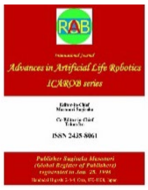
SUGISAKA MASANORI

Journal of Advances in Artificial Life Robotics
Vol. 1(4); March (2021), pp. 168–174
ON LINE ISSN 2435-8061; ISSN-L 2435-8061
https://alife-robotics.org/jallr.html



Research Article

Cradle Design and Implementation Based on Artificial Intelligence

Ting Zhao, Qing He, Zhuofan Xu, Zhou Yang, Zhenjiang Chen, Shuo Jiang
Tianjin University of Science and Technology, Tianjin, 300222, China

ARTICLE INFO

Article History

Received 25 October 2019
Accepted 07 September 2020

Keywords

Bionic cradle
Infant crying
ROS
Natural language interaction
Autonomous navigation

ABSTRACT

In order to reduce the burden of child care and better child care.A cradle with artificial intelligence technology is designed for families to raise child . The data of baby shaking are collected and analyzed by the Micro Control Unit, 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.

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.

The pace of contemporary society is speeding up, and the work pressure is increasing. For young people who are about to become parents or have already become parents, the pressure is even more significant. On the one hand, they have no experience as a parent, and on the other hand, they have to work hard, leaving little energy left for their children every day. Some parents can not get a good rest for a long time because they need to take care of their babies at night, and even seriously affect their health and normal work. In order to reduce the pressure on young parents to coax their babies, automatic baby cradles have emerged.

In the early days, the baby cradle simply replaced the parents' hands. The simple mechanical transmission structure could only output at a fixed frequency, so the baby could not feel the feeling of "parents". In the new century, the electric baby carriage has only added recording and playing functions, so parents still have to devote a lot of energy to taking care of their children.

In order to solve the pain point of parenting, we have carefully designed the intelligent cradle bed. It can imitate the parents' cradle frequency, understand the baby's crying, such as whether it is hungry, report the child's physical

Corresponding author's E-mail: heqing@tust.edu.cn, URL: www.tust.edu.cn

condition to the parents, such as whether it has a fever, etc. it can also move autonomously to the place where the parents want it to go. It is the intelligent nursing sister-in-law who liberates parents.

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 timeSecond, autonomous navigation. Based on slam technology and Beidou navigation, the environment layout map can be quickly constructed when the bassinet moves in an unfamiliar environment, which can provide accurate positioning and navigation reference for the autonomous movement of the bassinet, as well as the reference for human-computer interaction. With real-time positioning, intelligent obstacle avoidance, path planning and other functions, the device can automatically move to any indoor accessible place, realize fixed-point movement, full autonomy, without manual interference. Thirdly, it is equipped with voice interaction system, based on iFLYTEK platform, and collects big data of baby crying. It can communicate with parents by voice, recognize baby crying, and intelligently judge crying caused by hunger, excretion or pain, so as to timely inform parents and inform their children of the situation.Voice interaction can realize parents' call for bassinet autonomous navigation 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 pai, camera, lidar, ultrasonic ranging sensor, motor, omni-directional wheel, encoder, drive board and beidou module. 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 and Beidou module are used to collect the surrounding environment information at the same time, which can collect information more accurately, understand the structure of the house, and transmit the collected data to raspberry pie for slam mapping, so as to realize 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. When working indoors, for the safety of the baby, anti-collision strips are installed around and around the chassis to prevent the baby from being injured due to the movement of the baby carriage. The chassis structure is shown in Fig 1.

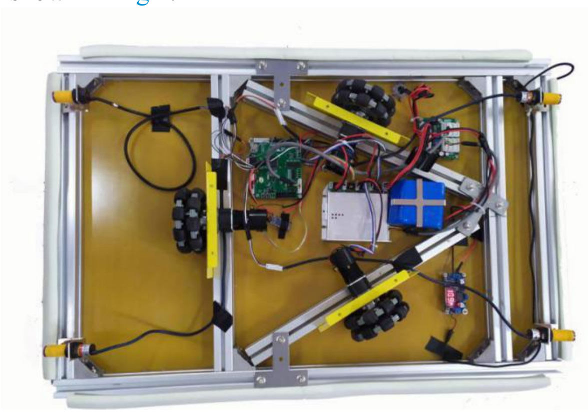


Fig.1. Chassis structure

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. Servo driver workflow is shown in Fig.5.

