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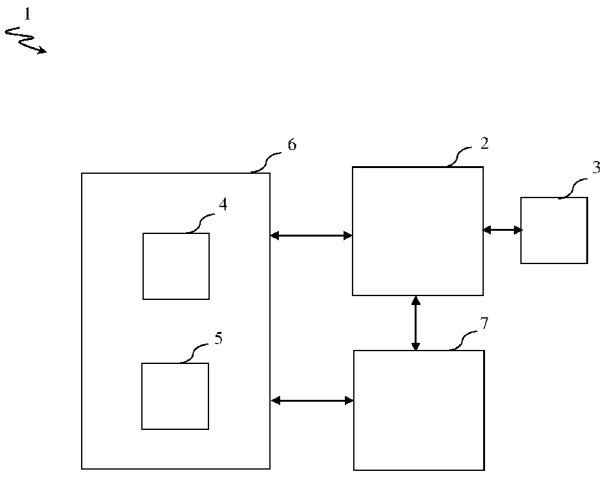
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(54) Title: A SYSTEM FOR PROVIDING SEARCH AND RESCUE OPERATION VIA A MICRO-ROBOT

Figure 1



(57) Abstract: The present invention relates to a system (1) for monitoring complex environments, detecting the location of victims, and providing life support via micro-robots (6) designed for search and rescue operations in collapsed structures such as buildings, mines and other confined spaces.

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DESCRIPTION

A SYSTEM FOR PROVIDING SEARCH AND RESCUE OPERATION VIA A MICRO-ROBOT

Technical Field

The present invention relates to a system for monitoring complex environments, detecting the location of victims, and providing life support via micro-robots designed for search and rescue operations in collapsed structures such as buildings, mines and other confined spaces.

Background of the Invention

Today, conventional search and rescue methods in collapsed structures are typically performed by human rescuers, dogs and large robotic equipment. However, these methods have a plurality of limitations. Rescue operations are delayed or cannot be completed as conventional equipment generally struggle to access tight spaces and micro-holes in collapsed structures. Current methods generally depend on manual efforts such as listening to voices which can be time-consuming and less effective in detecting victims.

For this reason, considering the studies and deficiencies included in the current technique, it is understood that there is a need for a system for monitoring complex environments, detecting the location of victims, and providing life support via micro-robots designed for search and rescue operations in collapsed structures such as buildings, mines and other confined spaces.

The United States patent document no. **US20160043771A1**, an application included in the state of the art, discloses a system for safely and efficiently

locating trapped or buried victims via multi-sensors. In the system included in the said invention, an ultra-wide band (UWB) radiometer sensor detects and precisely calculates the position of the victim relative to a known position of a sensor probe or a monitoring unit of a sensor system. In the said invention, a sensing probe comprising a combination of acoustic or sound transducers such as sensors, transducers, radiometers, optical and infrared cameras, microphones and speakers may be guided towards the victim. In addition, the condition of the victim is determined, and the victim is contacted via this probe. With unique coding of ultra-wideband signals, a more exact position of each victim can be detected.

Summary of the Invention

An object of the present invention is to realize a system developed for monitoring complex environments, detecting the location of victims and providing life support via micro-robots designed for search and rescue operations in collapsed structures such as buildings, mines and other confined spaces.

Another object of the present invention is to realize a system developed for providing enhanced accessibility via the micro-robot navigating through narrow spaces and micro-holes that conventional search and rescue equipment cannot reach by means of its compact, human finger-sized, two-jointed and three-bone design.

A further object of the present invention is to realize a system developed for providing food, water, medicine and other essential resources to victims through a communication and life support line in collapsed structures such as buildings, mines and other confined spaces.

A further object of the present invention is to realize a system developed for creating rescue plans, prioritizing and using resources efficiently based on specific

requirements and conditions by monitoring the health of multiple victims at different excavation sites.

