Mechanical And Electrical Description With Software Flow Chart

1 Hardware Structure

Our team has 5 robots to take part in the competition .All of them are from Beijing university of technology robot association， each robot is comprised of 4 parts, including the visual system, the decision-making system (i.e. the airborne laptop), the motion-control system and the communication system.

1.1 The visual system

Our robots havea panoramic vision.We made that possiable by equipping each robot 2-DOF motion platform and a panoramic camera with CCD sensor and a conical reflective mirror. The camera provides a 360 angle of view. The reflective mirror diminishes the size of the blind spots. The blind side is the area right in front of the robot. The image captured by the camera coincides with the overhead view vertically but they are reverse horizontally

Panoramic camera.

The panoramic vision is the result of the conical reflector on the top of the robot, which collects the images of the surrounding objects and converge them in the camera. The advantage is that one single picture captures 360-degree image within a certain range, however, the images may need rectification algorithm as the objects further afield may be distorted.（shown in Fig.1）

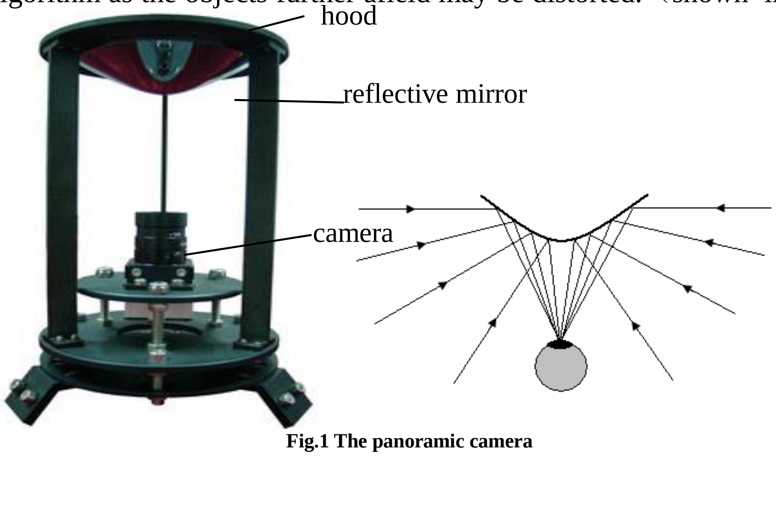


Fig.1 The panoramic camera

Color threshold and visual recognition.

The robots identify the objectives on the field by calibrating the colors, the color is the primary characteristics of each target. The visual identification system describes the color through three-color components (red, green, blue). However, the changes of light intensity caused great errors with the measurements even if the color components are constant, which may cause miscalculation on the division of the color threshold. Therefore, we convert the three color components into HIS to search and divide different color areas, which is more reliable and widely adopted. HIS describes a color with hue, saturation and intensity, there is also an independent hue component and intensity component in HIS space, which is better for color discrimination.(shown in Fig.2)

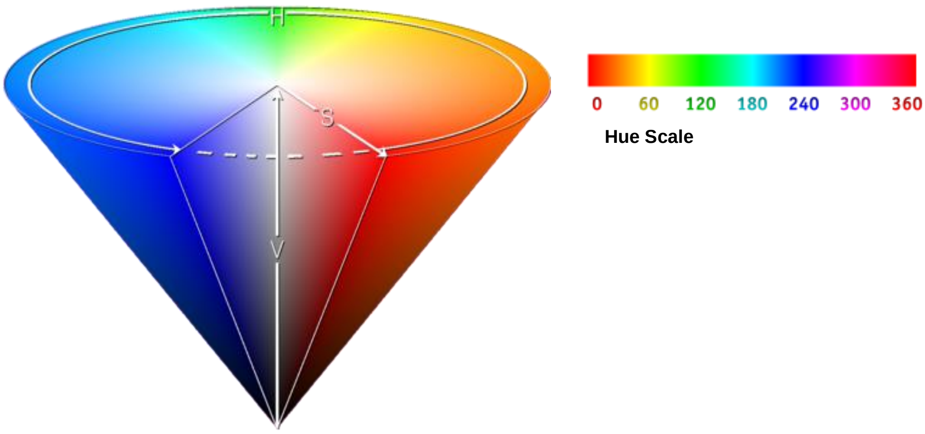


Fig.2 Color calibration

The frequency and the curve of pixel distribution are used to determine the color of the objects. The computers get the results in binary and process the images. The image processing procedure is shown in Fig.3.

