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Research Article

# Design of an Intelligent Electronic Guide Dog Based on Jetson Nano

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ABSTRACT

Blind travel has always been the core issue of social concern, and how to assist the blind to travel safely has always been an urgent problem to be solved urgently. Although some intelligent blind guide products have flooded into the market in recent years, such as guide boxes, guide battles, etc., but most of their functions only stay in the obstacle avoidance stage, lack of path planning, intelligent recognition functions, blind person positioning and are not easy to carry. Based on the above shortcomings, an intelligent mobile blind guide robot is designed in this paper. The blind guide robot is equipped with a variety of sensors and combined with the powerful computing power of the main control board to form a complete obstacle avoidance system to achieve autonomous navigation and obstacle avoidance in a complex environment. It controls GPS positioning through Jetson-Nano, plans the route, detects obstacles with the help of cameras and ultrasonic sensors, and gives users feedback through the alarm sound of the buzzer.After experiments, the GPS positioning accuracy can reach 2.5m, the positioning delay time is 3s on average, and the camera recognition accuracy can reach 83.3% on average, which can meet the guidance needs of the blind in indoor and outdoor life.



## 1. Project Research Background

According to the data of the World Health Organization, there are currently about 285 million visually impaired people in the world, of whom 39 million are blind, and a survey in China has found that there are 21 million visually impaired people, of whom 23.8% are blind. As a vulnerable group in society, the blind face difficulties in daily life and social interactions, among which travel is one of the main difficulties in the life of the blind [1].

At present, the way for blind people to travel is usually accompanied by family members, guide dog assistance, and guide equipment assistance. Family companionship is the safest of all the ways for blind people to appear, but it wastes a lot of time and energy of the companion; Guide dog assistance is currently the most common way for blind people to appear, but the training cycle of guide dogs is long and the cost is high; Traditional guide equipment for the blind is low-cost and can assist the blind to avoid obstacles, but it lacks functions such as path planning, intelligent recognition, and blind positioning, and is not easy to carry [2]. Therefore, there is an urgent need for new guidance equipment to meet the needs of the blind today.

The constant expansion of visual impairment groups has brought about an increase in the demand for blind guide facilities in the market. And that's not all, with the constant improvement of urban construction, people's living environment is also changing, the conventional blind guide equipment has been incapable to meet this transformation. The scope of the guide cane is limited, the function is single, and the guide box can not detect the unknown danger, therefore, the guide robot was born and gradually attracted the attention of various industries and enterprises.

At the moment, research work on guide assistance has been conducted in countries on the face of the earth, focusing on the research of walking AIDS, wearable marching AIDS, and mobile marching AIDS. as far back as 2010, Japan developed an electronic guide stick, which uses supersonic sensors to make the visually impaired people feel the obstacles, and to effectively remind users through the vibration handles. The belt-like action accessory developed in the United States uses ultrasound to create a panoramic map of the region, allowing the

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visually impaired to "regain their eyes". Apart from, the foreign research and development of smart trolleys and smart wheelchairs also provide the foundation and help for the research and development of mobile guide AIDS. China's research in this industry is comparatively late, the immediate research focus is still on the guide rod, the research work on the blind guide robot is still in preparation. In the final analysis, the technology is not impeccable. Whether it is sensor technology, tracking strategy and independent path planning capabilities, China needs to be further improved. To this end, this paper designs an intelligent mobile guide robot, equipped with a variety of sensors, combined with the powerful computing power of the main control board, to form a complete obstacle avoidance system, which can realize autonomous navigation and obstacle avoidance in complex environments.

## 2. Scheme Design

In this paper, an intelligent mobile guide robot for the blind is designed. The robot uses STM32 as the main controller and Jetson Nano as the auxiliary controller, and is equipped with a variety of sensors such as ultrasonic, Bluetooth, GPS, camera, buzzer, etc., which can form a complete obstacle avoidance system and realize autonomous navigation and obstacle avoidance in complex environments. And through Jetson Nano control GPS positioning, independent route planning, ultrasonic sensor automatic obstacle avoidance, Bluetooth module motion control, the camera recognizes vehicles, pedestrians, road shoulders, etc., and the buzzer alarms when a pedestrian is detected.

