A Design and Implementation of Intelligent Cradle

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Abstract

The equipment is designed for families to raise children, the device is a cradle of artificial intelligence technology. The data of baby shaking are collected and analyzed by the sensor, so that the cradle bed can bionic cradle shaking. The SVM database training of infant crying can realize the recognition of infant crying and determine the specific meaning of crying, such as hunger, excretion, pain and other factors, and timely inform parents; Based on ROS robot operating system and iflytek platform, it can carry out natural language interaction and autonomous navigation. Parents can call the baby cradle and let it reach the designated position automatically to achieve autonomous obstacle avoidance and path planning without manual interference. At the same time, the camera can view the baby's status and transmit the real-time picture to the mobile phone APP.

Keywords: bionic cradle, infant crying, ROS, iflytek, platform, natural language interaction, autonomous navigation

1. Introduction

Since entering the 21st century, the development of robots has become faster and faster. With the development of science and technology, the integration degree of robot is higher and smaller. The diversified functions of service robots are gradually recognized by the market. According to China's industrial information network, the sales volume of service robots in 2016 was 6.8 million, an increase of 25.93% compared with 2015. From 2011 to 2014, the global average compound growth rate of home service robots is about 22%, and the sales volume is expected to increase to 31 million in 2019. Service robots will affect all aspects of human production and life.

In today's information age, people are busy in various activities and affairs, such as work, social interaction and so on[1]. According to the statistics of the United Nations, 140 million newborns were born in the world in 2018, with 15.23 million in China alone. With the opening of the two child policy, the number of newborns is increasing year by year[2]. A large group of novice parents urgently need a more labor-saving care service robot[3]. In order to solve the problem of parenting, we have developed an intelligent cradle, which can imitate the cradle frequency of parents, understand the crying of babies, and move autonomously, so that novice parents are more relaxed.

2. System overview

This equipment is a cradle bed combining artificial intelligence technology. The cradle bed can realize many functions such as automatic follow, intelligent cradle, natural language interaction, early childhood education, cry recognition, etc. Cradle bed integrates speech recognition and processing and big data processing technology. By installing ROS platform in raspberry pi, its distributed framework can build voice interaction module, bottom motion module, Bluetooth communication module, etc. Three special functions can be realized: first, imitating the swing frequency when human coax the baby, automatically rocking the cradle with different degrees of bionic frequency, imitating grandma gently rocking, imitating mom to coax the baby to sleep rocking, imitating dad to play rocking, and at the same time, timing the cradle time;Second, autonomous navigation, based on slam technology, allows the bassinet to move in a strange environment, quickly build the layout of the environment, provide accurate positioning and navigation reference for the bassinet autonomous movement, as well as human-computer interaction reference. With the functions of real-time positioning, intelligent obstacle avoidance, path planning, etc., the device can move to any indoor and reachable place autonomously, realize fixed-point movement, and be autonomous in the whole process without any human intervention. Third, it is equipped with a voice interaction system, based on iFLYTEK platform, and at the same time collects big data of baby crying, which can communicate with parents voice, recognize baby crying, and intelligently judge baby crying due to hunger, excretion or pain and other factors, so as to inform parents in time; voice interaction can realize parents calling cradle car to self navigate to parents.

3. The hardware structure design

The core platform of the device is the robot operating system (ROS). Its distributed network uses the communication mode of TCP / IP to realize the point-to-point loose coupling connection between modules. The hardware consists of raspberry pi, camera, lidar, ultrasonic ranging sensor, motor, omni-directional wheel, encoder and drive board. The encoder is installed on the cradle motor to calculate the rotation angle of the cradle and fix the rotation angle from the mechanical structure and the upper limit of the software program; the drive board controls the movement of the baby carriage chassis, the chassis adopts three omni-directional wheels, which can realize the omni-directional movement ability of the baby carriage; the microphone recognizes the baby crying for data collection and processing, and uses iFLYTEK platform for natural language Interaction; the camera is used to observe the situation in the stroller and transmit the real-time picture to the mobile app; the ultrasonic ranging sensor is installed around the stroller chassis to avoid obstacles; the lidar is used to collect the surrounding environment information, and the collected data is transmitted to the raspberry pi for the slam drawing, so as to realize the indoor autonomous navigation.