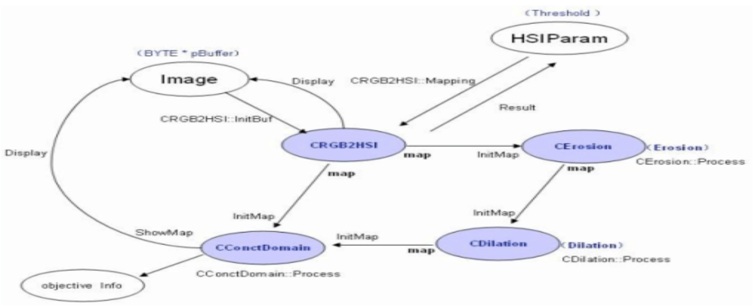


Fig. 12

Fig.3 Image processing

1.2 The mechanism of self-position

Our robot identifies its location on the field by comparing its location and angel with the sidelines on the field. The panoramic image needs rectification and the shape of the sidelines on the field needs restoration before the processing of the data. As shown in Fig.4, the untreated image is on the left and the one after rectification is on the right.

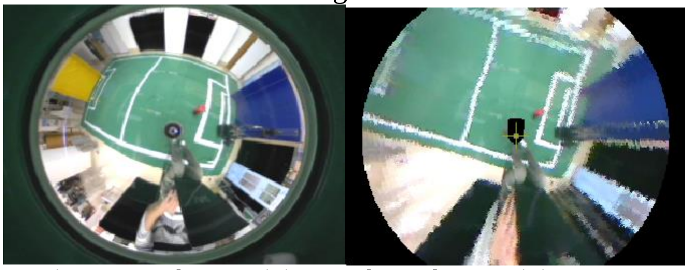


Fig.4 Untreated panoramic image and treated panoramic image

The determination of the relative position of the field tag line is done by matching it with a prepared field line template.(shown in Fig.5). The field line template is shown in blue color on the screen, while the white lines captured in the image are marked as the purple and red dots. The two sets of lines did not overlap in the left figure, therefore, the matching program rotates the purple dots constantly until its main part coincides roughly with the blue template (shown in right). By recording the rotational angle and the translational distance of the dots, the robots can identify its absolute coordinates on the field.

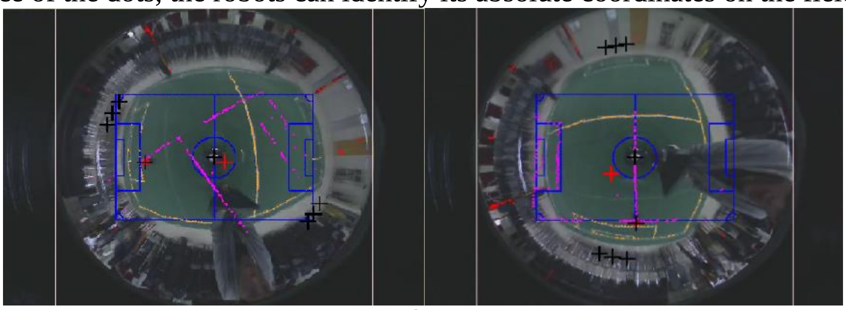


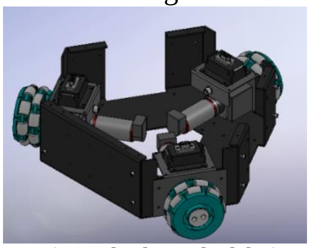
Fig.5 Self-positioning

1.3 Motion-controlsystem

Equipped with three-wheeled omni-directional system with omni-wheels and high-precision/high-power motor, our robots can move flexibly and achieve stunts like swerving, making sharp turns and encircling the target.

