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(54) Benævnelse: **SYSTEM TIL EVAKUERING AF EN ELLER FLERE MOBILE ROBOTTER**

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GUO J H ET AL: "Programming of the Fire Escaping Paths Using Bayesian Estimated Algorithm", 2014 INTERNATIONAL SYMPOSIUM ON COMPUTER, CONSUMER AND CONTROL, IEEE, 10 June 2014 (2014-06-10), pages 1271-1274, XP032612781, DOI: 10.1109/IS3C.2014.328 [retrieved on 2014-06-27]

DESCRIPTION

FIELD OF THE INVENTION

[0001] The present invention relates to a system and method for evacuating one or more mobile robots from a confined area. Specifically the system and method involve one or more mobile robots equipped with sensors or receivers for receiving evacuation commands directing the one or more mobile robots to leave the evacuation area and enter a location outside the evacuation area.

BACKGROUND OF THE INVENTION

[0002] In mobile industrial robot fleets situations occur where certain areas needs to be kept free of one or more mobile robots. Such situations can be fire alarms where the robots must leave areas of fire escape routes or areas around fire doors. Another situation is in hospitals where priority needs to be given for transport of patients in a narrow corridor and where the porter must be able to ensure that robots are not blocking the way during the transport of the patient. Another situation is in a warehouse where certain areas can be used by both robots and large trucks with limited visibility. Here it can also be necessary to evacuate the area for robots in times where the large trucks are entering the area.

[0003] Prior art systems typically solves the above mentioned situations by dividing the relevant physical area into sub areas which can all individually be set in two states; i) a state that allows robots to enter the area and ii) a state that does not allow the robots to enter the area. Each robot then check status of each area before it enters the area and only enters if the status allows this. If the status changes when a robot is inside an area the robots simply stops. Alternatively the robots use audio and visual signals when driving in restricted areas as to enhance identification of the presence of the robots.

[0004] There is a need to optimize access to limited resources for robots operating in the same space. The optimized access will allow the robots to move more efficiently within a common space as well as perform designated tasks more efficiently. In particular, the optimized access prioritizes the resource allocation to minimize aggregate time robots wait in order to obtain the resources needed to move or perform a task. To this end, there is a need to coordinate the resource allocation and reservation amongst robots. There is a further need to have the robots coordinate the resource allocation and reservation autonomously without human intervention so that the resources can be efficiently allocated in real-time. Accordingly, there is a need to supplement local navigational techniques with global navigational

[0005] techniques and independent and autonomous robot operation through coordinated resource allocation

[0006] US 2017/0030725 A1 describes a computer-implemented method, system, and/or computer program product that controls self-driving vehicles (SDVs). An emergency message is transmitted to a receiver within a self-driving vehicle (SDV). The emergency message describes an emergency state of an emergency vehicle and an identified future route of the emergency vehicle. In response to the SDV receiving the emergency message, the SDV is redirected, via an auto-control hardware system on the SDV, to a location and on a route that does not conflict with the identified future route of the emergency vehicle.

[0007] US 2017/0185085 A1 describes techniques for navigating semi-autonomous mobile robots. A semi-autonomous mobile robot moves within an environment to complete a task. A navigation server communicates with the robot and provides the robot information. The robot includes a navigation map of the environment, interaction information, and a security level. To complete the task, the robot transmits a route reservation request to the navigation server, the route reservation request including a priority for the task, a timeslot, and a route. The navigation server grants the route reservation if the task priority is higher than the task priorities of conflicting route reservation requests from other robots. As the robot moves within the environment, the robot detects an object and attempts to classify the detected object as belonging to an object category. The robot retrieves an interaction profile for the object, and interacts with the object according to the retrieved interaction profile.

[0008] US 2018/0099412 A1 describes devices, systems, and methods for social behavior of a telepresence robot. Upon determination that a person is involved in an emergency, a social path component of the robot may determine a path to cause the robot to move out of a high-traffic area, move out of the way of the person or object involved in an emergency, or the like. The robot may be configured to detect or receive an indication of the urgency of the approaching object. For example, the speed of an approaching gurney may be indicative of the urgency of the situation. The robot may be more sensitive to emergencies in an emergency department region. For example, the robot may be more likely to stop and wait at the side when people move by.

