Research on the early warning and prevention system of infectious diseases based on large cruise ships

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Abstract. In order to improve the ability of large cruise ships to deal with infectious disease epidemics and reduce the losses caused by outbreaks on cruise ships, this project has designed the design of infectious disease early warning and prevention and control systems for large luxury cruise ships. The system consists of a large cruise ship infected person identification and tracking system, an infectious disease prevention and isolation system, and an infectious disease treatment system. It can quickly identify and isolate suspected infected persons on large cruise ships, and at the same time, it can reduce the ability of the virus to spread in the air, effectively reduce the probability of outbreaks of infectious diseases on cruise ships, and ensure the health of boarding personnel.

Key words: epidemic; cruise ship; prevention and control; infectious disease early warning.

1. Research background and significance

In early 2020, a new type of coronavirus called nCoV-2019 appeared in countries around the world and gradually spread. Somewhat unexpectedly, many well-equipped cruise ships have become the hardest hit areas for virus infections. The most serious of these, the Diamond Princess cruise ship, has had 712 passengers and crew infected with the virus. Other cruise ships around the world are not doing well either [1]. Since the virus has the characteristics of fast spread, high concealment, and difficult control on cruise ships, how to quickly lock and isolate the infected people on the cruise ship while sailing, and use certain technical means to reduce the spread of the virus in the air as much as possible It has become a high concern of governments and scientific research institutions all over the world to be solved [2].

In order to ensure the air quality of each cabin in the cruise ship, large cruise ships mainly complete the gas exchange between the cabin and the outside through the fresh air system installed on board. It is spread among the cabins through the fresh air system. Another major way the virus spreads on cruise ships is through human-to-human contact. Due to the large number of places on large cruise ships and most of them are confined spaces, there is a large flow of people between places, so the risk of virus transmission through human-to-human contact is high. On the other hand, there is currently a lack of emergency isolation space on the cruise ship to deal with sudden epidemics. If the whole ship isolation measures similar to the "Diamond Princess" cruise ship are adopted, it is likely to further deteriorate the infection on board and cause more serious losses. Therefore, it is necessary to design a set of infectious disease early warning and prevention system suitable for large cruise ships [3].

2. Research status at home and abroad

2.1 Automatic identification technology of sick persons

At present, the research and design of infectious disease prevention and control systems for large cruise ships at home and abroad are still in their infancy, and there is no scientific and systematic response plan. At present, the large-scale screening method for infected persons during sudden outbreaks at home and abroad is mainly body temperature detection. In recent years, domestic intelligent body temperature detection technology has achieved some staged results [4].

The AT300/600 online accurate temperature measurement infrared thermal imager developed by Arrow Optoelectronics has high temperature measurement accuracy, the temperature detection error range is ±0.3 °C, and has an auto-focus function. The body temperature information can also be displayed on the terminal computer in real time. When the thermal imager detects a person whose temperature exceeds the set threshold temperature, the sound and light alarm system will be triggered to remind the staff to conduct further physical examination on the person with fever [5].

Figure 1. Arrow's thermal imager and monitoring interface

China's domestic smart prevention and control helmets integrate a variety of advanced technologies such as metamaterial technology, infrared thermal imaging technology, and intelligent AI algorithms to achieve rapid non-contact body temperature monitoring in mobile scenarios, effectively prevent cross-infection, and protect prevention and control workers. The intelligent prevention and control helmet has high portability and precision, which can greatly improve the speed of temperature checking [6].

Figure 2. Smart prevention and control helmets in China

2.2 Isolation techniques for sick persons

In terms of the isolation of infected patients, the relevant scientific research institutions in the United States have developed the CBCS container biological control system [7]. CBCS is the world's first multi-person air transport medical transport unit with complete biological protection capability, which can be used for high-containment air transport of various types of highly pathogenic organisms. There are 3 rooms, including a patient treatment area for 4 patients and 4 caregivers; an anteroom where protective equipment can be safely donned and doffed; a rest area for two caregivers. CBCS can isolate infected patients in an emergency to avoid the spread of the virus epidemic.