The movement of the wheels.

The kinematic theories dictates that the direction of a moving object is controlled by the velocity of each supporting wheel and other restrictive conditions. The three-wheel omni-directional system has three independent motor units distributed evenly on the chassis as shown in figure 1. Each unit comprises a DC motor, an omni-wheel and a DC driver. The direction of the wheel coincides with that of the tangential direction of a circle.(shown in Fig.6& 7)



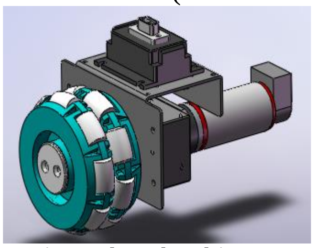


Fig.6 The three-wheel device **Fig.7 Independent drive system**

The directional movement of the three-wheel system can be realized by the cooperation of the three independent wheels. Only the velocity along the tangential direction of the wheel affects the velocity of the robot. The velocity along the axis of the motor has no effect on the overall velocity as it is transformed into the sliding velocity by the small wheels on the main wheel.

Speed of a single drive unit split as shown in Fig. 8

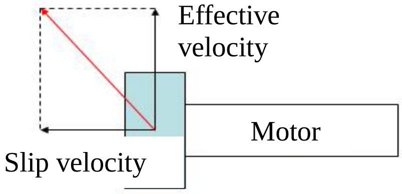


Fig.8 The velocity diagram of the driver motor

Fig.9 illustrates the movement and velocity of the three-wheel system. In the figure, the right rear of the robot is considered 0 degree, the angel grows clockwise. The movement angel and velocity are marked ‘fAngel’ and ‘nLV’.

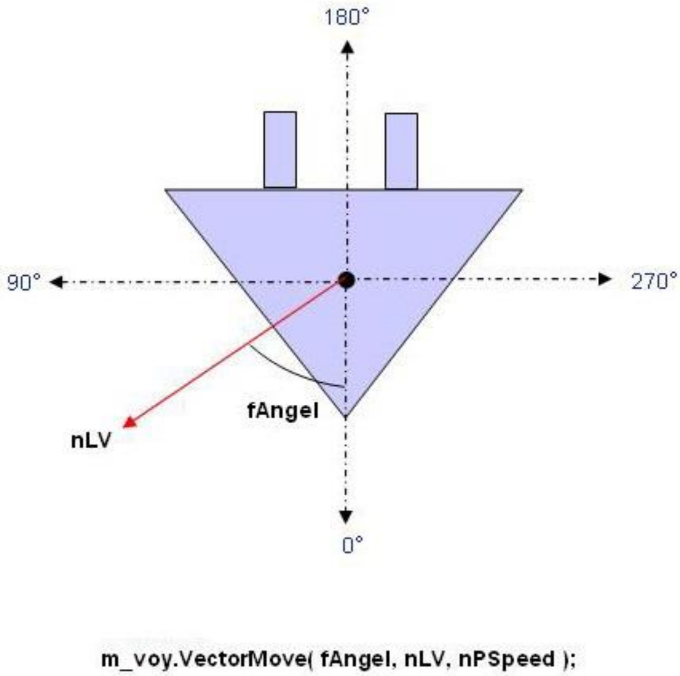
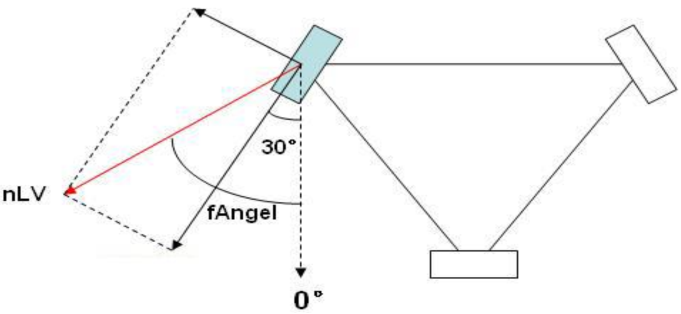
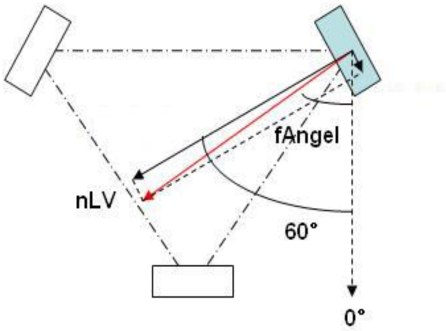


