A Design of Modular Photovoltaic Environmentally Friendly Portable Stroller

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Abstract

The work is centered on ROS and integrates speech recognition and natural language processing modules to enhance the environmental awareness of the stroller and monitor the baby's condition to ensure a timely and appropriate response. The Raspberry Pi is the main control unit of the stroller and connects to a cloud-based IoT platform via the MQTT protocol. The platform facilitates seamless communication between the Raspberry Pi and cloud data for efficient data visualization on mobile devices. This innovative solution solves the challenge of balancing parental responsibilities with career advancement, promoting healthier and happier babies while allowing parents to maintain a harmonious work-life balance.

Keywords: Natural Language Processing, MQTT Protocol, Data Visualization, Cloud Computing, Raspberry Pi

1. Introduction

In order to reduce greenhouse gas emissions and at the same time enhance the safety and interactivity of the stroller, this work designs a modular photovoltaic intelligent portable stroller system with active safety, micro-environmental monitoring and remote monitoring of mobile terminals [1], and carries out a scientific and intelligent design of the software and hardware of the photovoltaic environmentally friendly portable stroller movement system and monitoring system [2].

The work uses polycrystalline solar panels to charge lithium-ion batteries, sets three power modes, and adopts aluminum alloy and other carbon-saving materials, which helps to reduce air pollution and greenhouse gas emissions, and responds to the national call for promoting green and low-carbon development [3]. The work uses STM32 development board as the bottom control center, and DC motor and drive circuit to build the bottom drive system hardware; adopts ROS as the core, and applies IoT technology with voice recognition and natural language processing module to realize the stroller's perception of the surrounding environment and the baby's state and make appropriate responses; adopts Raspberry Pi as the upper host computer of the stroller, and builds a cloud IoT platform and a cloud IoT platform based on MQTT protocol, and uses Raspberry Pi as the upper host computer. Raspberry Pi is used as the host controller of the stroller, and a cloud-based IoT platform based on MQTT protocol is built and the interaction scheme between Raspberry Pi and cloud data is designed to realize the convenient interaction function of data visualization in the mobile terminal [4].

The rest of the paper is organized as follows. The second part introduces the system program design. The third part introduces the working principle of the stroller, which includes the design of automatic following and safe obstacle avoidance function, automatic cradle function design, microenvironment sensing system design, baby crying sound sensing and recognition design and baby expression recognition design. The fourth part summarizes the main content of this paper.

2. System Programming

The team carried out the overall design and technical analysis of the system for the modular photovoltaic smart eco-friendly baby stroller. The function realization part of the stroller is a set of integrated motion device, which contains modules such as automatic cradle, autonomous following, etc.; and the monitoring part is a complete set of intelligent IoT solutions, which contains modules such as intelligent interaction, active safety, and visual surveillance [5]. The multi-angle view of the smart eco-friendly stroller is shown in Fig.1.

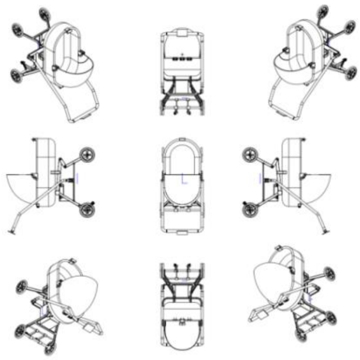

Fig. 1 The multi-angle view of the smart eco-friendly stroller

The modular photovoltaic intelligent eco-friendly stroller realizes the corresponding functions by controlling a variety of intelligent modules such as motor drive module, autonomous motion module, automatic brake module, automatic bed shaking module, deep learning module, visual monitoring module, intelligent interaction module and so on through the embedded system, and the intelligent system based on the Internet of Things (IoT) can make the stroller connected to the mobile terminal and provide real-time feedback for the parents on all kinds of information of the baby in the stroller. The system block diagram is shown in Fig. 2.

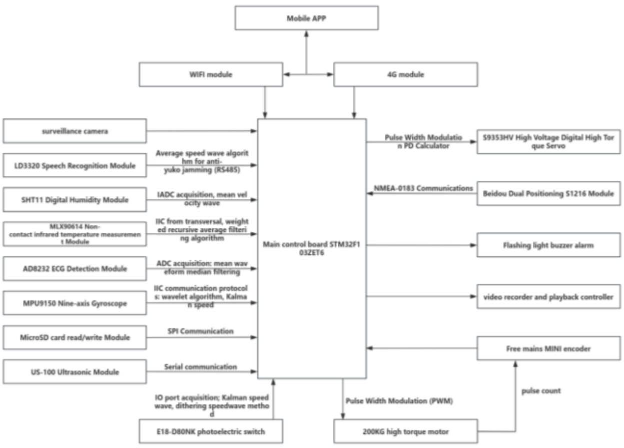

Fig. 2 The system block diagram

The sensor data collected by the controller is susceptible to external interference and is not highly accurate. In this work, different sensor data types are processed by mean filtering, weighted recursive average filtering, median filtering, Kalman filtering, dithering filtering, first-order hysteresis filtering, etc., and the data accuracy is improved. The schematic diagram of data processing is shown in Fig. 3.

