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Design and Implementation on Multi-Function Smart Wheelchair

Huaming Zhou
Heilongjiang Province Key Laboratory of Laser Spectroscopy Technology and Application
Harbin University of Science and Technology
Harbin, China
270227986@QQ.com

Xiaoyu Yu
College of Electron and Information, University of Electronic Science and Technology of China,
Zhongshan Institute,
Zhongshan, China
yuxy@zsc.edu.cn

Qing Wu
Heilongjiang Province Key Laboratory of Laser Spectroscopy Technology and Application
Harbin University of Science and Technology
Harbin, China
wuqing@hrbust.edu.cn

Yuji Iwahori
Department of Computer Science,
Chubu University,
Aichi, Japan
iwahori@isc.chubu.ac.jp

Haibin Wu
Heilongjiang Province Key Laboratory of Laser Spectroscopy Technology and Application
Harbin University of Science and Technology
Harbin, China
woo@hrbust.edu.cn

Aili Wang*
Heilongjiang Province Key Laboratory of Laser Spectroscopy Technology and Application
Harbin University of Science and Technology
Harbin, China
aili925@hrbust.edu.cn

***Abstract*—With the increase of population aging, chronic diseases and accidental injuries, more and more people are facing the plight of diminished or even lost walking ability. As a kind of mobile service robot, the smart wheelchair has strong environmental adaptability, smooth motion control and friendly human-computer interaction experience, and is an indispensable tool in rehabilitation engineering and elderly assistance engineering, which has important research value and social significance. In this paper, the system structure framework of the multi-function smart wheelchair and the specific technical scheme of each module are formulated based on the modular design idea, and the intelligent control hardware platform with Arduino UNO controller as the core is built to complete the control software writing, and an intelligent wheelchair for the elderly and disabled guardianship is designed. This multi-function smart wheelchair combined with IoT technology can realize distance navigation, obstacle avoidance, medication reminder, sign measurement, remote monitoring, GPS positioning, and upload information through OneNET cloud platform, which can view the location of the wheelchair and the safety status of the elderly from the map in real time in the cell phone APP and PC backstage, in order to improve the control and monitoring capability of the wheelchair.**

Keywords— Smart Wheelchair, Navigation and Obstacle Avoidance, Multi-mode Motion Control, Medication Reminder, Remote Medical Monitoring

I. INTRODUCTION

Demographic aging is currently a serious emerging trend in China and the globe. Nowadays, the proportion of elderly people aged 60 and above has reached 178 million, accounting for 13.26% of the total population of the country. The population aged 65 and above has reached 119 million, accounting for 8.87%. It is guaranteed that 437 million people will reach the plateau of aging in 2050, accounting for about 30% of the total population. As revealed by the National Health Organization Investigation, the incapacity and semi-disability of elderly people in China will be 44 million by the end of 2021[1]. Especially for this special group, it poses a burden for individual families as well as a substantial stress on society to render care. As for the other hand, the number of "empty nest families" in China is expected to increase, and by 2030, about 90% of the elderly will be "empty nesters", with the number exceeding 200 million. The growth in the incidence of "empty nest families" has prompted overwhelming demand for care for the elderly. The health care needs of the elderly in China are of higher demand, which is not satisfied by the existing nursing technicians, and the care problems faced are ever grimmer[2].

The accelerated aging of the population and the growing number of people with disabilities have put tremendous pressure on China's society and economy, and the demand for elderly care services is intensifying[3]. It has become an important social issue to ensure the quality of life of the elderly and disabled people[4]. As the mobility of elderly and physically disabled people is scarce, wheelchairs are essential for many elderly and disabled people as the useful tool to assist them in walking[5]. Nonetheless, ordinary wheelchairs constantly necessitate the assist of others in usage, which is very laborious and inconvenient and has a great limiting effect on the user's mobility time and range of action. Whereas the existing electric wheelchair products generally have disadvantages such as unfriendly human-machine interface, inconvenient operation, and low safety[6]. Alternatively, irrespective of ordinary wheelchairs or electric wheelchairs, the majority of products on the market today

serve a single function and fail to meet the needs of users for a variety of different functions, making it rare to realize the requirements of users for independent mobility and self-care[7].