[0009] GUO J H ET AL: "Programming of the Fire Escaping Paths Using Bayesian Estimated Algorithm," 2014 INTERNATIONAL SYMPOSIUM ON COMPUTER, CONSUMER AND CONTROL, IEEE, 10 June 2014 describes a fire monitoring and escaping system that is applied in the intelligent home and uses mobile robots with flame sensor to detect fire sources. The supervised computer receives the locations of the detected fire sources and calculates the risk values of the cross points of the motion platform using joint probability. Then the supervised computer programs motion paths and escaping paths, and controls mobile robots to guide the human leaving the fire field. Mobile robots contain two types moving in the platform. One is the fire detection robot using ultraviolet sensor to search fire sources. The other represents the human walking in the motion platform autonomously.

[0010] JP 2017-215625 A describes a disaster prevention coordination system that includes a plurality of cleaning robots. For example, ,a facility is divided into four work areas A1 to A4 on

the left, right, top, and bottom for the corridors and lounges that are common areas. Robots 36-1 to 36-4 are assigned to perform cleaning work automatically while traveling in the work areas A1 to A4.When an interface device receives a fire information signal from, a table interface displays a facility map indicating the fire target area on the table screen. The cleaning robots receive a safety confirmation instruction signal from the desktop interface device and stop the previous cleaning work and move around areas A1 to A4 according to a predetermined traveling pattern to detect smoke concentration. If the smoke concentration is detected by the concentration sensor 88 and the predetermined danger level has not been reached, a safety confirmation response signal indicating that it is a safe area is transmitted to the desktop interface device.

[0011] WO 2018/051349 A1 describes a system of robots that may interact together to detect safety concern conditions, and/or to take actions in response. In some embodiments, robots monitor facility locations during an already identified emergency condition to provide status data which may be used to suggest one or more target locations and/or access routes for emergency services personnel. In some embodiments, robots are activated to help address the emergency condition. For example, they take action to mitigate an emergency directly (for example, extinguish a fire), guide emergency personnel, and/or help ensure human safety.

SUMMARY OF THE INVENTION

[0012] The invention is defined by the appended claims.

[0013] The present invention solves the above discussed problems by defining a number of individual evacuation zones and letting the robot management system receive evacuation alarms per individual zone and then as soon as this happens send command for robots to evacuate the specific zone as fast as possible. Either just evacuate to outside evacuation zone or to go to specific positions during the alarm.

[0014] Accordingly, in a first aspect of the present invention there is provided a system according to claim 1.

[0015] Embodiments are provided according to the dependent claims.

[0016] In a second aspect of the present invention there is provided a method according to claim 15.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Figure 1 shows a diagram of the modules applicable to the system of the present invention.

Figure 2 shows a map with zones and positions applicable to the system of the present invention.

Figure 3 shows flow diagram applicable to an evacuation procedure with the system of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] In the following detailed description, numerous details, examples, and embodiments are set forth and described. As one skilled in the art would understand in light of the present description, the system and is not limited to the embodiments set forth, and the system may be practiced without some of the specific details and examples discussed. Also, reference is made to accompanying figures, which illustrate specific embodiments in which autonomous coordination of robots can be practiced. It is to be understood that other embodiments can be used and structural changes can be made without departing from the scope of the embodiments herein described.

[0019] Referring to Figure 1 there is shown a local area network with different devices for communication. The local area network connects many different systems and devices which need communication between them. Hence it can be seen in the figure that the robot management system is integrated to the enterprise resource planning (ERP) system which handles sales orders, finance and logistic issues. It is also connected to the fire alarm system, the alarm buttons for the different physical areas which individually may require evacuation, and it is connected to the WIFI routers which connect to the mobile robots. This enables the robot management system to receive alarms from either physical buttons or via the ERP or fire alarm systems and send directions for evacuating specific areas to the mobile robots.

