Design of Path Planning Robot Based on Machine Vision

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Abstract. We established a path planning mobile robot system based on machine vision. The robot has multiple sensors to scan for obstacles. After catching the images, the robot will greyscale, process the images and find the most efficient path based on the ant colony algorithm. Finally, the robot will reach the destination with the corporation of motors and other components under the control of the motherboard. Simulations prove that the path planning mobile robot can find the most efficient way with censors and programs, and it can also reach its destination with the cooperation of the moving components.

Keywords: Robot, Arduino, Path Planning, MachineLearning.

1. Design Idea

1.1. Summary of the Design

Since the quality of life is getting better, people's demand for path planning mobile robots is increasing. Path planning mobile robots can help people complete many tasks automatically, such as food delivering, fire rescue under dangerous conditions, and guiding blind people to their destinations.

We designed a path planning mobile robot to complete the tasks mentioned above. The robot will collect the information surrounding it using machine vision. Then the collected images will be processed in grayscale by the microcontroller to plan the route. This step is preceded by the ant colony algorithm. At the same time, the microcontroller will send instructions to the other components of the robot to achieve the moving function of the robot.

1.2. Features of the Design

Most of the path planning robots require auxiliary marks on the road to calculate the most efficient path. Our design can scan the road and collect the data on its own, so that it does not require any auxiliary marks to plan the path. Compared to a traditional mobile robot, our robot is designed to be more intelligent. With more powerful motors and higher torques, the robot can move smoothly on different complex roads to achieve harder tasks such as rescue after an earthquake or fire disaster.

2. Overall Design

2.1. Main Control Module Design

Our design is based on an STM-32 microcontroller, the highest clock frequency is 33MHz, and it has its own PWM output module, and the number of processor bits is 8. For this design, there are high requirements for the acquisition accuracy and speed of AD port data. The 8-bit processor cannot meet the requirements of this design in terms of data transmission speed and data acquisition accuracy. Differential turning requires at least 4-channel PWM generation modules. This microcontroller is used as the controller. It not only has a series of rich hardware resources, 128kB Flash. 172 additional instructions were added to improve paging access and perform 32-bit computations but were designed to implement fully compatible instructions with previously written code. The 16-bit controller (MCU) is optimized for a wide range of low-cost electronic applications, and the 128KB flash is sufficient for this design and programming application, which also saves resources and costs.

2.2. Drive Module Design

Our design is driven by the L298N driver chip, which is a high-voltage, high-current motor driver chip produced by ST Company. The chip is packaged with 15 pins. The main features of the chip are high working voltage, which can reach a 46V maximum; the large output current, which has an instantaneous peak current that can reach 3A with the 2A continuous working current; and a 25W rated power. The high-voltage and high-current full-bridge driver with two H bridges can be used to drive inductive loads such as DC motors, stepper motors, and relay coils; it is controlled by standard logic level signals. Under the condition of not being affected by the input signal, the device is allowed or prohibited to work. There is a logic power input terminal, so that the internal logic circuit part works under low voltage. An external detection resistor can be connected to feed back the change amount to the control circuit. Using the L298N chip to drive the motor, the chip can drive a two-phase stepper motor or a four-phase stepper motor, and can also drive two DC motors.

2.3. Visual Module Design

Our robot is designed to have a 360-degree rotating camera, which collects videos through an USB input and sends the videos to the STM32 microcontroller. The microcontroller will process the videos and present the processed data through a real time LCD monitor.

2.4. Overall Design Idea

Our general design includes hardware design and software design. Hardware design module is divided into the main control module, the driver module, and the vision module. The software design module is divided into images collector program, path planning program, and motors controlling program. The hardware and software modules cooperate together to achieve the final goal.

3. Hardware Designs

3.1. Power Circuit

The 5V power supply module is used to supply power to the microcontroller system, sensor module, etc. Commonly used power supplies include series linear regulated power supplies (LM2940, 7805, etc.) and switching regulated power supplies (LM2596, LM2576, AS1015, etc.). The former has the advantages of small ripple and simple circuit structure, but low efficiency and high-power consumption; the latter has low power consumption and high efficiency, but the circuit is more complicated, and the circuit ripple is large.

For the microcontroller core daughter board, a stable and reliable 5V power supply needs to be provided. LM2940 is a low-dropout voltage regulator chip produced by National Semiconductor Corporation. It has excellent voltage regulation linearity and can output a maximum current of 1A. At the same time, it integrates overheating, overload and short-circuit protection functions, the peripheral circuit is simple, the maintenance and replacement are convenient, the price is low, the voltage regulation linearity is very good, and the output ripple is small. Although the load capacity is weak, the current required by the core daughter board is only about 300mA, so this design selects LM2940 to supply power to the microcontroller core daughter board. Even if the battery terminal voltage fluctuates greatly or drops, the output of the LM2940 can be guaranteed to be within a stable range that can be tolerated, which plays a key role in the stable operation of the minimum system of the single-chip microcomputer.

