

DESCRIPTION

TITLE OF INVENTION: ABNORMAL STATE DETECTION APPARATUS, ABNORMAL STATE DETECTION SYSTEM, AND ABNORMAL STATE DETECTION METHOD

TECHNICAL FIELD

[0001]

The present disclosure relates to an abnormal state detection apparatus, an abnormal state detection system, and an abnormal state detection method.

BACKGROUND ART

[0002]

Conventionally, techniques related to fire detection on automobile carrier ships have been proposed. Patent Literature 1 discloses a fire detection and notification system for automobile carrier ships. The fire detection and notification system disclosed in Patent Literature 1 measures the surface temperature of automobiles loaded on a ship by means of thermopile sensors, and detects whether or not a fire has occurred based on the measured temperature.

CITATION LIST

PATENT LITERATURE

[0003]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2005-312642

SUMMARY OF INVENTION

[0004]

However, with the fire detection and notification system disclosed in Patent Literature 1, since vehicles are normally loaded on automobile carrier ships at as high

a density as possible, the layout of loaded vehicles frequently changes depending on the types and number of vehicles to be loaded. For this reason, with conventional configurations, it is necessary to change the layout, orientation, and the like of the thermopile sensor units each time depending on the types and layout of the loaded vehicles, and it may be difficult to achieve high accuracy in detecting the occurrence of fire depending on the layout and orientation.

[0005]

The present disclosure has been made in view of the problems associated with such conventional technology. An object of the present disclosure is to provide an abnormal state detection apparatus capable of appropriately detecting the occurrence of fire or the risk of fire with respect to vehicles loaded on an automobile carrier ship.

[0006]

An abnormal state detection apparatus according to an aspect of the present disclosure is an abnormal state detection apparatus that detects a fire occurring in a vehicle loaded on an automobile carrier ship, and includes: a navigation information acquisition unit that acquires navigation position information of the automobile carrier ship; a camera information acquisition unit that acquires camera information, which is information including image data of the vehicle and a surrounding space of the vehicle captured by a camera; a temperature information acquisition unit that acquires, based on the camera information, temperature information of the vehicle and the surrounding space of the vehicle, and temperature change information per unit time; an abnormal state determination unit that determines, based on assumed temperature information based on the position information, the temperature information, and the temperature change information, whether or not a fire has occurred in the vehicle and the surrounding space of the vehicle, or whether there is a risk of fire therein; and a notification unit that, when a determination is made by the abnormal state determination unit that a fire has occurred, or that there is a risk of fire, notifies at least one of a rotating light, an alarm device, a user terminal, and an administrator terminal provided on the automobile carrier ship that a fire has occurred, or that there is a risk of fire.

[0007]

An abnormal state detection system according to another aspect of the present disclosure includes: the abnormal state detection apparatus; a camera that captures an image of the vehicle loaded on the automobile carrier ship; and at least one of the rotating light, the alarm device, the user terminal, and the administrator terminal.

[0008]

An abnormal state detection method according to another aspect of the present disclosure is an abnormal state detection method for detecting a fire occurring in a vehicle loaded on an automobile carrier ship, and the method is executed by a computer and includes: acquiring navigation position information of the automobile carrier ship; acquiring camera information, which is information including image data of the vehicle and a surrounding space of the vehicle captured by a camera; acquiring, based on the camera information, temperature information of the vehicle and the surrounding space of the vehicle, and temperature change information per unit time; determining, based on assumed temperature information based on the position information, the temperature information, and the temperature change information, whether or not a fire has occurred in the vehicle and the surrounding space of the vehicle, or whether there is a risk of fire therein; and when it is determined that a fire has occurred, or that there is a risk of fire, notifying at least one of a rotating light, an alarm device, a user terminal, and an administrator terminal provided on the automobile carrier ship that a fire has occurred, or that there is a risk of fire.

[0009]

According to the present disclosure, it is possible to provide an abnormal state detection apparatus capable of appropriately detecting the occurrence of fire or the risk of fire with respect to vehicles loaded on an automobile carrier ship.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

[Fig. 1] FIG. 1 is a diagram illustrating a schematic configuration of an abnormal state detection system according to the present embodiment.

[Fig. 2] FIG. 2 is a diagram illustrating a configuration of an abnormal state detection apparatus according to the present embodiment.

[Fig. 3] FIG. 3 is a block diagram illustrating a functional configuration of the abnormal state detection apparatus according to the present embodiment.

[Fig. 4A] FIG. 4A is a diagram illustrating an example of image data applied to the abnormal state detection system according to the present embodiment.

[Fig. 4B] FIG. 4B is a diagram illustrating an example of image data applied to the abnormal state detection system according to the present embodiment.

[Fig. 4C] FIG. 4C is a diagram illustrating an example of determination information applied to the abnormal state detection system according to the present embodiment.

[Fig. 5] FIG. 5 is a flowchart illustrating an example of processing performed by the abnormal state detection apparatus according to the present embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0011]

Hereinafter, an abnormal state detection system 10 and an abnormal state detection apparatus 100 according to the present embodiment will be described in detail with reference to the drawings. Note that dimensional ratios in the drawings are exaggerated for convenience of explanation and may differ from actual ratios.

[0012]

(Regarding Fire on Automobile Carrier Ships)

In recent years, with the growing global demand for environmental measures, the spread of electric vehicles (EVs) has been increasing rapidly. In addition, rapid and abnormal global warming has been progressing, and a risk of fire during the navigation of automobile carrier ships has been increasing.

[0013]

As a result, in addition to fires caused by wiring displacement due to wave action as disclosed in Patent Document 1, for example, fires in EVs equipped with lithium (Li)-ion batteries have been increasing due to abnormal temperature rises inside vehicle-loaded ship cabins.

[0014]

For example, it is generally known that not only Li-ion batteries but also ordinary lead-acid batteries have a storage temperature upper limit of approximately 40 to 50°C. In addition, in recent years, not only EVs and hybrid vehicles but also gasoline vehicles have an increasing number of automotive electrical components, so that it has become common for automobiles to consume approximately 5 to 10 mA at all times as backup power for automotive ECUs and electrical components.

