US012387596B1

(12) **United States Patent**
Kim et al.

(10) **Patent No.: US 12,387,596 B1**
(45) **Date of Patent: Aug. 12, 2025**

(54) **METHOD AND SYSTEM FOR SMART EVACUATION GUIDANCE IN ROAD TUNNEL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/818,281**

(22) Filed: **Aug. 28, 2024**

(51) **Int. Cl.**
G08G 1/09 (2006.01)

(52) **U.S. Cl.**
CPC ***G08G 1/091*** (2013.01)

(58) **Field of Classification Search**
CPC G08G 1/091; G08B 3/1008; G08B 7/066
See application file for complete search history.

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(57) **ABSTRACT**

A method and system for smart evacuation guidance in a road tunnel are disclosed. In an embodiment, a guidance device installed within a road tunnel includes: a power supply part; a first safety device activated by power from the power supply part, for guiding evacuation from the road tunnel in a first direction; a second safety device activated by power from the power supply part, for guiding evacuation in a second direction opposite to the first direction; a controller; and a control part that controls the first safety device and the second safety device, individually, in accordance with a control signal transmitted from the controller, wherein the controller includes a communication part that communicates with a repeater disposed in the road tunnel and receives the control signal from an evacuation guidance system of a disaster control center for the road tunnel and transmits the same to the control part.

10 Claims, 8 Drawing Sheets

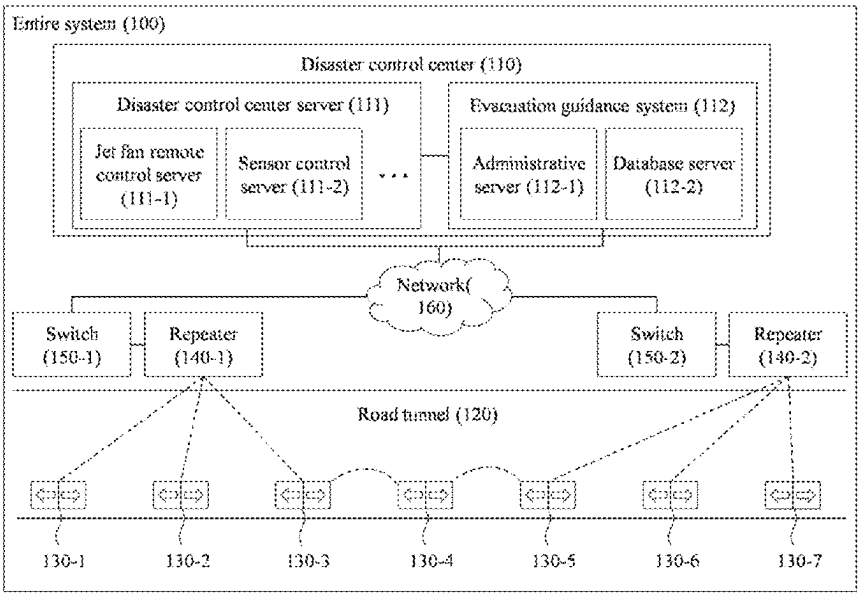


FIG. 1

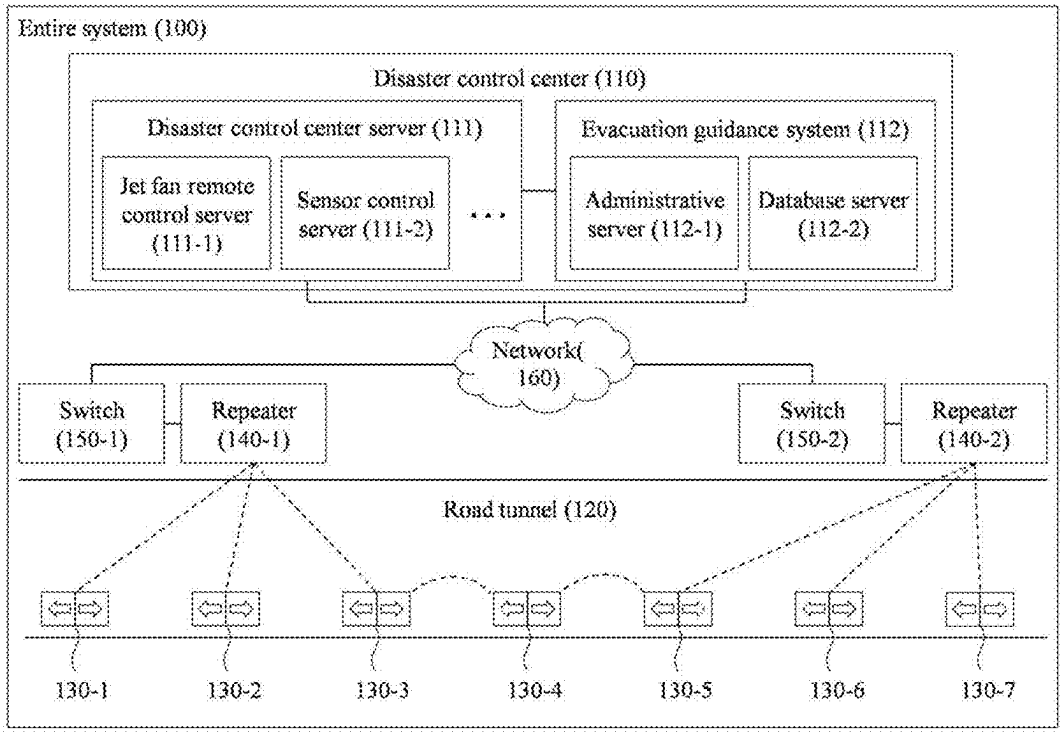

Entire system (100)
Disaster control center (110)
Disaster control center server (111)
Jet fan remote control server (111-1)
Sensor control server (111-2)
• • •
Evacuation guidance system (112)
Administrative server (112-1)
Database server (112-2)
Network(160)
Switch (150-1)
Repeater (140-1)
Switch (150-2)
Repeater (140-2)
Road tunnel (120)
130-1
130-2
130-3
130-4
130-5
130-6
130-7