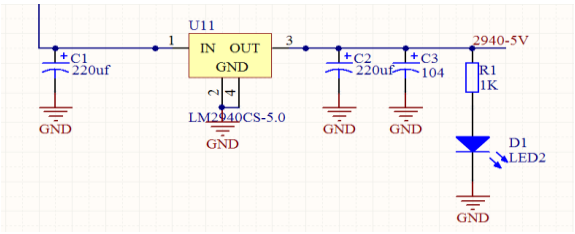


Figure 1. Circuit diagram for LM2940

3.2. Data Transmission Circuit

Our design uses the NRF24L01 chip to achieve the data communication function. The chip communication speed can reach up to 2M (bps). It occupies a total of 5 GPIO ports of the main control chip, and a total of 6 pins for an interrupt input pin to realize the wireless communication between the optical flow sensor and the aircraft. The 5 pins are CSN, SCK, MISO, MOSI, IRQ.

It should be noted that the mutual communication range between the wireless communication modules is limited, so the signal that wants to maintain good communication needs to be equipped with an antenna in the wireless module, in order to reduce the weight of the antenna and the space it occupies on the control board. area, this design uses a small ceramic antenna.

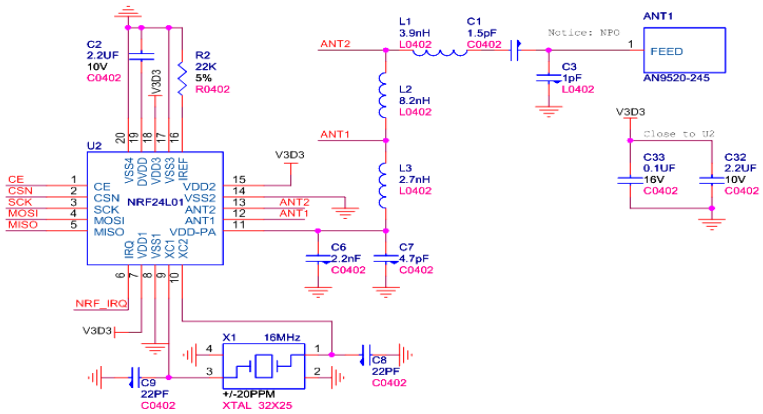


Figure 2. Communication module circuit diagram

4. Software Program Design

4.1. Software Develop Tools

The software design uses STM-STUDIO, a graphical user interface that allows real-time sampling and visualization of user variables while the application is running. It is designed to run on PCs with Microsoft Windows operating system. The tool works with STM32 microcontrollers via JTAG or SWD (Serial Wire Debug) interface. TM-STUDIO supports ST-LINK hardware with JTAG, SWD and SWIM protocols. STMSTUDIO also supports RLink (in-circuit debugger and programmer from Raisonance, supporting JTAG, ICC and SWIM interfaces), STice advanced emulation system and STTSLink as additional hardware targets. Run STMStudio.exe from the desktop icon or program folder shortcut created during installation setup.

4.2. The Design of Graph Collection

Image acquisition software technology mainly includes predictive coding, transform coding and statistical coding: predictive coding, including intra-prediction and inter-frame prediction. The transmission of video signals generally includes three transmission modes: video baseband does not convert, frequency and amplitude change, and analog-to-digital conversion of video signals. The signal circuit of the transmission mode in which the video baseband does not convert will be very simple, and it is widely used in traditional video transmission systems.

4.3. The Design for Path Navigation

Path planning is another important link for mobile robots to achieve navigation. Path planning refers to planning a collision-free optimal path from the starting point to the target point according to one or some optimization indicators (such as the shortest time, the shortest path, etc.). According to the different ways in which robots perceive environmental information, path planning can be divided into three types: model-based path planning, which is mainly used in structured environments. The planning methods include topology method, grid method, etc.; It is used in unstructured environments, such as artificial potential field method, fuzzy logic algorithm, genetic algorithm, etc.; behavior-based path planning decomposes the planning problem into several relatively independent units, such as obstacle avoidance, tracking, etc.

4.4. The Design of Programs based on Ant Colony Algorithm

According to research, when the ant colony moves from the ant nest to the food source, it will randomly choose a bifurcated path, that is, the probability of starting to choose different paths to the food source is the same, but each ant individual will release a kind of information The ants in front will choose a path with equal probability and then release pheromone in the path. The amount of pheromone is the same, the concentration of pheromone with a shorter path will be higher, and the concentration of pheromone above the path with a longer path will be smaller., the following ants will choose a path according to the concentration of pheromone. The number of ants will increase, and eventually all ants will choose the shortest optimal path, which is the basic idea of the ant colony algorithm.

5. Conclusion

The future development direction of path planning robots based on machine vision will move closer to artificial intelligence to achieve the purpose of simplified operability and high practicability. The commercial use of path planning robots will promote the development of the industry and provide opportunities for solving real life problems. Through the path planning robot competition and other modes, the research on path planning robots can be popularized to young people. The industrialization of the path planning robot module will accelerate the design and development from the disassembly of the whole machine to the parts and promote the performance optimization of the path planning robot. On the national side, path planning robots will play a more important role in the development of science and technology.

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