Figure 3. CBCS containerized biological control transportation system

The research status at home and abroad shows that: at present, there is no on-board infectious disease early warning and prevention system suitable for cruise ships and other large passenger ships on the market. However, due to the high density of people on large cruise ships, the large number of places with high traffic flow, the limited number of epidemic prevention personnel available, the high airtightness of the internal living cabins, and the cruise ship cannot obtain the support of the advanced medical system onshore when it is offshore. Due to the special environment, it is not suitable to directly apply the existing intelligent infectious disease prevention and control system to ships. Therefore, it is of great research significance to innovate the infectious disease early warning and prevention system suitable for large cruise ships [8].

3. Design of early warning and prevention and control system

3.1 Design of the tracking system for infectious diseases infected persons on large cruise ships

The infected person tracking system based on machine vision designed in this project is mainly composed of a body temperature and image information acquisition device (as shown in Figure 4) and a background analysis system based on machine vision. The body temperature and image information acquisition device is mainly composed of ceiling fixed brackets that can automatically adjust the angle, binocular vision cameras, thermal imaging cameras, serial port connectors, wires and electronic control components. The body temperature and image information collection devices will be installed at the passages and entrances of places with a large flow of people on the cruise ship.

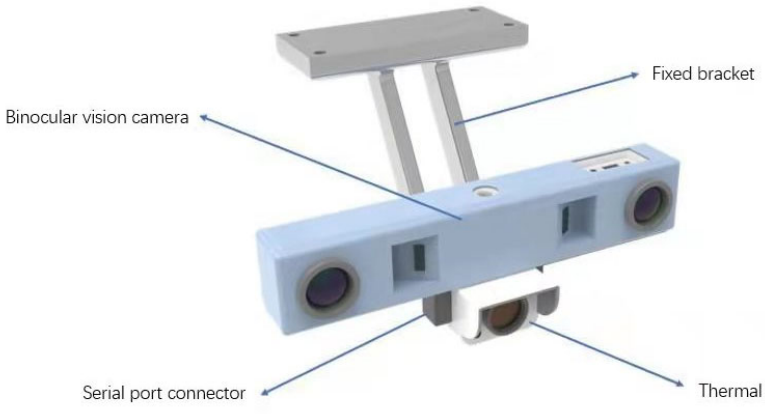

Figure 4. Schematic diagram of body temperature and image information acquisition device

The working process of the analysis system (to collect real-time body temperature data and multi-angle facial information of people within a fixed range through thermal imaging cameras and binocular vision cameras, and send the collected information to the machine vision-based background analysis system through a wired network. The analysis system will compare the facial information of the person with abnormal body temperature with the information in the database of boarding

personnel through machine vision software, and finally lock the identity information of the person with abnormal body temperature to complete the tracking of suspected infected persons [9].

3.2 Design of infectious disease prevention and isolation system for large cruise ships

3.2.1 Design of multi-layer composite fresh air purification system.

At present, the traditional fresh air system installed in large cruise ships has a certain ability to purify the floating dust in the air, but the purification ability of organic matter in the air is weak, and dust, bacteria and viruses are easily accumulated in the fresh air duct. When an outbreak occurs on a cruise ship, the virus may be transmitted between cabins through the fresh air system. The multi-layer composite fresh air purification system designed in this project can effectively filter suspended particles in the air, and has a good inactivation effect on bacteria and viruses suspended in the air [10-12]. The multi-layer composite fresh air purification system designed in this project (as shown in Figure 5) is mainly composed of TiO2 composite photocatalytic disinfection module, coarse filter module, electrostatic dust removal module, mesh metal filter module and slide-type self-cleaning device. composed of other parts.