In order to solve the mentioned problems, we designed an multi-function smart wheelchair for elderly and disabled person guardianship. The multi-function smart wheelchair combined with IoT technology can realize distance navigation, obstacle avoidance, medication reminder, sign measurement, remote monitoring, GPS positioning, and upload information through OneNET cloud platform, which can view the location of the wheelchair and the safety status of the elderly from the map in real time in the cell phone APP and PC backstage, in order to improve the control and monitoring capability of the wheelchair. The system provides a full range of services for elderly people with limited mobility and lower limb disabilities, improving their ability to live independently and enhancing their self-confidence and well-being, as well as providing a degree of convenience for family members and medical staff.

II. System Design

The working principle of multi-function smart wheelchair is given by the block diagram along with all components. Fig 1 explains it's working. The multi-function smart wheelchair we designed mainly includes the following modules:

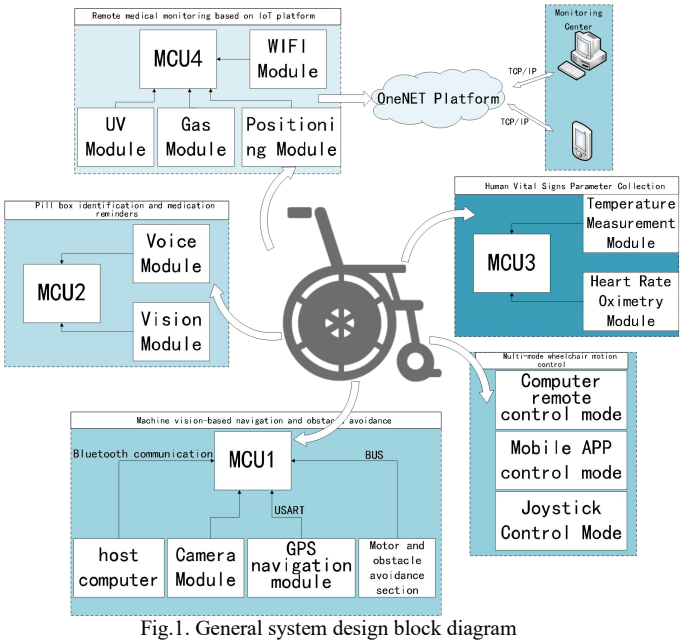

Fig.1. General system design block diagram

1. machine vision-based navigation and obstacle avoidance module; Based on machine vision navigation and obstacle avoidance module is divided into upper computer subsystem and lower computer subsystem. The upper computer subsystem comprises a cell phone APP and a USB camera, and the lower computer subsystem is classified into a master control module, a power module, a walking module, and a human-machine interaction module. To facilitate the development and subsequent function expansion, the Arduino-based development board is selected as the lower computer master control module.

2. pill box recognition and medication reminder module; The module combines artificial intelligence computing platform to realize alarm clock reminder and record medication function. The hardware design includes Kendryte K210, a highly reliable and stable AI chip, LD3320 voice recognition module, and the software design uses ASPP-YOLOv4 detection network. The design can arrange patients' medication scientifically and reasonably to avoid drug omission and abuse. Caregivers and elderly family members can check the elderly's medication through the cell phone terminal and realize medication monitoring.

3. Human vital signs parameter collection module; The module mainly includes the measurement of ECG, heart rate and body temperature. The information monitoring aspect is mainly performed by CC2530 as the main controller for the wireless sensor network. And the collected human vital characteristics parameters such as body temperature, heart rate and blood oxygen concentration information are sent to the main controller through the wireless sensing network for vital characteristics information monitoring.

4. Multi-mode intelligent wheelchair motion control module; In computer remote control mode, the multi-function smart wheelchair is jointly controlled by the user and the navigation and obstacle avoidance system, and the user's computer remote control holds the main control. The multi-function smart wheelchair in cell phone APP control mode can read the details of the multi-function smart wheelchair through the APP, such as left and right wheel speed, slope, power, remaining mileage, etc. The parameters of the multi-function smart wheelchair can also be set through the APP, such as setting the gear, setting the steering sensitivity and setting the driving sensitivity.

5. Remote medical monitoring module based on IOT platform; The training device is composed of S12SD UV sensor module, MQ-2 harmful gas detection module, GPS positioning module of GYGPSV2_SCH sensor, blood oxygen measurement module, body temperature measurement module, electrocardiography measurement module, Esp8266WIFI module, etc. The module enables remote monitoring and GPS positioning, and uploads the information through the OneNET cloud platform, so that the elderly's family can observe their basic vital characteristics in real time, and grasp the exact location and movement of the elderly in real time.