[0020] Referring to Figure 2 there is shows a map of a small physical area in which the mobile robots operate. In the map there is an evacuation zone and 3 evacuation positions. These positions are the positions to which the mobile robots move when evacuating the evacuation zone when an alarm is active. The evacuation zone is assigned with 2 different evacuation directions and this is indicated by the arrows named "Direction for evacuation". This means that when an evacuation alarm is raised the mobile robot will evacuate in different direction depending on its position inside the evacuation zone when the alarm is raised.

[0021] Referring to Figure 3 there is shown an event diagram illustrating a possible implementation of the logic for evacuation. In this example the robots inside the area that is to be evacuated calculate their preferred route to a position outside the evacuation area and communicates this planned route to the robot management system which will identify possible conflicts and direct some of the robots to alternative positions to solve the conflicts. In another implementation the robot management system dictates the route/direction and evacuation

position and communicates this to all robots which all just follow the instructions for evacuation.

[0022] The system of the present invention is particularly useful for evacuation purposes in a factory, a warehouse, a hospital or a service/repair shop or similar. Within the scope of the invention one or more mobile robots are configured to transport components from A to B or to perform tasks at various positions in the area. A wireless communication system, such as Local Area Network with WiFi, Zigbee, Z-wave or similar, may be used to control the robots. Alternatively there is a network such as LORA, NB-IoT or LTE.

[0023] The system also includes a robot management system which is a SW program that handles and prioritizes jobs of the fleet of robots. The robot management system communicates with all the robots in the area using the wireless communication system.

[0024] The robot management system has an application programmable Interface (API) through which other systems can interact with the robot management system. This can for instance be a physical alarm button that is connected to the wireless communication or it can be the fire alarm system that is also connected to the Local Area Network.

[0025] When an evacuation alarm is raised for a given area the robots can move out of the area in different ways. One way is to move to a specific position outside the area given for the robot. Another way is to leave to the nearest of a number of different evacuation positions outside the area. Another way is to leave the area moving in a specific direction and then locate the nearest evacuation position outside the area.

[0026] If multiple robots are being evacuated at the same time then they can move to the same position outside the area or they can move to different positions if each position can only be occupied by one robot. The combination can also exist where each robot finds the nearest or fastest route to an outside position but each position is only allowed to have one robot parked so the robot management system can communicate with each robot who calculates time or distance to different positions outside the area and sends this information back to the robot management system which decides which robot shall move to which position based on evaluation of the fastest way to evacuate the entire area and still only have one robot parked at each position.

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in

compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US20170030725A1 **[0006]**
- US20170185085A1 **[0007]**
- US20180099412A1 **[0008]**
- JP2017215625A **[0010]**
- WO2018051349A1 **[0011]**

Non-patent literature cited in the description

- Programming of the Fire Escaping Paths Using Bayesian Estimated Algorithm**GUO J H et al.**2014 INTERNATIONAL SYMPOSIUM ON COMPUTER, CONSUMER AND CONTROLIEEE20140610 **[0009]**

Patentkrav

1. System til evakuering af mobile robotter, der opererer i en eller flere zoner i en bygning, hvor systemet omfatter:
mobile robotter, der er i stand til at modtage, ved anvendelse af en sensor eller modtager, en eller flere evakueringskommandoer fra et robotstyringssystem, der er konfigureret til at styre de mobile robotter, hvor den ene eller de flere evakueringskommandoer omfatter information om en eller flere evakueringszoner,
hvor systemet er konfigureret til at definere en evakueringshandling, der skal udføres ved den ene eller de flere evakueringszoner, hvor evakueringshandlingen instruerer de mobile robotter, der opererer i en eller flere evakueringszoner, til at forlade den ene eller de flere evakueringszoner og gå ind i evakueringspositioner uden for den ene eller de flere evakueringszoner og ind i bygningen som reaktion på den ene eller de flere evakueringskommandoer,
hvor evakueringspositionerne er valgt fra gruppen, der består af dedikerede parkeringspladser til de mobile robotter, specifikke rum og dockingstationer, kendetegnet ved, at de mobile robotter er konfigureret til at bestemme den korteste eller hurtigste vej ud af den ene eller de flere evakueringszoner og til evakueringspositionerne og kommunikere den bestemte vej til robotstyringssystemet,
hvor robotstyringssystemet er konfigureret til at identificere og løse konflikter mellem mobile robotter, der forsøger at evakuere til den samme evakueringsposition ved at kommunikere en ny evakueringsposition til nogle af de mobile robotter og instruere de mobile robotter til at forlade den ene eller de flere evakueringszoner og gå ind i evakueringspositionen.

