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A Design of Service Robots in Epidemic Disease Isolation Environment

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Abstract: *Currently, most of the robots on the market only concerns about alleviating the work pressure of medical staff, and rarely consider the needs of the quarantined at the same time. Therefore, this article proposes an ideal robot model that focuses on more than the heavy workload of personnel at the centralized isolation point. Also, it pays attention to the needs of quarantined people in addition to diet and necessary medical supplies in order to guarantee their mental health.*

Keywords: *Multi-functional; Logistics support; Emotion recognition technology; Theoretical model of robot*

1. Introduction

Covid-19 epidemic broke out in Wuhan, China in December 2019[1]. Following China, large-scale outbreaks have occurred in many countries and regions including the United States, the Philippines, Germany, France, Iran, and Italy. The virus has infected many people around the world, has seen more and more deaths, and has evolved into the largest medical emergency of this century.

The main way of transmission of COVID-19 is through respiratory droplets and close contact, such as sneezing and close conversations. At present, the world has not developed a specific drug for Covid-19. Based on the understanding of the law of infectious diseases that the virus "passes from person to person", non-medical intervention based on traditional isolation methods can cut off the chain of virus transmission and is the most basic and effective means to stop the spread of the epidemic.

From January 28th to May 22nd, 2020, a centralized isolation point in Wuhan, China lasted 115 days, achieving "zero cross-infection" among medical staff and quarantined personnel. It is reported the basic situation of the centralized isolation point is given. The work team is mainly composed of medical personnel, health supervision teams, security personnel and logistics support personnel, and other teams to work together. The personnel of each type of work must be on duty for 24 hours. The work mode is usually that the personnel of each type of work are grouped and then alternated on duty. This mode consumes a lot of physical strength for the personnel; in addition, these workers, especially a medical team, often deal with potentially infected people, and also is in a long-term psychological strain. It can be seen that these personnel working in the isolation point have suffered tremendous psychological and physical testing and torture. Meanwhile, there were many problems such as lack of medical supplies, heavy disinfection tasks, shortage of medical staff, difficulty in investigation and prevention, etc. Considering the situations, it is foreseeable that investment and use of robots for epidemic prevention and control will undoubtedly help a lot. Yang et al. focused on analyzing the feasibility of intelligent robots in fighting the epidemic [2]. They pointed out that robots can replace humans to complete some highly repetitive and dangerous tasks. Individuals who are quarantined often feel lonely and scared psychologically. While basic diet and some necessary medical supplies were provided, almost all their other needs were ignored. Specifically, for compatriots who have returned from abroad, they experienced a really hardship. They returned to the embrace of the motherland, after an extremely long flight. However, because of related policies, they were placed in an isolation place for observation. This is exactly the reason why they were more lonely and helpless than others. In the meantime, medical staff and other workers there are faced with such a heavy workload all day long, and it is unrealistic for them to send other non-essential items to the quarantined individuals. For these reasons, intelligent service robots which can satisfy the mentally and physiologically needs of quarantined individuals from abroad will surely help.

At present, most of the robots on the market only focus on alleviating the pressure of medical staff,

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but rarely take into account the needs of the quarantined. Therefore, this article proposes an ideal robot model that not only help to reduce work stress of medical staff, but also help to meet some extra needs of quarantined people to help with their mental and physical health. The second part of this article investigates and synthesizes part of the information about the service robot in the scene related to the medical observation isolation point. The third part proposes an ideal model of a multifunctional robot that can be used in the isolation point and describes the function of the robot. The fourth part of this article concentrates on the process of perception, planning and action involved, and how some of the robot's function has been realized. The main functions of the robot are: (1) Life assistance of the quarantined person: it specifically includes the transportation of domestic waste generated by the quarantined individuals, and also functions like taking medicines, food, and commodities; (2) Emotional interaction: When the quarantined person feels psychologically unwell, it can interact with people and relieve the psychological pressure of quarantined individuals; (3) Other functions: it can help medical staff to measure the body temperature of quarantined individuals. It can also disinfect objects and surroundings, manipulate an elevator, and charge independently. The fourth part analyzes the development of related technologies, compares it with the technical level required to achieve the ideal model, and analyzes the gap between the two. Furthermore, in the fifth part of this article, the emotional interaction function is specifically analyzed, expounding the urgency of developing this technology, and summarizing the possible directions for improvement. Finally, the content of this article is summarized, and the prospects of the idealized robot are prospected.

2. Epidemic-related Robot Applications

In this pandemic, many technology companies have launched their own robots to help alleviate the various difficulties faced in hospitals. These robots have played an important role in the battle between humans and COVID-19.

