FANTASIA 2008 Team Description Paper

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Abstract. This paper gives an overview of our SSL team 2008, including mechanical system, electrical part, vision system and decision system. The implement we ever did and the development will be done in near future is described as well.

1 Introduction

FANTASIA is a robot soccer team from School of Innovation and Experiment, Dalian University of Technology, China. We have joined RoboCup Small Size League since 2006. We won the third place of SSL in the China Open 2007. This year we are doing experiments on new motors, and are developing other parts of the system to improve our robots to join the World RoboCup 2008.

2 Mechanical System

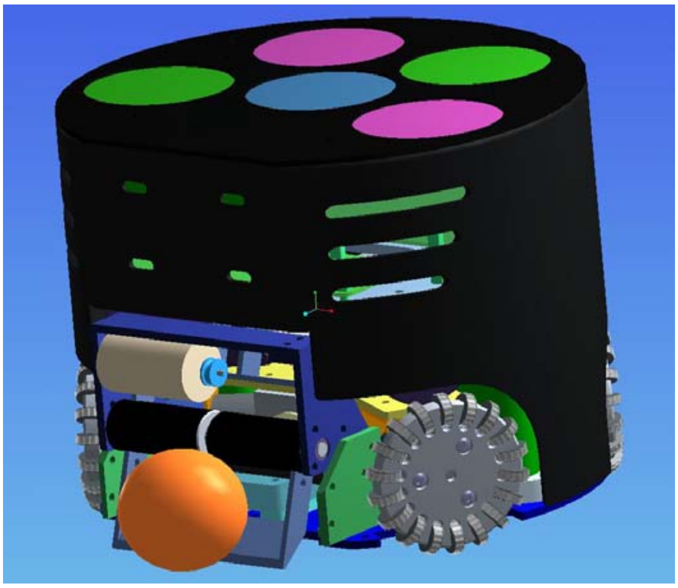

Fig.1. 3D CAD figure of the robot

There are three main mechanical systems in Fantasia's robot as follows:

2.1 Driving System

Our robots are equipped with four custom-built omni-directional wheels. Each is driven by a 30 watt brushless motor with an encoder for accurate wheel travel and speed estimation. As for robot's speed and acceleration tested with $30^{\circ}-45^{\circ}$ orientation of front and rear wheels, our robot can run with maximum velocity 3 m/s and increase speed with maximum acceleration 9.8 m/s^2 in theory.

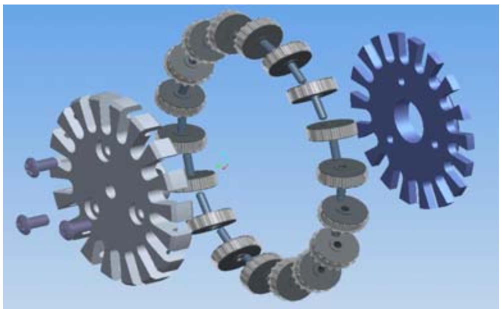

Fig.2.3D CAD figure of the omni wheel

2.2 Kicking System

The kicking system consists of two separate kicking sub-systems. One is designed for hard forward shooting and the other is designed for chip kick. Both the two sub-systems have their own electro-magnets. The main kicker is capable of propelling the ball at speeds up to 9.8m/s, and is fully variable by adjusting the time the capacitor's voltage so that passes can be carried out. The chip kicker can propel the ball up to 80cm in height and 4m in length. Both kickers are driven by a bank of two capacitors charged to 150V.

2.3 Dribbling System

The dribbling system is used for catching and handling the ball in game. It has a dribbling bar made of foam rubber, which is driven by a DC-Motor with a high speed. The system is mounted on a hinged mechanism, which can reduce vibration during dribbling.

Our robot fits within the maximum dimensions specified in the official rules, specifications are 178mm in diameter, 146mm in height, weight 2.5kg and 15% of ball coverage.

3 Electrical System

We use a soft core microprocessor based on an FPGA chip as the central controller which manages all the peripherals in the electrical system of the robot. And we build the peripherals as IP cores for the functions of each part of the robot, such as wireless communication, motor control and ball shooting.

3.1 Wireless Communication Peripheral

To communicate with the AI computer we use two NRF2401 wireless modules to form a full duplex channel with maximum speed of 1Mbps.