2. System ifølge krav 1, hvor de mobile robotter er autonome mobile robotter.

3. System ifølge krav 1, hvor robotstyringssystemet ligger fjernt fra de mobile robotter.

4. System ifølge krav 3, hvor robotstyringssystemet kommunikerer med de mobile robotter via en trådløs kommunikation.

5. System ifølge et hvilket som helst af kravene 1 til 4, hvor robotstyringssystemet er konfigureret til at behandle information fra de mobile robotter, hvor informationen omfatter en status på hvilken af de mobile robotter, der er inden i eller uden for den ene eller de flere evakueringszoner.

6. System ifølge et hvilket som helst af kravene 1 til 5, hvor robotstyringssystemet er konfigureret til at behandle kommandoer fra en ekstern kilde, såsom en aktuator eller et virksomhedsressourceplanlægningssystem, hvor kommandoerne omfatter aktivering af alarmer.

7. System ifølge krav 1, hvor de mobile robotter, baseret på den bestemte korteste eller hurtigste vej, udfører en udgang (”exit”) ud af den ene eller de flere evakueringszoner.

8. System ifølge et hvilket som helst af de foregående krav, hvor de mobile robotter ikke får lov til at komme ind i den ene eller de flere evakueringszoner i løbet af en fastsat tid.

9. System ifølge krav 1, hvor de mobile robotter er programmeret til at bevæge sig til en alternativ evakueringsposition, hvis en bestemt evakueringsposition er optaget, eller hvis vejen dertil er blevet blokeret.

10. System ifølge et hvilket som helst af de foregående krav, hvor hver af den ene eller de flere evakueringspositioner er specifikke for en given mobil robot.

11. System ifølge et hvilket som helst af de foregående krav, hvor de mobile robotter er konfigureret til at bestemme den nærmeste evakueringsposition for en flerhed af evakueringspositioner.

12. System ifølge krav 11, hvor de mobile robotter er konfigureret til at forlade den ene eller de flere evakueringszoner i en bestemt retning som reaktion på den ene eller de flere evakueringskommandoer og derefter bestemme den nærmeste evakueringsposition for en flerhed af evakueringspositioner.

13. System ifølge et hvilket som helst af de foregående krav, hvor information, der er opnået af de mobile robotter i løbet af evakueringen, slettes efter afslutning af evakueringen, hvorved de mobile robotter nulstilles til en situation før evakueringen.

14. System ifølge et hvilket som helst af de foregående krav, hvor den ene eller de flere evakueringszoner er valgt fra gruppen, der består af korridorer, brandnødsituationszoner, nødudgange, branddøre og elevatorer.

15. Fremgangsmåde til evakuering af mobile robotter, der er styret af et robotstyringssystem, fra specifikke zoner i en bygning, hvor fremgangsmåden omfatter trinene til:
udsendelse, med robotstyringssystemet, af en eller flere evakueringskommandoer til mobile robotter til at evakuere fra en eller flere evakueringszoner;
modtagelse af den ene eller de flere evakueringskommandoer med sensorer eller modtagere af de mobile robotter; kendetegnet ved bestemmelse, med hver mobile robot, af den korteste eller hurtigste vej ud af den ene eller de flere evakueringszoner og til evakueringspositioner uden for den ene eller de flere evakueringszoner og ind i bygningen som reaktion på den ene eller de flere evakueringskommandoer, hvor evakueringspositionerne er valgt fra gruppen, der består af dedikerede parkeringspladser til de mobile robotter, specifikke rum og dockingstationer;
at kommunikere den bestemte vej til robotstyringssystemet;
identificering, med robotstyringssystemet, af konflikter mellem mobile robotter, der forsøger at evakuere til den samme evakueringsposition ved at kommunikere en ny evakueringsposition

til nogle af de mobile robotter; og
at instruere de mobile robotter til at forlade den ene eller de flere evakueringszoner og gå ind i evakueringspositionen.