FIG. 2

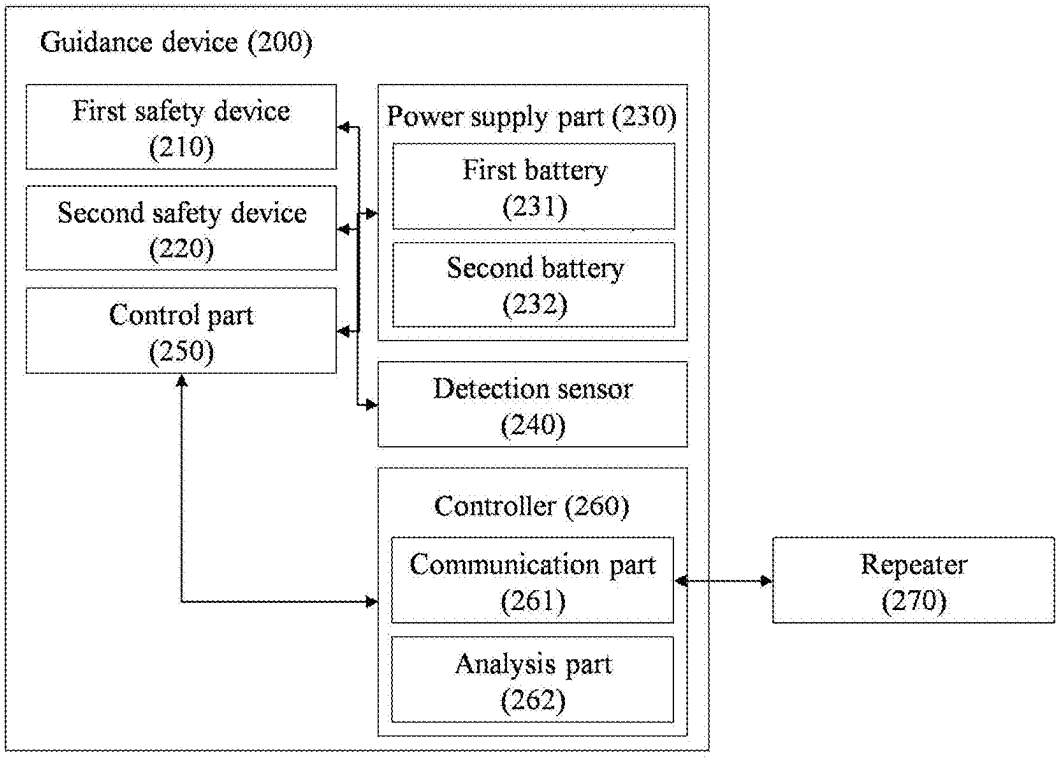

Guidance device (200)
First safety device (210)
Second safety device (220)
Control part (250)
Power supply part (230)
First battery (231)
Second battery (232)
Detection sensor (240)
Controller (260)
Communication part (261)
Analysis part (262)
Repeater (270)

FIG. 3

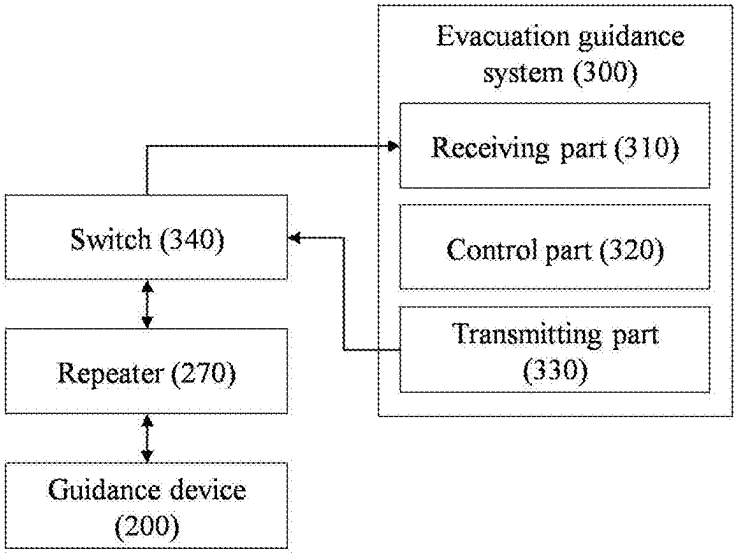

Evacuation guidance system (300)
Receiving part (310)
Control part (320)
Transmitting part (330)
Switch (340)
Repeater (270)
Guidance device (200)

FIG. 4

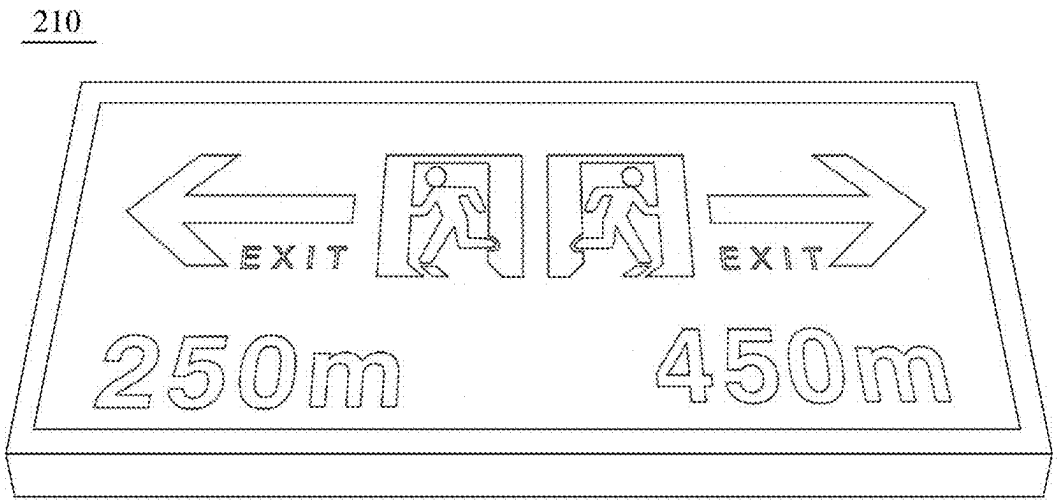


FIG. 5

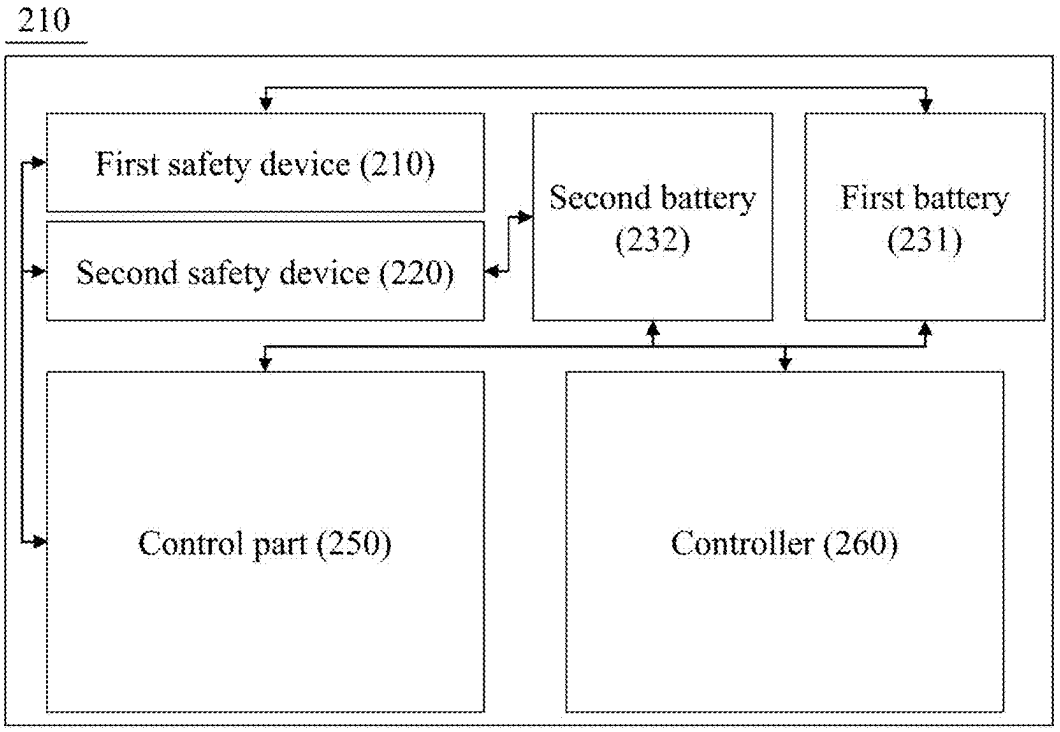

210
First safety device (210)
Second safety device (220)
Second battery (232)
First battery (231)
Control part (250)
Controller (260)