[0015]

Furthermore, in order to save fuel costs, the ventilation equipment inside the storage rooms where automobiles are stored may be stopped on automobile carrier ships while underway. For this reason, situations exist where the temperature inside the storage rooms exceeds 40°C.

[0016]

In addition, due to recent abnormal weather conditions and the like, there are cases where automobile carrier ships navigate through high-temperature ocean regions, and the temperature inside the storage rooms where the automobiles are stored may exceed 45°C, which is the permissible ambient temperature of Li-ion batteries. For this reason, it is common practice to store vehicles equipped with Li-ion batteries, which have a relatively higher risk of ignition at high temperatures compared to lead-acid batteries, on the lower floors within automobile carrier ships where the room temperature inside the storage rooms is less likely to rise, and to transport them by sea; in any case, such a rise in room temperature inside the storage rooms is considered to be one of the factors increasing the risk of fire on automobile carrier ships.

[0017]

Furthermore, once a fire breaks out in an automobile, the spread of fire is rapid and it tends to be too late to respond, in which case evacuation from the scene becomes unavoidable. In addition, there are many cases where the scene has been destroyed by fire, and furthermore there are many cases where surveillance cameras and the like are not installed, which also creates the problem that it has not been possible to trace back the root cause of the problem or the circumstances of the accident.

[0018]

In general, ships are required to implement fire alarm equipment such as smoke detectors. However, with existing smoke detectors, there are cases where a long time is required from the occurrence of fire to the detection operation, for reasons such as smoke flowing and dispersing when the ventilation equipment inside the loading rooms is in operation, the distance from the smoke source to the smoke detector being long, or the amount of smoke generated in the early stages of fire being small.

[0019]

In addition, there is a high possibility that the scale of fire may expand and cause primary and secondary damage, and fire detectors that use smoke as the detection target generally operate after a fire has occurred—so-called after-the-fact detection and after-the-fact reporting. For this reason, combined with detection delays due to smoke dispersion as described above, there has been the problem that extremely severe damage is easily incurred.

[0020]

Furthermore, as disclosed in Patent Document 1, in the method of measuring vehicle body surface temperature to compensate for the disadvantages of conventional smoke detectors, in the case of a Li-ion battery fire, there are many cases where it is already too late by the time the vehicle body surface temperature has risen.

[0021]

As of November 2023, Japan, as the shipowner of automobile carrier ships, is said to have the world's largest number of such ships at 298 vessels, far ahead of the world's second-largest Norway (142 vessels), third-largest South Korea (80 vessels), fourth-largest Israel (59 vessels), and fifth-largest China (40 vessels). On the other hand, China has been rapidly increasing the construction of new automobile carrier ships in recent years, and in this context, it is of paramount importance to Japan's national interest to reliably protect the automobile carrier ships currently owned by Japan from risks such as fires and to advance safety measures further and carry out safe navigation; at the same time, it is necessary for Japan, which is the world's top country in the field of automobile carrier ships, to recognize the existence of the problems described above and to take the

lead in the world in developing abnormal state detection apparatuses to resolve these problems.

[0022]

The abnormal state detection apparatus 100 according to the present embodiment detects the possibility of fire occurrence from various perspectives, namely "temperature management and appropriate operation of ventilation equipment", "monitoring of rapid temperature rise inside storage rooms", "smoke detection monitoring" and "flame detection monitoring", and records, monitors, and issues alerts on the fire occurrence risk from multiple angles. That is, the abnormal state detection apparatus 100 according to the present embodiment detects, records, monitors, and issues alerts on the occurrence of fire or precursor events thereof ("rapid temperature rise", "smoke generation"), or the risk of such occurrences.

[0023]

Therefore, the abnormal state detection apparatus 100 according to the present embodiment quickly and reliably detects not only fires caused by conventional wiring contact and the like, but also various possibilities of fire occurrence on automobile carrier ships arising from factors such as air flow inside storage rooms, ship movement, and temperature rises inside storage rooms due to navigation through tropical high-temperature regions. That is, the abnormal state detection apparatus 100 according to the present embodiment makes it possible to minimize damage by quickly and reliably detecting various possibilities of fire occurrence on automobile carrier ships, including Li-ion battery fires accompanying the rapid global spread of EVs.

[0024]

(Configuration of Abnormal State Detection System 10)

The schematic configuration of the abnormal state detection system 10 according to the present embodiment will be described with reference to FIG. 1. The abnormal state detection system 10 is configured to include a camera 40 that captures images of a vehicle 50 loaded on the automobile carrier ship and the surrounding space of the vehicle 50, an administrator terminal 20, a user terminal 30 operated by a user 31, and an abnormal state detection apparatus 100.

[0025]

Note that in the present embodiment, the surrounding space of the vehicle 50 includes the vehicle body surfaces of the vehicle 50 within the camera's field of view, such as the roof panels and hoods of a plurality of vehicles 50 located within a range of approximately 30 m radius from the camera. In addition, the surrounding space of the vehicle 50 includes, for vehicles of which only a portion of the vehicle body such as the roof panel can be seen from the camera's field of view because they are in the shadow of adjacent vehicles and the like, the surface of that portion of the vehicle body, and the surrounding space of approximately 1 to 3 m around from such vehicle body surfaces up to the ceiling of the storage room.

[0026]

In addition, the abnormal state detection system 10 may include a rotating light 60 and/or an alarm device 70 that provides a notification when a fire or a precursor event thereof has occurred, or when there is a risk thereof. Furthermore, the abnormal state detection system 10 may include a cloud server 200.

[0027]

In the abnormal state detection system 10, the abnormal state detection apparatus 100, the cloud server 200, the administrator terminal 20, and the user terminal 30 are capable of communicating with each other via the network 80.

[0028]

The administrator terminal 20 is implemented as, for example, a PC (personal computer) installed in the command room or wheelhouse of a ship, and displays fire detection information and/or image data transmitted from the abnormal state detection apparatus 100.

[0029]

The user terminal 30 is a terminal operated by the user 31 such as a crew member or worker who patrols the ship, and is implemented as a device such as a smartphone or tablet. In addition, the user terminal 30 displays fire detection information and/or image data transmitted from the abnormal state detection apparatus 100.