2.1 Medical material handling robot

The primary problem facing the outbreak after the outbreak is the shortage of medical supplies, and manual handling has great limitations. The transportation capacity of medical system is limited and inefficient. Also, its capacity is restricted. In order to solve the problem of low manual handling efficiency, robots capable of autonomous handling operations came into being.

Takahashi et al. [3] developed an autonomous omnidirectional mobile distribution robot system for hospitals, which can be used to transport luggage, important specimens and other materials. Yuan et al. [4] designed an express vehicle platform based on in-wheel motor drive, which can adjust the size of the distribution container according to the size of the package, realize the separation of the container and directly replace the container as a whole.

2.2 Shopping delivery robot

In order to avoid the spread of diseases in the hospital and protect the health of medical staff and patients, autonomous mobile robots are used for drug delivery [5]. Diligent Robotics deployed a commercial mobile robot Moxi to respond to the COVID-19 crisis by selecting supplies from supply cabinets and transporting them to the wards of medical institutions.

2.3 Medical care robot

In the prevention and control of the epidemic, the entire process from the diagnosis of suspected patients to the treatment of confirmed patients is indispensable to the care of medical staff. In order to relieve the pressure of medical staff, it is necessary to introduce nursing medical robots, such as the initial diagnosis of patients with new coronary pneumonia. By detecting nasopharyngeal and oropharyngeal swabs, the application of nursing medical robots can accelerate the detection process [2].

The robot developed by Bialystok University of Technology in Poland is designed as an auxiliary machine for medical staff in children's hospitals and an accompanying robot for young patients. It is equipped with many sensors and diagnostic functions, including temperature measurement [6]. The temperature measuring and capturing distance of the temperature measuring robot is 30 m, and the temperature measuring mechanism of the robot can rotate freely in 360°, and can achieve a pitch of

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-40 °to 60 °. The temperature measurement time is ≤1s, and the error is within 0.1°C.

2.4 Disinfection robot

During the epidemic, Geek+ Technology developed Lavender, a disinfection robot with ultraviolet light. This kind of autonomous mobile robot is designed to avoid obstacles automatically and can work 24 hours a day. The disinfection robot can run and charge without manual intervention. SLAM technology is used to navigate the robot in a challenging space surrounded by medical equipment. The use of multiple sensors enables robots to detect objects and interact with the building's infrastructure so that these robots can operate in complex environments and even operate elevators. The Aimbot robot from UBTECH is also used to spray liquid preparations to disinfect hospitals and indoor areas such as hospitals and health rooms (Figure 1).

Figure.1 Robot Aimbot form UBTECH, used to disinfect the environment

2.5 Social robot

During the flu pandemic, people are worried about loneliness and isolation, which have been greatly magnified when they are quarantined at home or other places [7]. During a flu pandemic, social robots can improve individual's mental health.

Social robots are the most eye-catching robots on the market. Social humanoid robot ARI is used to ask patients questions related to symptoms. Also, social robots like PARO (Japan AIST company), Aibo (Japan Sony Corporation) and iCat (Netherlands Philips Electronics) can be shaped into pets to help relieve stress. Among them, the Palo robot (seal-like) can help to reduce patients' anxiety [8].

3. Ideal Robot Model

The robots currently used in hospitals and isolation points are still insufficient. One thing is that among the robots reported by the media, social robots used in this scenario are relatively rare. Another thing is that other robots are designed to relieve medical staff's stress. In addition to help with medical needs, these robots cannot satisfy extra needs like chatting of quarantined individuals. But satisfying these 'extra' needs are actually vital to their physical and mental health. Therefore, a service robot is designed in this work, aiming at solving those problems mentioned above, which have been ignored for

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a long time.

3.1 Living assistance for quarantined persons

3.1.1 Food delivery

Realizing automatic map navigation and obstacle avoidance in the isolation point, and realize the task of taking food from the room of the quarantined person to the place where the meal is served, and then returning to the room of the quarantined person.

3.1.2 Taking medicine

According to the needs of the quarantined person, the robot is able to take specific medicine in the designated floor room and then return to the quarantine room.

3.1.3 Taking goods

After placing an order at the quarantine point sales office, the robot can automatically go to the sales office to take the goods, and then return to the quarantine room.

3.1.4 Waste disposal

After the quarantine personnel pack their own household garbage, the robot can send the garbage to the designated place at the quarantine point, at a designated time. Then it returns to the quarantine room waiting for next instruction.