### *2.1. Functional description*

(1) Automatic obstacle avoidance of ultrasonic sensor.
(2) Bluetooth Module Motion Control, autonomous navigation.
(3) GPS positioning, autonomous route planning.
(4) Cameras identify vehicles, pedestrians, shoulders, etc, and the buzzer alarm when encountering pedestrians.

### *2.2. System composition*

The system framework of the intelligent mobile guide robot system can be divided into the following parts: main control module, motion control module, obstacle avoidance module, positioning module, visual recognition module and power supply module.

### *2.3. Work principle introduction*

The microcontroller stm32f103rct6 drive motor drive plate controls the speed of the rear two-wheel motor through PWM wave voltage regulation, and the stm32 microcontroller directly drives the steering machine through PWM pulse width modulation to control the steering of the first two wheels. SCM communicates with GPS module through serial port to obtain the position information. The ultrasonic module is directly controlled by the microcontroller to avoid the obstacles in front of it. The other main control board Jetson Nano controls the camera to obtain the wide-angle line-of-sight information in front of the camera, compare and analyze with other information collected from vehicles, road signs, pedestrians, and assist in obstacle avoidance.

The principle framework is shown in Fig. 1.

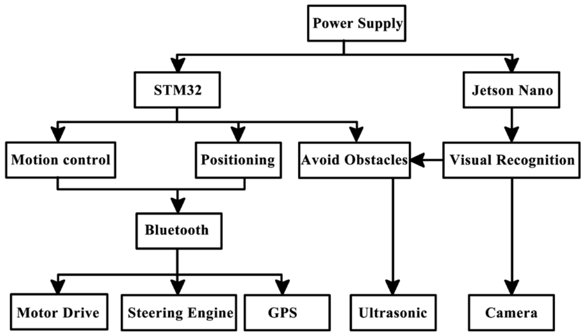

Fig 1 STM32F103ZET6 chip

### *2.4. Main control part design*

With stm32 and Jetson Nano as the main control, stm32 is responsible for the underlying motion control, ultrasonic sensor and GPS module, Jetson Nano is responsible for visual information processing and analysis, and the two main control modules communicate through serial ports.

(1) Stm32f103rct6 Introduction

Using ArmCortex-M3 kernel, Harvard structure, with independent instruction bus and data bus, widely used for robot motion control.48KBSRAM, 256KBFLASH, 2 advanced timers, 2 basic timers, 4 universal timers, 2 DMA controllers (12 channels in total), 312 bit ADC, 5 serial ports, 112 bit DAC, 51 universal IO ports, and 1 SDIO interface. It has the advantages of powerful function, wide working temperature range, fast response, low power consumption, and is extensively used in microcontroller motion control.

(2) Jetson Nano Introduction

The Jetson Nano A02 is an open source hardware with CUDA core, 45W low power consumption, 128 core Maxwell GPU, and GB large memory. Compared with Raspberry Pi or other AI edge computing units, it has strong image processing capability, low power consumption, and high cost performance. Many algorithms can obtain real-time performance, so it is used as the main control of visual recognition.

### 2.5. Sport control design

The servo drive system is adopted, the first two wheels use the TBSK20 steering machine to directly receive the stm32 signal by PWM wave electric voltage regulation to control the steering, the second two wheels use the encoder motor, with TB6612 as the drive chip, and the PWM pulse width modulation technology is used to control the motor speed by changing the duty cycle, and then control the speed of the car. Compared with the traditional differential system, the motor power of the robot can be directly converted into the driving force, and the steering mechanism is controlled by an independent servo, which has a simpler structure, high control efficiency and high stability. Secondly, the software-led power system can be adjusted according to the different ways defined by the software, or the working conditions of the system, which is less difficult to operate and more intelligent. At the same time, the loss of tires and accessories is small, which meets the application needs of long-term stable operation, and has great advantages in flexible control.