Detailed Description of the Invention

"A System for Providing Search and Rescue Operation Via a Micro-Robot" realized to fulfil the objectives of the present invention is shown in the figure attached, in which:

Figure 1 is a schematic view of the inventive system.

The components illustrated in the figure are individually numbered, where the numbers refer to the following:

1. System
2. Electronic Device
3. Cable
4. Sensor
5. Camera
6. Micro-robot
7. Server

The inventive system (1) developed for monitoring complex environments, detecting the location of victims and providing life support for search and rescue operations in collapsed structures such as buildings, mines and other confined spaces comprises

- at least one electronic device (2) which is configured to exchange data by using any remote communication protocol and to run at least one application thereon;

- at least one cable (3) which is configured to provide a communication line for support pipelines that provide victims with basic life resources;

- at least one sensor (4) which is configured to detect physical changes in the environment where it is located;

- at least one camera (5) which is configured to capture images in the environment where it is located;

- at least one micro-robot (6) which is configured to establish connection with the electronic device (2) by using any remote communication protocol; to enable data exchange with the sensor (4) and the camera (5) through this established connection; to move flexibly in limited/narrow spaces and micro-holes via its compact design with two joints and three bones; and to comprise a software that provides autonomous movement and navigation in collapsed structures;

- at least one server (7) which is configured to establish communication with the electronic device (2) by using any communication protocol; to exchange data with the micro-robot (6), the sensor (4) and the camera (5) that are run on the micro-robot (6) through this established communication; to optimize the navigation strategies and victim detection capabilities that it has accessed via the micro-robot (6) through reinforcement learning algorithms; to train micro-robots (6) in order to effectively locate victims and enhance the efficiency of search and rescue operations; to allow users to create excavation plans, monitor victims, and manage life support resources by managing the control and data of the micro-robot (6) through navigation and monitoring software; to monitor the health of multiple victims in different excavation sites via health monitoring software; to allow prioritization and efficient use of resources by creating recovery plans based on specific requirements and conditions.

The electronic device (2) included in the inventive system (1) is configured to exchange data by using any remote communication protocol. The electronic

device (2) is a device in the form of a cell phone, computer, laptop computer, or tablet computer. The electronic device (2) is configured to establish connection with the micro-robot (6) by using any remote communication protocol included in the state of art, and to exchange data with the sensor (4) and the camera (5) through this established connection. The electronic device (2) is configured to establish connection with the server (7) by using any remote communication protocol included in the state of art, and to enable data exchange with the micro-robot (6), the sensor (4), and the camera (5) through this established connection. In the preferred embodiment of the invention, the electronic device (2) is configured to exchange data with the server (7) by using a data bus such as the Internet.

The cable (3) included in the inventive system (1) is configured to provide a communication line between the electronic device (2) and the micro-robot (6). The cable (3) is configured to serve as a path for support pipelines that provide victims with basic life resources such as food, water, medicine and other essential resources.

The sensor (4) included in the inventive system (1) is positioned on the micro-robot (6) and is a device in the form of lidar, radar, infrared and pressure sensor. The sensor (4) is configured to detect physical changes in the environment where it is located. In the said invention, the sensor (4) is configured to detect victims in the environment where it is located.

The camera (5) included in the inventive system (1) is positioned on the micro-robot (6) and is configured to capture images in the environment where it is located. In the said invention, the camera (5) is configured to detect and monitor the victim.

The micro-robot (6) included in the inventive system (1) is configured to exchange data with the electronic device (2) by using any communication

protocol included in the state of the art. The micro-robot (6) included in the system of the said invention is a device in the form of a robot having a compact design with two joints and three bones. The micro-robot (6) is configured to have at least one sensor (4) and a camera (5) thereon. The micro-robot (6) is configured to establish connection with the electronic device (2) by using any remote communication protocol included in the state of art, and to enable data exchange with the sensor (4) and the camera (5) through this established connection. In the said invention, the micro-robot (6) is configured to move flexibly in limited/narrow spaces and micro-holes via its compact design with two joints and three bones. In the said invention, the micro-robot (6) is configured to comprise a software that provides autonomous movement and navigation in collapsed structures. In the said invention, the micro-robot (6) is configured to establish communication via the cable (3) after detecting a victim and to activate life support pipelines in order to provide the essential resources.