3.2 Motor Control Peripheral

On the robot there four brushless DC motors for running and one brush DC motor for dribbling the ball. For each brushless motor we have three n-channel and three p-channel mosfets which provide the driving current, a 512p/r encoder from which we can get the speed of the motor, and the motor speed control and drive peripheral in the FPGA chip which controls the speed and direction of the motor. For the brush motor we use one n-channel mosfet for the driving current and speed control.

3.3 Shooting Peripheral

The kickers are driven by two 2200uF capacitors charged to 150V which is generated by a DC-DC converter. The kicker is capable propelling the ball at speeds up to 10 m/s, and is power-variable.

4 Vision System

Our vision system consists of two individual high speed cameras, transferred separately through 10-bit RS-644 (LVDS) lines to frame grabbers running in a PC. Each raw image of two which captured by the cameras is processed in a single core of dual-core CPU. At the end of the processes, the information of ball and robots from each thread is combined into a vision data package, which will be sent to decision system later.

4.1 Hardware

Two UNIQ UC680[1] cameras with two Matrox Meteor-II Digital[2] grabbers, one for each half field, running at 60 fps with the resolution of 659×494 pixels. Vision system PC is carrying a Intel Core 2 Duo CPU over-clocking at 3.0GHz and 2.0 GB RAM.

4.2 Calibration

Using Tsai's method[3] to calculate the calibration constants, which is used to establishing the relation from image to the real world. The calibration procedure is right after camera being set up, which is done by a calibration pattern paper and an Identification algorithm.

Fig.3. Result of calibration using Tsai's method.

4.3 Object Identification

Objects are detected by color segmentation, which is done in YUV color space. All the recognition processes are based on weight of similarity including shape, size, color and historical data, etc. of the object. Our vision system can also recognition different patterns without define the their color class, so it is possible to recognize the direction of opponent robots, with which we can improve our defence strategy.

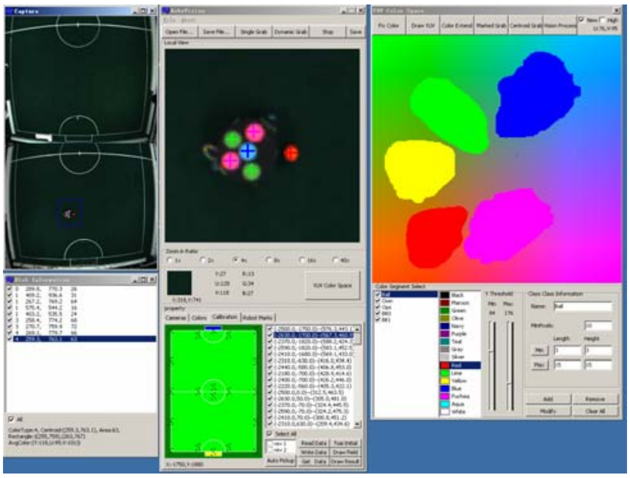

Fig.4. The user interface of object identification part of vision system.

5 Decision System

Decision System is used to calculate the command for each robot per frame by the information received from the Vision System. Decision System contains two parts: World and Thinker.