FIG. 6

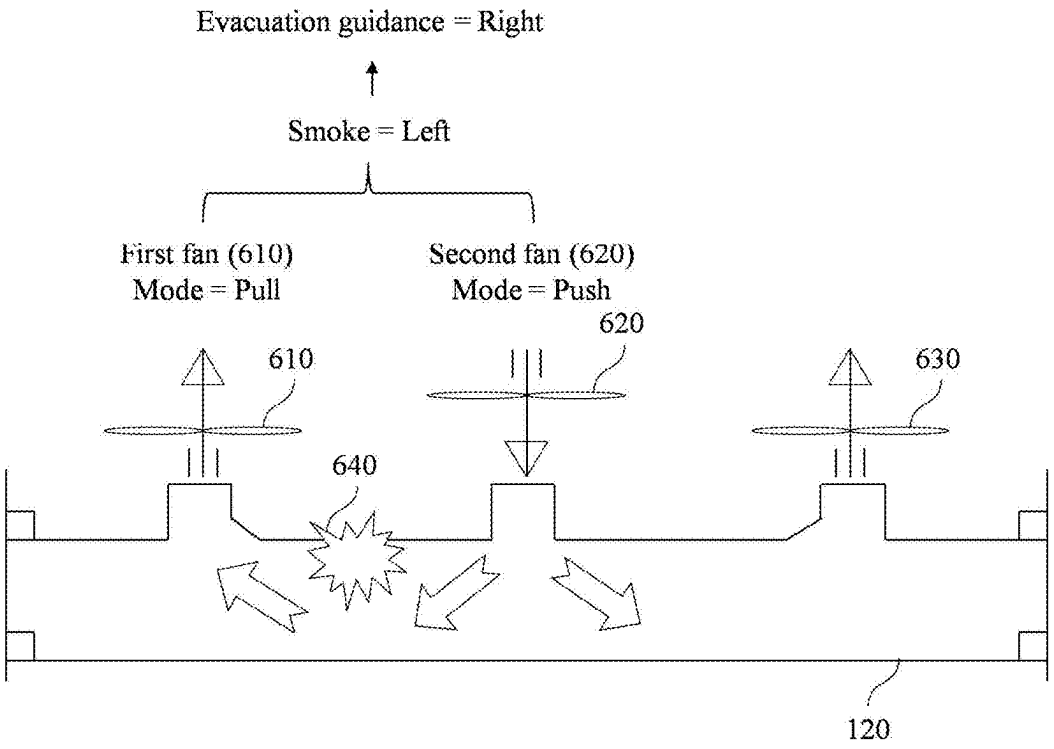

Evacuation guidance = Right
Smoke = Left
First fan (610)
Mode = Pull
Second fan (620)
Mode = Push
610
620
630
640
120

FIG. 7

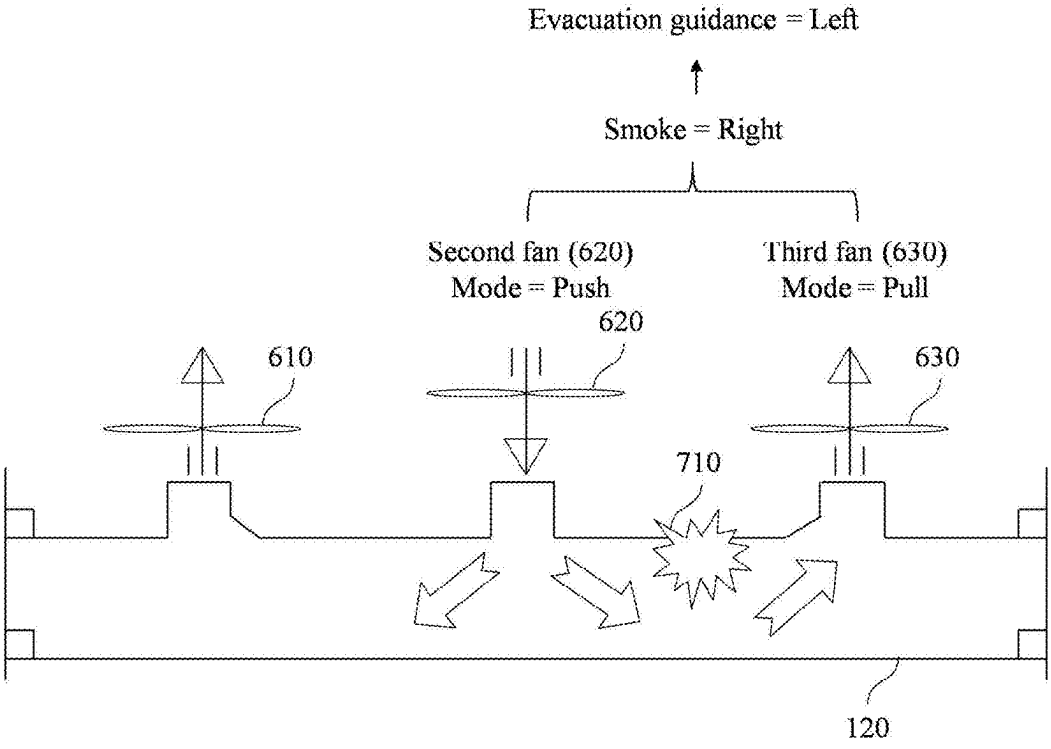
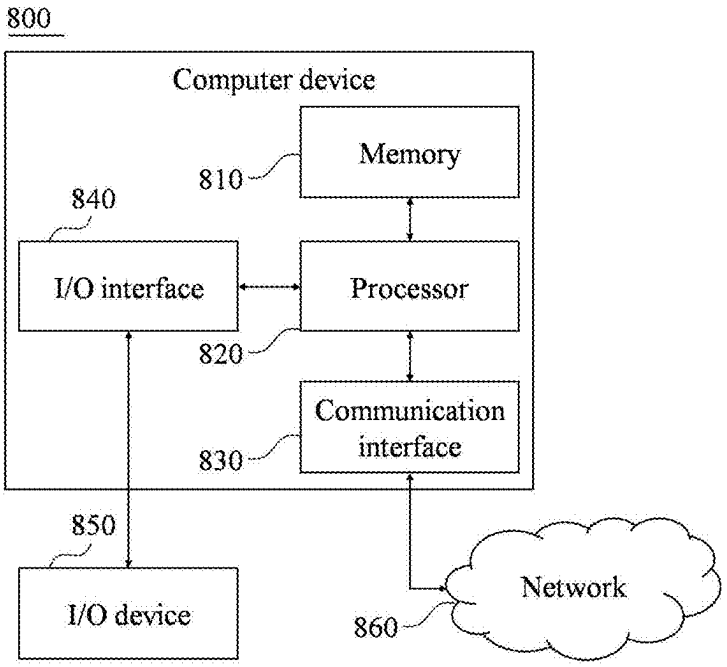

Evacuation guidance = Left
Smoke = Right
Second fan (620)
Mode = Push
Third fan (630)
Mode = Pull
620
610
630
710
120

FIG. 8


800
Computer device
Memory
810
840
I/O interface
Processor
820
Communication interface
830
850
I/O device
Network
860

METHOD AND SYSTEM FOR SMART EVACUATION GUIDANCE IN ROAD TUNNEL

CROSS-REFERENCE TO RELATED APPLICATION

This application is based on and claims priority under 35 U.S.C. 119 to Korean Patent Application No. 10-2024-0074000, filed on Jun. 5, 2024 in the Korean intellectual property office, the disclosures of which are herein incorporated by reference in their entireties.

