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(71) Applicant: ABB SCHWEIZ AG [CH/CH]; Brown Boveri
Strasse 6, 5400 Baden (CH).

(72) Inventor: LANDERNÄS, Krister; Tegelbruksvägen 17,
734 31 Hallstahammar (SE).

(74) Agent: KRANSELL & WENNBORG KB; P.O. Box
27834, 115 93 Stockholm (SE).

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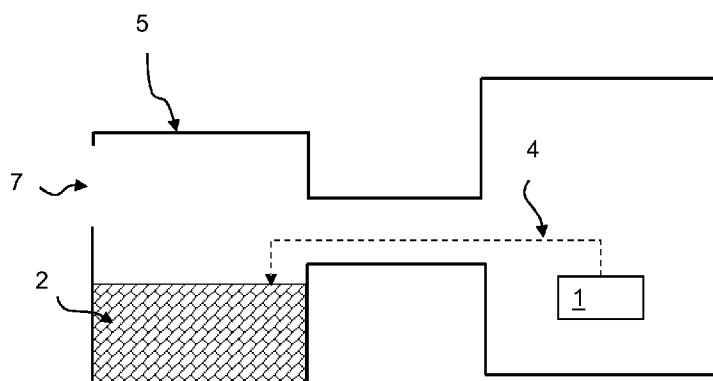


FIG. 2

(57) Abstract: The present disclosure relates to robotics, and in particular to mobile robots. In particular the disclosure relates to a control arrangement and a method for operating a mobile robot in a safety mode. According to a first aspect, the disclosure relates to a method for operating a mobile robot (1) in a safety mode. The method comprises receiving an instruction to activate a safety mode of the mobile robot (1), obtaining location information identifying one or more safety areas (2) associated with the activated safety mode and obtaining a present position of the mobile robot (1). The method also comprises controlling the mobile robot (1) to move to one of the safety areas (2) upon determining that the present position of the mobile robot (1) is located outside the one or more safety areas (2) and controlling the mobile robot to stop inside the safety area (2). Thereby, increased safety may be achieved as the mobile robot will not only stop, but also move to a "safety area" if something goes wrong. The disclosure also relates to a control arrangement, to a mobile robot, to a computer program and to a computer program product for performing the method.



A mobile robot and a method for operating a mobile robot in a safety mode

Technical field

5 The present disclosure relates to robotics, and in particular to mobile robots. In particular the disclosure relates to a control arrangement and a method for operating a mobile robot in a safety mode. The disclosure also relates to a control arrangement, to a mobile robot, to a computer program and to a computer program product for performing the method.

10 Background

The introduction of mobile robots is foreseen to become the next frontier in industrial automation. In areas like logistics and healthcare, mobile robots are already starting to be introduced. Many times, robots are working side by side with regular staff and in healthcare also near patients.

15 As well as other safety critical systems, robots may need to enter a safety mode if something goes wrong. For stationary robots this for example implies stopping the movement of the robot arm in a controlled fashion. Several techniques for handling emergency-stops for stationary robots have been proposed. For example, EP1705539A1 discloses an emergency-stop device provided in a robot
20 system, a machine tool or the like, arranged to promptly detect failure of a circuit through which an emergency stop signal is supplied to an CPU, without stopping the mobile robot system, the machine tool or the like, to improve reliability.

However, for mobile robots, the safety mode becomes more complex, since it can depend on location and situation. Consequently, there is a need for improved
25 ways of operating mobile robots in a safety mode.

Summary

It is thus an object of the disclosure to alleviate at least some of the drawbacks with the prior art. It is a further object to provide improved ways of operating mobile robots in a safety mode.

According to a first aspect, the disclosure relates to a method for operating a mobile robot in a safety mode. The method comprises receiving an instruction to activate a safety mode of the mobile robot, obtaining location information identifying one or more safety areas associated with the activated safety mode and obtaining a present position of the mobile robot. The method also comprises controlling the mobile robot to move to one of the safety areas upon determining that the present position of the mobile robot is located outside the one or more safety areas and controlling the mobile robot to stop inside the safety area. Thereby, increased safety may be achieved as the mobile robot will not only stop its motion, but also move to a "safety area" if something goes wrong.

According to some embodiments, the obtaining location information comprises obtaining one or more safe routes associated with the safety areas and wherein the controlling comprises controlling the mobile robot to move along one of the obtained safe routes to one of the one or more safety areas. Thereby, increased safety may be achieved as the mobile robot will move along a safe route.

According to some embodiments, the method comprises obtaining pose information identifying one or more safe poses associated with the safety mode and controlling the mobile robot to move to one of the one or more safe poses identified by the pose information. Thereby, the robot arm may be stopped in a safe pose e.g. straight up, when the robot is located in the safety area, and on its way there.

According to some embodiments, the instruction to activate the safety mode originates from the mobile robot itself, from another mobile robot or from an external device. Thereby, the safety mode may be activated in different situations.

According to some embodiments, the method comprises evaluating the obtained present position of the mobile robot with respect to the one or more safety areas. By analyzing the present position of the mobile robot with respect to the one or more safety areas, it is possible to determine whether relocation is needed.