3.2 Emotional interaction

3.2.1 Emotion recognition

Understanding human emotions by judging human facial expressions and intonation.

3.2.2 Intelligent communication

Conduct conversations with humans based on the recognized emotions and voices, and be able to display more information to the user through the display on the chest.

3.2.3 Anthropomorphism design

With flexible arms and body, bionic eye design, voice communication accompanied by body movements.

3.2.4 Sports coach

Equipped with a display screen, it can guide humans to perform some fitness activities, so that the isolated individuals can maintain good physical health.

3.3 Other functions

3.3.1 Personal identity verification

This robot can recognize human faces, and it is convenient to pair with collected body temperature information and upload.

3.3.2 Temperature measurement

Equipped with infrared imaging and visible light equipment, real-time transmission of video images to the monitoring center for analysis and processing.

3.3.3 Disinfection

It can disinfect itself and the items and objects it taken, and also, it can disinfect the surrounding wherever it goes.

3.3.4 Elevator manipulation

When moving between different floors, the robot can press the buttons of an elevator so that it can use it to get to any floor of a building.

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3.3.5 Elevator manipulation

This robot is able to know how long it can work and go to specific places to have itself charged before it runs out of battery.

4. Perception, Planning and Action Capabilities of the Ideal Robot Model

Perception, planning, and action are the early robot control processes, usually abbreviated as SPA. Scientist use these basic concepts to represent the three key capabilities that each robot must have for effective operation. Perception: The robot needs to have the ability to perceive important situations in the surrounding environment, such as the presence of obstacles or navigation aids. What kind of information does the robot need about the environment? How does it collect this information? Plan: The robot needs to use the sensed data, according to the existing strategy, determine how to deal with it. Is there a strategy? According to the strategy and the perceived data, how can the robot make a reasonable response? Action: Finally, the robot must take actual actions according to the requirements of the plan. Have you assembled the robot so that it can complete such tasks? Can it take actions at any time as required by the order?

Generally, the robot's perception process is realized by sensors. According to the different objects detected by the sensors, robot sensors can be divided into internal sensors and external sensors. Perception is also the basis of planning and action. Therefore, this section explains how the function of the ideal robot model is realized from the two directions of external perception and internal perception, and how the perception process plays a role in it.

4.1 External perception

The external sensor is a sensor used to detect the environment and conditions of the robot. These detection quantities mainly include distance, external force or external torque, sound, image. The following is the external perception involves in this robot model and what roles they play in the realization of some functions.

4.1.1 Image

Equipped with a visible light camera, the robot can obtain information such as the color and light intensity of people and objects in the surrounding environment, and perform feature extraction after calculation processing to realize object recognition, face recognition, facial expression recognition, body gesture recognition. To realize emotion recognition and intelligent communication, it extracts features on people’s faces and limbs, judges and recognizes people’s emotions, and then synthesizes them with semantics.

When picking up items, it identifies the type of them. If an item is recognized as garbage, then the robot outputs instructions to the disinfection equipment to disinfect the garbage. It will detect human faces when it measures temperature. If a human face is detected, this robot will turn on the face information recognition module and temperature measurement module, then measure the temperature and sends the identity information and body temperature information to the server after matching them, which is convenient for epidemic prevention and control.

4.1.2 Sound

Equipped with acoustic sensors, it accepts sound wave information propagated in gas (non-contact perception), liquid or solid (contact perception), and then interprets and processes it into command information that the robot processor can understand.

When the robot interact with a user intelligently, firstly, it accepts and explains the human voice, compares its information with the knowledge base. Then it will be matched with an most similar question. Finally, it gives the answer to the user, and take actions based on semantics.

4.1.3 Temperature perception

Equipped with a thermal imaging camera, which is used to obtain and interpret the infrared radiation emitted by the target object, and obtain the temperature information of the target object through photoelectric conversion, signal processing and other means.

When measuring body temperature: Convert the temperature distribution image of the target object into a video image, and finally package it with the recognized face information and send it to the

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information center.

4.1.4 Angle and distance perception

Equipped with lidar, it can scan and collect the surrounding environment in real time, obtain a series of scattered point cloud data with accurate angles and distances as environmental information. This is key to avoid obstacles, by which it can make adjustments to the route in real time during its navigation.

When delivering food and picking up items, the robot will move constantly. While the robot is moving, it constantly detects angle and distance and to avoid obstacles autonomously, which is the basis for completing this type of task referring to travelling.