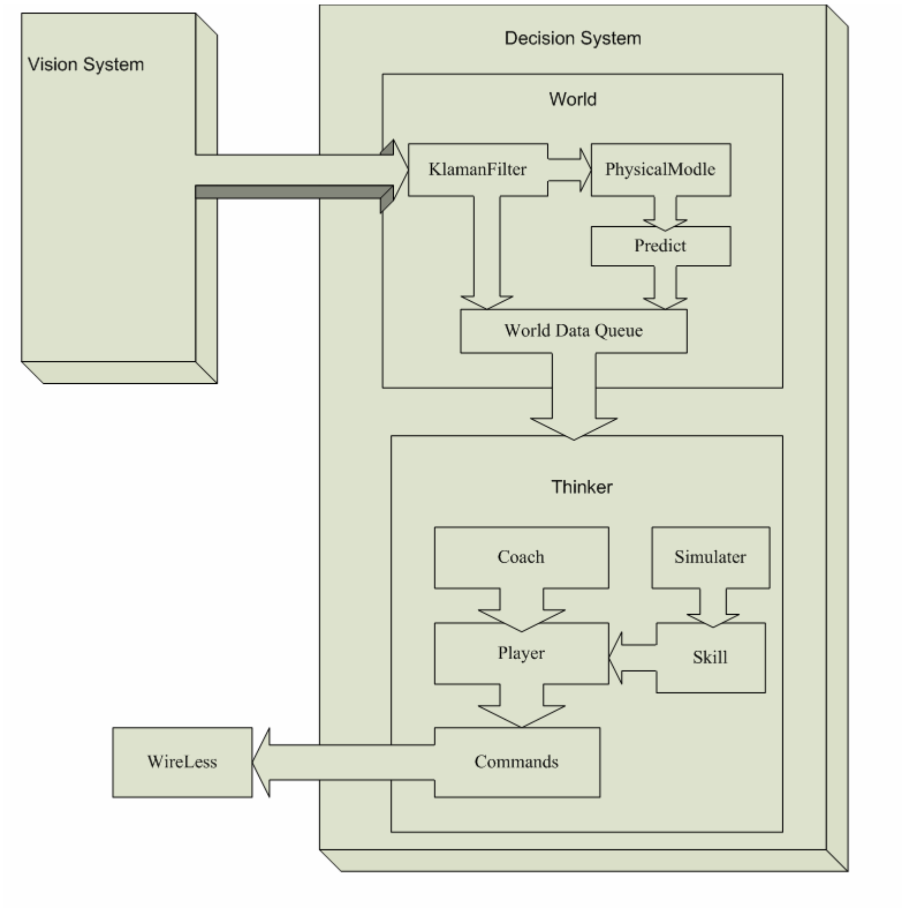

Fig5. Decision System Architecture

5.1 World

World part is a Data Set and Data Processor of the Decision System. It contains three main parts: Vision Data Process, Physical Model and Data Queue.

5.1.1 Vision Data Process

The data received from the Vision System can't be directly used to do the position the robots because of some reasons. First, the vision data has amount of noise, so we used the Kalman filter to reduce it. Second, the information received from the Vision System was with a delay caused by the camera, Vision System and the communication, so we compensated it by the predicted position and rotation of the robots and ball var their Physical Model which will be introduced as follow.

5.1.2 Physical Model

Physical Model provides a series of the physical rules of the movement of the ball and the robot. It can be used to predict the position, victory, rotation of the robots and the position track of the ball. Because the factors affecting the physical model, such as the friction factor, are vary in different environment and hardly measured, we use the nonlinear least second to approach the physical model.

5.1.3 Data Queue

Data Queue is a container to store the data used by the decision system. When the vision information is processed by Vision Data Process and the physical model, it will be pushed into the data queue with the time stamp. So the Decision System can easily obtain the information of each frame by the given time stamp.

5.2 Thinker

Thinker part is the core of the Decision System. Thinker calculates the commands for the robots which should be executed at each frame based on the data stored in the Data Queue.
Thinker contains three main parts: Coach, Player, and Simulator.

5.2.1 Coach

Coach, as it named, just like the coach in the human soccer team, is used to distribute the tasks to the robot players. We defined some tasks such as running to position, shooting, passing to some robots and so on. Coach is a centralize controller, because it can obtain the information of the whole game and easily program the most reasonable tasks for each robot. These tasks are not the real commands sent to the robot, just the high-level commands.

5.2.2 Player

Player is the executer of the task received from the coach. Each player controls one robot. Player can choose the correct command to execute its task by the Simulator. After the commands of all the robots are made out, they will be sent to the robots var the wireless.

5.2.3 Simulator

Simulator can simulate the position, rotation and other property of a robot's movement after a reasonable command is given. So Player can obtain the result of executing different commands to choose the most suitable one.

References

[1] Matrox Electronic Systems Ltd., http://www.matrox.com, 2008.

[2] Uniq Vision Ltd., http://www.uniqvision.com/, 2008.

[3] ROGER Y. TSAI: A Versatile Camera Calibration Technique for High-Accuracy 3D Machine Vision Metrology Using off-the-shelf TV Cameras and Lenses. IEEE Journal of Robotics and Automation, Vol. RA-3, No. 4, Auguest 1987.