Autonomous Navigation Building Climbing And Handing Robot Based on SLAM

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Abstract

When there is no elevator at the station and airport or the elevator is crowded, the ramp of baggage checking is steep, the weight of luggage package is too heavy, it takes time and effort, and it is very easy to knock against and cause damage to the contents of the package.Our climbing robot carries out autonomous navigation based on visual SLAM. Equipped with ROS robot operating system, it adopts laser SLAM mapping navigation technology and tracks as running parts, which is suitable for various terrains. The adoption of binocular vision, can be more accurate analysis of the surrounding environment. The robot is equipped with MPU9250 attitude sensor, which is convenient for solving robot attitude. Jetson Nano was used as the upper computer and STM32F429 as the lower computer.

Keywords: SLAM build figure, Arduino, Gmaooing algorithm, Machine learning, Artificial intelligence (AI)

1. Introduction

Manually moving heavy objects upstairs is time-consuming and laborious, and it is extremely easy to bump and cause damage to the objects. Places with a large flow of people are also prone to road congestion, and people with disabilities and the elderly also have difficulties in getting upstairs. Nowadays, with the rapid development and progress of artificial intelligence technology, robotics has attracted much attention, and the requirements for robots' mobility are getting higher and higher. Mobile robots that can climb obstacles autonomously have become a hot research topic, such as: autonomous stair-climbing robots based on vision guidance, and wheel-track composite stair-climbing robots[1,2].Therefore, the scientific and practical significance of the climbing robot is very high.

A stair climbing robot based on SLAM mapping has been developed to realize autonomous positioning and navigation of the robot. Its vision system can accurately analyze the surrounding environment and autonomously avoid obstacles. The crawler type of transportation makes it adapt to a variety of environments. The robot can memorize the walking route through machine learning, and quickly plan the shortest path according to the use situation, which provides great convenience for the user.

2. The Hardware Structure

The robot is equipped with MPU9250 attitude sensor, which is convenient for solving robot attitude. Jetson Nano was used as the upper computer and STM32F429 as the lower computer.

2.1. *Sensor*

2.1.1. Nine axis attitude sensor

The MPU9250 module consists of two parts, one part is the MPU6500 three-axis gyroscope and three-axis accelerometer, and the other part is the AK8963 three-axis magnetometer. It has a 3-axis gyroscope, a 3-axis accelerometer and a 3-axis magnetometer. The output is 16-bit digital; the robot is equipped with such a sensor to exchange data with the microcontroller through the integrated circuit bus IIC interface, and it detects four The elements enter the DMP digital motion processor on the chip to calculate Euler angles and calculate the robot's posture in real time. Adjust travel speed through

Fig. 3. Jetson Nano chip

traditional PID algorithm.

2.1.2. *Image Sensor*

OV7670 image sensor, small size, low working voltage, provides all the functions of a single-chip VGA camera and image processor. Through SCCB bus control, it can output 8-bit impact data with various resolutions such as full frame, sub-sampling, and window fetching.

Fig. 2. OV7670 camera module

2.2. *Main control chip*

The Jetson Nano hardware is a quad-core Cortex-A57 CPU, and the GPU is the smallest Maxwell architecture graphics card, with only 128 CUDA units, equipped with 4GB LPDDR4 memory and 16GB storage space. Supports high-resolution sensors, can process multiple sensors in parallel, and can run multiple modern neural

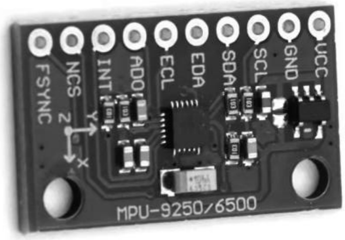

Fig. 1. Nine-axis attitude sensor modu

networks on each sensor stream. It also supports many common artificial intelligence frameworks.

Just insert the microSD card with the system image to start, built-in SOC system-level chip, can parallel processing such as TensorFlow, PyTorch, Caffe/Caffe2, Keras, MXNet and other neural networks, these neural networks can be used to achieve image classification, target detection , Voice segmentation and intelligent analysis and other functions, performance is better than Raspberry Pi, more practical, can meet the requirements.

2.3. *Lower computer*

STM32F429 uses Crotex M4 core, the highest frequency is 180MHz, there are up to 8 UART serial ports, Flash is 1M, SRAM is 256KB, pin is 176pin, high performance, fully meets the pin and memory requirements required by the design.

It has the following characteristics:

- Operating temperature range: -40 ~+105℃.
- Operating Voltage: 1.7~3.6 V.
- Integrated high-speed embedded memory and up to 4K bytes of backup SRAM, as well as a large number of enhanced I/O and peripherals connected to 2 APB buses, 2 AHB buses and a 32-bit multi-AHB bus matrix.

STM32F429 works with OV7670 to collect images, and upload the images to the host computer through the serial port, the host computer receives and processes the data,

Fig. 6. track

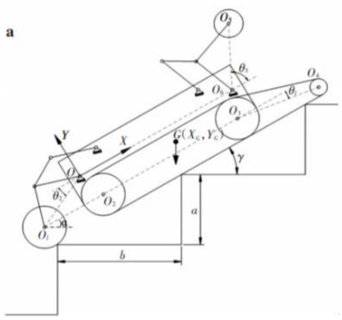

Fig. 7. supporting structure

and finally displays the color image.