TECHNICAL FIELD

The present disclosure relates to a method and system for smart evacuation guidance in a road tunnel.

BACKGROUND OF THE DISCLOSURE

Large and long tunnels carry the risk of mass casualties in disasters because they are a confined space, which necessitates a proper evacuation guidance system for efficient evacuation in case of a complex disaster. In a situation where a vehicle cannot escape from a road tunnel in the event of an emergency in the tunnel, such as fire, it is essential for the evacuee to evacuate to the outside after moving to a safe place of refugee such as a cross passage or a shelter via a cross-connecting path.

Guidance lighting is a light for guiding evacuation in the event of an emergency, which refers to a light that is lit by commercial power under normal circumstances and is automatically lit by emergency power in the event of a commercial power failure. Current evacuation guidance lighting installed in road tunnels is required to guide the evacuee toward an exit in the event of an emergency such as fire.

PRIOR ART DOCUMENT

Korean Patent Registration No. 10-2260248

SUMMARY

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

The present disclosure provides a method and system for smart evacuation guidance in a road tunnel.

An embodiment of the present disclosure provides a controller included in a guidance device installed within a road tunnel, the guidance device including: a power supply part; a first safety device activated by power from the power supply part, for guiding evacuation from the road tunnel in a first direction; a second safety device activated by power from the power supply part, for guiding evacuation in a second direction opposite to the first direction; and a control part that controls the first safety device and the second safety device, individually, in accordance with a control signal transmitted from the controller, wherein the controller includes a communication part that communicates with a repeater disposed in the road tunnel and receives the control signal from an evacuation guidance system of a disaster control center for the road tunnel and transmits the same to the control part.

According to one aspect, the control signal may contain information for controlling the first safety device and the second safety device, individually, in the event of an emergency in the road tunnel, depending on whether the direction of evacuation from the road tunnel determined by the evacuation guidance system is either the first direction or the second direction.

According to another aspect, the control part may collect state information for each component of the guidance device, and the controller may further include an analysis part that receives the collected state information from the control part and analyzes the same.

According to another aspect, the analysis part may analyze whether the guidance device has a failure, based on the collected state information, and, in the event of a failure, may send information on the failure to the repeater through the communication part, in order to convey the information on the failure to the evacuation guidance system.

According to yet another aspect, the analysis part may predict at least one of the lifetime and performance of the guidance device based on the collected state information, and may send a maintenance alert to the repeater through the communication part, in order to convey the maintenance alert to the evacuation guidance system based on the predicted lifetime or performance.

According to a further aspect, the guidance device may further include a detection sensor for detecting information on at least one of surrounding temperature, flames, and smoke in the road tunnel, and the communication part may receive the detected information from the detection sensor and sends the same to the repeater, in order to convey the information detected by the detection sensor to the evacuation guidance system.

According to a further aspect, the power supply part may include: a first battery for supplying power to the first safety device; and a second battery for supplying power to the second safety device.

Another embodiment of the present disclosure provides a guidance device installed in a road tunnel, including: a power supply part; a first safety device activated by power from the power supply part, for guiding evacuation from the road tunnel in a first direction; a second safety device activated by power from the power supply part, for guiding evacuation in a second direction opposite to the first direction; a control part that controls the first safety device and the second safety device, individually, in accordance with a control signal received from an evacuation guidance system of a disaster control enter for the road tunnel; and a communication part that communicates with a repeater disposed in the road tunnel and receives the control signal from the evacuation guidance system and transmits the same to the control part.

Yet another embodiment of the present disclosure provides an evacuation guidance system implemented in a disaster control center for a road tunnel, the evacuation guidance system including: a receiving part that receives information on a jet fan disposed in the road tunnel from a jet fan remote control server which is included in the disaster control center, in order to remotely control the jet fan; a control part that determines the direction of evacuation for each of the plurality of guidance devices disposed in the road tunnel, based on the information on the jet fan, and creates a control signal for controlling the first safety device and the second safety device, individually, which are respectively included in the plurality of guidance devices disposed in the road tunnel, according to the determined direction of evacuation; and a transmitting part that sends the created control

signal to a repeater disposed in the road tunnel, in order to convey the created control signal to each of the plurality of guidance devices, wherein the first safety device guides evacuation from the road tunnel in a first direction, and the second safety device guides evacuation in a second direction opposite to the first direction.

The present disclosure may provide a method and system for smart evacuation guidance in a road tunnel.

DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this disclosure will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a view illustrating an example of a structure of an entire system for smart evacuation guidance in a road tunnel, according to an embodiment of the present disclosure.

FIG. **2** is a view illustrating an example of an internal configuration of a guidance device, according to an embodiment of the present disclosure.

FIG. **3** is a view illustrating an example of an internal configuration of an evacuation guidance system, according to an embodiment of the present disclosure.

FIGS. **4** and **5** are diagrams depicting an example of implementation of a guidance device according to an embodiment of the present disclosure.

FIGS. **6** and **7** are diagrams depicting an example of a control logic of a guidance device, according to one embodiment of the present disclosure.

FIG. **8** is a block diagram illustrating an example of a computer device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

While illustrative embodiments have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the disclosure.

Hereinafter, an embodiment will be described in detail with reference to the accompanying drawings.

FIG. **1** is a view illustrating an example of a structure of an entire system for smart evacuation guidance in a road tunnel, according to an embodiment of the present disclosure. The entire system **100** for smart evacuation guidance in the road tunnel may include a disaster control center **110**, a road tunnel **120**, a plurality of guidance devices **130-1** to **130-7**, a plurality of repeaters **140-1** and **140-2**, a plurality of switches **150-1** and **150-2**, and a network **160**.

The disaster control center **110** may serve as a central management center for managing the road tunnel **120**. To this end, the disaster control center **110** may include a disaster control center server **111** for controlling and/or managing a jet fan, a sensor, etc. which are basically installed in the road tunnel **120**. The disaster control center server **111** may include servers that are already well known in relation to the management of the road tunnel **120**, including a jet fan remote control server **111-1** and a sensor control server **111-2**, for example. Additionally, the disaster control center **110** may further include an evacuation guidance system **112** according to an embodiment of the present disclosure. The evacuation guidance system **112** may remotely control the plurality of guidance devices **130-1** to **130-7** installed in the road tunnel **120** that will be described hereinbelow.

The plurality of guidance devices **130-1** to **130-7** may be disposed at first preset intervals in the road tunnel **120**. Thus, the number of guidance devices disposed in the road tunnel **120** may vary depending on the length of the road tunnel **120**. The plurality of repeaters **140-1** and **140-2** and the plurality of switches **150-1** and **150-2** also may be installed at second preset intervals in the road tunnel **120**, and therefore the number of repeaters disposed in the road tunnel **120** and the number of switches disposed in the road tunnel **120** also may vary depending on the length of the road tunnel **120**.

