A Research on the Platform for Biped Robot Soccer

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Abstract: In this paper, a new biped robot soccer game platform was proposed. The platform is based on biped humanoid robot, it combined the research of robot control, wireless communication, machine vision, which make the humanoid robot game possible. Based on this platform, one can develop more advanced humanoid robot.
Key Words : Humanoid; Biped; Robot Soccer; Machine Vision;

Robot Soccer is a dynamic process in which multi-agent compete. In Recent years, FIRA's MiroSot has a great development on the area of the speed, image grab quality and speed, and AI strategy for robot.

While in the area of biped robot, the biped walking is really difficult. Researchers have make great effort to improve the stability and autonomous. But the speed and view ability need to be further improved.

In this paper, we develop a platform for the biped robot soccer in hoping that based on this competition platform, further research can be achieved on biped humanoid robot.

1、 Mainframe

In this paper, a platform for the competition of humanoid biped robot soccer was proposed. The platform consist four part, humanoid biped robot, communication system, vision system, strategy system.

1.1 Construct of humanoid biped robot system

The construct of humanoid system is difficult. So currently, we base our system on the commercial available robot, such as KHR and Robonova. Our research include gait analysis and optimaize and wireless communication module design.

1.2 Communication system

The communication system consist two, one on the robot, the other on the robot. The computer module has software on PC to communicate through RS232 with a box. The box send command wireless to the receiver module on robot.

1.3 Vision system

The system consists of camera on top of the field and image analyses system. The camera grab the color information on the field and transmit to computer through fireware 1394. Through image analyze by software, the golf ball and robot is recognized, then the location and direction of the ball and robot was transmitted to the strategy system to make decision。

1.4 Strategy System

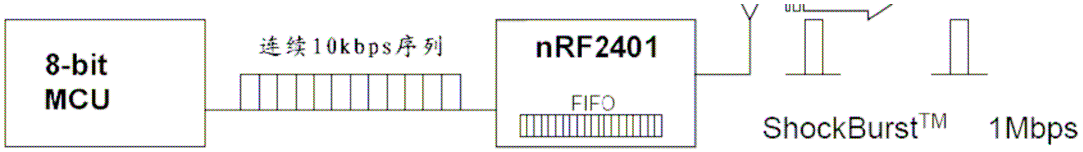
The strategy system will make decision according to the information of ball position and robot position and direction. Then change the robot's location, direction, and kick the ball.

2、 Biped Humanoid robot

For humanoid robot, the basic action design include forward, backward, rotate, kick ball etc.

Compared to human beings, the robot action design is more difficult. The reason is that , first the joint is make up of mechanical connector, which is not flex as human joint, Second the sensation of robot is not so good to adjust the balance, third the robot foot is plain, so when the foot is not touch the ground with full foot, and not so plain, down to the plain, it may lose balance and increase the possibility to fall down.

To increase the stability of robot, the action of robot must be very precise. In the design of action, we have made the precise design.



3、Wireless communication system

In this unit, wireless signal sent from PC is received. After analyze, the signal is sent to the control board of robot to control the robot's action. The design of this units concerns mainly to power supply, single chip computer, wireless communication, hardware design.

3.1 Power supply module

As for the units core module nRF2401 and C8051F005 can only be worked on 3.6V，and the electric level transform and interrupt module must work on 4.5V~5.5V。So we need two kinds of power supply, which are 2.7~3.6V and 4.5~5.5V。

For energy cost of single chip is few, it can get the power directly from robot, whose voltage is 5V, and we use a AS1117-3.3 to transform it to 3.3V.

3.2 The design of hardware control system

Robot control system is based on C8051F005，which has many benefit such as fast speed（70% of instruction can be carried in 1 or 2 time cycles, only 4 instruction need more than 4 system cycles）, plenty of resource on chip(21 interrupt source, plenty of analog and digital interrupt control, 7 reset source, inner dependent timer, one real 12bit or 10 bit multi channel ADC), wide range of working voltage（2.7-5.5V）, lower power cost (idle and sleep function which consume only 1～2.5mA), easy debug.

Because of the above attribute, C8051F005 is widely used.

3.3 Wireless Communication Unit

In this system, the nRF2401 wireless communication chip make by NORDIC is used. nRF2401 is half dual trans receive chip, the chip has 128 selective frequency, 1Mbps speed, stable and small volume, easy to program.

The structure is shown in the above figure. There are four working model for nRF2401, communicate model, configure model, ready and shutdown model. The working model is determined by PWR_UP, CE, CS.

nRF2401 communication can be shockBurst™ or direct. ShockBurst™ 工 model is shown on the figure above. In this model, data transmitted from single chip to the chip's FIFO stack, the transmitted speed is low （which is 10bps in the figure），and then transmitted in 1Mbps, the benefit of which are, less energy consumer, as shown in the figure, if transmit signal will cost 10mA and we transmit the at 1Mbps speed, the chip in transmit state will be 100 times for 10kbps. The energy cost will be greatly decrease；2）system cost decrease, we can use low speed single chip to transmit high frequency signal. 3)high anti-jamming ability：Data stay in the air is short, so decrease the jamming possibility.