2.4. *GPRS wireless communication module*

This design uses the E29V GPRS module to realize the communication between the small program and the main control part. It is small in size and supports TCP/UDP transparent transmission, MQTT transparent transmission, HTP transparent transmission, AT command function SMS transparent transmission, data transparent transmission and other functions to meet the requirements.

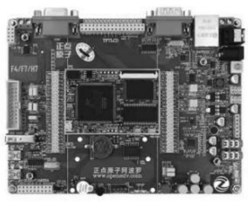

Fig. 4. STM32F429 chip

3. Mechanical structur

The movement adopts plastic crawlers to minimize damage to the ground and adapt to many kinds of environments. The measured maximum load-bearing capacity of the supporting structure is 137.87KG, which can carry most of the luggage in life.

Fig. 5. GPRS wireless communication module

4. Design functional modules

With these functional modules, the robot can have "eyes" and "logical thinking" and become more intelligent through machine vision and machine learning.

4.1. *Digital image processing*

The application of digital image processing technology makes the robot's perception of the environment more clear.
For the collected image, according to the spatial distribution of its light intensity, it can be expressed in the form of the following function:

$$I=f(x,y,z,\lambda,\ t) \tag{1}$$

4.2. *Machine learning*

Machine learning is a branch of AI, which explores ways to make computers improve efficiency based on experience[3]. Machine learning can enable robots to memorize long-term routes, and quickly plan the shortest path based on future use, and will follow the user's Use records to push related endpoints.

4.2.1.*Dijkstra algorithm*

Dijkstra algorithm uses breadth-first search to solve the single-source shortest path problem of weighted directed graphs or undirected graphs, and the algorithm finally obtains a shortest path tree[4]. It can realize global path planning, so that the robot can quickly calculate the optimal path that needs to be taken

4.2.2.*Naive Bayes Algorithm*

Naive Bayes makes the assumption of independence, assuming that each feature is independent and uncorrelated, and calculates the probability:

$$P(y \mid x_1,\cdots,x_n)=\frac{P(y)P(x_1,\cdots,x_n \mid y)}{P(x_1,\cdots,x_n)} \tag{2}$$

The Naive Bayes algorithm analyzes the data, predicts where the user may go, and at the same time calculates the optimal path.

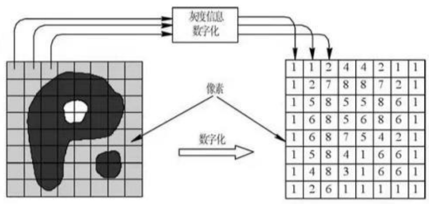

Fig.8 . Digital image processing

4.2.3 *A**

In a * algorithm, heuristic information is represented by function f *: f * (x) = g * (x) + h * (x)

Where: g * (x) is the cost of the best path from the initial node to node X;

H * (x) is the cost of the best path from X to the target node;

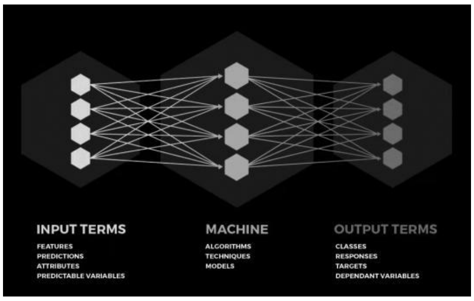

Fig. 9. Machine learning

F * (x) is the total cost of the best path from the initial node to the target node through node X.

Based on the above definitions of G * (x) and h * (x), G (x) and H (x) in the heuristic search algorithm are limited as follows:

① G (x) is an estimate of G * (x), and G (x) > 0;

② H (x) is the lower bound of h * (x), that is, H (x) ≤ h * (x) for any node X.

The ordered search algorithm when the above conditions are met is called a * algorithm.

For a search algorithm, when the best path exists, it can be found, then the algorithm is called admissible. It can be proved that a * algorithm is a Connor algorithm. In other words, for the ordered search algorithm, when the condition of H (x) ⩽ h * (x) is satisfied, as long as the best path exists, it can be found.

The heuristic search of a * algorithm is to search in the state space. First, evaluate the location of each search to get the best location, and then search from this location to the target. In this way, compared with Dijkstra algorithm, it can omit a large number of unnecessary search paths and improve the efficiency.

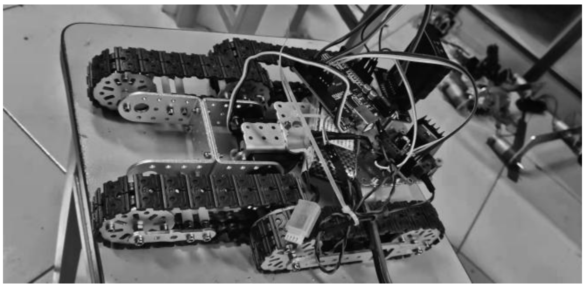

Fig. 10. Physical prototype

5. Conclusion

The above is the analysis and theoretical support for the Autonomous Navigation Building Climbing And Handing Robot Based on SLAM after reading a lot of literature. We have made a theoretical prototype to prove the feasibility of the idea.

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