3.1. Chassis motion control structure

The bassinet chassis is made of aluminum alloy. Because the bassinet needs to have safe omni-directional movement ability in the room, the omni wheel ql-10 (Omni wheels is a wheel that can move in many different directions) is selected as its moving tool. It includes a wheel hub and a plurality of driven wheels. Each driven wheel is embedded with two rolling bearings. Compared with the mcnamm wheel, the omni-directional wheel has faster speed, more flexible movement mode and more stable movement system. When three omni-directional wheels are used at the same time, the translation in any direction can be realized, and any complicated arc motion can be performed. The driving mode is three-wheel independent driving, three hollow cup DC servo motors control three omni-directional wheels respectively, and use imdr4e servo driver to drive the motor via CAN bus and RS232 communication interface. The maximum moving speed of bassinet is 0.65m/s, the maximum rotation speed is 200 ° / s, and the minimum turning radius is 0m. The chassis is slightly lower, so it is suitable for indoor and flat road operation. For the safety of the baby, crash strips are installed around the chassis. The chassis structure is shown in Fig.1.

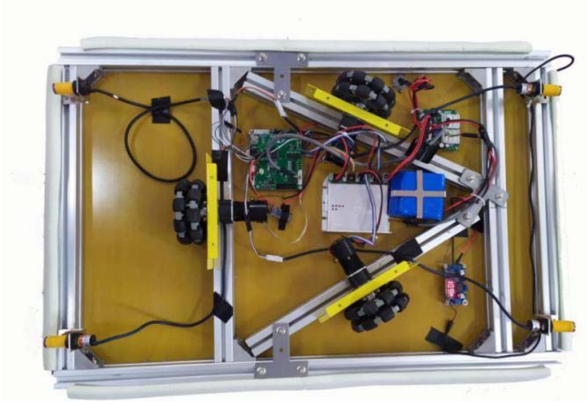

Fig.1. Chassis structure

3.2. Cradle mechanical structure

The bassinet structure is arranged on the bassinet chassis, which is composed of four brackets, an electric motor, a rocker and a bassinet. Two brackets are set up on both sides to fix on the chassis, one side of which is fixed to install the motor, the motor is connected with the rocker, the other side is directly connected with the rocker, and the two rocker are connected with the cradle. Through the motor to give the rocker force, through the rocker swing to drive the cradle swing. The mechanical structure of cradle is shown in Fig.2.

Fig.2. Cradle rocker structure

The motor is connected by the rocker. The motor rotates to drive the rocker to swing back and forth. The rotation angle and speed of the motor are calculated by the encoder. The control board yf00702ea controls the maximum rotation angle of the motor to prevent the shaking from being too intense. At the same time, in the mechanical structure, the shaking limit position is designed to prevent the parents from throwing the baby out by mistake. The cradle motor and encoder are shown in Fig.3.and the control board YF00702EA is shown in Fig.4.

Fig.3. Motor and encoder

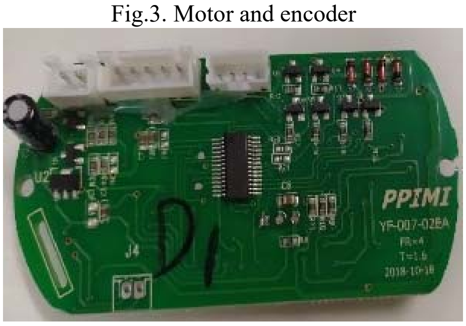

Fig.4. Control board YF00702

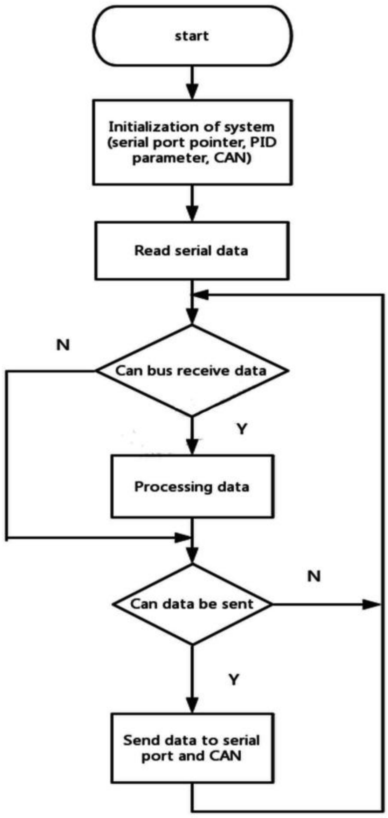

Fig.5. Servo driver workflow

3.3. Ultrasonic obstacle avoidance sensor

The model of ultrasonic obstacle avoidance sensor used in this bassinet is ULB-1 ultrasonic distance sensor, which has the characteristics of high resolution, high precision and low consumption. Not only in the design, but also in the interference noise processing, with anti noise interference ability. And for the different size of the target, and the change of the supply voltage, do the sensitivity compensation. In addition, it also has standard internal temperature compensation, which makes the measured distance data more accurate[4]. ULB-1 ultrasonic ranging sensor is shown in Fig.6.