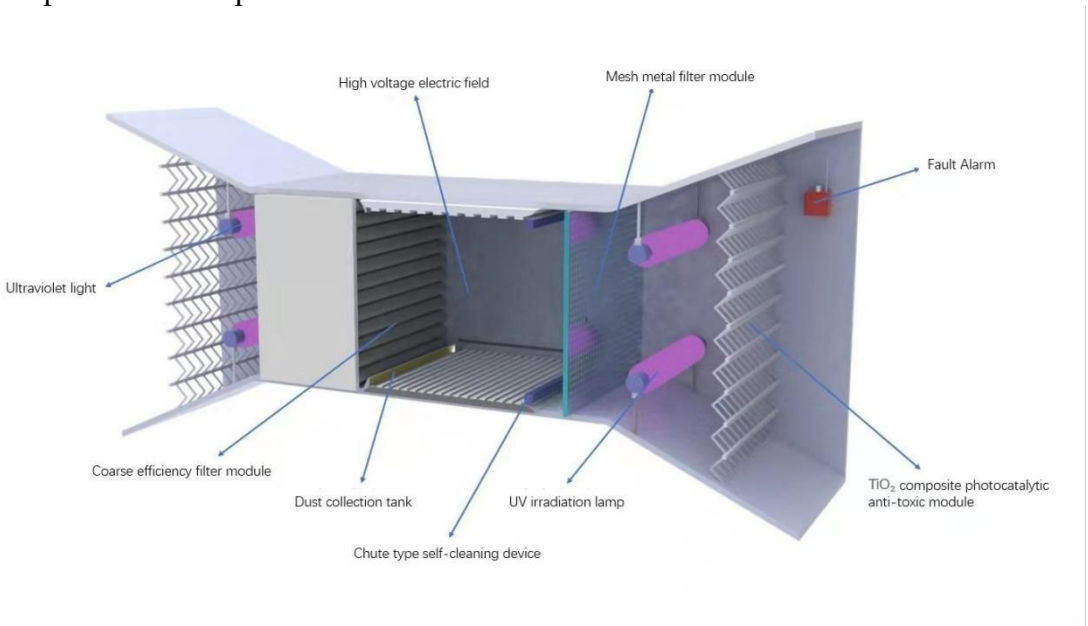

Figure 5. Schematic diagram of the structure of the multi-layer composite fresh air purification system

When the multi-layer composite fresh air purification system is running, the air in the fresh air system pipeline will first pass through the TiO2 composite photocatalytic detoxification module at the entrance, and this process will deactivate the viruses and other organisms in the input air for the first time. At the same time, this process will also reduce the possibility of viruses being introduced into the return air process. Next, the air will pass through the coarse filter module, high-voltage electric field and mesh metal filter module. This process will purify most of the inorganic particles suspended in the air. Finally, the air will pass through the TiO2 composite photocatalytic detoxification module at the end, and this process will further inactivate the viruses and other organic substances suspended in the air. In the end, most of the dust and pathogens in the air after the entire purification process have been filtered and eliminated by the system, and the virus concentration at this time will be far below the infection threshold. This system will greatly reduce the risk of boarding personnel contracting the virus through the fresh air system. Probability.

3.2.2 Design of new lifeboats with isolation function.

Existing large cruise ships carry multiple enclosed lifeboats, which are generally idle. If these enclosed lifeboats are properly modified, they will not only have lifesaving capabilities, but also have

the ability to protect infected persons. Isolation function, which will comprehensively improve the ability of cruise ships to deal with malignant infectious diseases. This project plans to design a new type of lifeboat with isolation function (as shown in Figure 6), which is refitted from an ordinary enclosed lifeboat, including the electrical interface of the ship and the fresh air system equipped with a filter module. The seats inside the new lifeboats will be converted into foldable sliding seats that can be adjusted into beds when an infected person enters the boat [13].

Figure 6. Schematic diagram of the new lifeboat with isolation function

3.2.3 Design of infectious disease treatment system for large cruise ships.

When an infectious disease outbreak occurs on a cruise ship, it is critical to treat the infected person in a timely manner. At present, there is no space on the cruise ship suitable for the treatment of patients with malignant infectious diseases, so it is particularly important to design a negative pressure treatment cabin suitable for the cruise environment. This project plans to design a multi-functional negative pressure treatment cabin based on a large cruise ship (as shown in Figure 7), which has a negative pressure system, an independent fresh air system, a disinfection system, video inspection equipment, communication equipment and necessary life support systems. In order to achieve better treatment effect, the treatment cabin is planned to be installed at the rear of the cruise ship.