III. Used Hardware and Software

In the plan of any model, both equipment and programming parts are required. Equipment gear help in detecting outside natural readings, though programming help in dynamic dependent on equipment readings. Interconnection and common correspondence of the two advancements bring about the best structure of the necessary model. Thus, during the viable execution of the wheelchair, diverse equipment and programming advances are included and used. Itemized examination of gear alongside their determinations are recorded in detail in the segment underneath.

A. Hardware Modules

1) Arduino Uno

Arduino Uno is opensource hardware and software platform, which is a micro controller board working like a mini CPU to control different electronic components. Its memory is 32KB and it operates on 5 volts DC. Analog and

digital components and sensors can be attached with Arduino board using analogue and digital pins of this board. Output components are connected to digital pins and sensors are connected to analog pins in the Arduino environment. Arduino is made viable with a PC with the assistance of an integrated development environment (IDE). This IDE help in performing appropriate correspondence between the two gadgets. Arduino interface is likewise congenial with the assistance of IDE. The code is composed and consumed into Arduino chip with the assistance of IDE and the yield has appeared on the sequential screen window of the equivalent IDE.

2) KendryteK210 module

The KendryteK210 module utilized in this design is equipped with the FreeRTOS operating system. It uses a RISC-V dual-core 64-bit processor and the power consumption of the entire machine is less than 1W in the INT16 test at a benchmark frequency of 400MHz.

3) ECG sensor module

The AD8232 module is selected to acquire the heart rate signal of human body in this system. The sensor adopts a bipolar high-pass filter to eliminate motion artifacts, while its filter combined with an instrumentation amplifier can achieve one pass high gain and high-pass filtering.

4) Wheelchair motor drive module

The system motor drive uses high-power MOS tubes to build the H-bridge motor drive circuit. The TLP181 opto-coupler is applied to the PWM pin output of the controller for signal isolation, which largely eliminates the influence of signal interference. The system wheelchair adopts a two-wheeled version.

5) Wi-Fi Module

The ESP8266 is used to control and instruct to the objects over the Internet. The ESP8266 module designed in factory with some pre-installed firmware that is allowed to control AT commands. These modules can be connected using some micro-controller such as Arduino Uno or we can update these modules using programming. This can be programmed using the Arduino integrated development environment (IDE).

B. Software Modules

1) Arduino IDE

Arduino IDE is the interfacing stage that helps in controlling, investigating, and observing hardware execution. Through Arduino IDE, code can be scorched, adjusted, and tried on prepared sensors. Moreover, execution assessment can likewise be performed with the assistance of the serial screen window in Arduino IDE.

2) OneNET Cloud Platform

The functions of OneNet's open intelligent cloud platform system is divided into three layers: device access layer, intelligent cloud platform network layer and application layer. OneNet platform provides the API interface based on HTTP method, these interfaces provide services in the form of RESTful, which access these interface by EDP protocol. EDP protocol is OneNet platform according to the characteristics of the Internet of Things custom a completely public long connection protocol based on TCP, it provides the device access, encrypted transmission and data storage, and other functions. Here, EDP protocol is implemented using EDPSDK protocol provided by OnetNet platform, which is used to report smart wheelchair data points to OnetNet.

3) Mobile Application

In default mode, there is no discourse to message transformation performed for wheel seat development. GUI-based showcase catches are utilized to control the development of engines and wheel seats. There is a catch joined to the application GUI that helps in delivering an association between the equipment modules of the wheel seat and controlling programming application. Other control catches are likewise joined to the GUI shows. That catches to control the forward, in reverse, both ways, development of the prototype. Ultrasonic sensor readings can likewise be shown on a versatile application.

IV. Results and Implementation

The system debate is mainly to debug the system hardware and software application parts.

A. Physiological Information and Motion Control Test

For the part of human vital characteristics information acquisition, the circuit control board design was carried out first, and the circuit board prototype was followed by the program design of each sub-node. Each node can work normally and stably.

Body temperature, ECG and blood oxygen collection parameters are all within a reasonable error range. The physical operation diagram of human vital information acquisition is shown in Figure 2 below.

