Wright Eagle Team of USTC

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Abstract. This paper contains an overview Wright Eagle team of USTC's for RoboCup 2008. We will describe mechanical design, vision, electrical design, control design and software design of our robots system. Past experience and future plans for our team will be described as well.

1 Introduction

Wright Eagle team of USTC has participated in the F-180 league of RoboCup since 2003 and has participated RoboCup china open. In June 2002, we won the championship in the smallsize league that is held in shanghai in our country using two wheels robot made by ourselves. In August 2003, we won the championship in the smallsize league that is held in Beijing in our country using three wheels robot made by ourselves. With the developed four wheels robots, we also won the championship in the smallsize league that is held in Guangzhou in 2004 and Changzhou in 2005. We emphasize on a systems approach to RoboCup and strive to improve our system each year on all three fronts: Mechanical Design, Electrical Design and Software Engineering.

2 Team Development

Team leader: Li Yongxin
Team members:
Li Yongxin (staff): general design and management.
Han Changyu (student): control system.
Zhou Zhiyang(student): DSP system board design.
Ma Menchao(student): global vision.
Hu Chao (student): mechanics.
Liu Anfang (student): Decision-making and coordination.

3 Robot Design

Our robots choose the half-automation distributive control. A main computer calculate the data get from the vision system, then give out the best strategy and send out the orders which are about the accurate robots positional and orientation information in full field. Each robot judges the orders they received and make its own decision how to move to carry out the cooperative strategy. Our robot vehicle is made of motion mechanism, pulling-ball mechanism, kick ball mechanism, chipping ball mechanism, some sensors, MPU board, AI system, motor control system, and etc.

3.1 Mechanical Design

On the basement of our previous robots, we have improved our current robots. We choose 4-wheel instead of old 3-wheel drive system. Because the game field is more larger, we need more powerful acceleration and faster speed. Though we will face a new real time control problem for this new model, our theoretical and experimental work is undergoing. In the new chassis we not only increase a pulling-ball device which is activated by a motor and solenoid-actuated rod, but also increase a chipping-ball device which is activated by a solenoid-actuated rod and a four bar linkage mechanism. The robots are equipped with four major DC-motors. Each micro DC motor drives the wheel respectively with a 14:1 gear ratio in hope of speeding up our robots. These motors also provide an impulse generator with 512 ticks per revolution encoder feedback to our MPU to allow closed-loop velocity and position control of the wheels.
In 2008, Our robot maximum diameter is 178 mm, maximum height is 142 mm, Percentage of ball coverage: 14~18%, maximum weight is 2.2 kg.

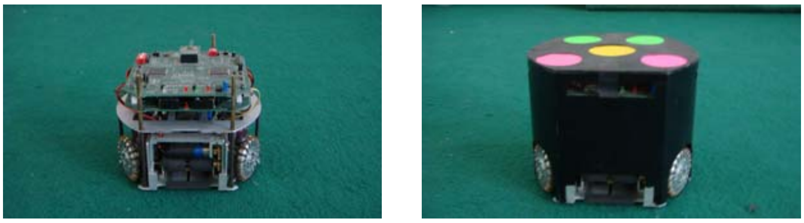

Fig. 1. robot vehicle: 2008 robot

Infrared sensors are located around our robot, which can feel and avoid the objects such as barrier robots and ball.

3.2 Electrical Design

The electrical design is consist of main DSP board for wireless communication and motor control board for 5 set of DC motors driver, sensors signal processing board for encoders, accelerometer(X, Y channels) and PSD signal for ball detector. The chip TMS320LF2407A DSP is selected as the controller because of its high-speed performance, highly integration of peripherals for multi-motor control, small size and low power consumption. Thus it is superior for embedded applications, such as robot control of Small Group. Dual-DSP (TMS320LF2407A) frame is applied to the motor control board for reduce the peripheral circuit. One DSP is the master, and the other one is slave. The master receives data from AI system which is send by the PC through asynchronous serial port. Under the control of the master, the slave DSP realizes the motion control algorithm. The master and the slave DSP communicate through SCI bus. Now a new TI 32-bit device, F2812, is available. It features 150-MIPS performance and complete system-on-a-chip integration that greatly reduces board space and system cost, leading to simpler and more cost effective designs. F2812 provides the industry’s highest level of Flash and peripheral integration, we are working to let it take the place of LF2407 so as to make the robot better.

This communication system is for the world wide 2.4-2.5 ISM band. The whole system includes a transmitter and the receivers in every robot. The host PC transmits data to the transmitter through the asynchronous serial port. The system, which realizes a fast bi-direction data transmission, can ensure the correction of receiving data through a simple communication protocol that includes CRC computation and re-transmission strategy. The frequency channels and the transmission power used in this system can easily be changed according to the local situation.