Fig.9description of the velocity and direction

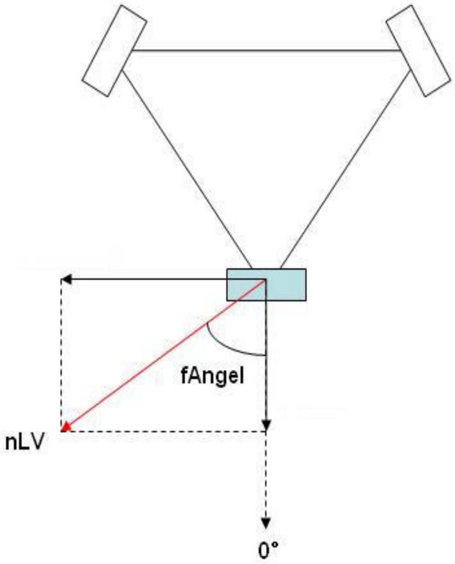
In this scenario, the wheels have different effects on the velocity of the robot. The valid velocity is the one along the axis of the motor, the sliding velocity is the one along the small wheels.



$$\mathrm{Motor_L} = -\mathrm{nLV} \times \sin(\mathrm{fAngel} - 30°)$$



$$\mathrm{Motor_R} = \mathrm{nLV} \times \sin(60° - \mathrm{fAngel})$$



$$\mathrm{Motor_B} = \mathrm{nLV} \times \sin(\mathrm{fAngel})$$

1.4 Themechanism for dribbling the ball

Our robot has the automatic device to dribble the ball (shown in Fig.10), with the help of the friction between the ball and the wheels. We can adjust the position of the wheels to control the robots to move the ball along its trajectory.

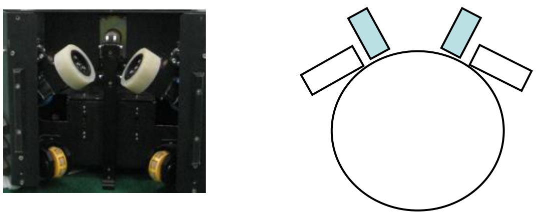


Fig.10 the device used in 2014 ChinaRobo Cup

1.5 The device for kicking the ball and shooting

The electromagnetic launcher is the device forpassing the ball and shooting. (shown in Fig.11) It enables our robots to kick theballin differentvelocity and altitudein order to perform different actions, such as push shot, flip shot or passing.

Fig.11 The shooting device

2 The electrical system

The core component of the robot is the main control computer, which transfers the data to the AVR control panel through USB communication technology. The AVR control panel then gives orders to the DSP motor servo system. The panoramic visual processing and control algorithms are conducted by the main control computer.(shown in Fig.12)