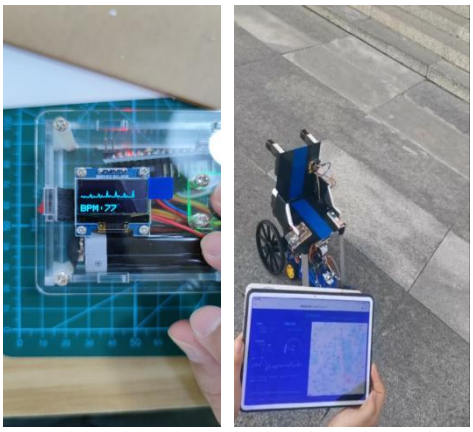

Fig.2. Human life information collection physical operation diagram

The motion control part uses cell phone APP control and computer control, by switching the control switch to choose different control methods. The cell phone APP control is a wireless control through Bluetooth communication. The virtual telemetry direction keys of the cell phone are collected to control the movement and walking of the wheelchair. The touch screen and cell phone control operation diagram is shown in Figure 3.

Fig.3. Touch screen and cell phone control operation diagram

B. Obstacle avoidance test

The overall maneuverability of the wheelchair's obstacle avoidance function was tested in a practical application, and the test results are shown in Figure 4. The test results indicate that the multi-function smart wheelchair has a certain degree of robustness and the feasibility of practical application.

Fig.4. Obstacle avoidance function test

C. Pill box identification test

Figure 5 shows the diagram of the actual operation process of pill box identification. The test results show that the pill box recognition module can accurately identify the elderly and realize the functions of alarm clock reminding and recording medication use. Caregivers and family members can check the elderly's medication through the cell phone terminal to realize medication monitoring.

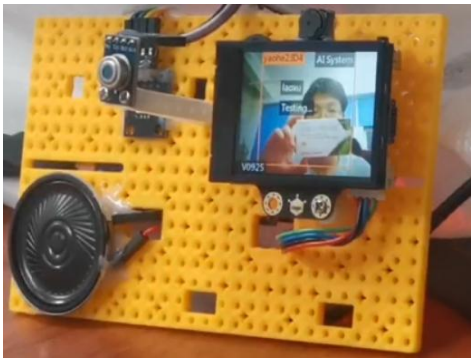

Fig. 5. Pill box identification process diagram

D. IoT remote monitoring test

Real-time data such as UV intensity, air condition, GPS location, and path display are shown in Figure 6, and users can observe the relevant data of the wheelchair at any time. The server receives the positioning information transmitted by the intelligent positioning terminal through the Internet for positioning data processing and storage, and sends the geographic location information to the intelligent monitoring terminal through the Internet. The intelligent monitoring terminal actively queries the location information and images of the current activity status of the elderly from the monitoring system of the server via the Internet.

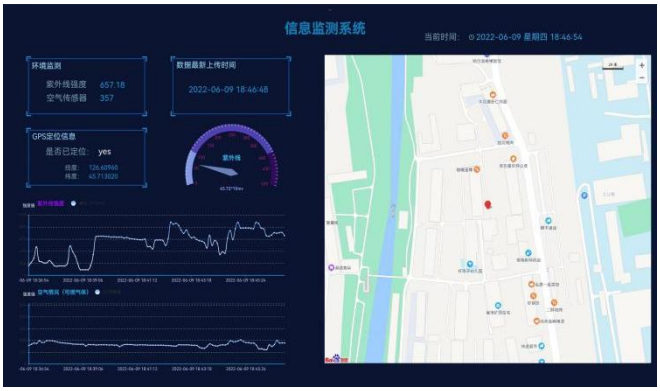

Fig.6. IoT remote monitoring of real-time data

V. Conclusion

In this paper, we develop the system structure framework of the multi-function smart wheelchair and specific technical solutions for each module based on the modular design idea, as well as build an intelligent control hardware platform with Arduino UNO controller as the core. This multi-function smart wheelchair combined with IoT technology can realize distance navigation, obstacle avoidance, medication reminder, sign measurement, remote monitoring, GPS positioning, and upload the information through OneNET cloud platform. At the end, the functions of the multi-function smart wheelchair and the cell phone interaction interface were tested. The test results indicate that the design works well in testing and evaluation, which shows the scientific and reasonable nature of the multi-function smart wheelchair design and provides a case study and design method that can be used as a reference for future smart wheelchair designs. Nevertheless, further improvements are needed in the design of the interaction interface in this paper to create a more effective set of methods and principles to guide the interaction interface design of smart wheelchairs.

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