FEATURES

1. Channel frequency can be changed from 2400MHz to 2520MHz.
2. There are total 16 channels that can be used in this system.
3. Bandwidth used by this system is 3MHZ.
4. The receiver can automatically find the channels in use and the searching time is less than 1 second.
5. The minimum output power is –20dbm.
6. The receiver sensitivity is –90dbm.
7. The baud rate of the wireless data transmission is 1MBPS.
8. The baud rate of host PC can up to 115.2kbps.
9. A data frame can transmit from the host PC to every robot in less than 10ms.
10. Every receiver has an indicator that will timely indicate if the data is correctly received.

The silicon N-channel/P-channel power MOS FET array chip is selected as motors power driver. It is very cheap and specially suitable for bridged motor driver. The better motion control is got by using PWM control method.

3.3 Controls Design

Because of the high acceleration and velocities of our robots, the stability and robot orientation become problems. The causes of the problems come from the vision subsystem detailed below, wireless communication disturbing and system latency. In order to resolve those problem, two control loops was used. The whole system (vision, wireless, motor control) is a loop which controlled by AI subsystem. The vision subsystem gets the robots and ball’s velocity, orientation and action information, and transmit those information to the AI subsystem, then the AI program calculate out the robots’ new velocity and direction, the AI subsystem transmit those data to the robots through wireless subsystem finally.

Another loop is motor control subsystem which receives command from AI subsystem, then calculate the rotate speed motors needed and generate relevant duty factor PWM .

It counts the pulse putout by the encoder and calculates the actual rotate speed of the motors. Fuzzy PID algorithm is adopted to reduce the difference between the needed rotate speed and actual rotate speed of the robots. Then the final velocity of the robots can be modified close to the value calculated by AI subsystem. Now we are working on a current feedback method in order to reduce the velocity difference further.
In addition, we did many experiments to support our robot motion control research: The delay time from vision to robots motion, the delay time of motor starts, friction, motion inertia, time of software running, etc. We still experiment on the method to make vehicles move more quickly and smoothly.

3.4 Vision

There are two kinds of vision capture devices. The original method is to use two Panasonic color CCD cameras with 1-8mm zoom lens for the entire field. We use interlaced video to generate images of 768x576 pixels. Two OK_C30 video PCI capture cards are installed on a win XP machine to capture videos synchronously. This year we use two digital cameras (Marlin F064C) which output videos by IEEE-1394/FireWire to generate images of 782x582 pixels. The Sensing Area of the camera is 6.4x4.8mm. This improvement can bring us large visual field, more distinct image, and less confusion of different colors.
Image processing algorithm is enhanced based on the previous algorithm. For better image manipulation the RGB color space is converted to HSV (Hue, Saturation and Value). To recognize a certain color, a combination of conditions on Hue, Saturation, Value and RGB is used. This procedure makes the color recognition independent from the brightness and some unwanted conditions. Vision System calculates the position, direction and the robots' ID numbers. It also determines the position of opposing robots as well as the position of the ball. Then it transfers them to strategy system.

3.5 Software design

This year we'll develop a new playbook system for high level decision. The playbook has two parts, play and play transmittal. A single play defines each robot's role or task, and the role is made by a sequence of actions and conditions. Play transmittal defines when to transmit and which play to transmit. In the Visual Playbook system, users can edit play and play transmittal using drag and drop.
Last year's 2D simulator was very successful. But the real robot soccer is a three dimensional world, we decide to write a new 3D simulator called SmallSim. We use "Open Dynamic Engine (http://opende.sourceforge.net)" as physical engine. In this simulator robots can have heights, can be built with any shape, the walls and goals also have heights. The ball can be kicked upward, flying and crossing robot's head. It also simulate wheels, the position and orientation of the wheels are stored in configuration files, so user can easily change robot's properties. By now, it can simulate omni-wheel robots and old style tow wheel robots.
To predict opponent's future position, Kalman Filter is not enough. We'll write an algorithm to guess what the opponent will do, and simulate its action. If succeed, we can greatly improve our robot's basic skills such as passing and dribbling.

4 Conclusion

Our team research F-180 robot for six years, and participate in the competition of China through 2002 to 2006. Many students and staffs are very interest in this research job. We are planning to set up the real-self-automation robot system. Vision system will calculate the robots data in full field more quickly and accurately. The strategy system and motor control will insure the best strategy decision and accurate command can be took out more efficiently. The next generation F-180 robot system will be more intelligent, accurate and stable.