[0030]

The camera 40 includes a thermal camera unit and a full high-definition camera unit, acquires camera information, which is information including image data of the vehicle 50 and the surrounding space of the vehicle 50 captured by a camera, and transmits the camera information to the abnormal state detection apparatus 100. The camera 40 in the present embodiment is a thermal camera with a wide viewing angle (60 to 90 degrees) and a full high-definition camera with a wide viewing angle (80 to 100 degrees). Having a wide viewing angle enables quick detection of changes in the vehicle body by monitoring the entire vehicle body, or as much of the vehicle body as possible, of the loaded vehicles within the field of view of the camera 40. Note that depending on the vehicle loading conditions inside the storage rooms, even if at least a portion of the vehicle body does not fall within the field of view of the camera 40, it is desirable to dispose the camera 40 such that the space immediately surrounding that portion of the vehicle body falls within the field of view of the camera 40.

[0031]

Note that in the present embodiment, the surrounding space of the vehicle 50 includes, as described above, the vehicle body surfaces of the vehicle 50 within the camera's field of view, such as the roof panels and hoods of a plurality of vehicles 50 loaded within a range of approximately 30 m radius from the camera. In addition, the surrounding space of the vehicle 50 includes, for vehicles of which only a portion of the vehicle body such as the roof panel can be seen from the camera's field of view because they are in the shadow of adjacent vehicles and the like, the surface of that portion of the vehicle body, and the surrounding space of approximately 1 to 3 m from such vehicle body surfaces up to the ceiling of the storage room.

[0032]

Note that since the camera 40 includes a wide-viewing-angle thermal camera and an ultra-wide-viewing-angle full high-definition camera, even a portion of the vehicle body of the vehicle 50 captured by the camera 40 is sufficient, and it is desirable to design the placement of the camera 40 such that almost all of the loaded vehicles 50 are within the imaging viewing angle of the camera 40.

[0033]

In addition, it is desirable for the entire vehicle body or a portion of the vehicle body captured by the camera 40 to be within both the viewing angle of the thermal camera and the viewing angle of the full high-definition camera, among the imaging viewing angles of the camera 40, in order to achieve higher accuracy.

[0034]

The vehicle 50 is an automobile or the like loaded on an automobile carrier ship, and a plurality of vehicles 50 with a wide variety of types are loaded on the automobile carrier ship at an extremely high density.

[0035]

The rotating light 60 and the alarm device 70, when a fire or a precursor event thereof has occurred, or when there is a risk thereof, acquire the relevant information from the abnormal state detection apparatus 100 and alert those in the vicinity that a fire or a precursor event thereof has occurred, or there is a risk thereof by means of the rotating light or sound.

[0036]

The cloud server 200 continuously acquires and accumulates navigation position information and weather information entered daily by operators, temperature transition information inside storage rooms collected and detected by the camera 40 and the abnormal state detection apparatus 100 described later via the network 80, and furthermore, "smoke generation" and "flame generation" event information such as the determination results of the abnormal state determination unit 117 likewise described later, and compiles these into a database to calculate the probability of occurrence in the near future. Note that navigation position information and weather information are not limited to being entered by operators, and may also be automatically collected and registered in the database via the network 80.

[0037]

For example, the cloud server continuously acquires and accumulates "navigation position information and weather information such as outdoor temperature and weather conditions" and "room temperature change information inside storage rooms on each deck", together with events such as "rapid abnormal temperature rise", "smoke

generation", and "fire" inside vehicle storage rooms of automobile carrier ships, and compiles these into a database.

[0038]

Therefore, the cloud server 200 calculates the correlation and prediction between "navigation position and weather information such as outdoor temperature and weather conditions" and "room temperature inside the storage rooms on each deck", and further calculates the occurrence probabilities of "rapid temperature rise", "smoke generation", and "flame generation" when such events occur, thereby making it possible to notify the bridge in advance, based on "near-future navigation positions and weather information" and the like, of "navigation position", "weather information", "which deck's vehicle storage room temperature is likely to rise", and "whether or not a rapid temperature rise is likely to occur as a result".

[0039]

In addition, vehicle type information such as "gasoline vehicle", "EV", and "PHEV" may be added to the cloud server 200. This makes it possible to lead to consideration of improvements in operational methods, such as which vehicle types should be loaded on which deck, and what loading methods should be used on which routes or in which seasons, thereby making it possible to realize not only conventional fire alarms based solely on "after-the-fact notification" and "after-the-fact reporting" accompanying event occurrences, but also fire alarms based on "advance prediction" and "advance reporting"

[0040]

For example, consider a case where there is a navigation plan for an automobile carrier ship to pass through the Strait of Hormuz 15 days after departing Japan and reach the vicinity of Dubai, UAE in the Middle East, and where the outdoor temperature in the relevant region is expected to exceed 40°C. In this case, when it is calculated based on the past correlations between outdoor temperatures and room temperatures that the room temperature on the 10th floor of the ship will exceed 55°C, even if there have been no past emergency events such as "smoke generation", "flame generation", or "rapid temperature rise" for the relevant shipping company, this system can clarify the risks in

areas that were previously managed based on empirical rules regarding the correlation between outdoor temperature and room temperature, thereby making it possible to more reliably prompt on-site personnel to recognize near-future risks and take action to avoid danger.

[0041]

Note that generative AI or the like may also be used for the calculation of occurrence probabilities in the cloud server 200, and the cloud server 200 may be installed at a location different from the automobile carrier ship. Alternatively, the cloud server 200 may be installed inside the automobile carrier ship.

[0042]

(Configuration of Abnormal State Detection Apparatus 100)

FIG. 2 is a block diagram illustrating the configuration of the abnormal state detection apparatus 100. As illustrated in FIG. 2, the abnormal state detection apparatus 100 is implemented as a general-purpose computer that includes a control unit 110, a storage unit 120, an input/output IF 130 (Interface), and a communication IF 140. Note that the configuration example of the abnormal state detection apparatus 100 illustrated in FIG. 2 is merely one example, and the present embodiment is not limited thereto. In addition, in a case where the administrator terminal 20 and the user terminal 30 are implemented as a personal computer, smartphone, tablet, or the like, the configuration illustrated in the block diagram of FIG. 2 may be applied thereto.