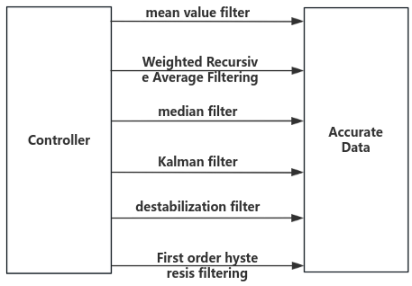

Fig.3 The schematic diagram of data processing

3. How Strollers Work

3.1. Automatic Following and Safe Obstacle Avoidance Function Design

The automatic following function is calculated by the ultrasonic distance measuring module through the acoustic wave reflection time length, to get the distance between the stroller and the person being followed, and through the PID algorithm to control the motor drive module to make the distance between the stroller and the person being followed stay within the set range [6]; the safety obstacle avoidance function also uses the ultrasonic distance measuring module to measure the distance, when the distance between the stroller and the obstacle in front of the stroller is less than the set value, the stroller brakes and stops. When the distance between the stroller and the obstacle in front is measured to be less than the set value, the stroller brakes and stops. In signal processing, Kalman filtering algorithm will be used to eliminate other interferences, to ensure that the smart stroller follows accurately, so that parents can have a more secure experience.

3.1.1. Distance Measuring Sensor

The ultrasonic distance module was selected for the distance sensor. Use low power consumption, low price and easy to connect HC-SR04 ultrasonic distance sensor. The module uses a transceiver split probe to range objects within a distance of 1cm-6m, to achieve the function of avoiding obstacles and following people. Ultrasonic distance measurement structure is shown in Fig. 4.

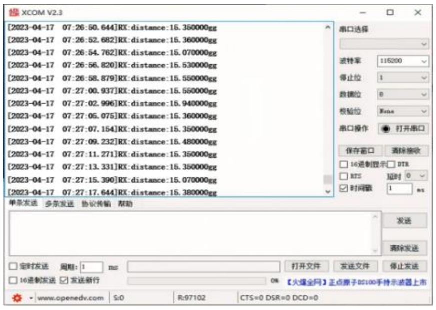

Fig. 4 Ultrasonic distance measurement structure

The team added temperature and humidity sensors to the work, thus using different speeds of sound for distance measurements by monitoring different temperatures, increasing the accuracy of the distance measurements and further securing the safety of the stroller. The temperature-speed of sound relationship graph is shown in Fig. 5.

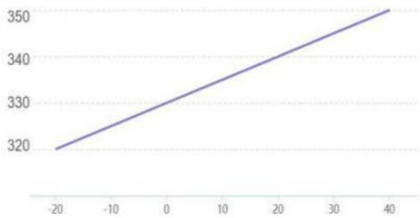

Fig. 5 The temperature-speed of sound relationship graph

3.1.2. Bluetooth Module

The system uses HC-05 Bluetooth module to realize two-way wireless function, through the micro-controller control device and voice control system communication, to realize the remote control cradle car front and back, left and right in all directions, or cell phone APP connects to Bluetooth to realize the cell phone APP control movement [7]. The cell phone Bluetooth app interface is shown in Fig. 6.

Fig.6 The cell phone Bluetooth app interface

3.2. Automatic Cradle Function Design

The design adopts the temperature and humidity compound sensor DHT11. It has humidity measurement elements to measure humidity and NTC temperature measurement elements to measure temperature, and its correction factor is stored in OTP memory by program.

3.2.1. Cradle Control Functional Design

The function of this module is divided into semi-automatic bionic rocking and fully automatic bionic rocking. When the semi-automatic cradle is turned on, parents can control it by connecting the cell phone APP through the Bluetooth module, and the stroller will simulate the parents' shaking once for every click on the turn on automatic shaking button; while when the fully automatic cradle is turned on, the automatic cradle module will work together with the cry detection module and the camera to automatically turn on the automatic cradle function when the baby's cry is detected and the function will decide the direction and strength of shaking according to the baby's posture fed back by the camera. This function will decide the direction and strength of rocking according to the baby's posture feedback from the camera, so that the baby is in the most comfortable cradle environment.