16. Fremgangsmåde ifølge krav 15, hvor robotstyringssystemet ligger fjernt fra de mobile robotter.

DRAWINGS

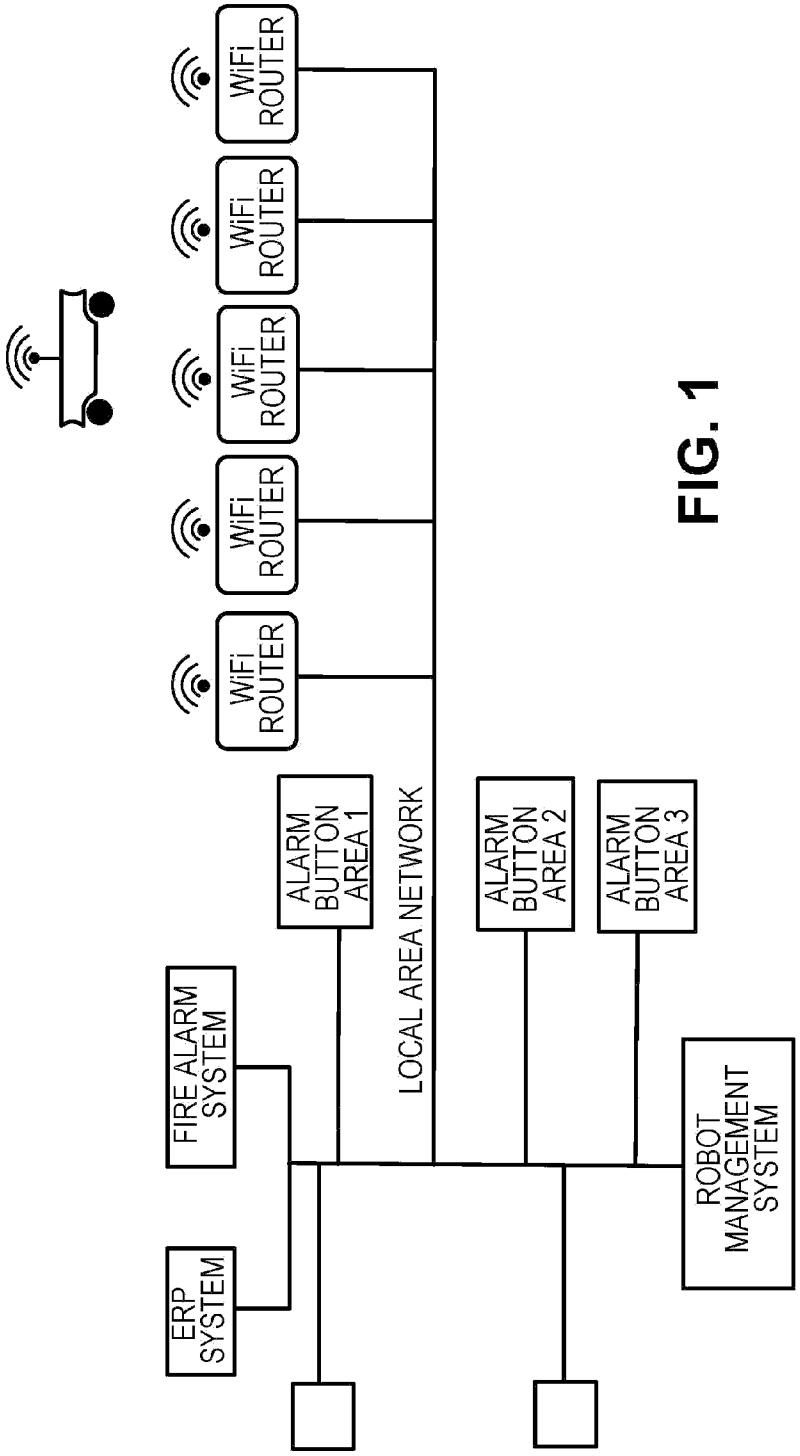