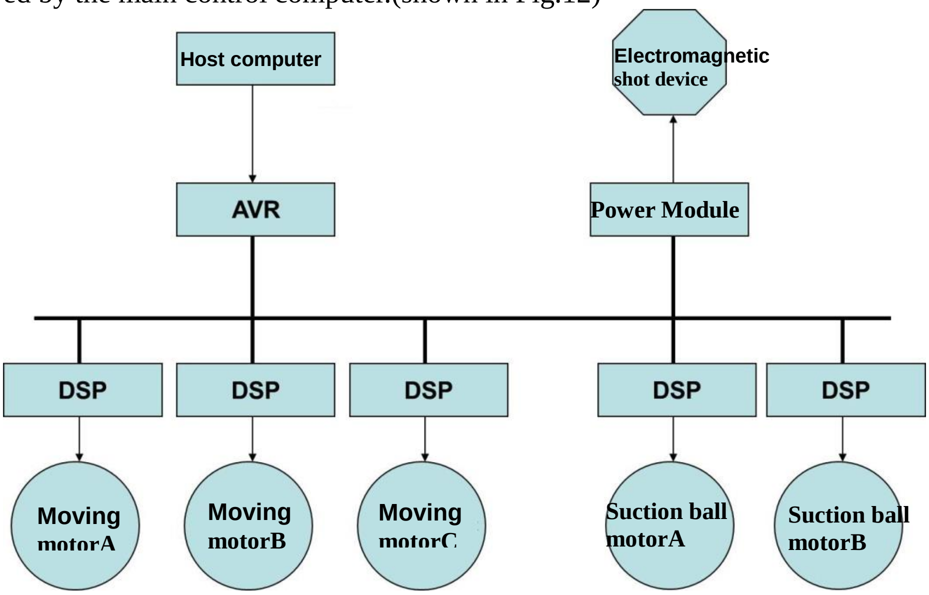


Fig.12 the diagram of the electrical system

3 Software System

3.1 Introduction of Middle Size Robot League Software

The structure ofsoftware system is shown in the picture follows, it's consisted of Communication Subsystem, Decision-making Subsystem and Motion Control Subsystem.The competition system is shown in Fig.13:

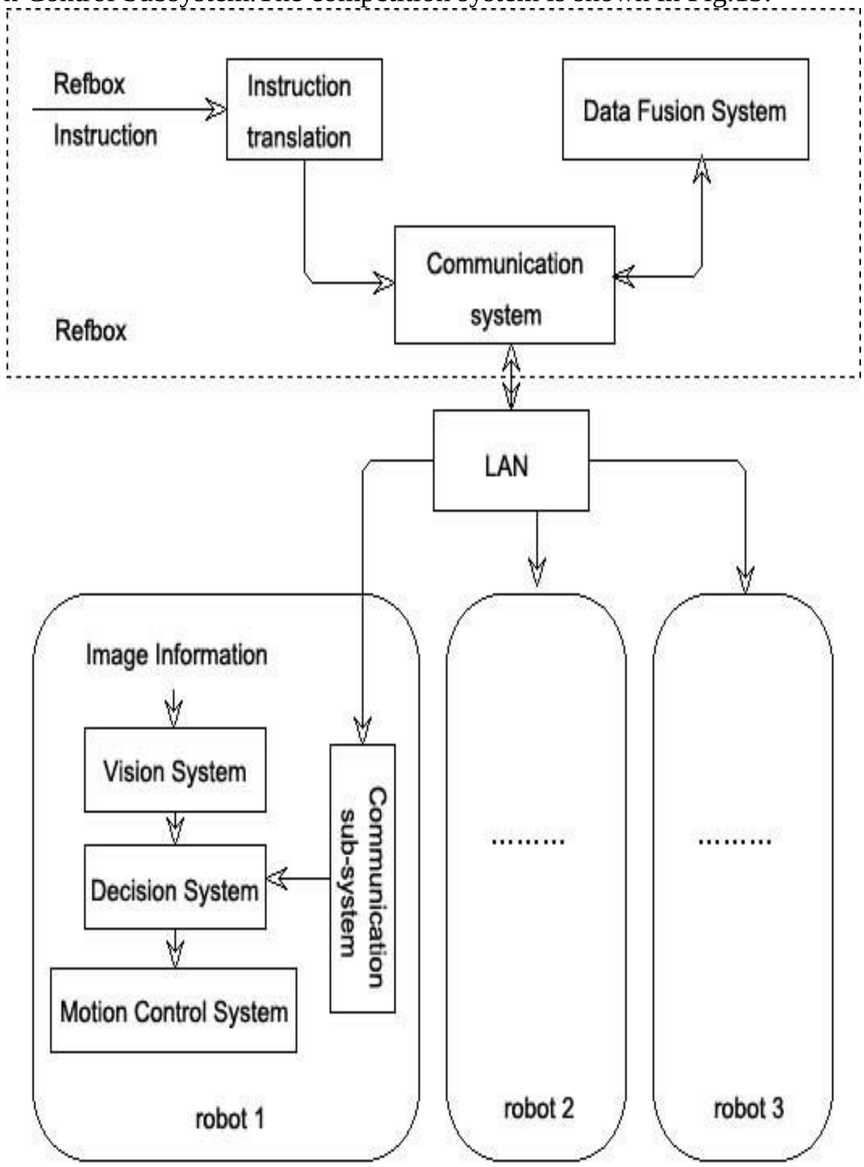


Fig 13Architecture of Software System

Communication Subsystem.

According to rules of the competition, RoboCup Middle Size Robot League System must adopt wireless communication. Communication subsystem is formed with computer resources, wireless routers and wireless network cards of each robot. In each cycle, mobile robots will transfer monitoring record and its identify results to the trainer through the communication subsystem; the trainer will sent environmental information and various motion commands to the robots in the field.(shown in Fig.14)