According to some embodiments, the evaluating comprises selecting, based on the present position of the mobile robot, a safety area to which the mobile robot shall be moved. Hence, different safety areas may be used depending on the location of the mobile robot when the instruction to activate the safety mode is received.

According to some embodiments, the selecting a safety area comprises selecting the safety area that is closest to the present position of the mobile robot. By selecting the closest safety area, the time required to reach the safety area may be minimised.

According to some embodiments, the selecting a safety area comprises selecting the safety area using a table that maps positions of the mobile robot to a respective safety area. This is a simple and fast way of selecting safety areas, which does not require time or processing power.

According to some embodiments, the selecting comprises selecting the safety area based on the type of safety mode, positions of other mobile robots and positions of other objects. Thereby, the safety area may be selected to avoid collisions.

According to some embodiments, the evaluating comprises determining, based on the present position of the mobile robot, a safe route to the selected safety area. Thus, if there are different possible safe routes one may be selected.

According to some embodiments, the method comprises determining whether any other mobile robot is positioned in the determined safe route. Thereby, it possible to move any robot that is in the way. According to some embodiments, the method comprises controlling another mobile robot to move in order to enable the mobile robot to move to one of the safety areas. Thereby, the mobile robot is enabled to move to the safety area.

According to a second aspect, the disclosure relates to control arrangement for operating a mobile robot. The control arrangement is configured to receive an

instruction to activate a safety mode of the mobile robot, to obtain location information identifying one of more safety areas associated with the activated safety mode and to obtain a present position of the mobile robot. The control arrangement is also configured to control the mobile robot to move to one of the
5 safety areas upon determining that the present position of the mobile robot is located outside the one or more safety areas and to control the mobile robot to stop inside the safety area.

According to a third aspect, the disclosure relates to mobile robot comprising a transportation mechanism configured to move the mobile robot to a safety area
10 and the control arrangement according to the second aspect.

According to a fourth aspect, the disclosure relates to a computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the method according to the first aspect.

According to a fifth aspect, the disclosure relates to a computer-readable medium
15 comprising instructions which, when executed by a computer, cause the computer to carry out the method according to the first aspect.

Brief description of the drawings

Fig. 1 illustrates a mobile robot and a control arrangement.

Fig. 2 illustrates a mobile robot operating in an area comprising a safety area.

20 Fig. 3 illustrates a scenario, where another robot is located in the route between a mobile robot a safety area.

Fig. 4 illustrates two different routes to a safety area.

Fig. 5a and 5b illustrate flow charts for operating a mobile robot in a safety mode.

Fig. 6 illustrates a robot controller configured to implement, at least parts of, the
25 proposed method.

Fig. 7 illustrates a control system configured to implement, at least parts of, the proposed method.

Detailed description

The inventive concept will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplifying embodiments are shown. The inventive concept may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, 5 these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the inventive concept to those skilled in the art. Like numbers refer to like elements throughout the description.

The proposed solution is based on the insight that when activating a safety mode 10 of a mobile robot, only moving the robot arm in a controlled fashion may not achieve a safe situation, as the mobile robot may be located in an unsafe area. It is therefore proposed to extend the concept of a safety mode for a mobile robot to also include the location of the mobile robot e.g. in an industrial building. More specifically, it is proposed to introduce safety areas and, in some embodiments, 15 also safe routes. The safety areas and safe routes are areas and routes that the mobile robot should use when a safety mode is active. In other words, it is herein proposed that when a safety mode is activated, the robot arm (and the mobile robot) will not only stop moving, but the mobile robot will also relocate itself to a safety area. In some embodiments, the mobile robot will follow a safe route to the 20 safety area.

For example, in an emergency stop situation the movement of the robot arm will typically immediately be stopped in a controlled fashion. However, the entire robot will continue to move until a safety area has been reached. A safety area is e.g. a place where the mobile robot is not in the way of other robots or people. In some 25 embodiments, the mobile robot is moved to the safety area along a safe route. The safety areas and safe routes may vary e.g. depending on the location of the mobile robot.

FIG. 1 shows an example mobile robot 1 where the proposed technique may be implemented. In Fig.1, the mobile robot 1 is an industrial robot comprising one

robot arm 15. However, it must be anticipated that the proposed technique may be used on any robot, e.g. in a robot comprising two arms.

The mobile robot 1 comprises a robot controller 100 and a robot arm 15 comprising an interface 13. In operation, a robot tool, such as a gripper, is typically attached to the interface 13 at the outer part of the robot arm 15. The robot arm 15 comprises one or more links connected to each other via joints and motion mechanisms adapted to set the robot arm 15 in motion. Each motion mechanism typically comprises a motor unit and a brake unit (not shown).

The mobile robot 1 is mounted on a mobile platform 14 comprising a transportation mechanism 12, e.g. wheels or a band, such that the mobile robot 1 may move around during operation. The transportation mechanism 12 is typically operated by a motor unit and a brake unit (not shown). In other words, the mobile robot comprises (or is provided with) a transportation mechanism 12 configured to move the mobile robot 1.