In the event of an emergency such as fire, the evacuation guidance system **112** may create an evacuation route within the road tunnel **120** based on information transmitted from the disaster control center **111**. The information transmitted from the disaster control center **111** may include, for example, jet fan information including jet fan operation information and jet fan scenario information and/or detected information from existing detection sensors installed in the road tunnel **120**. Such information may be extensively used as data related to the operation of a smoke control equipment that is built in relation to the road tunnel **120** and the disaster control center **111**. Also, the evacuation route created by the evacuation guidance system **112** may basically include information on the direction of evacuation the plurality of guidance devices **130-1** to **130-7** each need to guide. Afterwards, the evacuation guidance system **112** may transmit to the plurality of guidance devices **130-1** to **130-7** a control signal containing information on their corresponding direction of evacuation via the plurality of switches **150-1** and **150-2** and the plurality of repeaters **140-1** and **140-2**. Therefore, the evacuation guidance system **112** is able to guide evacuation in the right direction by using information such as the location of an emergency such as a fire in its early stage and the direction of smoke control.

The plurality of guidance devices **130-1** to **130-7** each may include components for selectively guiding the evacuee to evacuate the road tunnel **120** in either a first direction or a second direction which is the opposite direction of the first direction. In this case, the plurality of guidance devices **130-1** to **130-7** may guide the evacuee to evacuate in the right direction according to information on the direction of evacuation obtained through a control signal transmitted from the evacuation guidance system **112**. Guidance of evacuation may basically involve visually and continuously showing the direction, and in some embodiments, may additionally involve presenting repetitive visual information or repetitive or continuous audio information.

The direction the evacuee has to follow to evacuate the road tunnel **120** needs to be varied in accordance with various types of locations, such as the location of the evacuee and the location of an emergency such as fire. The plurality of guidance devices **130-1** to **130-7** may present information on the right direction of evacuation, thereby enabling the evacuee to quickly evacuate in a safe direction.

The plurality of guidance devices **130-1** to **130-7** and the plurality of repeaters **140-1** and **140-2** may basically communicate with one another via wireless communication. For example, the plurality of guidance devices **130-1** to **130-7** and the plurality of repeaters **140-1** and **140-2** may communicate with one another by using LoRa (Long Range) which is a LPWA (low-power, wide-area) wireless communication networking technique dedicated to Internet-of-things, which has benefits like low cost and high efficiency

compared to wired communication. LoRa is an RF communication technique which uses allowable frequency bands of 900 MHz, which may provide high transmission performance and transmissivity with ultra-low power of 10 mW, from several hundreds of meters or longer in the center of a city to several thousands of meters or longer in the outdoors. Actual test results of LoRa in South Korea showed a transmission distance of about 340 m in the center of a city consisting of complicated building structures, and the transmission distance can be greatly increased by setting up a repeater function in LoRa communication software. For example, at least one (the guidance device **130-4** in the embodiment of FIG. **1**) of the plurality of guidance devices **130-1** to **130-7** may communicate with their corresponding repeater via LoRa relay communication with a neighboring guidance device (the guidance device **130-3** or **130-5** in the embodiment of FIG. **1**).

Although the foregoing description has been made with respect to wireless communication as an example of communication between the plurality of guidance devices **130-1** to **130-7** and the plurality of repeaters **140-1** and **140-2**, it does not mean that wired communication will be excluded. Rather, the plurality of guidance devices **130-1** to **130-7** and the plurality of repeaters **140-1** and **140-2** each may further include a wireless communication module, in addition to a wired communication module.

The plurality of repeaters **140-1** and **140-2** may communicate with the disaster control center server **111** and the evacuation guidance system **112** over the network **160** via the plurality of switches **150-1** and **150-2**. The network **160** may include one or more of such networks as PAN (personal area network), LAN (local area network), CAN (campus area network), MAN (metropolitan area network), WAN (wide area network), BBN (broadband network), and the internet, for example. Also, the network **160** may include, but not limited to, one or more of network topologies, including a bus network, a star network, a ring network, a mesh network, a star-bus network, a tree or hierarchical network, etc. In the embodiment of FIG. **1**, it is assumed that the plurality of switches **150-1** and **150-2** and the network **160** are connected via optical communication, and that the network **160** uses TCP-IP (Transmission Control Protocol/Internet Protocol).

FIG. **2** is a view illustrating an example of an internal configuration of a guidance device, according to an embodiment of the present disclosure. The guidance device **200** according to the embodiment of FIG. **2** may correspond to one of the plurality of guidance devices **130-1** to **130-7** described previously with reference to FIG. **1**, and may include a first safety device **210**, a second safety device **220**, a power supply part **230**, a detection sensor **240**, and a control part **250**, and may further include a separate controller **260**. The first safety device **210**, the second safety device **220**, the power supply part **230**, the detection sensor **240**, and the control part **250** may be components for actuating the guidance device **200**. The controller **260** may be a component that is included in the guidance device **200** so as to allow the guidance device **200** to interoperate via the repeater **270** with the disaster control center server **111** and the evacuation guidance system **112** which have been described with reference to FIG. **1**.

The first safety device **210** may be a component that is activated by power from the power supply part **230** to guide evacuation from the road tunnel **120** in a first direction, and the second safety device **220** may be a component that is activated by power from the power supply part **230** to guide evacuation from the road tunnel **120** in a second direction opposite to the first direction. In this case, in some embodiments, the power supply part **230** may include a first battery **231** and a second battery **232** to transmit electric power to the first safety device **210** and the second safety device **220**, respectively. In an embodiment, the first battery **231** and the second battery **232** may be rechargeable batteries, and the guidance device **200** may receive electric power in a wired manner via the power supply part **230** and charge the first battery **231** and the second battery **232**. Afterwards, if power cannot be supplied in a wired manner when an emergency occurs, the control part **250** may supply electric power to the first safety device **210** and the second safety device **220**, respectively, using the first battery **231** and the second battery **232**. Since only one of the first and second safety devices **210** and **220** is actuated in the case of an emergency, the first battery **231** and the second battery **232** may be operated for the first safety device **210** and the second safety device **220**, respectively, in order to increase safety.

Meanwhile, the controller **260** may basically include a communication part **261** for communicating with the repeater **270**, and in some embodiments, may further include an analysis part **262** for analyzing state information for each component of the guidance device **200** that is transmitted from the control part **250**.

First, the controller **260** may receive through the communication part **261** a control signal transmitted by the evacuation guidance system **112** via the repeater **270**, and may transmit the received control signal to the control part **250**. Such a control signal may contain information for controlling the first safety device **210** and the second safety device **220**, individually, in the event of an emergency in the road tunnel **120**, depending on whether the direction of evacuation from the road tunnel **120** determined by the evacuation guidance system **112** is either a first direction or a second direction opposite to the first direction. In this instance, the controller **260** may transmit the control signal to the control part **250**, and the control part **250** may control the first safety device **210** and the second safety device **220**, individually, in accordance with the control signal. For example, when it is required to guide evacuation in the first direction, the control part **250** may activate the first safety device **210**, and when it is required to guide evacuation in the second direction, may activate the second safety device **220**. As already explained, a control signal for guiding evacuation in a direction different from the direction in which evacuation is guided by the other guidance devices may be transmitted to at least one of the plurality of guidance devices **130-1** to **130-7** disposed in the road tunnel **120**, depending on the locations of the plurality of the guidance devices **130-1** to **130-7** and the location of the emergency.