The server (7) included in the inventive system (1) is configured to establish communication with the electronic device (2) by using any remote communication protocol included in the state of art, and to exchange data with the micro-robot (6), the sensor (4) and the camera (5) that are run on the micro-robot (6) through this established communication. The server (7) is configured to establish communication with the electronic device (2) through a data network such as the Internet. In the said invention, the server (7) is configured to optimize the navigation strategies and victim detection capabilities that it has accessed via the micro-robot (6) through reinforcement learning algorithms. In the said invention, the server (7) is configured to train micro-robots (6) in order to effectively locate victims and enhance the efficiency of search and rescue operations. In the said invention, the server (7) is configured to allow users to create excavation plans, monitor victims, and manage life support resources by managing the control and data of the micro-robot (6) through navigation and monitoring software. In the said invention, the server (7) is configured to monitor the health of multiple victims in different excavation sites via health monitoring software; and to allow

prioritization and efficient use of resources by creating recovery plans based on specific requirements and conditions.

Industrial Application of the Invention

In the inventive system (1), the micro-robots (6) autonomously navigate through collapsed structures during search and rescue missions by using their compact design and the sensor (4) arrays in order to access confined spaces. The reinforcement learning algorithm enables robots to efficiently locate and identify the victims by optimizing navigation strategies. The micro-robot establishes communication via the cable (3) after detecting a victim and activates life support pipelines in order to provide the essential resources. Health monitoring software continuously monitors the health of multiple victims and allows rescuers to prioritize resources accordingly.

Within these basic concepts; it is possible to develop various embodiments of the inventive “A System (1) for Providing Search and Rescue Operation Via a Micro-Robot”; the invention cannot be limited to examples disclosed herein and it is essentially according to claims.

CLAIMS

1. A system (1) developed for monitoring complex environments, detecting the location of victims and providing life support for search and rescue operations in collapsed structures such as buildings, mines and other confined spaces; **comprising**

- at least one electronic device (2) which is configured to exchange data by using any remote communication protocol and to run at least one application thereon;

- at least one cable (3) which is configured to provide a communication line for support pipelines that provide victims with basic life resources;

- at least one sensor (4) which is configured to detect physical changes in the environment where it is located;

- at least one camera (5) which is configured to capture images in the environment where it is located; and **characterized by**

- at least one micro-robot (6) which is configured to establish connection with the electronic device (2) by using any remote communication protocol; to enable data exchange with the sensor (4) and the camera (5) through this established connection; to move flexibly in limited/narrow spaces and micro-holes via its compact design with two joints and three bones; and to comprise a software that provides autonomous movement and navigation in collapsed structures; and

- at least one server (7) which is configured to establish communication with the electronic device (2) by using any communication protocol; to exchange data with the micro-robot (6), the sensor (4) and the camera (5) that are run on the micro-robot (6) through this established communication; to optimize the navigation strategies and victim detection capabilities that it has accessed via the micro-robot (6) through reinforcement learning algorithms; to train micro-robots

(6) in order to effectively locate victims and enhance the efficiency of search and rescue operations; to allow users to create excavation plans, monitor victims, and manage life support resources by managing the control and data of the micro-robot (6) through navigation and monitoring software; to monitor the health of multiple victims in different excavation sites via health monitoring software; to allow prioritization and efficient use of resources by creating recovery plans based on specific requirements and conditions.

2. A system (1) according to Claim 1; **characterized by** the electronic device (2) which is a device in the form of a cell phone, computer, laptop computer, and tablet computer configured to exchange data by using any remote communication protocol.