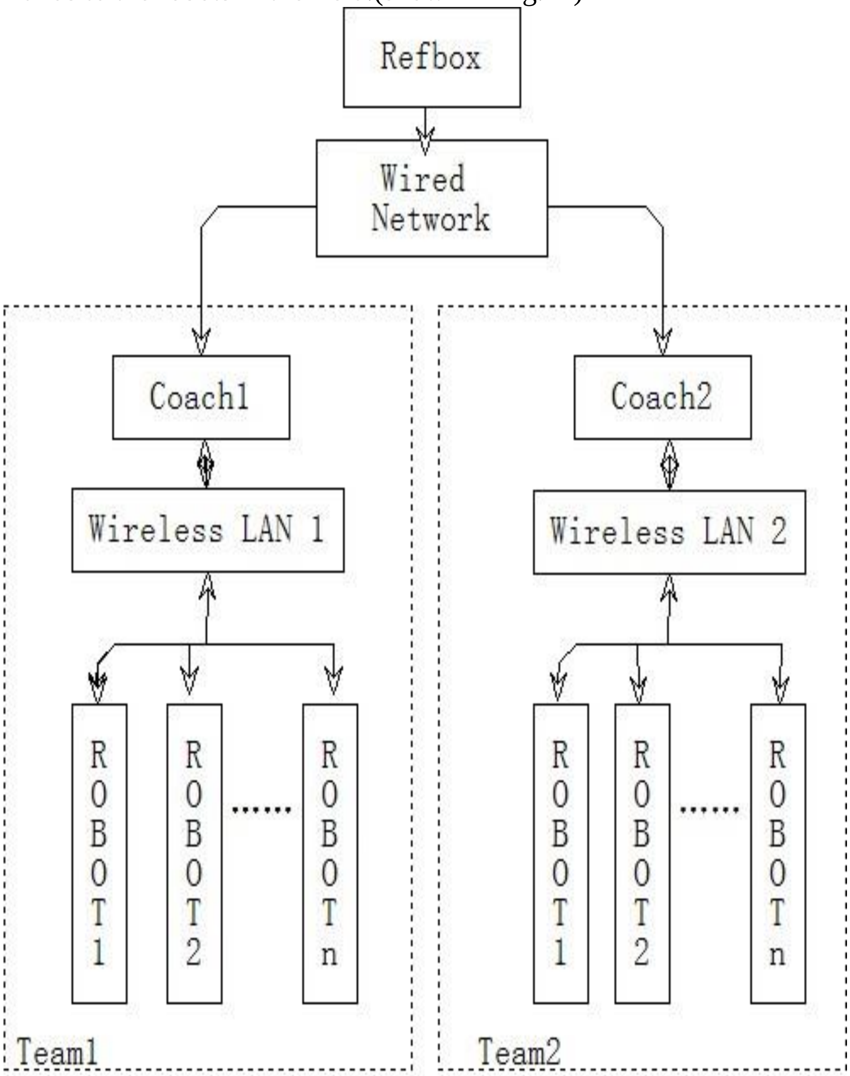


Fig. 14 Schematic Diagram of Communication Subsystem

Decision-making Subsystem.

In the soccer robot system, the decision-making subsystem is the center of the whole system. Each robot has its independent decision subsystem, and the decision-making function is realized by the computer's decision program. It decides robots' moving tracks based on the data and the mobile command message from the preset control strategy. In this system, we use the Think-pad laptop as the epigynousmachine, which communicate via the 1394 interface and the 1394 camera, as well as connect with a motor controller through the USB serial data cables.(shown in Fig.15)

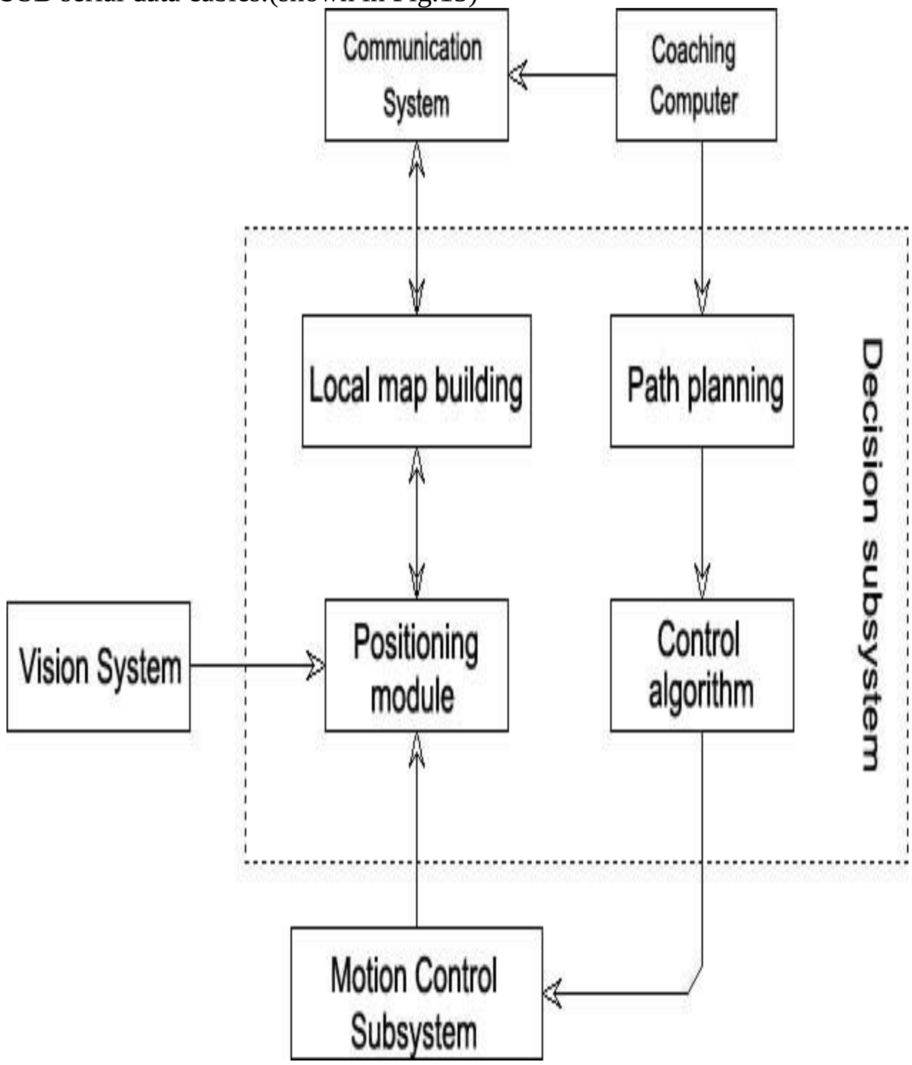


Fig. 15 Schematic Diagram of Decision-making Subsystem

Motion Control Subsystem.