[0043]

The control unit 110 controls the entire abnormal state detection apparatus 100 by, for example, operating an operating system. Furthermore, the control unit 110 operates based on a program (not illustrated) stored in the storage unit 120 and executes each function provided in the control unit 110. Note that the program is not limited to being stored in the storage unit 120, and may instead be stored in, for example, a ROM or the like (not illustrated) inside the abnormal state detection apparatus 100.

[0044]

The storage unit 120 includes an acquired information DB 121 (see FIG. 3), a detection information DB 122 (see FIG. 3), and a determination information DB 123 (see

FIG. 3). Note that the storage unit 120 may be either a single unit or a plurality of units in terms of configuration. For example, a configuration may be adopted in which a single storage unit 120 is divided into areas for storing data. Alternatively, data may be distributed and stored in a plurality of storage devices installed at physically separate locations.

[0045]

The input/output IF 130 illustrated in FIG. 2 is, for example, a component (Interface) for a user to exchange data with the abnormal state detection apparatus 100. Specifically, pre-registered ship interior floor plans and elevation drawings are displayed on an LCD screen connected to the abnormal state detection apparatus 100, the positions of the cameras 40 are plotted on them, and these are linked to the control unit 110. This makes it possible to clearly notify crew members of the past and current room temperature information inside the storage rooms, as captured by each camera 40, and of which vehicle 50, captured by which camera 40, is experiencing an emergency event such as a "rapid temperature rise", "smoke generation", or "flame generation", by means of a window pop-up display of the relevant camera image along with colors, signs, and sounds.

[0046]

In addition, the input of weather information and navigation information to the cloud server 200 described above, as well as future risk information calculated based on such information, are also displayed on the relevant screen. Furthermore, in the present embodiment, the input/output IF 130 is connected to the rotating light 60 and the alarm device 70, and also functions as an interface for outputting fire alarms.

[0047]

The communication IF 140 is an interface for enabling the abnormal state detection apparatus 100 to communicate with external devices via the network 80.

[0048]

(Functional Configuration of Abnormal State Detection Apparatus 100)

Next, the functional configuration of the abnormal state detection apparatus 100 will be described. FIG. 3 is a block diagram illustrating the functional configuration of the abnormal state detection apparatus 100. As illustrated in FIG. 3, the control unit 110

includes the following functional units: a navigation information acquisition unit 111, a camera information acquisition unit 112, a temperature information acquisition unit 113, a rapid temperature rise detection unit 114, a smoke generation detection unit 115, a flame generation detection unit 116, an abnormal state determination unit 117, and a notification unit 118.

[0049]

The navigation information acquisition unit 111 acquires navigation position information of the automobile carrier ship. Specifically, the navigation information acquisition unit 111 acquires navigation plan information through operator input or from a voyage management system, and acquires navigation history by automatically receiving radio waves from a plurality of GPS (Global Positioning System) satellites via a GPS receiver (not illustrated) provided on the automobile carrier ship to obtain the current position of the automobile carrier ship. In addition, the navigation information acquisition unit 111 stores the acquired position information in the acquired information DB 121.

[0050]

The camera information acquisition unit 112 acquires camera information, which is information including image data of the vehicle 50 and the surrounding space of the vehicle 50 captured by a camera. In addition, the camera information acquisition unit 112 stores the acquired camera information in the acquired information DB 121. The image data of the vehicle 50 and the surrounding space of the vehicle 50 captured by a camera may be, for example, data as illustrated in FIG. 4A. In addition, it is desirable that the image data of the vehicle 50 and the surrounding space of the vehicle 50 captured by a camera be a high-resolution image of FullHD quality or higher as shown on the left side of FIG. 4A, and thermal image data as shown on the right side of FIG. 4A, and by acquiring these two kinds of camera image data, it is possible to acquire camera information for performing "temperature information inside storage rooms", "rapid temperature rise detection", "smoke detection", "flame detection", and the like.

[0051]

The temperature information acquisition unit 113 acquires temperature

information of the vehicle and the surrounding space of the vehicle based on the camera information. In addition, the temperature information acquisition unit 113 acquires temperature information from each camera and calculates temperature change information indicating the temperature change per unit time from the acquired temperature information. The temperature information acquisition unit 113 stores the acquired temperature information and temperature change information in the acquired information DB 121.

[0052]

The rapid temperature rise detection unit 114 performs rapid temperature rise detection based on a pre-set definition for each camera of "what temperature rise per unit time constitutes a rapid temperature rise", using the temperature information acquired and calculated by the temperature information acquisition unit 113 described above. The predetermined temperature per unit time in the rapid temperature rise detection unit 114 is, for example, a temperature rise of 20°C or more per minute, and in such a case, it is determined that a rapid temperature rise has occurred. Note that the predetermined temperature per unit time in the rapid temperature rise detection unit 114 is not limited to being determined as 20°C or more per minute, and may be determined based on a temperature lower or higher than 20°C over a time period shorter or longer than one minute.

[0053]

The smoke generation detection unit 115 detects, based on the camera information, whether or not smoke is generated in the vehicle and the surrounding space of the vehicle. Specifically, the smoke generation detection unit 115 detects whether or not smoke is generated in the vehicle and the surrounding space of the vehicle based on pre-trained data using images of smoke generation and camera information acquired via the full high-definition camera unit of the camera 40.

[0054]

For example, the smoke generation detection unit 115 may calculate the degree of smoke generation, indicating whether or not smoke is generated, using a pre-trained machine learning model based on image data of smoke, such as "color", "density",

"shape", and "changes in those pieces of information over time", and generate the result as a determination status. In this case, for example, the degree of smoke generation may be expressed as a percentage with 100 as the maximum value; however, in situations like the present system where prompt judgment is required, it is desirable to make it possible to adjust the similarity judgment level with a pre-trained model through parameter settings and the like, and to promptly report and notify the detection of smoke generation (including suspicion thereof). In addition, the smoke generation detection unit 115 stores the result of detecting whether or not smoke is generated in the vehicle and the surrounding space of the vehicle in the detection information DB 122.