Moreover, the control part **250** may collect state information for each component of the guidance device **200**. For example, the state information is state information of the guidance device **200**, which may include information on the state of power supply, the state of the batteries **231** and **232**, and/or the operating state of the power supply part **230**. In this case, the controller **260** may receive such state information from the control part **250** and analyze the state information through the analysis part **262**. As a more specific example, the analysis part **262** may analyze whether the guidance device **200** has a failure, based on the collected state information, and, in the event of a failure, may send information on the failure to the repeater **270** through the communication part **261**, in order to convey the information on the failure to the evacuation guidance system **112**. As another example, the analysis part **262** may predict at least one of the lifetime and performance of the guidance device

200 based on the collected state information, and may send a maintenance alert to the repeater 270 through the communication part 261, in order to convey the maintenance alert to the evacuation guidance system 112 based on the predicted lifetime or performance. Accordingly, the guidance device 200 is able to provide a constant support for a stable operation environment by providing predictive maintenance. In order to create such failure information or a maintenance alert, the analysis part 262 may include artificial intelligence-based firmware. In some embodiments, the analysis part 262 may simply receive state information from the control part 250 and send it to the repeater 270 through the communication part 261, in order to convey the state information to the evacuation guidance system 112. In this case, the evacuation guidance system 112 may use a machine learning engine to directly analyze the state information and create information on a failure in the guidance device 200 or a maintenance alert. Such failure information or a maintenance alert may be provided to an administrator of the evacuation guidance system 112 in various ways. For example, the evacuation guidance system 112 may transmit failure information or a maintenance alert to a terminal of the administrator.

Meanwhile, the detection sensor 240 included in the guidance device 200 may detect information on at least one of temperature, flames, and smoke. In this case, the controller 260 may receive the detected information from the detection sensor 240 and send it to the repeater 270, in order to convey the information detected by the detection sensor 240 to the evacuation guidance system 112. As already explained, the plurality of guidance devices 130-1 to 130-7 may be disposed at first preset intervals in the road tunnel 120, and the evacuation guidance system 112 is aware of information on the location of each of the plurality of guidance devices 130-1 to 130-7. Accordingly, the evacuation guidance system 112 is able to identify a more accurate location of an emergency such as fire. For example, the guidance device 200 may serve as a fire detector in the road tunnel 120.

FIG. 3 is a view illustrating an example of an internal configuration of an evacuation guidance system, according to an embodiment of the present disclosure. The evacuation guidance system 300 according to the embodiment of FIG. 3 may include a receiving part 310, a control part 320, and a transmitting part 330.

The receiving part 310 may receive information on a jet fan disposed in the road tunnel 120 from the jet fan remote control server 111-1 which is included in the disaster control center 110, in order to remotely control the jet fan. As already explained, the receiving part 310 may receive at least some of data related to the operation of the smoke control equipment that is built in relation to the road tunnel 120 and the disaster control center 111, and the received information may include information on the jet fan.

The control part 320 may determine the direction of evacuation for each of the plurality of guidance devices 130-1 to 130-7 disposed in the road tunnel 120, based on the information on the jet fan, and may create a control signal for controlling the first safety device 210 and the second safety device 220, individually, which are respectively included in the plurality of guidance devices 130-1 to 130-7 disposed in the road tunnel 120, according to the determined direction of evacuation.

The transmitting part 330 may send the created control signal to the plurality of repeaters 140-1 and 140-2 disposed in the road tunnel 120, in order to convey it to each of the plurality of guidance devices 130-1 to 130-7. The embodiment of FIG. 3 shows an example in which a particular switch 340 and a particular repeater 270 are used to send the control signal to a particular guidance device 200.

As already explained, the first safety device 210 of the guidance device 200 may guide evacuation from the road tunnel 120 in a first direction, and the second safety device 220 may guide evacuation in a second direction opposite to the first direction. The control part 250 of the guidance device 200 may selectively activate either the first safety device 210 or the second safety device 220 in accordance with the control signal and guide the evacuee to evacuate in a particular direction which is either the first direction or the second direction.

Moreover, as explained with reference to FIG. 2, the guidance device 200 may further include a detection sensor 240 for detecting information on at least one of surrounding temperature, flames, and smoke in the road tunnel 120. In this case, the receiving part 310 may additionally receive information detected by the detection sensor 240 from the guidance device 200 via the repeater 270 and the switch 340. At this point, the control part 320 may determine the direction of evacuation by using the additionally received, detected information. In other words, the control part 320 may identify a more accurate location of an emergency such as fire, by using information detected by the detection sensor 240 of the guidance device 200, as well as the direction of smoke control by the jet fan or information from the existing sensors installed in the road tunnel 120.

In addition, as already explained, the guidance device 200 may collect state information for each component of the guidance device 200, analyze whether the guidance device 200 has a failure or not based on the collected state information, and in the event of a failure, send information on the failure to the repeater 270, in order to convey the information on the failure to the evacuation guidance system 112. In this case, the receiving part 310 may additionally receive the information on the failure via the repeater 270 and the switch 340, and the control part 320 may provide the administrator with the information on the failure through the transmitting part 330. As another example, the guidance device 200 may collect state information for each component of the guidance device 200, predict the lifetime and/or performance of the guidance device 200 based on the collected state information, and send a maintenance alert to the repeater 270, in order to convey the maintenance alert to the evacuation guidance system 112 based on the predicted lifetime and/or performance. In this case, the receiving part 310 may additionally receive information on the maintenance alert via the repeater 270 and the switch 340, and the control part 320 may provide the administrator with the maintenance alert through the transmitting part 330.

As another example, the guidance device 200 may transmit state information collected through the control device 260 to the evacuation guidance system 112. In this case, the receiving part 310 may receive such state information, and the control part 320 may analyze the state information, create information on a failure or a maintenance alert, and provide the created failure information to the administrator through the transmitting part 330.

FIGS. 4 and 5 are diagrams depicting an example of implementation of a guidance device according to an embodiment of the present disclosure. FIG. 4 is a view illustrating an example of implementation of a guidance device 200 in the form of distance indicating guidance lighting. An arrow and a distance to a safe place of refugee such as an end of the tunnel, a cross passage, or a shelter may be indicated on the outside of the guidance device 200. In

this case, when one of the first and second safety devices **210** and **220** shown in FIG. **5** is activated, the light at one of the arrows may be lit to provide visual evacuation information to the evacuee. Inversely, if the guidance device **200** remains constantly turned on, the guidance device **200** may keep only the light at one arrow turned on by stopping the operation of one of the first and second safety devices **210** and **220** and turning it off. As already explained, the controller **260** may receive a control signal from the evacuation guidance system **112** and transmit it to the control part **250**, and the control part **250** may supply power to the first safety device **210** through the first battery **231** or to the second safety device **220** through the second battery **232** in accordance with the control signal, whereby one of the first and second safety devices **210** and **220** may be selectively activated.