3.4 PCB design for anti-jamming

We design the PCB according to the basic anti-jamming principal, which include separate analog and digital ground, single point link to ground at power supply. We also put the analog and digital component at different part, the analog component is at the right, and digital component

concentrate at left part. To further increase anti-jamming, we sprent Cu at both side, digital ground sprent grid and analog ground filled. A 100μF and 0.1μF decoupling capacity was parallel connect between analog component and ground. This method effectively decreases the analog noise and high frequency and lower frequency noise.

3.5 Software design

According to the system desire for robot, system software has the following main function: receive command from upper computer, control the action of robot, and software anti-disturb.

The system is designed in module, it include main program, serial interrupt service program and control subroutine.

3.5.1 Main program

The function in the main program is control the system. It includes initialization, watch-dog reset, process for new command and output control. The program is coded in high level C language. After the robot is power on, it will be in a state to receive upper computer's command. We use NRF2401 and C8051F005 to receive command from PC, the communicate speed is 1Mb/s。

3.5.2 Communication interrupts service

The Robot's movement is under the control of upper computer. Communication module received command; it will generate INT0 interrupt, and enter interrupt service subroutine. After received command, the robot will search the correspond code and write it to data buffer.

3.5.3 Serial interrupt service

When the action code was sent to the buffer, single chip computer will enter serial interrupt subroutine, which will send the action code to robot through serial port, and make the robot to do the action.

The communication protocol of upper computer and lower computer is as follow：

1st Byte	2nd Byte	3rd, 4th Byte
address	Robot Address	Robot command Number

4、Vision System

Vision system gets object's position information from image, and sent to the strategy module. The image is grabbed by the camera on top of field. This camera can get image at 30frame/sec, and the resolution is 640*480. The object on the field include ball, robot of both side. They are distinguishing from each other by different color.

4.1Color segmentation and object recognition

The first step of vision is color segmentation. It will associate each pixel to one type, in practice we make the color segmentation at HSV color space.于 HSV. We design a screen color pick to get the color we have interest, and define the properate color.

The object need to be recognize include : orange ball, blue and yellow robot1, green and purple robot2. Currently, the object recognition is based on the object color. The process is as follow.

For ball, we get all the point which has similar with orange, and average each point's coordinate to get the ball's center.

For robot, we attach two color block at top of the robot, find each block's center, and after average we can get the center. And draw a line between the two center, we can get the direction of robot.

4.2 Communication with Strategy System

The location information recognize by vision module was sent to strategy system. In the communication process, a structure array was sent, which include ball position, position and direction of robot at both side.

5、Strategy System

The strategy system will make decision according to the location of robot and ball. Its function is as the brain to human being，which is the central controller of the whole system. It analyses the field state, and try to kick the ball into operant's goal.

Because of the instability of the whole system,

it is very important for accuracy of the strategy system, so that decrease the whole system's instability.

5.1 Communicate with vision system

To decrease the coupling, we implement the strategy and vision in two modules, so that they can design and implement at the same time. The two module exchange information using Windows Socket. This makes it possible for the two program to run at same computer and also at different computer. In later case, more resource is applicable, and in the former case, debug the program is easier.

5.2 Communication with Robot

The robot action is saved on the robots memory. And assign a number for each action. After make a decision, the strategy module send the proper action number to the computer' serial port, which is transmit wireless to the robot receive module. And then the action was performed by robot.

The core part of transmit box is C8051F019 single chip computer and NRF2401 hyper frequency wireless transmit module. With the help of electric transmit circuit and logic circuit. The control command was send at PC's serial port, the RS-232 electric level is changed by MAX232 to TTL. Then the signal is transmitted wireless by ANT.

5.3 Decision Making

The robot need sometime to finish an action. If the previous action have not finished, and a new command is emitted, the robot will do the new action, which will make confuse. So the time control for sending new command is crucial for the stable of robot.

Recognition of an image by vision system will take 100ms; one robot action usually takes 2000-3000ms. We can get time for various actions through test, and based on this data, we can make sure that each action can be finished.

Currently our robot strategy is relative simple; a path planning is designed, which is very important for current robot, because humanoid robot has a relative low speed. Because of the inaccuracy move of robot, we use approach strategy to guide the robot. When the ball is far, the robot moves to the ball. When it is near, we make a precise judgment, and change the direction to kick the ball.

6、Conclusion

In this paper, a new platform for humanoid biped robot was proposed, which integrated humanoid robot control, wireless communication, machine vision and AI. Based on this platform, much relative technology can be progressed.

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