[0055]

The flame generation detection unit 116 detects whether or not flame is generated in the vehicle and the surroundings of the vehicle based on camera information (temperature measurement information and images captured by the thermal camera) acquired via the thermal camera unit of the camera 40. Specifically, the flame generation detection unit 116 compares extremely high temperature detections that appear to be flame from temperature information measured by the thermal camera unit of the camera 40 with camera image information acquired from the thermal camera unit at the relevant high-temperature detection locations using data pre-trained with images in which flame is generated, and detects whether or not flame is generated in the vehicle and the surrounding space of the vehicle using both temperature information and image information.

[0056]

For example, the flame generation detection unit 116 may compare both pieces of information—namely the temperature information measured by the thermal camera unit of the camera 40 indicating an extremely high temperature of approximately 1000°C or more, and the camera image information from the thermal camera unit acquired at the location where the relevant high temperature was detected—using a pre-trained model based on image data of flame such as "color" and "shape" and "changes in those pieces of information over time", and determine whether or not flame is generated, thereby generating a determination status. Alternatively, the flame generation detection unit 116

may calculate the degree of flame generation, indicating whether or not flame is generated, using the high temperature information acquired by the thermal camera unit and a pre-trained model, and generate the result as a determination status. In this case, for example, the degree of flame generation may be expressed as a percentage with 100 as the maximum value. In addition, the flame generation detection unit 116 stores the result of detecting whether or not flame is generated in the vehicle and the surrounding space of the vehicle in the detection information DB 122.

[0057]

The abnormal state determination unit 117 determines whether or not a fire has occurred, or whether there is a risk of fire in the vehicle and the surrounding space of the vehicle, based on the position information, the temperature information, the temperature change information, a smoke generation status from the smoke generation detection unit 115, and/or a flame generation status from the flame generation detection unit 116. In addition, the abnormal state determination unit 117 stores the determination result in the determination information DB 123.

[0058]

The abnormal state determination unit 117 determines, based on the position information and the temperature information, whether or not the temperature information is higher than the assumed temperature in the currently navigating region, and determines that a fire has occurred in the vehicle and the surrounding space of the vehicle, or that there is a risk of fire therein, when the temperature is significantly higher than the assumed temperature.

[0059]

The assumed temperature may be information stored in advance in the storage unit 120 in association with position information. Alternatively, the assumed temperature may be determined by acquiring weather information corresponding to the position information from a weather information providing application, and using the temperature corresponding to the position information as the assumed temperature. That is, the assumed temperature is the temperature assumed in the region where the automobile carrier ship navigates, and corresponds to the assumed temperature information.

[0060]

In addition, in the abnormal state determination unit 117, the determination that a fire has occurred in the vehicle and the surrounding space of the vehicle, or that there is a risk of fire therein, may be made when the temperature indicated by the temperature information is 100°C higher than the assumed temperature. This comparison temperature with the assumed temperature is not intended to limit the configuration of the present embodiment, and a threshold value lower or higher than 100°C may be set to determine that a fire has occurred in the vehicle and the surrounding space of the vehicle, or that there is a risk of fire therein.

[0061]

In addition, the abnormal state determination unit 117 determines, based on the temperature change information, whether or not flame is generated in the vehicle and the surroundings of the vehicle. Specifically, the abnormal state determination unit 117 determines that flame is generated in the vehicle and the surroundings of the vehicle when, for example, the temperature rises by 20°C or more per minute. Note that the determination based on temperature change information in the abnormal state determination unit 117 is not limited to the case where the temperature rises by 20°C or more per minute. For example, the abnormal state determination unit 117 may determine that flame is generated in the vehicle and the surrounding space of the vehicle, or that there is a risk of flame generation therein, when the temperature rises by approximately 20°C over a time period shorter or longer than one minute.

[0062]

In addition, the abnormal state determination unit 117 determines that smoke is generated in the vehicle and the surrounding space of the vehicle, or that there is a risk of smoke generation therein, based on a smoke generation status from the smoke generation detection unit 115. For example, in a case where a smoke generation status from the smoke generation detection unit 115 is indicated by the degree of smoke generation, it may be determined that smoke is generated in the vehicle and the surrounding space of the vehicle, or that there is a risk of smoke generation therein, when the degree of smoke generation is 70% or more.

[0063]

In addition, the abnormal state determination unit 117 determines that flame is generated in the vehicle and the surrounding space of the vehicle, or that there is a risk of flame generation therein, based on a flame generation status from the flame generation detection unit 116. For example, in a case where a flame generation status from the flame generation detection unit 116 is indicated by the degree of smoke generation, it may be determined that flame is generated in the vehicle and the surrounding space of the vehicle, or that there is a risk of flame generation therein, when the degree of flame generation is 70% or more.

[0064]

FIG. 4C is a diagram illustrating an example of the determination information DB 123 in which determination results determined by the abnormal state determination unit 117 are stored. In the example illustrated in FIG. 4C, for example, in the case of camera 1, it is determined that no fire has occurred. On the other hand, in the example illustrated in FIG. 4C, in the case of camera X, based on the acquired camera information, it is determined that a fire has occurred in all of the following determinations: determination based on temperature information, determination based on temperature change information, smoke detection, and flame detection, and the determination result indicates that a fire has occurred.

[0065]

The notification unit 118, when it is determined that a fire has occurred, or that there is a risk of fire, notifies at least one of the rotating light 60, the alarm device 70, the user terminal 30, and the administrator terminal 20 provided on the automobile carrier ship that a fire has occurred, or that there is a risk of fire.

[0066]

For example, the notification unit 118 may provide different content depending on whether it is determined that a fire has occurred or that there is a risk of fire when notifying the rotating light 60. For example, the notification unit 118 may send a notification such that the rotation speed of the rotating light 60 becomes faster when it is determined that a fire has occurred compared to when it is determined that there is a risk

of fire. This allows crew members who see the rotating light 60 to recognize the level of urgency with respect to the fire occurrence or risk of occurrence.