The motor drive schematic diagram is shown in Fig.2.

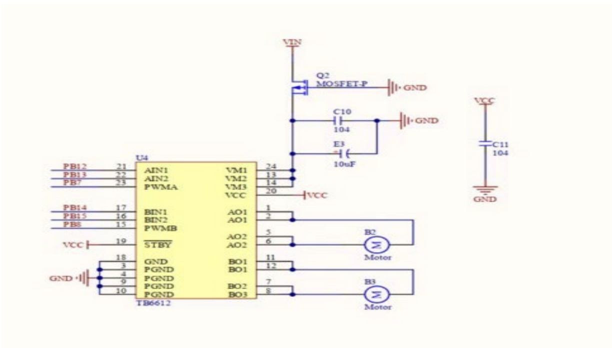

Fig 2 Motor drive module

### 2.6. Design of obstacle avoidance module

The intelligent mobile guide dog is equipped with an ultrasonic sensor and a vision sensor, both of which can independently realize the obstacle avoidance function. The ultrasonic sensor in this paper uses HC-SR04 module, which has a non-contact distance sensing function of 2cm-400cm, and the ranging accuracy is 3mm.

The principle of ultrasonic sensor ranging is to obtain the distance information of the obstacle by calculating the time interval between the time of sending the source sound wave and the time of receiving the echo signal. The calculation formula is as follows [3].

Test distance =（High level time × speed of sound）/ 2

(The speed of sound is 340m/s.)

The schematic diagram of ultrasonic module is shown in Fig.3.

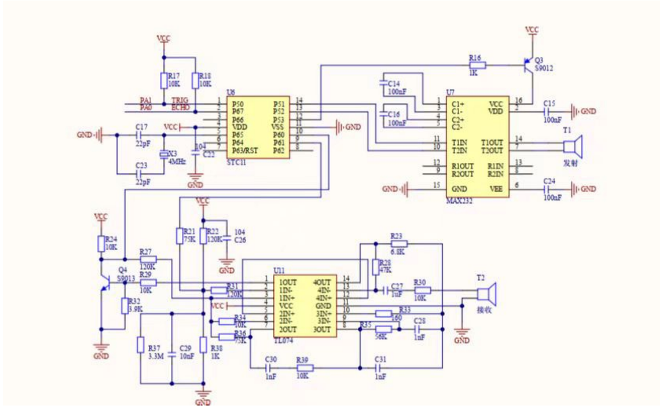

Fig 3 Ultrasonic module

### 2.7. Gps module design

The GPS positioning module uses the ATGM336H of Zhongke Microelectronics, the number of channels is 32 channels, the sensitivity of cold start acquisition is -148dBm, the tracking sensitivity is -162dBm, the positioning accuracy is 2.5 meters (CEP50, open ground), which has high sensitivity, supports the single system positioning of the BDS / GPS / GLONASS satellite navigation system, and the receiver module with any combination of multi-system joint positioning. ATGM336H can directly replace U-blox's MAX series of multiple GPS modules, the main interface signal is Pin-Pin compatible, consistent installation hole, low power consumption, built-in antenna detection circuit, with antenna short circuit protection function.

The schematic diagram of the GPS module is shown in Fig.4.

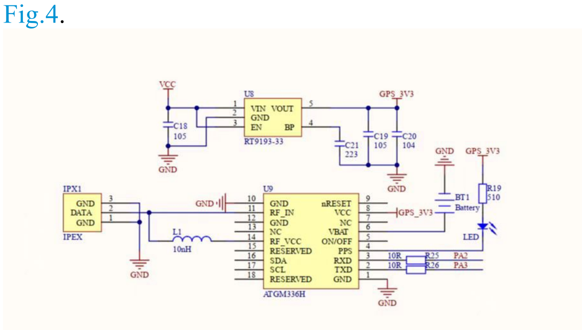

Fig 4 GPS module

### 2.8. Visual recognition module design

With a Jetson Nano NX AI HD camera and 160 focal field wide Angle, the optical sensor chip is SONY IMX219, which is suitable for image data acquisition and information processing. The program used in this project is the yolov3 algorithm under the Alexey AB streamlined darknet framework, which has a strong performance in the field of real-time target detection and can fit the computing power of Jetson Nano. Real-time running time in Jetson Nano can reach a detection rate of 10 to 20 frames, and can cope with 90% of the scenes in daily life [3].