3.2.2. Attitude Sensing Module

The stroller is equipped with posture sensing module MPU6050, which sets the balance state data limit, autonomously monitors the swinging condition of the cradle without voice control [8], and the Raspberry Pi accepts the data and transmits it to the control board, which ensures that the cradle is always kept in a horizontal state without human intervention, providing safety for infants and toddlers to move around in the cradle. The test results of the attitude sensing module are shown in Fig. 7.

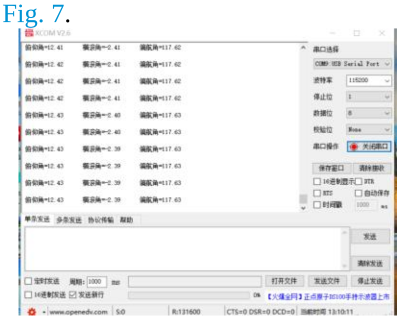

Fig.7 The test results of the attitude sensing module

3.2.3. Voice Interaction Module

The stroller is also equipped with voice interaction module LD3320, which can recognize the user's commands and make corresponding interactive commands. Considering that some babies are accustomed to listening to their parents' voices to sleep, when the stroller is told to "play mommy's words" or other commands, it will play the audio recorded by the parents in advance to coax the child to sleep, which reduces the pressure on parents' childcare. The test data of the voice interaction module is shown in Fig. 8.

Fig.8 The test data of the voice interaction module

3.3. Design of Microenvironment Sensing Systems

Sensing system design, temperature and humidity sensors can monitor the temperature and humidity in the stroller, when the temperature is too high, it will remind the baby moms and dads through the cell phone to ventilate in time, and when the humidity is too low, it will prompt the baby moms and dads to turn on the humidification device; the light intensity sensor automatically senses the strength of the light around the sun, and when it meets with the strong light environment, the sunshade will automatically extend and unfold, and play the effect of the sun, and if the baby moms and dads want to let their children sunbathe in the sun, they can turn it off the automatic sun-shading function through the cell phone app and turn the sunshade on.

3.3.1. Light Intensity Sensor

BH1750 internal by the photodiode, operational amplifier, ADC acquisition, crystal, etc. PD diode through the photovoltaic effect will be converted into an input light signal into an electrical signal, amplified by the operational amplifier circuit, the voltage collected by the ADC, and then through the logic circuit is converted into a 16-bit binary number stored in the internal registers, in short, is that the stronger the light, the greater the photocurrent, the greater the voltage is. larger, and using its high resolution can detect a larger range of light intensity changes.

3.3.2. Temperature and Humidity Sensor

DHT11 is a temperature and humidity composite digital signal sensor, the sensor to digital acquisition technology and sensor technology integrated development, with years of market reputation and excellent performance. The sensor's clever single-wire serial interface design scheme, so that power consumption, volume has a greater reduction in the extremely demanding scenarios, the sensor can still maintain good performance and stability. The temperature and humidity sensor operation interface is shown in Fig. 9.

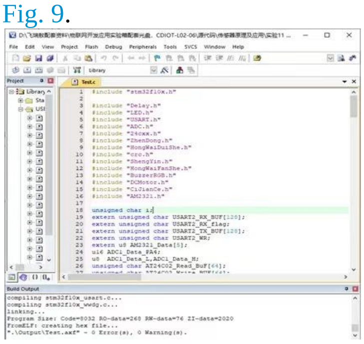

Fig.9 The temperature and humidity sensor operation interface

3.4. Infant Cry Sensing and Recognition Design

Infant cry perception and recognition design uses a cry recognition system, when the baby cries, the detection device will receive the cry signal, and then filtering processing, feature extraction through the basic acoustic features to get the feature data [9]. The results of the human infrared sensor test are shown in Fig. 10.

Fig.10 The results of the human infrared sensor test

3.4.1. Sound Classification Algorithm Based on Inception-v4 network

By studying Dunstan's theory of infant cry classification, our team collected videos and audios of infant cries from video websites and manually edited and labeled them to obtain the speech spectrograms of five categories of infant cry sound samples, which are the speech spectrograms of sound samples of cries due to wanting to hiccup, being uncomfortable, feeling sleepy and wanting to go to sleep, being hungry and wanting to eat, and being bloated and in pain in the abdomen [10]. The five kinds of speech maps are shown in Fig. 11.