The robot controller 100 is configured to control the operation of the mobile robot 1 by controlling the speeds of the motion mechanisms of the robot arm 15 and of the transportation mechanism 12. The robot controller 100 communicates with a control system 200. The robot controller 100 and the control system 200 will be described in detail below, with reference to Fig. 6 and Fig. 7.

In some embodiments the mobile robot 1 also comprises positioning circuitry 11 configured to determine a present position, or location, of the mobile robot. The location circuitry uses standard positioning means e.g. a GPS unit. Alternatively, the present location may be determined by the control system 200, which determines the position of the mobile robot e.g. using cameras or triangulation.

The control system 200 may also know the location of the mobile robot 1 in beforehand, according to predetermined working plan of the robots. Thus, the positioning circuitry 11 may be omitted, and is therefore illustrated with dashed lines.

Fig. 2 illustrates a mobile robot 1 operating in an area (e.g. an industrial building) delimited by walls 5. The area comprises a safety area 2, where the mobile robot 1 should be located when the safety mode is activated. The safety area 2 is selected such that the mobile robot 1 will not block the emergency exit 7. In this example, the shortest way to the safety area 2 would also be a safe route 4.

Fig. 3 illustrates a situation, where a second robot 3 prevents a first mobile robot 1 from moving into a safety area 2. In this scenario the safety mode would typically imply that both robots 1, 3 would stop moving. However, because the mobile robot 1 is outside the safety area 2, it must move into the safety area 2 before stopping. In this scenario the second robot 3 needs to move out of the way before stopping, to allow the first robot 1 to enter the safety area 2. It is easy to envision other cases like this.

Fig. 4 illustrates two possible routes 4, 4' for moving a mobile robot 1 from its present position to a safety area 2. In this case the longer route 4 is considered to be a safe route 4 because the shorter route 4' passes an emergency exit 7, which should not be used in order to avoid the risk that the mobile robot 1 would be in the way of (or even block) the emergency exit 7.

The proposed technique will now be described in further detail with reference to Fig. 5a, which illustrates a flow chart of method for operating a mobile robot 1 in a safety mode. Reference is also made to the examples of Fig. 1 to Fig. 4. The method may be performed when a safety mode is activated for one or more mobile robots 1, 3. For example, it may be a fire alarm that activates the safety mode in several robots in an industry area. Alternatively, the safety mode is activated because an error is detected in the mobile robot 1. In this case the safety mode is typically not activated in other mobile robots 3 in the industry area. In other words, they would typically continue to operate in normal mode.

The method is typically implemented as a computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the method. According to some embodiments the computer

program is stored in a computer-readable medium that comprises instructions which, when executed by a computer, cause the computer to carry out the method. Since the proposed functionality is critical it may reside either in a control system 200 e.g. a local cloud-based controller and/or in the mobile robot itself, i.e.

5 in the robot controller 100. This redundancy will prevent wrong behaviour in case the network goes down. The cause for the safety mode to initiate can originate from the mobile robot 1 (e.g. some malfunction) or it can be initiated from an external system (e.g. fire alarm). This implies that the safety mode could affect one, several or all robots in a given area.

10 The method is typically initiated when the safety mode is activated. In other words, the method comprises receiving S1 an instruction to activate a safety mode of the mobile robot 1. For example, the safety mode is activated due to a fire alarm or when an internal sensor of the mobile robot 1 indicates that something is wrong. Hence, the instruction to activate the safety mode may
15 originate from the mobile robot 1 itself, from another mobile robot 3 or from an external device, such as from the control system 200.

To activate the safety mode, the mobile robot 1 must know where it would be safe to stop. For this purpose, location information that identifies safety areas 2 may be pre-defined within the robot controller 100 or may be determined by the robot
20 controller 100, based on information that the robot controller 100 has about its surroundings. Alternatively, location information is provided by a control system 200. In other words, the method further comprises obtaining S2 location information identifying one or more safety areas 2 associated with the activated safety mode.

25 The location information may also define one or more routes 4 that the mobile robot 1 should use while moving to the safety areas. Stated differently, in some embodiments the obtaining S2 location information comprises obtaining one or more safe routes 4 associated with the safety areas 2. The routes may be defined such that the mobile robot 1 is not in the way of people or other mobile robots 3

operating in the same area. Alternatively, or in addition, the routes are defined such that the mobile robot 1 may be moved to the safety area as quickly as possible.

The safety mode may also imply that the robot arm (or arms) 15 (if present) should be stopped in a certain position (also referred to as a pose of the mobile robot 1), e.g. straight up. If the arm does not point straight up when it is stopped, there is a risk that the mobile robot 1 will collide with an obstacle on its way to a safety area. If the robot comprises several arms, then it must be appreciated that each arm 15 may be associated with a certain pose. Hence, in some embodiments the method, comprises obtaining S3 pose information identifying one or more safe poses associated with the safety mode.

To be able to activate the safety mode the present location of the mobile robot needs to be determined. Hence, the method further comprises obtaining S4 a present position of the mobile robot 1. The present position may be provided by the positioning circuitry 11 of the mobile robot (if present). Alternatively, the present position may be retrieved from a control system 200, as described in connection with Fig. 1.