[0067]

Similarly, the notification unit 118 may also provide different content depending on whether it is determined that a fire has occurred or that there is a risk of fire when notifying the alarm device 70, the user terminal 30, and/or the administrator terminal 20. For example, the notification unit 118 may send a notification such that the sound of the alarm device 70 becomes louder, and the display on the user terminal 30 and/or the administrator terminal 20 is displayed with greater urgency when it is determined that a fire has occurred compared to when it is determined that there is a risk of fire. This allows crew members who hear the sound of the alarm device 70, see the display on the user terminal 30, or see the display on the administrator terminal 20 to recognize the level of urgency with respect to the fire occurrence or risk of occurrence.

[0068]

(Overview of Processing Flow of Abnormal State Detection System 10)

Next, the processing related to abnormal state detection in the abnormal state detection apparatus 100 (the abnormal state detection method) will be described based on the flowchart of FIG. 5. The flowchart illustrated in FIG. 5 is also terminated by a power-off or processing termination interrupt. In addition, in the following description of the flowchart, descriptions that overlap with the above description of the abnormal state detection system 10 and the abnormal state detection apparatus 100 will be omitted or simplified.

[0069]

In step S501, the navigation information acquisition unit 111 acquires navigation position information of the automobile carrier ship. Specifically, the navigation information acquisition unit 111 acquires the current position of the automobile carrier ship by means of a system such as AIS (Automatic Identification System), which is installed on the automobile carrier ship and automatically transmits and receives information such as the ship's own position using GPS information. In addition, the navigation information acquisition unit 111 stores the acquired position information in

the acquired information DB 121. After that, the processing proceeds to step S502.

[0070]

In step S502, the camera information acquisition unit 112 acquires camera information, which is information including image data of the vehicle 50 and the surrounding space of the vehicle 50 captured by a camera. In addition, the camera information acquisition unit 112 stores the acquired camera information in the acquired information DB 121. The image data of the vehicle 50 and the surrounding space of the vehicle 50 captured by a camera may be, for example, data as illustrated in FIG. 4A. Such image data may also be thermal image data as shown on the right side of FIG. 4B. After that, the processing proceeds to step S503.

[0071]

In step S503, the temperature information acquisition unit 113 acquires temperature information of the vehicle and the surrounding space of the vehicle based on the camera information. In addition, the temperature information acquisition unit 113 calculates temperature change information indicating the temperature change per unit time from the acquired temperature information. The temperature information acquisition unit 113 stores the acquired temperature information and temperature change information in the acquired information DB 121. After that, the processing proceeds to step S504.

[0072]

In step S504, the rapid temperature rise detection unit 114 determines, based on the temperature change information, whether or not flame is generated in the vehicle and the surroundings of the vehicle. Specifically, the rapid temperature rise detection unit 114 determines that flame is generated in the vehicle 50 and the surroundings of the vehicle 50 when, for example, the temperature rises rapidly by 20°C or more per minute. Note that the determination based on temperature change information in the rapid temperature rise detection unit 114 is not limited to the case where the temperature rises by 20°C or more per minute. For example, the abnormal state determination unit 117 may determine that flame is generated in the vehicle and the surrounding space of the vehicle, or that there is a risk of flame generation therein, when the temperature rises by approximately 20°C over a time period shorter or longer than one minute.

[0073]

In step S504, when the rapid temperature rise detection unit 114 determines that a rapid temperature rise has occurred (step S504: YES), the processing proceeds to step S507. On the other hand, in step S504, when the rapid temperature rise detection unit 114 determines that a rapid temperature rise has not occurred (step S504: NO), the processing proceeds to step S505.

[0074]

In step S505, the smoke generation detection unit 115 detects, based on the camera information, whether or not smoke is generated in the vehicle 50 and the surrounding space of the vehicle 50. Specifically, the smoke generation detection unit 115 detects whether or not smoke is generated in the vehicle and the surrounding space of the vehicle based on the acquired camera information, using a model pre-trained on images in which smoke is generated.

[0075]

In step S505, when the smoke generation detection unit 115 detects that smoke is generated in the vehicle 50 and the surrounding space of the vehicle 50 (step S505: YES), the processing proceeds to step S507. On the other hand, in step S505, when the smoke generation detection unit 115 detects that smoke is not generated in the vehicle 50 and the surrounding space of the vehicle 50 (step S505: NO), the processing proceeds to step S506.

[0076]

In step S506, the flame generation detection unit 116 detects, based on the camera information, whether or not flame is generated in the vehicle 50 and the surroundings of the vehicle 50. Specifically, the flame generation detection unit 116 detects whether or not smoke is generated in the vehicle 50 and the surrounding space of the vehicle 50 based on the acquired camera information, using a model pre-trained on images in which flame is generated.

[0077]

In step S506, when the flame generation detection unit 116 detects that flame is generated in the vehicle 50 and the surrounding space of the vehicle 50 (step S506: YES),

the processing proceeds to step S507. On the other hand, in step S506, when the flame generation detection unit 116 detects that flame is not generated in the vehicle 50 and the surrounding space of the vehicle 50 (step S506: NO), the processing ends.

[0078]

In step S507, the abnormal state determination unit 117 determines, based on the position information, the temperature information, the temperature change information, the smoke generation status, and/or the flame generation status, whether or not a fire has occurred in the vehicle 50 and the surrounding space of the vehicle 50, or whether there is a risk of fire therein. In addition, the abnormal state determination unit 117 stores the determination result in the determination information DB 123.

[0079]

In step S508, the notification unit 118, when it is determined that a fire has occurred, or that there is a risk of fire, notifies at least one of the rotating light 60, the alarm device 70, the user terminal 30, and the administrator terminal 20 that a fire has occurred, or that there is a risk of fire. After that, the processing ends.

[0080]

For example, the notification unit 118 may provide different content depending on whether it is determined that a fire has occurred or that there is a risk of fire when notifying the rotating light 60. For example, the notification unit 118 may send a notification such that the rotation speed of the rotating light 60 becomes faster when it is determined that a fire has occurred compared to when it is determined that there is a risk of fire. This allows crew members who see the rotating light 60 to recognize the level of urgency with respect to the fire occurrence or risk of occurrence.