Fig.6. ULB-1 Ultrasonic ranging sensor

3. 4. Laser radar

Lidar systems are often based on pulsed laser diodes and silicon avalanche photodiode (APD) arrays, with exploiting 905nm wavelength light[5].It is used to collect the information of the surrounding environment, transmit the collected data to raspberry pi, and use it for SLAM mapping to realize the indoor autonomous navigation, as shown in Fig.7.

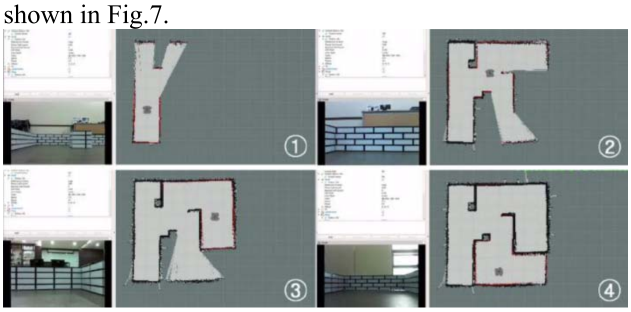

Fig.7. Experimental construction

4. System circuit module design

4.1. Research and analysis of CAN bus

The Controller Area Network (CAN bus) is a bus based on differential signaling originally developed for automotive industry[6].CAN bus topology and physical layer, can bus bit value representation is shown in Fig.8.

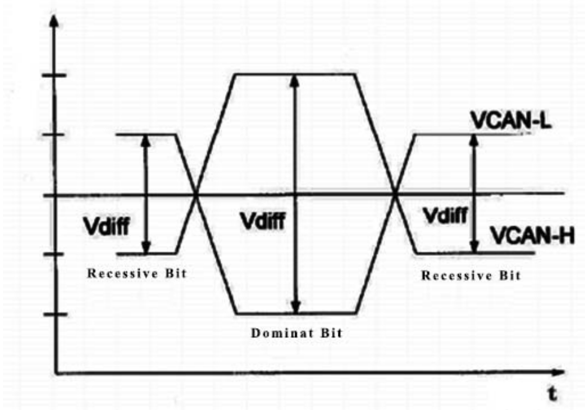

Fig.8. CAN bus bit value characterization

Compared with other network protocols, CAN has the following two outstanding advantages:

- high reliability. The short frame mode is selected for data transmission, and the transmission medium is double insulated wire. CAN can effectively shield all kinds of electromagnetic interference outside. At the same time, CAN is defined with a variety of fault diagnosis mechanisms, which makes it highly reliable and very suitable for use in the controller subnet[7].
- good expansibility.CAN adopts multi main mode communication, and the identifier is defined in the frame structure. The access of controller in the network does not require any change of software or hardware of all controller application layers.

4.2. Crying recognition

From the "donate a cry" project shared on GitHub, all the infant crying data recorded and uploaded by the user's mobile phone were screened to obtain 450 clear infant crying data with a duration of about 5 s. The data has been converted to CAF or 3gp with a uniform bit format of 128kbps, and all the data used has been converted to WAV format with a sampling rate of 8 kHz.

The feature extraction method of baby crying: when baby crying, the detection device (microphone) will receive the signal, and then through filtering processing, and then through the basic acoustic features for feature extraction, get the feature data[8]. Infant cry can be divided into several crying units, which have different acoustic characteristics. The flow chart of cry recognition system is shown in Fig.9.