3. A system (1) according to Claim 1 or 2; **characterized by** the electronic device (2) which is configured to establish connection with the micro-robot (6) by using any remote communication protocol, and to exchange data with the sensor (4) and the camera (5) through this established connection.

4. A system (1) according to Claim 3; **characterized by** the electronic device (2) which is configured to establish connection with the server (7) by using any remote communication protocol, and to enable data exchange with the micro-robot (6), the sensor (4), and the camera (5) through this established connection.

5. A system (1) according to Claim 4; **characterized by** the electronic device (2) which is configured to exchange data with the server (7) by using a data bus such as the Internet.

6. A system (1) according to any one of the preceding claims; **characterized by** the cable (3) which is configured to provide a communication line between the electronic device (2) and the micro-robot (6).

7. A system (1) according to any one of the preceding claims; **characterized by** the cable (3) which is configured to serve as a path for support pipelines that provide victims with basic life resources such as food, water, medicine and other essential resources.

8. A system (1) according to any one of the preceding claims; **characterized by** the sensor (4) which is positioned on the micro-robot (6) and is a device in the form of lidar, radar, infrared and pressure sensor.

9. A system (1) according to any one of the preceding claims; **characterized by** the sensor (4) which is configured to detect physical changes in the environment where it is located.

10. A system (1) according to any one of the preceding claims; **characterized by** the sensor (4) which is configured to detect victims in the environment where it is located.

11. A system (1) according to any one of the preceding claims; **characterized by** the camera (5) which is positioned on the micro-robot (6) and is configured to capture images in the environment where it is located.

12. A system (1) according to any one of the preceding claims; **characterized by** the camera (5) which is configured to detect and monitor the victim.

13. A system (1) according to any one of the preceding claims; **characterized by** the micro-robot (6) which is configured to exchange data with the electronic device (2) by using any communication protocol.

14. A system (1) according to any one of the preceding claims; **characterized by** the micro-robot (6) which is a device in the form of a robot having a compact

design with two joints and three bones and is configured to have at least one sensor (4) and a camera (5) thereon.

15. A system (1) according to any one of the preceding claims; **characterized by** the micro-robot (6) which is configured to establish connection with the electronic device (2) by using any remote communication protocol, and to enable data exchange with the sensor (4) and the camera (5) through this established connection.

16. A system (1) according to any one of the preceding claims; **characterized by** the micro-robot (6) which is configured to move flexibly in limited/narrow spaces and micro-holes via its compact design with two joints and three bones.

17. A system (1) according to any one of the preceding claims; **characterized by** the micro-robot (6) which is configured to comprise a software that provides autonomous movement and navigation in collapsed structures.

18. A system (1) according to any one of the preceding claims; **characterized by** the micro-robot (6) which is configured to establish communication via the cable (3) after detecting a victim and to activate life support pipelines in order to provide the essential resources.

19. A system (1) according to any one of the preceding claims; **characterized by** the server (7) which is configured to establish communication with the electronic device (2) by using any remote communication protocol, and to exchange data with the micro-robot (6), the sensor (4) and the camera (5) that are run on the micro-robot (6) through this established communication.

20. A system (1) according Claim 19; **characterized by** the server (7) which is configured to establish communication with the electronic device (2) through a data network such as the Internet.