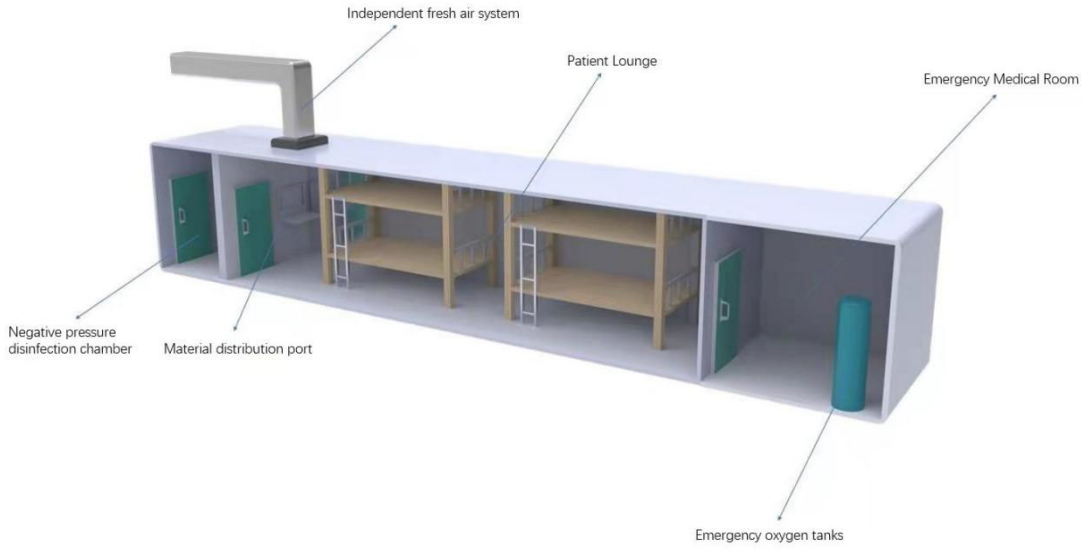

Figure 7. Structure design diagram of multifunctional negative pressure therapy cabin based on large cruise ships

4. Conclusions and innovations

(1) Infected personnel tracking system based on machine vision. According to the multiple binocular vision cameras and thermal imaging cameras installed on the cruise ship, the personnel with abnormal body temperature on the ship are locked, and their multi-angle facial image information is compared with the information of the boarding personnel, so as to quickly locate the suspected infected person.

(2) An infectious disease prevention and isolation system based on large cruise ships. The system consists of a multi-layer composite fresh air purification system and a new type of lifeboat with isolation function. In order to prevent the virus from cross-spreading between cabins with the help of the fresh air system on the cruise ship, this project has designed a multi-layer composite fresh air purification system, which can greatly reduce

Through the dust and active organic matter of the fresh air outlet, it can effectively prevent the virus from spreading through the ship's fresh air system. The new lifeboat with isolation function designed in this project can fundamentally improve the isolation ability of the cruise ship for infected persons.

(3) Multifunctional negative pressure therapy cabin based on large cruise ships. This project plans to design a multi-functional negative pressure treatment cabin suitable for large cruise ships. This treatment cabin has high sealing and independent air-conditioning fresh air system, and has a certain ability to support and treat infected persons.

(4) A comprehensive information monitoring platform for infectious diseases based on large cruise ships. This project plans to develop a visual information exchange platform, which can monitor the working conditions of the fresh air purification system and the infected person tracking system in real time. When the system is abnormal, the platform can issue a warning to the ship management personnel in time. At the same time, the identity information and the location of the suspected infected person determined by the infected person tracking system will also be displayed on the platform. This platform can also monitor the operation parameters of the multi-functional negative pressure treatment cabin and the new lifeboat with isolation function, as well as the infected personnel. of vital signs.

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