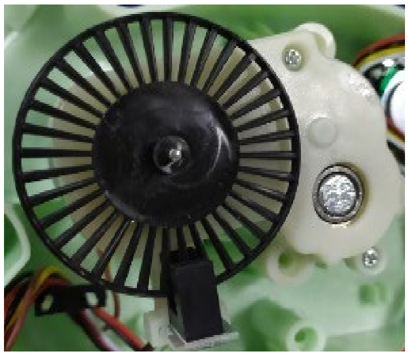


Fig.3. Motor and encoder

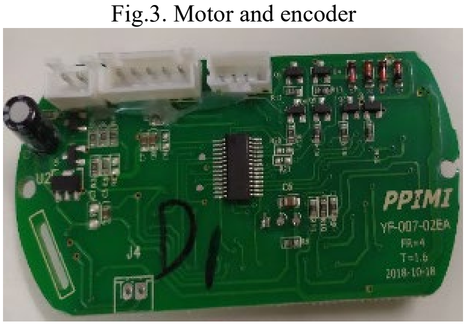


Fig.4. Control board YF00702

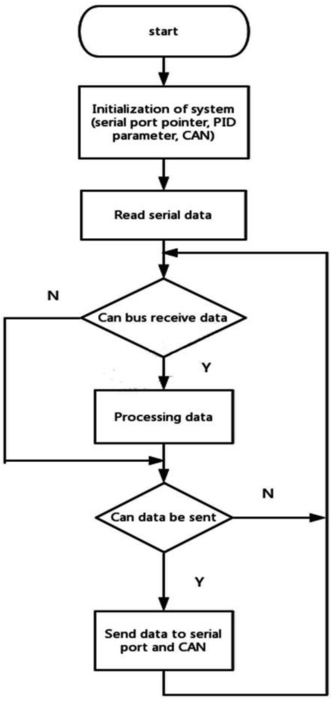


Fig.5. Servo driver workflow

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.

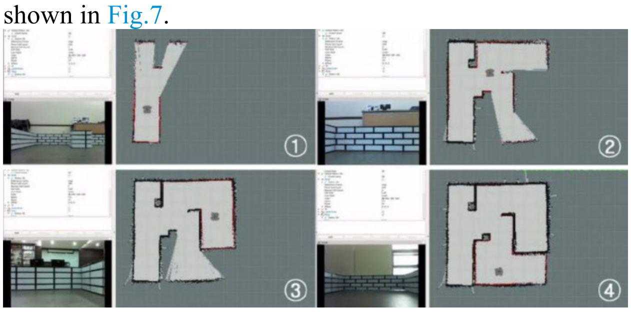


Fig.7. Experimental construction

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.

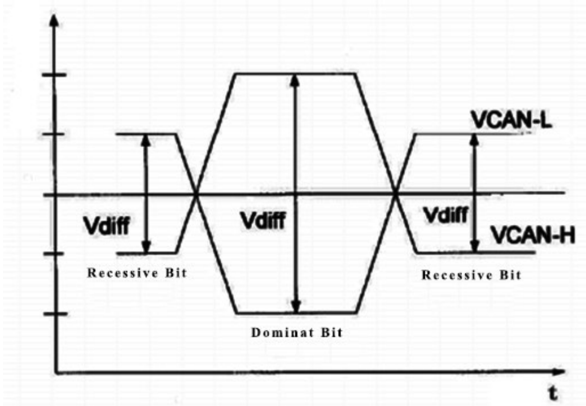


Fig.8. CAN bus bit value characterization

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

- Good reliability. The data transmission adopts short frame mode, and the transmission medium is double insulated wire. It can effectively shield all kinds of external electromagnetic interference. At the same time, can defines a variety of fault diagnosis mechanisms, which makes it has high reliability, and is very suitable for use in 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*

In the project of "donating crying" shared on GitHub, 450 clear baby crying data were obtained by filtering the data recorded and uploaded by users' mobile phones. The duration of the data was about 5S. The data was converted to CAF or 3gp, and the unified bit format was 128kbps. The whole data was converted to WAV format, and the sampling rate was 8kHz. Feature extraction method of baby crying: when the baby cries, the detection device (microphone) will receive the signal, and then through filtering processing, and then through the basic acoustic features to extract the feature data [8]. Baby crying can be divided into several crying units, which have different acoustic characteristics. The flow chart of cry recognition system is shown in Fig 9.

