RMIT United

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1 Introduction

The RMIT United team consists of two types of custom-made robots, one goalie robot and three field player robots. The field players are distinguished by a powerful kicking device and are essentially the same as our previous year's entry (figure 1) except for the addition of a plastic protective shell. The goalie robot is based on the same robot as the field players, except that its uses a solenoid based kicker mounted along the side of the robot. The robots primarily use vision for perception.

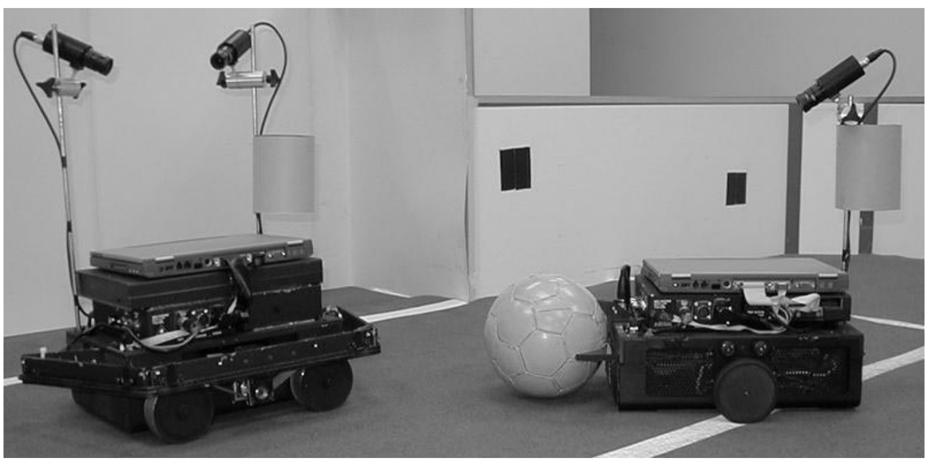

Figure 1. RMIT United robot players and goalie (2000 version pictured).

2 Robots

The robot's main chassis is machined from a single piece of 12.5mm U-section aluminium. With all components, including notebook computer, each robot weighs around 15 kilograms. Figure 2 summarizes the system architecture.

The robot is controlled via a serial link, from the on-board computer, operating at 115.2k baud. To attempt to reduce control latency, encoder and status packets can be returned by the robot every 10 milliseconds, even if no command is issued.

The field robots have a special kicking device based around a heavy brass cylinder that slides along an axial rod. The cylinder is pulled back against two elastic cords by a worm drive motor (actually a windscreen wiper motor). A solenoid actuated clutch restrains the cylinder until the robot is ready to kick. When the kicker is armed (via a command from the notebook), it will kick when a touch sensor is activated. This system can kick the ball about 20 metres along a carpeted surface. The goalie robot has a solenoid actuated kicker that is triggered in a similar way.

All robots use a 28VDC power system and will operate for up to 90 minutes on battery power. The robots can sustain a speed of 2.0 m/s which can be reached within 2 seconds from a standing start.

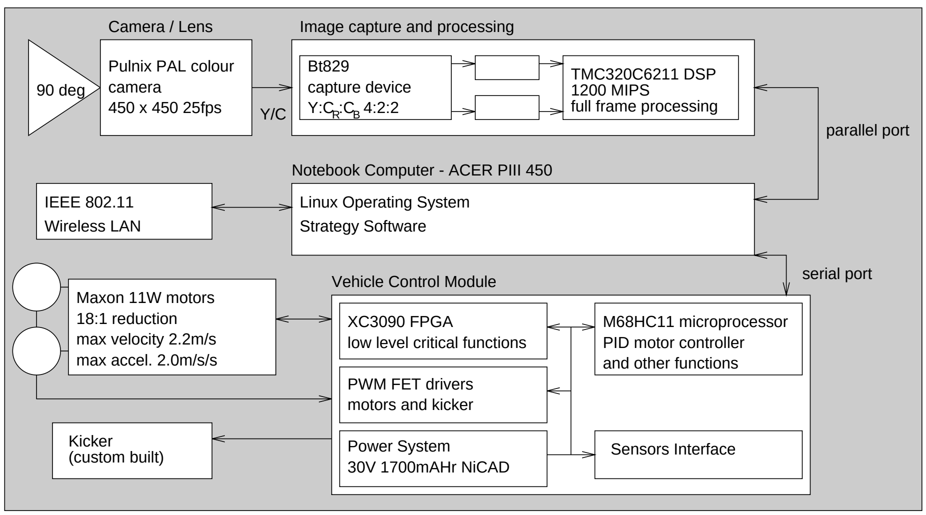

Figure 2. Hardware architecture of soccer robot.