The Jetson Nano interface diagram is shown in Fig.5.

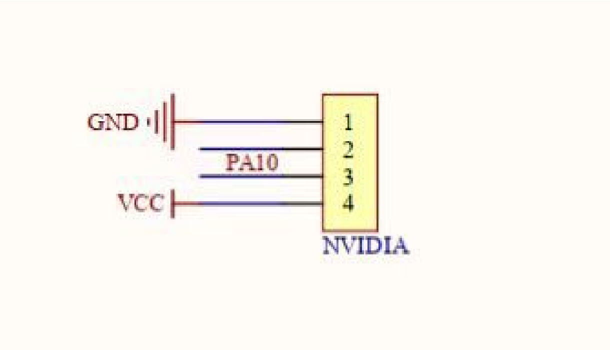


Fig 5 The Jetson Nano interface

### 2.9. *Power supply module*

Because there are many drive modules, the car adopts two parts to power supply stm32 and Jetson Nano respectively. First, 3 sections of 12V 1500mA power supply stm32, and another 3 sections of 12V 1500mA power supply, and AMS1117 5.0 is used to supply power to Jetson Nano with low voltage drop regulator.

The principle of antihypertensive is shown in Fig.6.

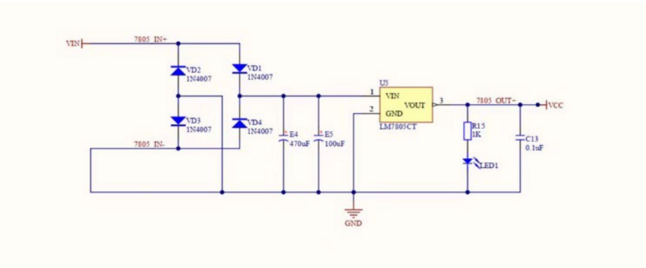

Fig 6.Anti-pressure module

## 3. Introduction of YOLO training algorithm

The program used in this project for target recognition is the YoloV3 algorithm under the darknet framework improved by AlexeyAB, which has strong performance in the field of real-time object detection and can be trained in accordance with Jetson Nano.

This project starts with devices with higher computing power than Jetson Nano, including the personal computer (windows platform) using the KIT T I data set published by the Toyota Technical University at Chicago (TTIC) and Karlsruhe Institute of Technology (KIT). It mainly includes data processing, training, use and deployment. Here is the first part. Download and use open source data sets or take a certain number of pictures in the field, and name the pictures in a certain order. The following example uses the KITTI-road dataset as an example. The dataset was manually annotated by using the labelIMG tool (The labelIMG tools: heartexlabs/label
Img):

(1) Configure the preset value tag file in labelIMG: Open the predefined_classes.txt file in the data path and write the label name of the object to be detected to the file. The operation is shown in Fig.7.

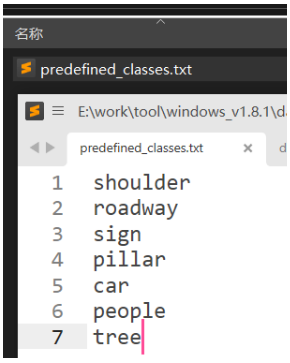


Fig 7 Enter the object label name

(2) Using the labelIMG software.

The operations are shown in Fig.8 and Fig.9.