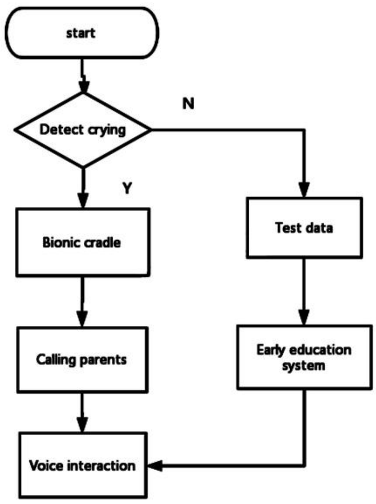


Fig.9. Flow chart of cry recognition system

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.

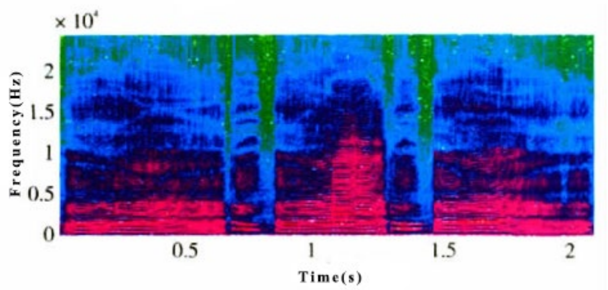


Fig.10. Two microphone array for corpus sample analysis

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.
- Place the intelligent cradle on the irregular ground and observe whether it is stable

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. Is the data collected by Bluetooth fully fed back to raspberry pie to make the cradle work normally

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.
- uPut 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.

References

1. Aiyan Wu, Xuewei Cui. Research progress of home robots [J]. Journal of Tangshan University, 2009, 22，3，pp. 69-P71
2. Binkun Liu,,Haitao Liu,Design of Intelligent Security stroller for data Communication based on STM32,Science and Technology & Innovation, 2018, 16, pp. 62-P63.
3. Yaoyao Zhang, Shuwan Lei ,Jiayi Zhou ,Gejile Hu . Design and exploration of automatic swing baby cradle [J]. Electronic production, 2013, 9, pp. 26
4. Razvan Luca, Fritz Troester, Robert Gall and Carmen SimionA parking space detection method and process based on ultrasonic and visual sensor fusion
5. Research on lidar signal detection and processing technology
6. Dosek, Roman, et al. "Secure high level communication protocol for CAN bus." Annals of DAAAM & Proceedings, 2015, p. 1009+. Gale Academic Onefile.
7. Yuan Gao, Xiu Wang,Shuo Yang,Yuanyuan Zhai, et al. Study on monitoring and evaluation system of sowing depth based on CAN bus [J / OL]. Alpika Tripathi, Geetika Srivastava, K.K. Singh and P.K. Maurya,Epileptic Seizure Data Classification Using RBAs and Linear SVM.Biomedical and Pharmacology Journal(Vol. 12, Issue 2.)June 1,2019.
8. Guangtao Ma,Shiming Zheng,Safety Design research of stroller,China Academic Journal Electronic Publishing House, 2016, 11, pp. 126-P127.
9. Shen Leixian, Pang Jiayi, Zhang Qingyun, Xu he. The design and implementation of positioning service platform based on Beidou [J]. Computer technology and development, 2019, (01): 1-4.

Authors Introduction

Miss. Ting Zhao

She is now an undergraduate student at Tianjin University of Science & Technology. Her research field is control science and control engineering, and intelligent control is her research direction.

Dr. Qing He

He is a lecturer in Tianjin University of Science & Technology. He received a doctor's degree in control science and engineering from School of Information, Zhejiang University, in 2007. His research field is Non-destructive and intelligent detection technology.

Mr. Zhuofan Xu

He is an undergraduate of Tianjin University of science and technology. After a period of study, he has participated in some competitions and won prizes

Mr. Zhou Yang

He is a second-year master candidate in Tianjin University of Science and Technology, majoring in instrument science and technology. His research firld is intelligent robot

Mr. Zhenjiang Chen

He is a graduate student majoring in control theory and control engineering of Tianjin University of science and technology. His research direction is knowledge

Mr. Shuo Jiang

He is now an undergraduate in Tianjin University of science and technology. His research direction is automatic control theory.