The present position of the mobile robot 1 and the location information may then be analyzed to determine whether the mobile robot 1 needs to be moved. In other words, the method comprises evaluating S5 the obtained present position of the mobile robot 1 with respect to the one or more safety areas 2.

An example of the evaluating S5 is described in Fig. 5b. In this example, the evaluating comprises evaluating S5a whether the mobile robot 1 is located outside the one or more obtained safety areas 2. This is for example done by comparing the coordinates of the present position with the coordinates of the one or more safety areas 2.

If the mobile robot 1 is located outside the one or more obtained safety areas 2, then a safety area 2 to which the mobile robot shall be moved is selected S5b,

based on the present position of the mobile robot 1. For example, the safety area 2 that is closest to the present position of the mobile robot may be selected.

Alternatively, the selection S5b may be made using a table that maps positions of the mobile robot 1 to a respective safety area. Hence, it is possible, that for each position in the industry area, there is a corresponding safety area and possibly also a safe route. Another possibility is that the safety area 2 is selected S5b based on the type of the safety mode, positions of other mobile robots 3 and positions of other objects. For example, one safety area 2 may be used for internal errors, while another safety area 2 may be used for emergency stops.

10 In some embodiments, the evaluating S5 further comprises determining S5c, based on the present position of the mobile robot 1, a safe route 4 to the selected safety area 2. If a table is used (as described above) then the safe routes may also be included in the table. In this case, it may also be relevant to investigate whether any other robots are positioned in the safe route, as they might need to
15 be moved in order to enable the relocation. Hence, in some embodiments the evaluating S5 comprises determining S5d whether any other mobile robot 3 is positioned in the determined safe route 4. Alternatively, a safe route may be determined S5c, such that other robots or people in the industry area are avoided.

Now turning back to Fig. 5a. After analyzing the present position in view of the location information the activation if the safety mode is started. If the pose
20 information identifying one or more safe poses associated with the safety mode has been obtained, then the method comprises controlling S6 the mobile robot 1 to move to one of the one or more safe poses identified by the pose information. After moving to the safe pose, the robot arm 15 is typically halted i.e. stopped. In
25 some embodiments a braking mechanism is activated. In other words, the robot arm 15 is moved to a safe pose, e.g. an upright position, before it is halted.

Furthermore, if it is determined that the present position of the mobile robot 1 is located outside the one or more safety areas 2, then the mobile robot needs to be

moved. If the mobile robot 1 is already in a safety area, the mobile robot 1 may simply stay where it is (i.e. stop), as described in step S10 below.

If the evaluation S5 reveals that there are other mobile robots 3 that prevent the evacuation to a safety area (e.g. as in Fig.4), then these mobile robots need to be
5 moved before the evacuation. In other words, in some embodiments, the method comprises controlling S8 another mobile robot 3 to move in order to enable the mobile robot 1 to move to one of the safety areas 2. This may be done by communicating with the other mobile robot 3 either directly or via the control system 200. Alternatively, the control system 200 is configured to control all
10 robots in the industry area, which makes it possible to coordinate the evacuation.

When all measures needed to clear the route to the safety area are taken, the moving of the mobile robot 1 to the safety area 2 starts. In other words, the method further comprises controlling S9 the mobile robot 1 to move to one of the safety areas upon determining S6 that the present position of the mobile robot 1 is
15 located outside the one or more safety areas 2. More specifically, the control arrangement 100, 200 controls the transportation mechanism 12 to relocate the mobile robot to a (selected) safety area. If the location information has identified one or more safe routes 4 associated with the safety areas 2 then the controlling S9 comprises controlling the mobile robot to move along one of the obtained safe
20 routes 4 to one of the one or more safety areas 2.

When the mobile robot 1 is positioned in a safety area, the mobile robot 1 is stopped, i.e. the transportation mechanism 12 is halted and possibly also braked. Stated differently, the method further comprises controlling S10 the mobile robot 1 to stop inside the safety area.

25 It must be noted that the steps may be carried out in another order e.g. so that the mobile robot 1 is first moved to the safety area 2 and then to the safe pose. Alternatively, the robot arm may be (moved and) stopped before the evaluation S5 of the present position starts.

The disclosure also relates to a control arrangement for operating a mobile robot 1. In some embodiments, such a control arrangement comprises a robot controller 100. In other embodiments, the control arrangement comprises a control system 200 or a combination of a robot controller 100 and a control system 200. The
5 robot controller 100 may also have overlapping functionality to achieve redundancy e.g. upon communication failure therebetween.

The control arrangement 100, 200 is configured to perform all aspects of the method described in Fig. 5a and 5b. The control arrangement 100, 200 may comprise one or several computing devices including at least one processor and
10 memory. In general, a software system for implementing the proposed technique may be structured in different ways, while still achieving the same effects and user experience. More specifically, the control arrangement 100, 200 is configured to receive an instruction to activate a safety mode of the mobile robot 1, to obtain location information identifying one of more safety areas 2 associated with the
15 activated safety mode and to obtain a present position of the mobile robot 1. In addition, the control arrangement 100, 200 is configured to control the mobile robot 1 to move to one of the safety areas upon determining that the present position of the mobile robot 1 is located outside the one or more safety areas 2 and to control the mobile robot 1 to stop inside the safety area. The control
20 arrangement 100, 200 is configured to implement all aspects of the method as described in connection with Fig. 5a and 5b.

