

SEARCH REPORT - PATENT	Application No. PA 2016 70155

SUPPLEMENTAL BOX

Continuation of Box [.]