Fig 8 Click on the Open Dir

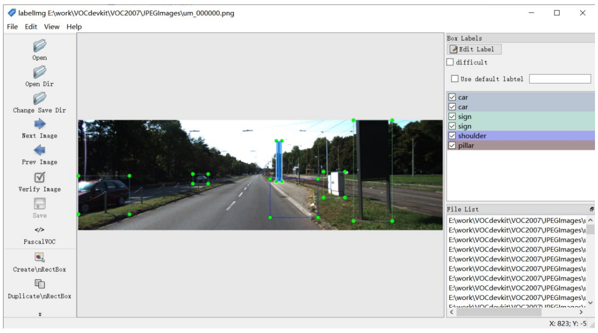


Fig 9 Select the path to the downloaded image dataset or the actual image file.

(3) To mark The operations are shown in Fig.10, Fig.11 and Fig.12.

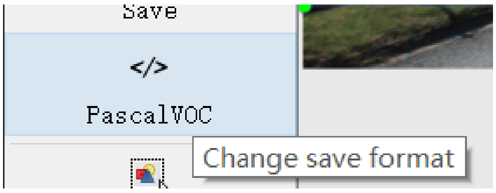


Fig 10.Select the Pascal VOC format dimension on the left side of the window.

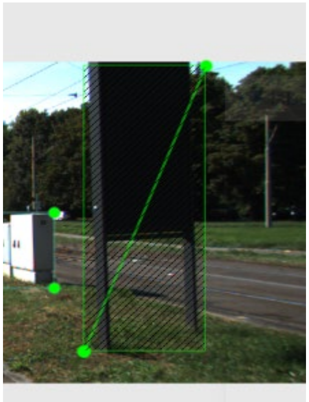

Fig 11 Press the shortcut key "w" to drag out the corresponding box on the image.

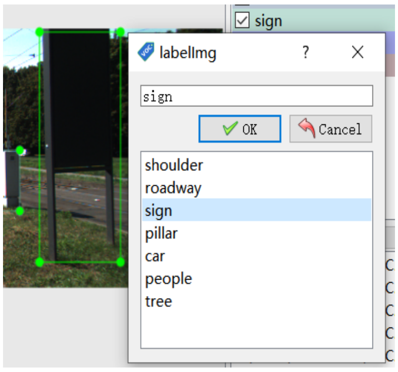


Fig 12 Then select the corresponding label in the pop-up window and click OK.

Right-key the box to modify the label or delete the box The annotation processing of the data set is completed after the annotation of all the picture files Then all the generated XML tag files are selected and cut to the scripts \ VOCdevkit \ VOC2007 \ Annotations folder, run the cut.py under scripts \ VOCdevkit \ VOC2007, and split the dataset, Then run the script under the project to further process the data, Open the voc_label.py script in the scripts directory, Edit the classes item in it, Keeping it consistent with the labels antecedently selected to make the dataset, The proportion of segmentation can be adjusted in the script, trainval_percent is the proportion of the datasets used for validation, The train_percent is the proportion of the data sets used for training: then run the voc_label.py in the scripts directory for format conversion, The streamlined classes item is High-temperature resistant with the target category tag that you want to identify. To match the dataset format, the set item was modified as Fig.13.

```
sets=[('2007', 'train'), ('2007', 'val'),('2007', 'test')]
```

Fig 13 Modify the set code

This script generates both the 2007_train.txt and the 2007_val.txt files. Need to be used during the training sessions. These two files contain the path of the pictures contained in the training set randomly and the validation set.

## 4. Conclusion

The intelligent electronic guide dog based on Jetson Nano introduced in this paper is a Visual Mobile Robot, which is used to assist the blind people to travel securely. It is equipped with an STM32 microcontroller and Jetson Nano AI edge computing device, integrating a variety of sensors including HC-SR04, HC-06, GPS, camera, etc., compared with the immediate guide box and guide stick, it has high cost performance and obvious advantages. The main control module, positioning module, visual recognition module, motion control module, power supply module and obstacle avoidance module are introduced in detail, and the schematic diagram is given to complete the design of the entire guide dog.

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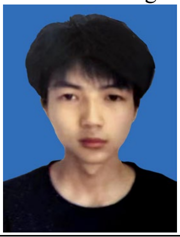

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