FIG. 1

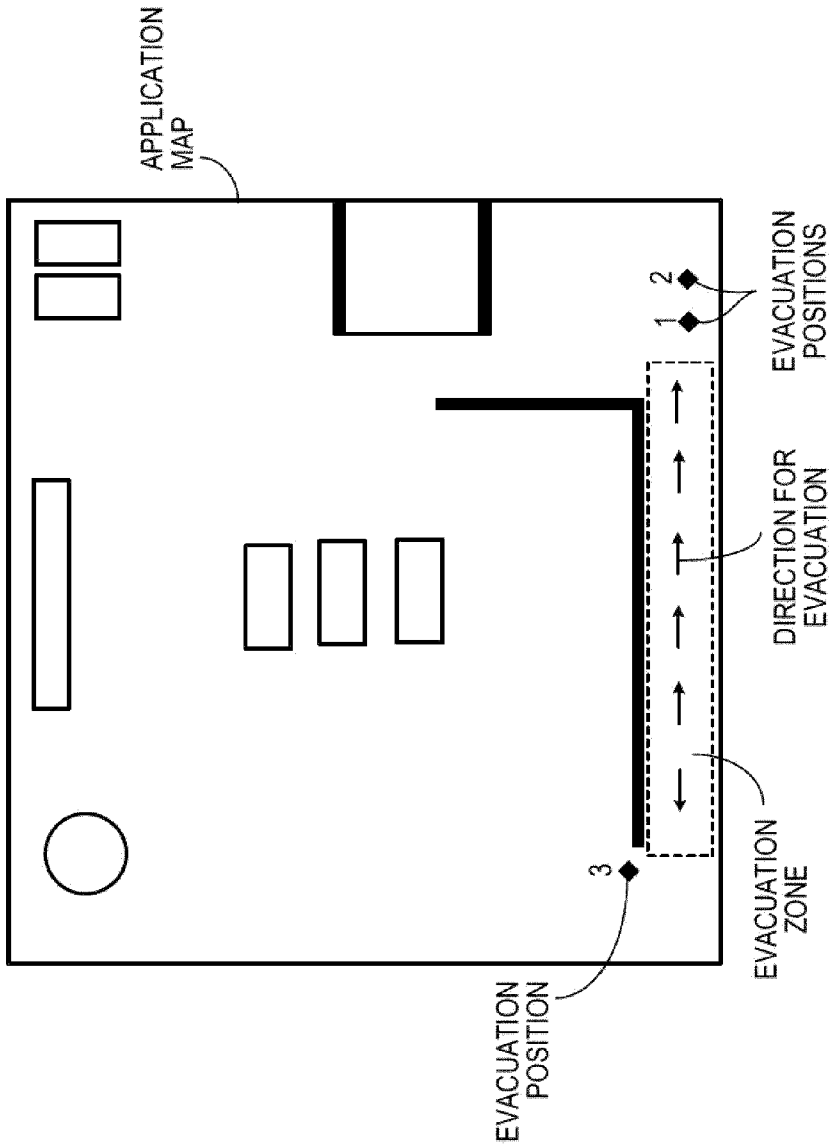
APPLICATION MAP
1
2
EVACUATION POSITIONS
DIRECTION FOR EVACUATION
EVACUATION ZONE
3
EVACUATION POSITION