Fig. 6 illustrates a robot controller configured to implement, at least parts of, the proposed method. The robot controller 100 typically comprises one, or several, processors 110 and memories 120. The processor 110 may be a processor
25 module such a CPU (Central Processing Unit) or a microcontroller. The memory 120 may comprise a non-volatile memory and/or a removable memory such as a USB (Universal Series Bus) memory stick. The robot controller 100 also comprises appropriate communication interfaces 130 for handling communication e.g. with a control system 200. The communication interfaces are typically using
30 wireless communication, to allow mobility of the mobile robot. The communication

interfaces are e.g. implemented using, Bluetooth, Wi-Fi or cellular communication (as standardised by 3GPP).

Fig. 7 is a control system 200 configured to implement, at least parts of, the proposed method. The control system 200 is e.g. a central control system configured to control one or more mobile robots 1. For example, one control system is configured to control a plurality of mobile robots 1, 3 in an industry area. In its simplest form, the remote system is a simple user device such as a personal computer, which has software configured to remotely control the mobile robots 1, 3 installed thereon. The control system 200 comprises a processor 210, a communication interface 230 and a memory 220. The processor 210 may be any commercially available processing device, such as a CPU, DSP, a microprocessor, an FPGA, an ASIC, or any other electronic programmable logic device, or a combination thereof.

The communication interface 230 is configured to enable communication with mobile robots 1. The communication interfaces are typically using wireless communication, to allow mobility of the mobile robot. The communication interfaces are e.g. implemented using, Bluetooth, Wi-Fi or cellular communication (as standardised by 3GPP).

The memory 220 may include non-volatile memory or volatile memory, or a combination thereof, including but not limited to ROM, PROM, EEPROM, flash memory, removable memory, RAM, DRAM, SRAM, cache memory, hard drive, storage medium, etc.

The present invention is not limited to the above-described preferred embodiments. Various alternatives, modifications and equivalents may be used. Therefore, the above embodiments should not be taken as limiting the scope of the invention, which is defined by the appending claims.

Claims

1. A method for operating a mobile robot (1) in a safety mode comprising:
 - receiving (S1) an instruction to activate a safety mode of the mobile robot (1).
 - 5 - obtaining (S2) location information identifying one or more safety areas (2) associated with the activated safety mode,
 - obtaining (S4) a present position of the mobile robot (1),
 - controlling (S9) the mobile robot (1) to move to one of the safety areas upon determining (S6) that the present position of the mobile robot (1)
 - 10 is located outside the one or more safety areas (2), and
 - controlling (S10) the mobile robot (1) to stop inside the safety area.
2. The method according to claim 1, wherein the obtaining (S2) location information comprises obtaining one or more safe routes (4) associated with
- 15 the safety areas (2) and wherein the controlling (S9) comprises controlling the mobile robot to move along one of the obtained safe routes (4) to one of the one or more safety areas (2).
3. The method according to claim 1 or 2, comprising:
 - 20 - obtaining (S3) pose information identifying one or more safe poses associated with the safety mode and
 - controlling (S7) the mobile robot (1) to move to one of the one or more safe poses identified by the pose information.
- 25 4. The method according to one of the preceding claims, wherein the instruction to activate the safety mode originates from the mobile robot (1) itself, from another mobile robot (3) or from an external device.
5. The method according to one of the preceding claims, comprising:
 - 30 - evaluating (S5) the obtained present position of the mobile robot (1) with respect to the one or more safety areas (2).

6. The method according to claim 5, wherein the evaluating (S5) comprises selecting (S5b), based on the present position of the mobile robot (1), a safety area (2) to which the mobile robot shall be moved.
- 5 7. The method according to claim 6, wherein the selecting (S5b) a safety area (2) comprises at least one of:
- selecting the safety area (2) that is closest to the present position of the mobile robot, or
 - selecting the safety area (2) using a table that maps positions of the
- 10 mobile robot (1) to a respective safety area.
8. The method according to claim 6 or 7, wherein the selecting (S5b) comprises selecting the safety area (2) based on the type of safety mode, positions of other mobile robots (3) and positions of other objects.
- 15 9. The method according to any of claims 5 to 8, wherein the evaluating (S5) comprises determining (S5c), based on the present position of the mobile robot (1), a safe route (4) to the selected safety area (2).
- 20 10. The method according to claim 9, comprising determining (S5d) whether any other mobile robot (3) is positioned in the determined safe route (4).
11. The method according to any of the preceding claims, comprising:
- controlling (S8) another mobile robot (3) to move in order to enable the
- 25 mobile robot (1) to move to one of the safety areas (2).
12. A control arrangement (100, 200) for operating a mobile robot (1) wherein the control arrangement is configured to:
- receive an instruction to activate a safety mode of the mobile robot (1),
- 30
- obtain location information identifying one of more safety areas (2) associated with the activated safety mode,
 - obtain a present position of the mobile robot (1),

- control the mobile robot (1) to move to one of the safety areas upon determining that the present position of the mobile robot (1) is located outside the one or more safety areas (2) and
- control the mobile robot (1) to stop inside the safety area.