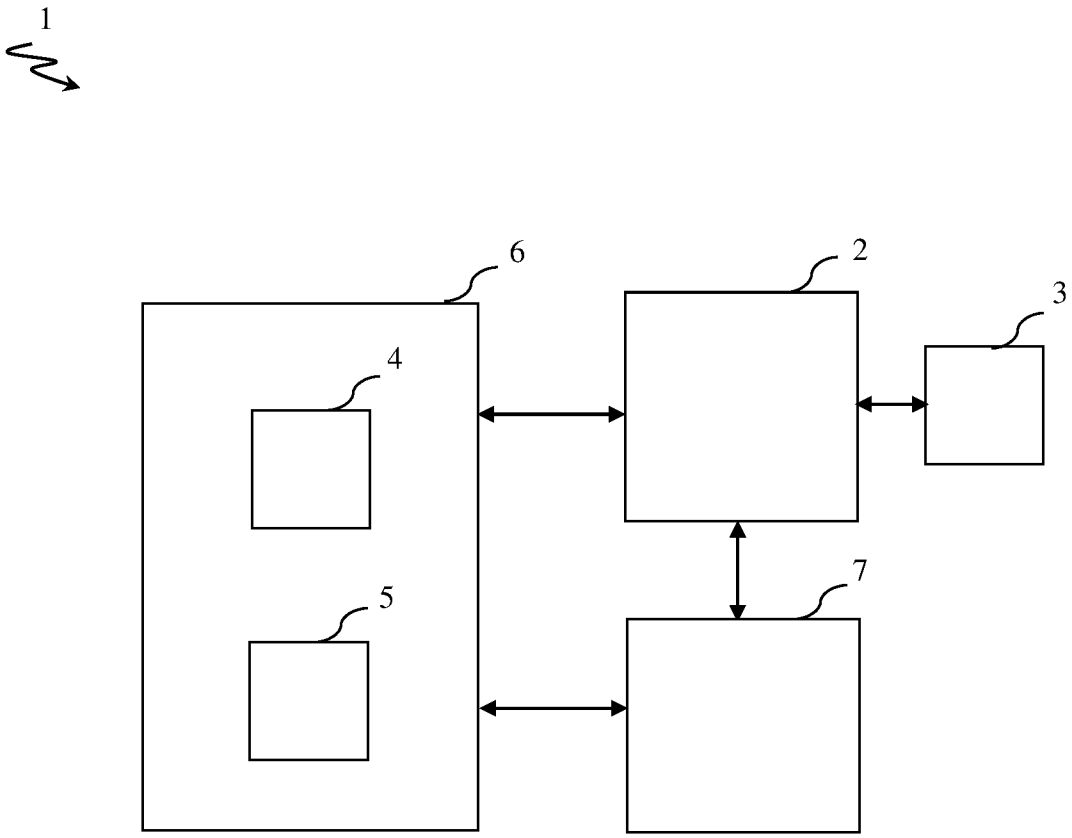
21. A system (1) according to any one of the preceding claims; **characterized by** the server (7) which is configured to optimize the navigation strategies and victim detection capabilities that it has accessed via the micro-robot (6) through reinforcement learning algorithms.

22. A system (1) according to any one of the preceding claims; **characterized by** the server (7) which is configured to train micro-robots (6) in order to effectively locate victims and enhance the efficiency of search and rescue operations.

23. A system (1) according to any one of the preceding claims; **characterized by** the server (7) which is configured to allow users to create excavation plans, monitor victims, and manage life support resources by managing the control and data of the micro-robot (6) through navigation and monitoring software.

24. A system (1) according to any one of the preceding claims; **characterized by** the server (7) which is configured to monitor the health of multiple victims in different excavation sites via health monitoring software; and to allow prioritization and efficient use of resources by creating recovery plans based on specific requirements and conditions.

Figure 1



INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2024/050713

A. CLASSIFICATION OF SUBJECT MATTER

G08B 5/00(2006.01)i; **G01S 19/00**(2010.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G08B 5/00; G01S 19/00

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)

EPODOC, GOOGLE PATENTS, AbS, IEEE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012210703 A (HANNO KAZUO) 01 November 2012 (2012-11-01) Whole document	1-24
A	Li, N., Tsigkanos, C., Jin, Z., Hu, Z., & Ghezzi, C. (2020). Early validation of cyber–physical space systems via multi-concerns integration. Journal of Systems and Software, 170, 110742.	1-24
A	Gong, Y., Sun, G., Nair, A., Bidwai, A., CS, R., Grezmak, J., ... & Daltorio, K. A. (2023). Legged robots for object manipulation: A review. Frontiers in Mechanical Engineering, 9, 1142421.	1-24

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