FIG. 2

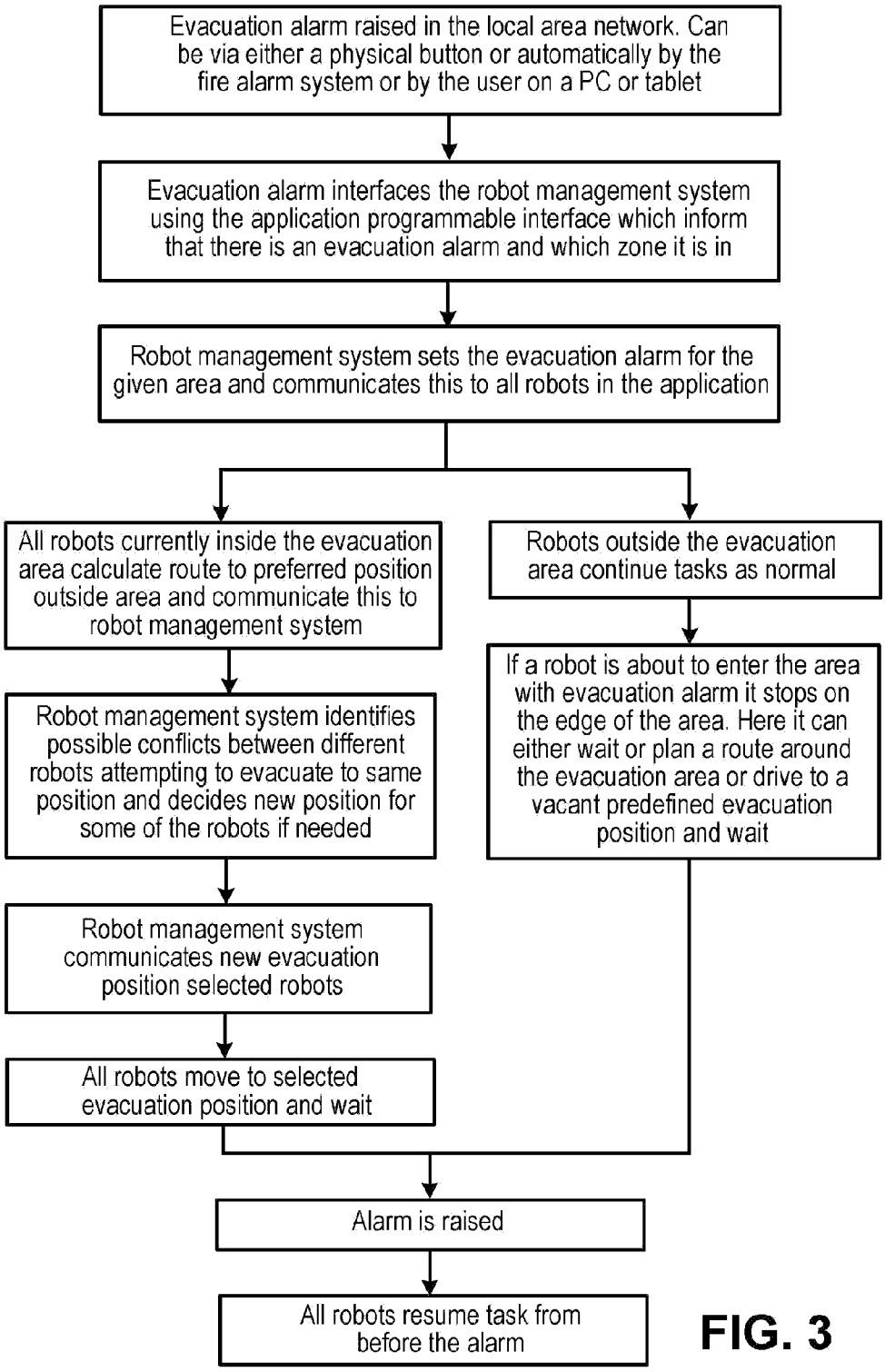
Evacuation alarm raised in the local area network. Can be via either a physical button or automatically by the fire alarm system or by the user on a PC or tablet
Evacuation alarm interfaces the robot management system using the application programmable interface which inform that there is an evacuation alarm and which zone it is in
Robot management system sets the evacuation alarm for the given area and communicates this to all robots in the application
All robots currently inside the evacuation area calculate route to preferred position outside area and communicate this to robot management system
Robots outside the evacuation area continue tasks as normal
Robot management system identifies possible conflicts between different robots attempting to evacuate to same position and decides new position for some of the robots if needed
If a robot is about to enter the area with evacuation alarm it stops on the edge of the area. Here it can either wait or plan a route around the evacuation area or drive to a vacant predefined evacuation position and wait
Robot management system communicates new evacuation position selected robots
All robots move to selected evacuation position and wait
Alarm is raised
All robots resume task from before the alarm

FIG. 3