5

13. A mobile robot (1) comprising:

- a transportation mechanism (12) configured to move the mobile robot (1) to a safety area and
- the control arrangement (100, 200) according to claim 12.

10

14. A computer program comprising computer readable instructions that when executed by a processor of a control arrangement, causes the control arrangement to execute the steps of any of claims 1 to 11.

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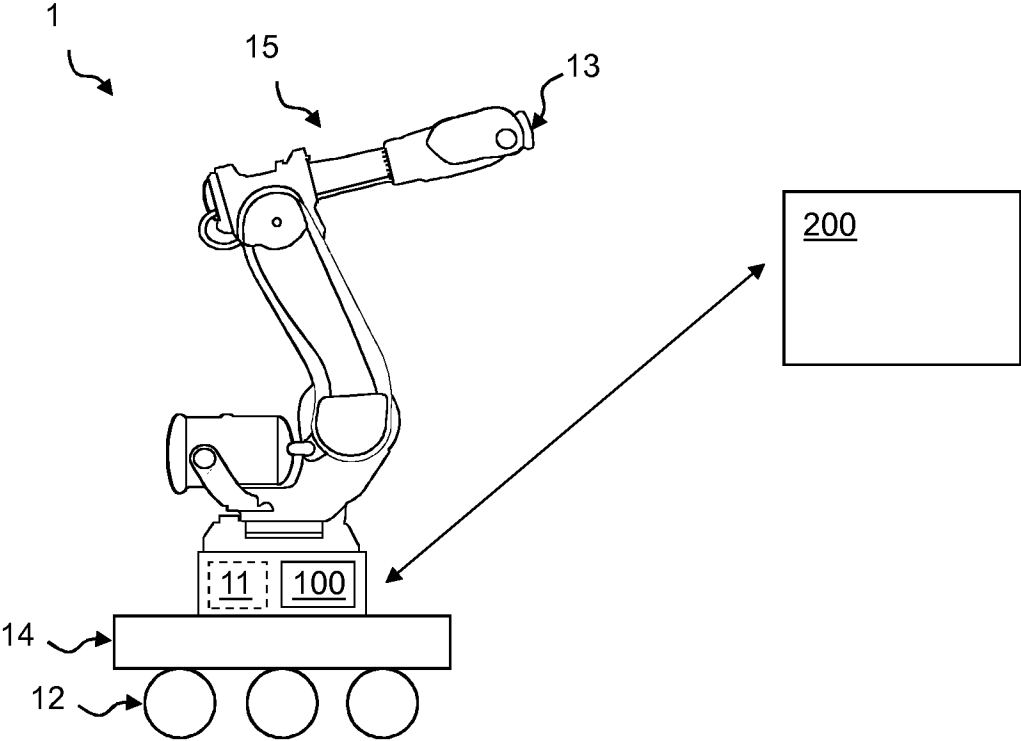