FIGS. **6** and **7** are diagrams depicting an example of a control logic of a guidance device, according to one embodiment of the present disclosure.

FIG. **6** shows an example in which a first fan **610** operates in a pull mode and a second fan **620** operates in a push mode, in relation to a fire location **640** in the road tunnel **120**. In this case, the evacuation guidance system **112** may send to the guidance devices positioned at the right of the fire location **640** a control signal for guiding evacuation to the right, based on information on the fire location **640** and operation information of the first fan **610** and the second fan **620**. On the other hand, the evacuation guidance system **112** may send to the guidance devices positioned at the left of the fire location **640** a control signal for guiding evacuation to the left.

FIG. **7** shows an example in which the second fan **620** operates in the push mode and a third fan **630** operates in the pull mode, in relation to a fire location **710** in the road tunnel **120**. In this case, the evacuation guidance system **112** may send to the guidance devices positioned at the right of the fire location **710** a control signal for guiding evacuation to the right, based on information on the fire location **710** and operation information of the second fan **620** and the third fan **630**. On the other hand, the evacuation guidance system **112** may send to the guidance devices positioned at the left of the fire location **710** a control signal for guiding evacuation to the left.

In accordance with such a control signal, the guidance devices each may turn off one of the two safety devices (e.g., the first and second safety devices **210** and **220**) and guide the evacuees in the direction of evacuation.

Referring back to FIG. **1**, the disaster control center server **111** of the disaster control center **110** and the evacuation guidance system **112** may interoperate in such a way that the evacuation guidance system **112** requests the disaster control center server **111** to send smoke control equipment operation information, and the disaster control center server **111** may send smoke equipment operation information to the evacuation guidance system **112** as a response. An example of message transmission for the interoperation, a Modbus TCP protocol may be used. A Modbus TCP server may be built in a system (e.g., the disaster control center **111**) for automatically controlling smoke equipment, and a Modbus TCP client may be built in the evacuation guidance system **112**. Using such a Modbus TCP protocol, the evacuation guidance system **112** may periodically request the disaster control center server **111** to send state information, and may use information received as a response in controlling the plurality of guidance devices **130-1** to **130-7**. Table 1 below shows an example of a layout of data the evacuation guidance system **112** receives as a response from the disaster control center server **111**.

Field	Length	Description
In operation	1 Byte	Type of operation (auto, manual)
Emergency	1 Byte	Type of emergency (fire, normal)
Operating state of each fan (six fans)	N Byte	Mode of operation of each fan (push, pull, stop, failure)

At least one of the evacuation guidance system **112** and the disaster control center server **111** may be implemented by including a computer device.

FIG. **8** is a block diagram illustrating an example of a computer device according to an embodiment of the present disclosure. As illustrated in FIG. **8**, the computer device **800** may include a memory **810**, a processor **820**, a communication interface **830**, and an input/output interface **840**. The memory **810** is a computer-readable recording medium, and may include a permanent mass storage device, such as random access memory (RAM), read only memory (ROM), and a disk drive. Here, the permanent mass storage device, such as ROM and a disk drive, is a separate permanent storage device which is distinct from the memory **810**, and may be included in the computer device **800**. Also, an operating system and at least one program code may be stored in the memory **810**. Such software components may be loaded onto the memory **810** from another computer-readable recording medium separate from the memory **810**. Such a separate computer-readable recording medium may include a computer-readable recording medium such as a floppy drive, a disk, a tape, a DVD/CD-ROM drive, a memory card, etc. In other embodiments, the software components may be loaded onto the memory **810**, not through a computer-readable recording medium but through the communication interface **830**. For example, the software components may be loaded onto the memory **810** of the computer device **800** based on a computer program installed by files received over a network **860**.

The processor **820** may be configured to process computer program instructions by performing basic arithmetic, logic, and input/output operation. The instructions may be provided to the processor **820** by the memory **810** or the communication interface **830**. For example, the processor **820** may be configured to execute the instructions received according to a program code stored in a recording device such as the memory **810**.

The communication interface **830** may provide a function for communication between the computer device **800** and other devices over the network **860**. In an example, a request, instruction, data, file, etc. generated by the processor **820** of the computer device **800** according to program code stored in a recording device such as the memory **810** may be transmitted to other devices over the network **860** under control of the communication interface **830**. Inversely, a signal, instruction, data, file, etc. from other devices may be received by the computer device **800** through the communication interface **830** of the computer device **800** over the network **860**. The signal, instruction, data, etc. received through the communication interface **830** may be transmitted to the processor **820** or memory **810**, and the file or the like may be stored in a storage medium (the above-mentioned permanent storage device) the computer device **800** may further include.

The input/output interface **840** may be a means for interfacing with an input/output device **850**. For example, the input device may include a microphone, a keyboard, or a mouse, and the output device may include a device like a display or speaker. In another example, the input/output interface **840** may be a means for interfacing with a device like a touchscreen whose input and output functions are integrated. The input/output device **850**, together with the computer device **800**, may be configured as one device.

In other embodiments, the computer device **800** may include fewer or more components than the one shown in FIG. **8**. However, there is no need to clearly illustrate most of the components according to the related art. For example, the computer device **800** may include at least some of the aforementioned input/output devices **850**, or may further include other components, such as a transceiver, a database, etc.

In this way, according to embodiments of the present disclosure, a method and system for smart evacuation guidance in a road tunnel may be provided.

The aforementioned system or apparatus may be implemented in the form of a hardware component, a software component, or a combination of a hardware component and a software component. For example, the apparatus and components described in the embodiments may be implemented using one or more general-purpose computers or special-purpose computers, like a processor, a controller, an arithmetic logic unit (ALU), a digital signal processor, a microcomputer, a field programmable gate array (FPGA), a programmable logic unit (PLU), a microprocessor or any other device capable of executing or responding to an instruction. The processor may perform an operating system (OS) and one or more software applications executed on the OS. Furthermore, the processor may access, store, manipulate, process and generate data in response to the execution of software. For convenience of understanding, one processor has been illustrated as being used, but a person having ordinary skill in the art may understand that the processor may include a plurality of processing elements and/or a plurality of types of processing elements. For example, the processor may include a plurality of processors or a single processor and a single controller. Furthermore, a different processing configuration, such as a parallel processor, is also possible.

Software may include a computer program, code, an instruction or a combination of one or more of them and may configure a processor so that it operates as desired or may instruct the processor independently or collectively. The software and/or data may be embodied in a machine, component, physical device, virtual equipment or computer storage medium or device of any type in order to be interpreted by the processor or to provide an instruction or data to the processor. The software may be distributed to computer systems connected over a network and may be stored or executed in a distributed manner. The software and data may be stored in one or more computer-readable recording media.

The method according to the embodiments may be implemented with program instructions which may be executed through various computer means, and may be recorded in computer-readable media. The computer-readable media may also include, alone or in combination, the program instructions, data files, data structures, and the like. The media may persistently store a computer-executable program or temporarily store the computer-executable program for execution or downloading. The media may be various recording means or storage means formed by a single piece of hardware or a combination of several pieces of hardware. The media are not limited to media directly connected to a certain computer system, but may be distributed over a network. Examples of the media may be those configured to store program instructions, including magnetic media such as hard disks, floppy disks, and magnetic tapes, optical media such as CD-ROMs and DVDs, and magneto-optical media such as floptical disks, ROM, RAM, and flash memory. Furthermore, other examples of the medium may include an app store in which apps are distributed, a site in which other various pieces of software are supplied or distributed, and recording media and/or store media managed in a server. Examples of the program instructions may include machine-language code, such as code written by a compiler, and high-level language code executable by a computer using an interpreter.