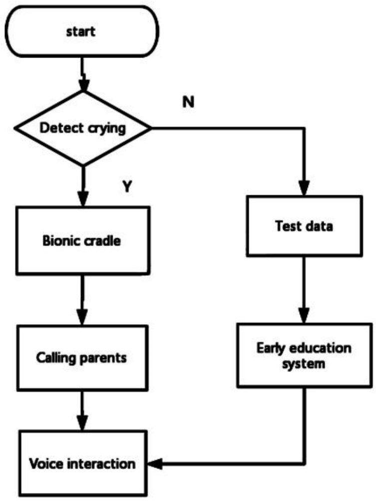

Fig.9. Flow chart of cry recognition system

As shown in Fig.10., there are three expiratory crying units (segments 1, 3 and 5) with longer duration and lower fundamental frequency, and two inspiratory crying units (segments 2 and 4) with shorter duration, dullness and higher fundamental frequency The duration of inspiratory crying unit is short, and sometimes it is pure sound, sometimes it is dullness, and its acoustic characteristics are not stable, so breath crying unit is used for analysis.

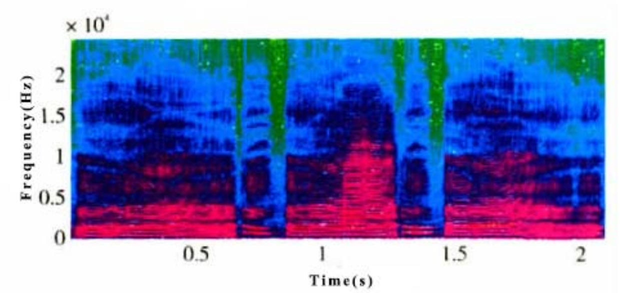

Fig.10. Two microphone array for corpus sample analysis

The crying type expiratory crying unit calculates the fundamental frequency (F0) and the first (F1), second (F2) and third (F3) formants of the crying signal frame by frame The fundamental frequency corresponds to the frequency of the glottal pulse excitation signal, and the resonance peak corresponds to the resonance frequency of the channel.

The device uses SVM cry recognition model, uses tensorflow in-depth learning keras tool kit to realize SVM model, Support Vector Machine (SVM) is a supervised machine learning algorithm. Firstly, preprocessing and feature extraction are carried out, including removing silent segment, adding window, framing and amplitude normalization. The feature vector extracted by SVM experiment is the statistical average feature of all frames in each corpus.

For the identification of this product, we use the kernel function with the highest recognition rate in the laboratory process, which is Gaussian kernel function, as the SVM baseline model.

5. Testing and conclusion

5.1. Test plan

The test scheme of omni-directional wheel is as follows:

- Write the control program of the omni-directional wheel, and then place it close to the longer wall and move it freely, so that it can directly observe the change of the gap between the intelligent bed and the wall, and record the error.
- Place the intelligent bed on the flat and easy to observe ground, determine its geometric center and mark it on the ground, make it rotate around the center point, observe the bed offset after a period of time, and record.
- Place the intelligent bed at the right angle bend, make sure the ground is flat and smooth, make it pass the right angle bend continuously, observe the friction and deviation, and record.

The test scheme of the shaker is as follows:

- Set the intelligent bed to a fixed gear, record the included angle and time, calculate the shaking frequency, record a long time, and calculate the error.
- Put the intelligent bed in different gears, and compare the changes of amplitude and frequency.

The scheme of ultrasonic obstacle avoidance test is as follows:

- Place the intelligent bed in the open and flat space, set obstacles of the same specification in the surrounding fixed area, so that the bed can only move towards the direction of the obstacles, return to the original place after the successful detection of the obstacle avoidance, and then move to other directions to judge the success probability and efficiency of the obstacle avoidance.
- Change the shape of obstacles, and then conduct obstacle avoidance test. Record data and analyze.

Bluetooth Test: transfer data of different types and sizes into Bluetooth at one time, and judge whether Bluetooth is in fault by many experiments.

The cry recognition test scheme is as follows:

- Put the cry data collected from the same infant with different purposes into the in-depth learning module, and compare the results of learning prediction with the actual situation to get the probability of success.
- Put the cry of different infants into the deep learning module to detect the success rate of deep learning.

5.2. Test results

After repeated tests, the crib can meet the needs of users for safety and intelligence, achieve the real sense of "people-oriented"[9], and protect the baby from harm in the daily life environment, with stable hardware and software. Omnidirectional wheel works safely and normally, avoiding obstacles accurately and timely. Bluetooth receives all kinds of data and works normally. It also has a certain recognition success rate for children's crying, which can help parents understand their children's physiological needs.

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