4.1.5 Tactile perception

Equipped with touch sensors, force-torque sensors, pressure sensors and slip sensors, to determine whether the robot's parts are in contact with external objects. And also, the robot can measure the contacted objects, and to adjust the contact force.

When the robot picks up an object or pressing an bottom on elevator, the robot needs to touch some objects. When the robot starts to grasp the object, the mechanical performance of the object cannot be determined by vision solely. The tactile sensor can determine the weight, texture, stiffness, centroid, friction coefficient and other mechanical properties through the interaction of the object, to provide additional information to supplement the information provided by vision system.

4.2 Analysis of Innovation Strategy of Shared Bicycle Enterprises

The internal sensor is a sensor used to detect the state of the robot itself. The detection quantities include mainly position or posture angle, velocity or angular velocity, acceleration or angular acceleration, internal force or internal torque. The following is the internal perception involves in this robot model and what roles they play in the realization of some functions.

4.2.1 Position and displacement

Equipped with various internal sensors, it can detect the translation distance of the robot, the angular position of each joint and facilitate the movement of the robot's arm, which is the basis for autonomous movement and grasping of objects.

4.2.2 Speed

Equipped with a speed sensor on the robot's arm. It can detect the operating speed of the robot arm joints, detect the rotation speed of the robot's motor, and calculate the speed of its movement, so as to control the speed or position of the robot during the delivery and retrieval of items.

4.2.3 Posture

Equipped with a gyroscope on the torso of the robot, it can detect changes in the posture and orientation of the robot while it is moving, which is also the basis for the realization of those functions involving autonomous movement.

4.2.4 Electricity sensing

It can automatically obtain the remaining power of the system. When the power is insufficient, the processor sends instructions to the motor module that controls the movement to make the robot move to the designated location. Then, after identifying the charging pile, it will move to the charging pile for wireless charging.

4.2.5 Force Sense

Equipped with force sensors, when the fingers, joints and limbs of the robot arm are working, these sensors can feel the force or moment of the robot's components. When the robot performs the functions of picking up and transporting items, it can respond to the working force or torque.

5. The importance of developing emotion recognition technology that integrates visual and auditory senses

American psychologist Melabian argue that emotional expression contains 55% facial expression , 38% voice and 7% other information[9, 10]. Facial expressions can directly reflect people's emotions.

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Therefore, the research of facial expression recognition technology based on visual information is another research hotspot after face detection and recognition [11, 12]. In addition, the voice signal also contains a lot of emotional information, which is closely related to the expression of emotion. In recent years, as a supplement to facial expression recognition, studying the speaker's emotional state from the perspective of speech signals has also become an important branch of emotion recognition. Visual related experiments have shown that applying appropriate auditory stimuli during visual perception can make the perception process faster and more accurate. Therefore, multi-modal emotion recognition that integrates speech, facial expressions and other physiological characteristics is an important research direction to build an emotional recognition knowledge system.

At present, new intelligent robots with emotions are the focus of research in the field of robotics. For example, the humanoid robot Sophia developed by the American Hansen Robotics Company was granted citizenship. "She" not only has an appearance that is highly similar to humans, but also can recognize human expressions and understand the emotional state of others. Emotion recognition technology is used to identify the emotions of the quarantined people. After the robots understand what these individuals feel, they take effective measures to alleviate their negative emotions, in order to meet those need that have been ignored in the current quarantine places.

In addition to multi-modal audio-visual fusion emotion recognition technology, there are some functions that also need further research. For example, autonomous navigation functions needs further improvement in computing efficiency. To avoid pedestrians naturally in path planning, intelligent voice interaction technology needs to be improved, which means the reasoning process of voice recognition and realize cross-domain task-based dialogue still need to be simplified. As to robotic grasping technology, it still lacks utilization of the semantic attributes of items and also the universality in semantic capture strategies.

6. Summary

Aiming at the lack of robots which really concerning on the mental and physical health of isolated individuals at the centralized isolation places, this work proposes an ideal model of a multifunctional robot. At present, the realization of this ideal robot still needs further research and testing in some aspects, but still, it is very likely to be successfully realized in the next five to ten years. In the future, COVID-19 may be completely defeated by humans at some time. However, this ideal robot proposed in this work are still to help as a companion to quarantined individuals infected with any infectious disease. In this COVID-19 epidemic, if the robot have been widely used in the early stage of the fight against infectious diseases in the future, the risk of infection of medical staff would be greatly reduced, and the physical and mental pressure of those medical staff would be reduced as well. Specifically, the robot proposed in this work cannot only meet the needs to survive, but also to stay in good mood and shape, which is key to quarantined individual’s health.

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