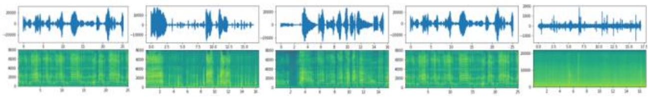

Fig. 11 The five kinds of speech maps

3.4.2. Network Model Structure Details

The database used in the work is the personal self-constructed infant crying database described in this paper, with a total of 7,500 spectrograms converted from infant crying data. In the experiment, the team used 6500 infant crying speech maps as a training set and 1000 infant crying speech maps as a test set. The categories were categorized using Oberschländerstein's theory of baby crying for 5 categories, which were manually labeled.

The tool used to build the network is the Tensorflow deep learning framework, and the task of categorizing different categories of infant cries is accomplished by modifying the Inception-v4 network model. The upper computer gives different feedback for different cries as shown in Fig. 12.

Fig. 12 Different feedback for different cries

3.5. Baby Expression Recognition Design

The baby expression recognition system consists of four main components, namely: baby expression image acquisition and detection, baby expression image preprocessing, baby expression image feature extraction, and matching and recognition.

3.5.1. Image Acquisition and Detection of Baby Expressions

In terms of baby expression image capture, different baby expression images can be captured by the camera lens. When the baby is within the capture range of the capture device, the capture device automatically searches and captures the baby expression image; baby expression detection is mainly used in practice for preprocessing of baby expression recognition, i.e., accurately calibrating the position and size of the face in the image. Baby expression images contain rich pattern features, such as histogram features, color features, template features, structural features and Haar features [11]. Baby expression detection is to pick out this useful information and use these features to achieve baby expression detection. Baby expression detection is shown in Fig. 13.

Fig. 13 Baby expression detection

Mainstream baby expression detection methods use Adaboost learning algorithm based on the above features, which combines some of the weaker classification methods together to combine new very strong classification methods, which can effectively improve the detection speed of the classifier.

3.5.2. Baby Expression Image Preprocessing

Image preprocessing for baby expressions is a process of processing images and ultimately serving feature extraction based on face detection results. The original image acquired by the system often cannot be used directly due to the limitations of various conditions and random interference, and it must be subjected to image preprocessing such as grayscale correction and noise filtering in the early stage of image processing. For the baby expression image, the preprocessing process mainly includes light compensation, gray scale transformation, histogram equalization, normalization, geometric correction, filtering and sharpening of the baby expression image.

3.5.3. Baby Expression Image Feature Extraction

The methods of infant expression feature extraction are summarized into two main categories, one is the knowledge-based characterization method; the other is the characterization method based on algebraic features or statistical learning.

Knowledge-based characterization methods are mainly based on the shape description of infant expression organs and the distance characteristics between them to obtain feature data that help to classify infant expressions. Infant expression consists of eyes, nose, mouth, chin and other localities, the geometric description of these localities and the structural relationship between them can be used as an important feature for recognizing the face; the basic idea of the algebraic feature-based method is to transform the high-dimensional description of the face in the spatial domain into a low-dimensional description in the frequency domain or in other spaces, and the characterization methods are the linear projection characterization method and the nonlinear projection characterization method.

3.5.4. Image Matching and Recognition of Baby Expressions

The feature data of the extracted baby expression image is searched and matched with the feature templates stored in the database, and the result obtained from the matching is outputted by setting a threshold value when the similarity exceeds this threshold value. Baby expression recognition is to compare the face features to be recognized with the obtained baby expression feature templates, and to judge the baby state information based on the degree of similarity.

4. Conclusion

The Modular Photovoltaic Environmentally Friendly Portable Stroller's is dedicated to innovatively solving social problems through a modular photovoltaic smart portable stroller system, while reducing greenhouse gas emissions and enhancing the safety and interactivity of the stroller. The work uses polycrystalline solar panels, aluminum alloy and other environmentally friendly materials, as well as three power modes, fully responding to the initiative of green and low-carbon development. In terms of hardware design, the STM32 development board builds the underlying control center and implements the active safety and motion system. In terms of software, ROS serves as the core, combining with IoT technology, speech recognition and natural language processing to equip the stroller with the ability to intelligently sense and respond to the surrounding environment and the baby's state. Through the Raspberry Pi as the host controller of the upper computer, a cloud-based IoT platform based on the MQTT protocol is built, which realizes the convenient interaction of data and the visualization and monitoring of the mobile terminal. By improving the intelligent level of the stroller, it enables parents to better balance their work and family responsibilities, and realizes the further penetration of intelligence and advancement in the field of childcare.

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Authors Introduction

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