[0081]

Similarly, the notification unit 118 may also provide different content depending on whether it is determined that a fire has occurred or that there is a risk of fire when notifying the alarm device 70, the user terminal 30, and/or the administrator terminal 20. For example, the notification unit 118 may send a notification such that the sound of the alarm device 70 becomes louder, and the display on the user terminal 30 and/or the administrator terminal 20 is displayed with greater urgency, when it is determined that a

fire has occurred compared to when it is determined that there is a risk of fire. This allows crew members who hear the sound of the alarm device 70, see the display on the user terminal 30, or see the display on the administrator terminal 20 to recognize the level of urgency with respect to the fire occurrence or risk of occurrence.

[0082]

As described above, the abnormal state detection apparatus 100 according to the present embodiment is the abnormal state detection apparatus 100 that detects a fire occurring in the vehicle 50 loaded on an automobile carrier ship. The abnormal state detection apparatus 100 includes the navigation information acquisition unit 111 that acquires navigation position information of the automobile carrier ship. The abnormal state detection apparatus 100 also includes the camera information acquisition unit 112 that acquires camera information, which is information including image data of the vehicle and the surrounding space of the vehicle captured by a camera. The abnormal state detection apparatus 100 also acquires the temperature information acquisition unit 113 that acquires, based on the camera information, the temperature information of the vehicle 50 and the surrounding space of the vehicle 50, and the temperature change information per unit time. The abnormal state detection apparatus 100 also includes the abnormal state determination unit 117 that determines, based on assumed temperature information based on the position information, the temperature information, and the temperature change information, whether or not a fire has occurred in the vehicle 50 and the surrounding space of the vehicle 50, or whether there is a risk of fire therein. The abnormal state detection apparatus 100 also includes the notification unit 118 that, when a determination is made by the abnormal state determination unit 117 that a fire has occurred, or that there is a risk of fire, sends a notification that a fire has occurred, or that there is a risk of fire. Note that the notification unit 118 notifies at least one of the rotating light 60, the alarm device 70, the user terminal 30, and the administrator terminal 20 provided on the automobile carrier ship that a fire has occurred, or that there is a risk of fire.

[0083]

With this configuration, the abnormal state detection apparatus 100 enables

detection according to the navigation status by detecting the occurrence of fire or the risk of fire based on the assumed temperature information based on the navigation position information of the automobile carrier ship, and the temperature information and temperature change status of the vehicle 50 and the surrounding space of the vehicle 50. This makes it possible for the abnormal state detection apparatus 100 to appropriately detect the occurrence of fire or the risk of fire with respect to the vehicle 50 loaded on the automobile carrier ship.

[0084]

In addition, the assumed temperature information of the abnormal state detection apparatus 100 may correspond to a temperature assumed in a region where the automobile carrier ship navigates. This makes it possible for the abnormal state detection apparatus 100 to perform fire determination in accordance with the temperature conditions of the region in which the automobile carrier ship navigates, enabling more appropriate fire detection.

[0085]

In addition, the abnormal state detection apparatus 100 may further include the smoke generation detection unit 115 that detects, based on the camera information, whether or not smoke is generated in the vehicle 50 and the surrounding space of the vehicle 50. The abnormal state determination unit 117 may also determine whether or not a fire has occurred in the vehicle 50 and the surrounding space of the vehicle 50, or whether there is a risk of fire therein, based on the position information, the temperature information, the temperature change information, and a smoke generation status from the smoke generation detection unit 115. This makes it possible for the abnormal state detection apparatus 100 to more appropriately detect the generation of smoke in the early stages of fire, and to more appropriately detect the occurrence of fire or the risk of fire with respect to the vehicle 50 loaded on the automobile carrier ship.

[0086]

In addition, the smoke generation detection unit 115 may detect whether or not smoke is generated in the vehicle 50 and the surrounding space of the vehicle 50, based on pre-trained data using images in which smoke is generated, and the camera information.

This makes it possible for the abnormal state detection apparatus 100 to perform more accurate detection processing for smoke generation.

[0087]

In addition, the abnormal state detection apparatus 100 may further include the flame generation detection unit 116 that detects, based on the camera information, whether or not flame is generated in the vehicle 50 and the surrounding space of the vehicle 50. The abnormal state determination unit 117 may determine whether or not a fire has occurred in the vehicle 50 and the surrounding space of the vehicle 50, or whether there is a risk of fire therein, based on the position information, the temperature information, the temperature change information, a smoke generation status from the smoke generation detection unit, and a flame generation status from the flame generation detection unit. This makes it possible for the abnormal state detection apparatus 100 to more appropriately detect the generation of flame, and to reliably detect the occurrence of fire or the risk of fire with respect to the vehicle 50 loaded on the automobile carrier ship.

[0088]

In addition, the flame generation detection unit 116 may detect whether or not flame is generated in the vehicle and the surrounding space of the vehicle, based on pre-trained data using images in which flame is generated, and the camera information. This makes it possible for the abnormal state detection apparatus 100 to perform more accurate detection processing for flame generation.

[0089]

In addition, the notification unit 118 may notify the rotating light 60, the alarm device 70, the user terminal 30, and/or the administrator terminal 20 of different content depending on whether it is determined that a fire has occurred, or that there is a risk of fire. With this configuration, crew members who see the rotating light 60, hear the sound of the alarm device 70, see the display on the user terminal 30, and/or see the display on the administrator terminal 20 can recognize the level of urgency with respect to the fire occurrence or risk of occurrence. This makes it possible for crew members on the automobile carrier ship to which the abnormal state detection apparatus 100 according to

the present embodiment is applied to take appropriate firefighting or fire prevention actions according to the fire occurrence situation or risk of occurrence.

[0090]

(Other Embodiments)

While the present embodiment has been described above, the embodiment is not limited to these descriptions, and various modifications are possible within the scope of the gist of the embodiment. In addition, it is also possible to combine some or all of the various embodiments to form a new embodiment.