FIG. 1

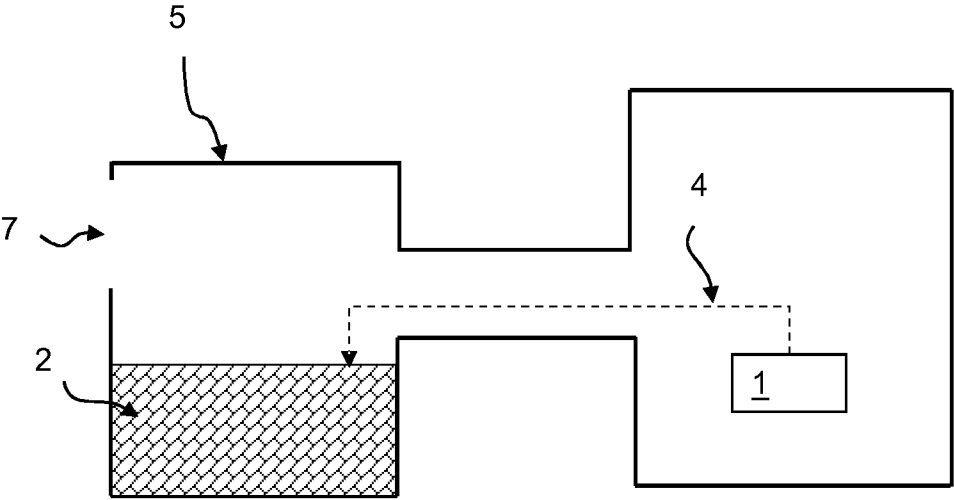


FIG. 2

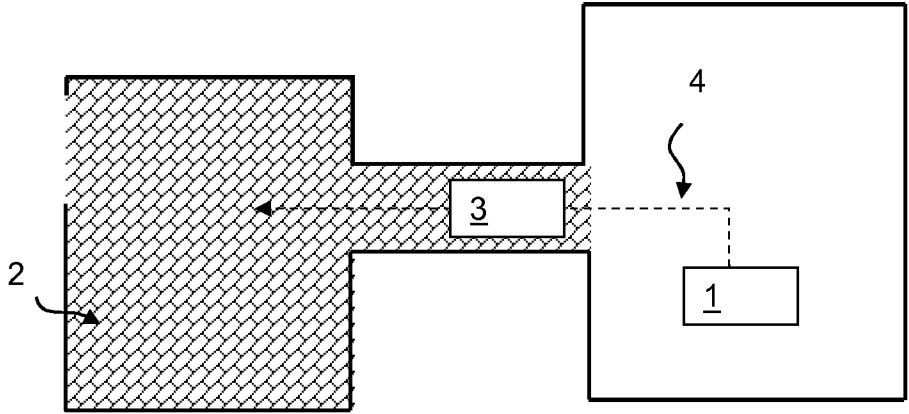


FIG. 3

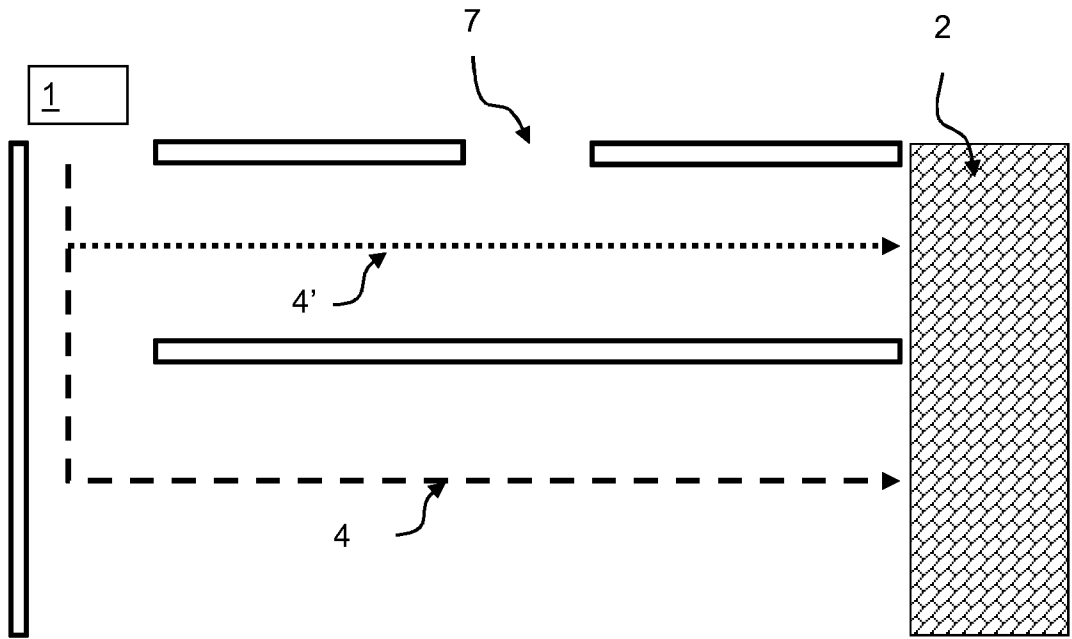


FIG. 4

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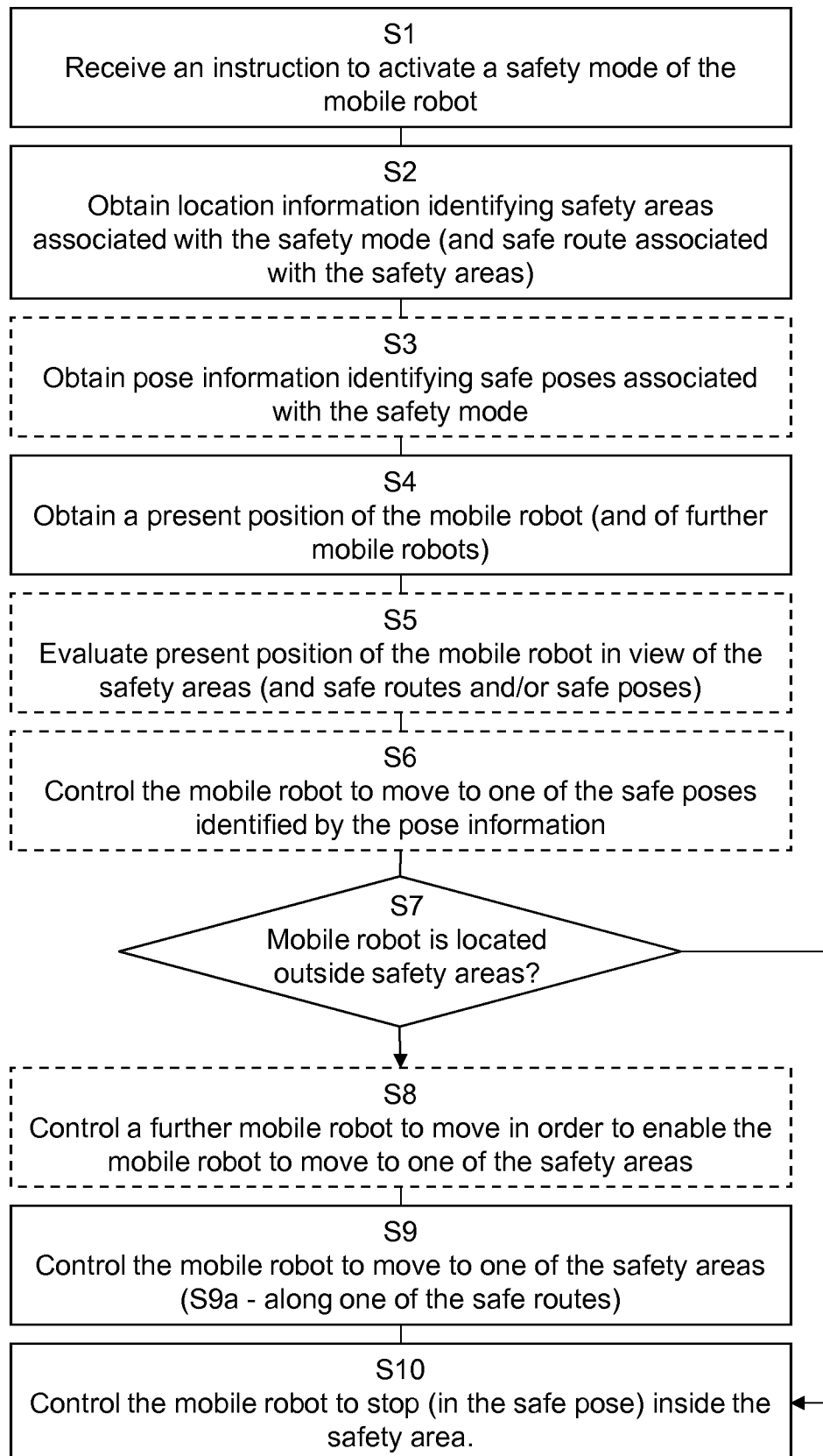