While a few exemplary embodiments have been shown and described with reference to the accompanying drawings, it will be apparent to those skilled in the art that various modifications and variations can be made from the foregoing descriptions. For example, adequate effects may be achieved even if the foregoing processes and methods are carried out in a different order than described above, and/or the aforementioned elements, such as systems, structures, devices, or circuits, are combined or coupled in different forms and modes than as described above or be substituted or switched with other components or equivalents.

Therefore, other implementations, other embodiments, and equivalents to the claims are within the scope of the following claims.

The embodiments of the disclosure in which an exclusive property or privilege is claimed are defined as follows:

1. A controller included in a guidance device installed within a road tunnel, the guidance device comprising:

a power supply part;

a first safety device activated by power from the power supply part, for guiding evacuation from the road tunnel in a first direction;

a second safety device activated by power from the power supply part, for guiding evacuation in a second direction opposite to the first direction; and

a control part that controls the first safety device and the second safety device, individually, in accordance with a control signal transmitted from the controller,

wherein the controller comprises a communication part that communicates with a repeater disposed in the road tunnel and receives the control signal from an evacuation guidance system of a disaster control center for the road tunnel and transmits the same to the control part,

wherein the control part collects state information for each component of the guidance device, and

the controller further comprises

an analysis part including an AI-based firmware for generating a maintenance alert to support predictive maintenance by receiving and analyzing the collected state information from the control part,

wherein the analysis part predicts at least one of the lifetime and performance of the guidance device based on the collected state information, and transmits the maintenance alert to the repeater through the communication part in order to convey the maintenance alert to the evacuation guidance system based on the predicted lifetime or performance, and

wherein the power supply part includes:

a first battery for supplying power to the first safety device when wired power supply to the first safety device becomes unavailable; and

a second battery for supplying power to the second safety device when wired power supply to the second safety device becomes unavailable, and

the first battery and the second battery are operated independently.

2. The controller of claim 1, wherein the control signal contains information for controlling the first safety device and the second safety device, individually, in the event of an emergency in the road tunnel, depending on whether the direction of evacuation from the road tunnel determined by the evacuation guidance system is either the first direction or the second direction.

3. The controller of claim 1, wherein the analysis part analyzes whether the guidance device has a failure, based on the collected state information, and, in the event of a failure, sends information on the failure to the repeater through the communication part, in order to convey the information on the failure to the evacuation guidance system.

4. The controller of claim 1, wherein the guidance device further comprises a detection sensor for detecting information on at least one of surrounding temperature, flames, and smoke in the road tunnel, and the communication part receives the detected information from the detection sensor and sends the same to the repeater, in order to convey the information detected by the detection sensor to the evacuation guidance system.

5. A guidance device installed in a road tunnel, comprising:

a power supply part;

a first safety device activated by power from the power supply part, for guiding evacuation from the road tunnel in a first direction;

a second safety device activated by power from the power supply part, for guiding evacuation in a second direction opposite to the first direction;

a control part that controls the first safety device and the second safety device, individually, in accordance with a control signal received from an evacuation guidance system of a disaster control center for the road tunnel; and

a communication part that communicates with a repeater disposed in the road tunnel and receives the control signal from the evacuation guidance system and transmits the same to the control part,

wherein the control part collects state information for each component of the guidance device, and

the guidance device further comprises

an analysis part including an Al-based firmware for generating a maintenance alert to support predictive maintenance by receiving and analyzing the collected state information from the control part,

wherein the analysis part predicts at least one of the lifetime and performance of the guidance device based on the collected state information, and transmits the maintenance alert to the repeater through the communication part in order to convey the maintenance alert to the evacuation guidance system based on the predicted lifetime or performance, and

wherein the power supply part includes:

a first battery for supplying power to the first safety device when wired power supply to the first safety device becomes unavailable; and

a second battery for supplying power to the second safety device when wired power supply to the second safety device becomes unavailable, and

the first battery and the second battery are operated independently.

6. The guidance device of claim 5, wherein the control signal contains information for controlling the first safety device and the second safety device, individually, in the event of an emergency in the road tunnel, depending on whether the direction of evacuation from the road tunnel determined by the evacuation guidance system is either the first direction or the second direction.

7. The guidance device of claim 5, wherein the analysis part analyzes whether the guidance device has a failure, based on the collected state information, and, in the event of a failure, sends information on the failure to the repeater through the communication part, in order to convey the information on the failure to the evacuation guidance system, or the analysis part predicts at least one of the lifetime and performance of the guidance device based on the collected state information, and sends a maintenance alert to the repeater through the communication part, in order to convey the maintenance alert to the evacuation guidance system based on the predicted lifetime or performance.

8. An evacuation guidance system implemented in a disaster control center for a road tunnel, the evacuation guidance system comprising:

a receiving part that receives information on a jet fan disposed in the road tunnel from a jet fan remote control server which is included in the disaster control center, in order to remotely control the jet fan;

a control part that determines the direction of evacuation for each of the plurality of guidance devices disposed in the road tunnel, based on the information on the jet fan, and creates a control signal for controlling the first safety device and the second safety device, individually, which are respectively included in the plurality of guidance devices disposed in the road tunnel, according to the determined direction of evacuation; and

a transmitting part that sends the created control signal to a repeater disposed in the road tunnel, in order to convey the created control signal to each of the plurality of guidance devices,

wherein the first safety device guides evacuation from the road tunnel in a first direction, and the second safety device guides evacuation in a second direction opposite to the first direction,

wherein the guidance device collects state information for each component of the guidance device, and

the guidance device further comprises

an analysis part including an AI-based firmware for generating a maintenance alert to support predictive maintenance by receiving and analyzing the collected state information,

wherein the analysis part predicts at least one of the lifetime and performance of the guidance device based on the collected state information, and transmits the maintenance alert to the repeater in order to convey the maintenance alert to the evacuation guidance system based on the predicted lifetime or performance, and

wherein the receiving part further receives information on the maintenance alert,

the control part provides the maintenance alert to an administrator through the transmitting part, and

the guidance device further comprises a power supply part, and

wherein the power supply part includes:

a first battery for supplying power to the first safety device when wired power supply to the first safety device becomes unavailable; and

a second battery for supplying power to the second safety device when wired power supply to the second safety device becomes unavailable, and

the first battery and the second battery are operated independently.

9. The evacuation guidance system of claim **8**, wherein the guidance device further includes a detection sensor for detecting information on at least one of surrounding temperature, flames, and smoke in the road tunnel, the receiving part additionally receives the detected information from the guidance device via the repeater, and the control part determines the direction of evacuation by using the additionally received, detected information.

10. The evacuation guidance system of claim **8**, wherein the guidance device analyzes whether the guidance device has a failure, based on the collected state information, and, in the event of a failure, sends information on the failure to the repeater, in order to convey the information on the failure to the evacuation guidance system,

wherein the receiving part additionally receives the information on the failure, and the control part provides the administrator with the information on the failure through the transmitting part.

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