[0091]

In the above-described embodiment, a configuration has been described in which the control unit 110 of the abnormal state detection apparatus 100 is provided with each function illustrated in FIG. 3, but the embodiment is not limited to this configuration. For example, some of the functions provided in the control unit 110 of FIG. 3 may be provided in the camera 40. By providing the camera 40 with some of the functions illustrated in FIG. 3, for example, by distributing functions such as rapid temperature rise detection, smoke generation detection, and flame generation detection to each camera 40 for calculation, it becomes possible not only to implement these functions more quickly, but also, in cases such as the present one where automobile carrier ships themselves are extremely large and thus often do not have a wide-band on-board network LAN, to reduce the load on the network by providing some of these functions on the camera terminal side, thereby enabling more stable communication. Furthermore, it is possible to reduce the computational load of the abnormal state detection apparatus 100 and to miniaturize the computer hardware in the limited space of the on-board server room, resulting in higher system stability and availability.

[0092]

A computer program (abnormal state detection program) that causes a computer to execute the above-described abnormal state detection method and a computer-readable recording medium on which the program is recorded are included within the scope of the present embodiment. Here, any type of computer-readable recording medium may be used. In addition, the above-described computer program is not limited to being recorded

on the above-described recording medium, and may also be transmitted via a telecommunication line, a wireless or wired communication line, or a network such as the Internet.

[0093]

The entire contents of Japanese Patent Application No. 2024-161288 (filing date: September 18, 2024) are incorporated herein by reference.

[0094]

While several embodiments of the present invention have been described above, these embodiments are presented as examples and are not intended to limit the scope of the invention. These novel embodiments can be implemented in various other forms, and various omissions, substitutions, and modifications can be made without departing from the gist of the invention. These embodiments and their modified examples are included in the scope and gist of the invention, and are also included in the scope of the invention described in the claims and its equivalents.

REFERENCE SIGNS LIST

[0095]

10	Abnormal state detection system
20	Administrator terminal
30	User terminal
40	Camera
50	Vehicle
60	Rotating light
70	Alarm device
80	Network
100	Abnormal state detection apparatus
110	Control unit
111	Navigation information acquisition unit
112	Camera information acquisition unit
113	Temperature information acquisition unit

114	Rapid temperature rise detection unit
115	Smoke generation detection unit
116	Flame generation detection unit
117	Abnormal state determination unit
118	Notification unit
120	Storage unit
121	Acquired information DB
122	Detection information DB
123	Determination information DB
130	Input/output IF
140	Communication IF
200	Cloud server

CLAIMS

[Claim 1]

An abnormal state detection apparatus that detects a fire occurring in a vehicle loaded on an automobile carrier ship, the apparatus comprising:

a navigation information acquisition unit that acquires navigation position information of the automobile carrier ship;

a camera information acquisition unit that acquires camera information, which is information including image data of the vehicle and a surrounding space of the vehicle captured by a camera;

a temperature information acquisition unit that acquires, based on the camera information, temperature information of the vehicle and the surrounding space of the vehicle, and temperature change information per unit time;

an abnormal state determination unit that determines, based on assumed temperature information based on the position information, the temperature information, and the temperature change information, whether or not a fire has occurred in the vehicle and the surrounding space of the vehicle, or whether there is a risk of fire therein; and

a notification unit that, when a determination is made by the abnormal state determination unit that a fire has occurred, or that there is a risk of fire, notifies at least one of a rotating light, an alarm device, a user terminal, and an administrator terminal provided on the automobile carrier ship that a fire has occurred, or that there is a risk of fire.

[Claim 2]

The abnormal state detection apparatus according to claim 1,
wherein the assumed temperature information corresponds to a temperature assumed in a region where the automobile carrier ship navigates.

[Claim 3]

The abnormal state detection apparatus according to claim 1 or 2, further

comprising a smoke generation detection unit that detects, based on the camera information, whether or not smoke is generated in the vehicle and the surrounding space of the vehicle,

wherein the abnormal state determination unit determines whether or not a fire has occurred in the vehicle and the surrounding space of the vehicle, or whether there is a risk of fire therein, based on the position information, the temperature information, the temperature change information, and a smoke generation status from the smoke generation detection unit.

[Claim 4]

The abnormal state detection apparatus according to claim 3,

wherein the smoke generation detection unit detects whether or not smoke is generated in the vehicle and the surrounding space of the vehicle, based on pre-trained data using images in which smoke is generated, and the camera information.

[Claim 5]

The abnormal state detection apparatus according to claim 3 or 4, further comprising a flame generation detection unit that detects, based on the camera information, whether or not flame is generated in the vehicle and the surrounding space of the vehicle,

wherein the abnormal state determination unit determines whether or not a fire has occurred in the vehicle and the surrounding space of the vehicle, or whether there is a risk of fire therein, based on the position information, the temperature information, the temperature change information, a smoke generation status from the smoke generation detection unit, and a flame generation status from the flame generation detection unit.

[Claim 6]

The abnormal state detection apparatus according to claim 5,

wherein the flame generation detection unit detects whether or not flame is generated in the vehicle and the surrounding space of the vehicle, based on pre-trained

data using images in which flame is generated, and the camera information.

[Claim 7]

The abnormal state detection apparatus according to any one of claims 1 to 6,
wherein the notification unit notifies the rotating light, the alarm device, the user terminal, and/or the administrator terminal of different content depending on whether it is determined that a fire has occurred, or that there is a risk of fire.

[Claim 8]

An abnormal state detection system comprising:
the abnormal state detection apparatus according to any one of claims 1 to 7;
a camera that captures an image of the vehicle loaded on the automobile carrier ship; and
at least one of the rotating light, the alarm device, the user terminal, and the administrator terminal.

[Claim 9]

An abnormal state detection method for detecting a fire occurring in a vehicle loaded on an automobile carrier ship, the method being executed by a computer and comprising:

acquiring navigation position information of the automobile carrier ship;
acquiring camera information, which is information including image data of the vehicle and a surrounding space of the vehicle captured by a camera;
acquiring, based on the camera information, temperature information of the vehicle and the surrounding space of the vehicle, and temperature change information per unit time;
determining, based on assumed temperature information based on the position information, the temperature information, and the temperature change information, whether or not a fire has occurred in the vehicle and the surrounding space of the vehicle, or whether there is a risk of fire therein; and

when it is determined that a fire has occurred, or that there is a risk of fire, notifying at least one of a rotating light, an alarm device, a user terminal, and an administrator terminal provided on the automobile carrier ship that a fire has occurred, or that there is a risk of fire.