FIG. 5a

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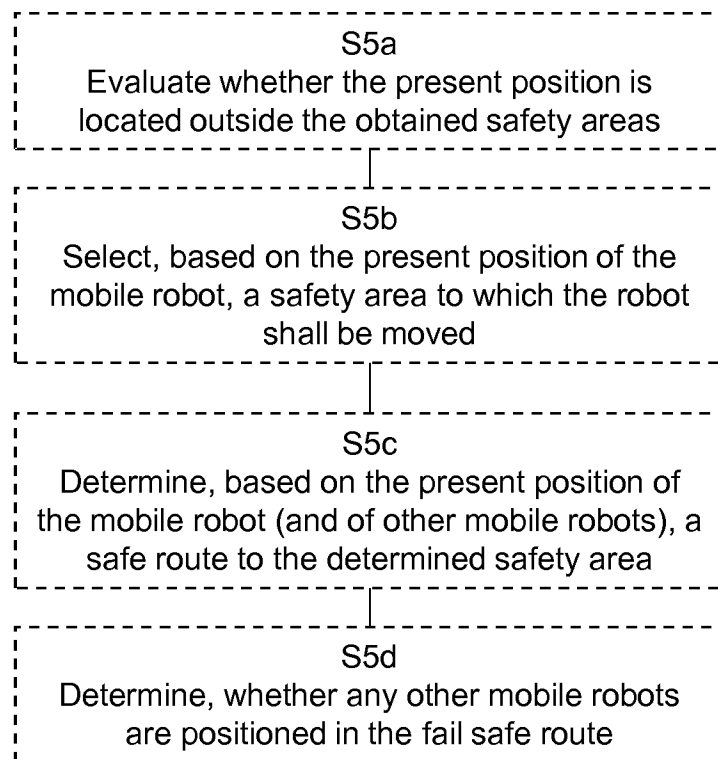


FIG. 5b

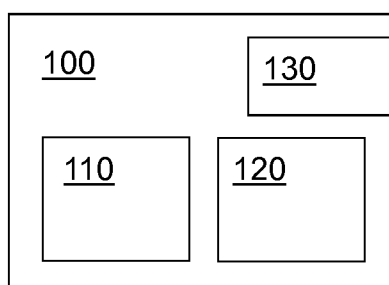


FIG. 6

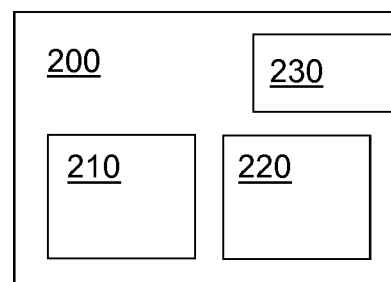


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/052841

A. CLASSIFICATION OF SUBJECT MATTER

INV. G05D1/02 G05B23/00 B25J9/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G05D G05B B25J

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	EP 3 379 201 A1 (DELPHI TECH LLC [US]) 26 September 2018 (2018-09-26) the whole document	1-14
X	----- CN 108 205 317 A (FUJI XEROX CO LTD) 26 June 2018 (2018-06-26) paragraphs [0077] - [0088]; figures 9,10	1-14
X	----- US 2016/320193 A1 (TUUKKANEN MARKO [DE] ET AL) 3 November 2016 (2016-11-03) paragraphs [0089] - [0144]; figure 6	1-14



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

16 October 2019

Date of mailing of the international search report

31/10/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Vañó Gea, Joaquín

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/052841

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			JP 2018101191 A	28-06-2018
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