3 Vision

The camera is a Pulnix PAL 1/3" CCD colour camera allowing resoloutions of up to 450 x 450 pixels at 25 frames per second with a 90 degree horizontal field of view. The analog video data, separated into luminance and chrominance components, is processed by a Brooktree Bt829 video stream decoder which allows filtering and scaling functions to be performed in hardware. This decoder is coupled through a pair of FIFO's to the DSP's enhanced direct memory access port. Effectively this system allows for frame rate data to be converted, filtered, scaled and then transferred into the DSP memory without any processor overhead. Each frame can then be processed and analysed at the full frame rate using the available 1200 MIPS of DSP processing power. The goalie robot has two cameras each with a dedicated DSP.

Due to the distortion introduced by the wide angle camera lens, the first step in processing a frame is to correct the lens' fisheye effect. Each frame is then segmented based on colour thresholds. Straight lines are detected using a modified version of the Hough transform[2], with the wall/floor interface and goal posts being identified via additional confidence and colour information (i.e. colour transitions).

Differentiation between objects is based on colour characteristics. Robots and the ball must initially meet predefined colour requirements before being thresholded based on size. Goal post angles and subsequent measures of their confidence are checked to meet predefined thresholds. The angle and radius of the wall/field interface lines are also calculated (for a distance measure of robot from the wall).

The size and relative distance of objects to the robot are calculated using trigonometric functions based on the camera height and angle. These object parameters are stored in an object table. The object table is passed to the Strategy module and can also be viewed via a GUI (representing a top-down version of the robot view from the camera's CCD) for debugging purposes.

4 Strategy Software

To play soccer effectively it is vital to know where you are on the field, and where other objects such as goals, team mates and opponents are in relation to you. This perception is referred to as a world model. Each robot maintains its own world model that forms the basis for its decision making. Muliple on-board sensors contribute to a robot's world model, vision (incorporating object recognition) being the most important. Odometry based on wheel rotation sensors and data received from other robots is also used. The raw information from the sensors is interpreted and combined in real-time to become the robot's world model. As well as each robot having its own world model, the robots also contribute to a shared (global) world model that is created by combining (fusing) into a single world model each robot's knowledge of its surroundings. This not only provides a common view of what's happening on the entire field, but also increases knowledge of individual robots of their environment. For example, if a robot cannot find the ball, rather than having to search the field using only its own sensors it can refer to the common world model which will almost certainly have an idea of the ball position.

The robots have an allocentric view of their environment, meaning they see themselves and other objects as a position relative to the entire field, rather than relative to their own position. The allocentric view is best suited to a strategy where multiple robots share information and use a common world model.

The strategy software, entirely written in Java, uses an object oriented behaviour based architecture[1]. In this implementation event recogniser objects detect changes in the world model state and trigger combinations of robot behaviours, such as positioning, intercepting or kicking the ball, based on predetermined relevance rules. It is intended to also implement some less time-critical deliberative software to use robot experiences to enhance the validity of the behaviour based system.

As in real soccer, different robots have different roles. There will be attackers, defenders, and a goalkeeper. Each role will have different priorities. For example, attacking robots may spend most of their time in the forward half, while defending robots would stay in the defensive half. Role assignment can offer benefits such as preventing multiple robots going for the ball at the same time and consequently impeding each other.

Cooperation between robots in both attack and defence scenarios will be implemented to address situations where a game objective can best be achieved by coordination between multiple robots. Teamwork and roles are closely related and both are enabled by the global world model and inter-robot communication.

The strategy software is expected to cope with many different scenarios that can occur during a typical game. These include penalty shoot outs, the technical challenge (a timed challenge where a robot is required to find the ball and shoot a goal) and the loss of a player due to a malfunction or penalty. The robots will also have different plans to use as required during the game, including a set play or series of moves

5 Conclusions

RoboCup is not just about having the most powerful kicking device. We have made great strides in improving our team's ability to get a shot at the goal. Our robots cooperate well and generally keep out of each others' way. In the future we look to make better use of cooperation by passing. The ability of the robots to turn while keeping possesion of the ball works well but requires fine tuning. We intend to implement learning techniques to make this skill more robust. We need to reduce the closed loop motion control latency in order to cope with the higher velocities of these robots. This year we are concentrating our efforts on improving the capability of the vision system and overall robustness of the strategy and hardware systems.

References

1. Ronald Arkin. *Behavior-Based Robotics.* MIT Press, 1998.
2. R. Davies. *Machine Vision : theories, algorithms, practicalities.* Academic Press, 1997.