The ball team members entities are the soccer robot sedan cars, which are the actuators of robot soccer competition system. The robot's motion control system is constitute with the mechanical part and the bottom control circuit part.(shown in Fig.16&Fig.17)

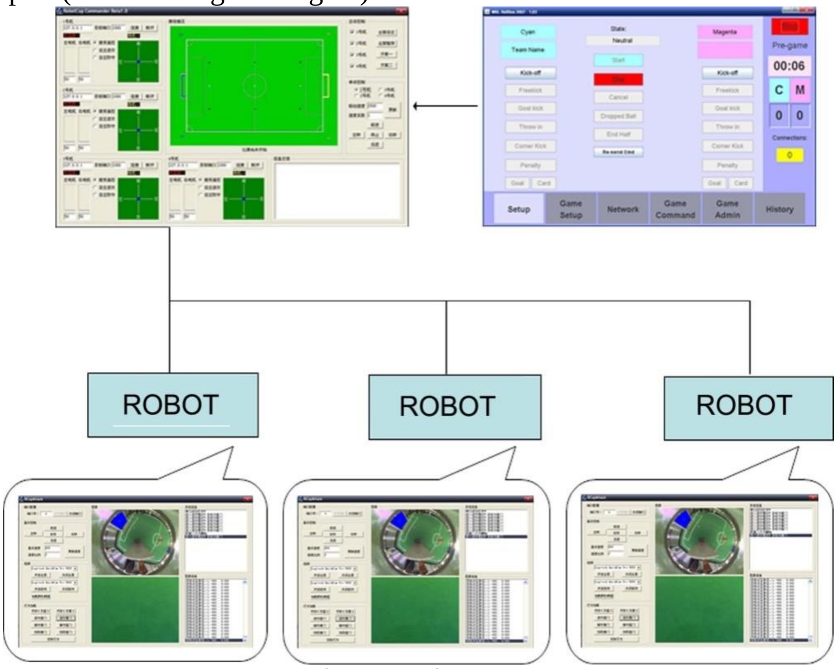


Fig.16 Application framework of Motion Control SubSystem

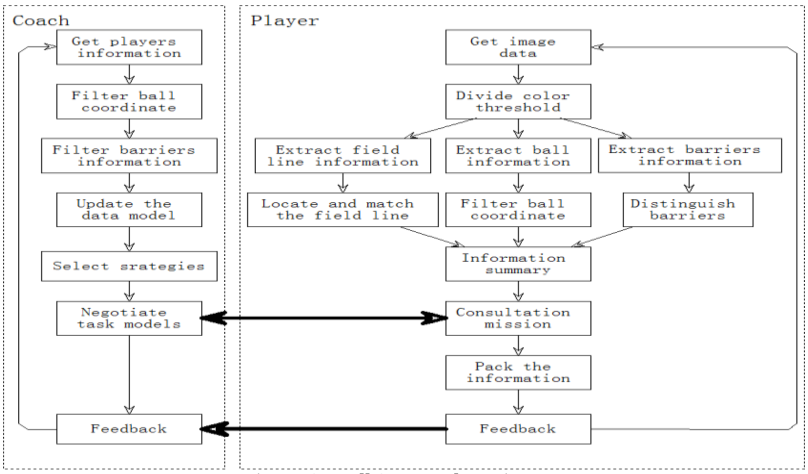


Fig.17 Overall System Flow Diagram