ViperRoos 2000

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1 Introduction

The ViperRoos are a team of soccer playing robots that made their debut in the F-180 league at RoboCup-2000. Each Viper robot is completely autonomous and relies on on-board vision, rather than an overhead camera, as its primary means of perceiving the world. In addition to participating in robot soccer competitions, the Viper robots have already been used successfully for other research investigations (for example [1]). The ViperRoos represent an innovative step towards cheap, autonomous robot hardware for use in both RoboCup competitions and general mobile robotics research.

This paper describes the technical aspects of the ViperRoos system, with a focus on the robot hardware and software. Performance-wise, the robots acquitted themselves well against teams with overhead cameras where the Viper robots are at an obvious disadvantage. The robots finished the round robin with one win and two losses. Figure 1 shows the ViperRoos team for RoboCup-2000.

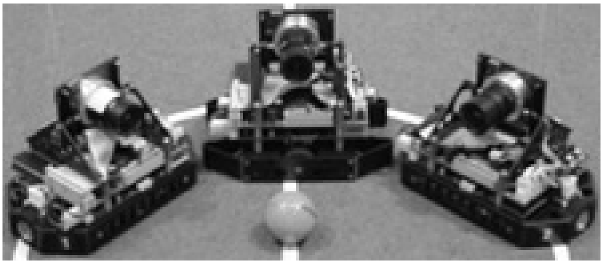

Fig. 1. The ViperRoos team: 2 Field Robots and Goalie (center)

2 Hardware Architecture

The VIPER robot platform extends from the reliable and proven base of the UQ RoboRoos [2] through the addition of on-board camera, dedicated vision processing hardware, and half-duplex radio communications. Figure 2 shows a schematic of the VIPER robot's hardware components.

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P. Stone, T. Balch, and G. Kraetzschmar (Eds.): RoboCup 2000, LNAI 2019, pp. 527-530, 2001.

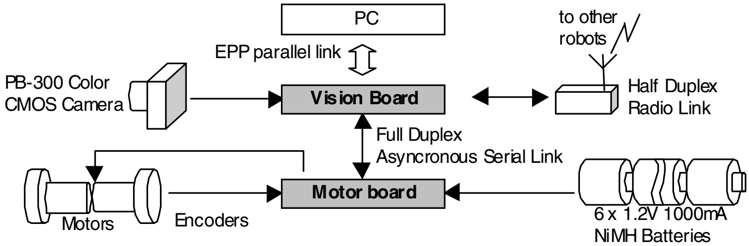

Fig. 2. Block diagram of Viper robot's major hardware components

Mechanically speaking, the VIPER is almost identical to its RoboRoos ancestor [2]. The robot uses the same aluminum chassis, which houses two coreless DC motors in a differential drive configuration. The chassis also houses two packs of 3 NiMH battery cells, which provides power to the entire system. Feedback from each motor is derived through externally mounted HEDS-9100 shaft encoders.

Electronically, the VIPER is built around two loosely coupled, custom-built processor boards dedicated in both a hardware and software sense to different parts of the robot intelligence problem. The motor controller board is built around a Motorola MC68332 MCU running at 20MHz and represents a second generation of the RoboRoos processor board. The MC68332 processor offers some computational power but primarily provides dedicated motor controller functions through its Timer Processor Unit (TPU). The motor board contains the ancillary power electronics for the MC68332, 512K of Flash memory, 256K of SRAM and the MOSFET H-Bridges for driving the DC motors. The vision board is built around a Hitachi SH7709 processor, part of the SH-3 series MCU's. The SH7709 provides reasonable computational power (up to 80MIPs) with a full set of peripheral units. The vision board communicates with the motor controller board via a 60kbs serial link utilizing the serial communication peripherals. The memory interface peripheral on the SH7709 enables glueless interfacing to a wide variety of memory including 16MB of 100MHz SDRAM for general program and data, up to 1MB of Flash, and 512K of SRAM for image capture. The Direct Memory Access (DMA) controller provides a simple digital interface to the Photobit PB-300 color CMOS image sensor housed on a separate custom-built board. The SH7709 captures and stores image data into SRAM via DMA whilst the processor computes the previously captured frame.

The Viper can communicate to the outside world via a half-duplex FM radio link, running at 19,200bps using the remaining free SCI port on the SH7709 processor and a BiM module from Radiometrix. The robot also has a high-bandwidth debugging interface via an Extended Parallel Port (EPP) connection to a PC. This high-bandwidth channel, which enables real-time video debugging, requires a cable connection and is not used while the robot is in motion.

3 Vision

On-board vision is the primary means of perception for the Viper robots. The performance of the visual perception system has direct impact on the effectiveness of the robot as a whole. Thus, most of the development effort for the ViperRoos in their debut year focused on evolving robust and efficient vision routines.

The vision processor receives frames at a frame rate of around 10Hz from the PB-300 CMOS image sensor. Each image is 512x128 color pixels arranged in a Bayer 2G format with two green, one red and one blue pixel for every 2x2 pixels. With a 2.8mm F1.4 CS-mount lens, the robot is able to view objects from 15cm to a field length away with horizontal viewing angle of 79 degrees.

The first stage of vision processing sub-samples and transforms the color space of the image from RGB to YUV to produce a 128x32 YUV image. The UV components of the filtered image are segmented into pixel types using predefined lookup tables. The UV segmentation table is calibrated before game time using custom written PC software to display the UV content of real time, raw image input graphically. Color segmentation in the UV space is, within our experiences, generally more robust to lighting variations than a similar RGB classification scheme. The segmented image is then filtered using opening operation of binary mathematical morphology [4] on each pixel type to remove noise artifacts. Once the pixels have been colour-segmented, a straightforward region growing algorithm, using the classified pixel types as seeds, is applied. The resulting regions, provided they meet certain criteria such as size, are interpreted to produce estimates of the relative location of obstacles and the ball. For game planning purposes, the egocentric bearings to objects in the image are translated into a Cartesian coordinate frame centred on the field itself.

For obstacle avoidance, a different mechanism is used. In short, any two adjacent pixels that are not field green are interpreted as obstacles to be avoided. The vision system produces what can be interpreted as a local, egocentric *proximity* map of obstacles in the environment. This information is then used by the navigation system to navigate a safe path to the desired location.

4 Intelligence Schemas

The ViperRoos are a behavior-based system where the active behaviors depend on the visual perception of ball. The current implementation is quite similar to the RoboCup 2000 RoboRoos control system [2] and is shown in figure 3. Since the field and goalie robots have different roles in the game, they exhibit different behaviors within the team. Each field robot wanders in its pre-designated search area until it sights the ball. When the robot sights the ball the kicking behavior that aligns the robot with the ball and kicks it, becomes active. In all other situations the robot reverts to wandering. The field robots navigate using a reactive, biologically plausible navigation schema that is an extension of the RoboRoos approach. For brevity, the system will not be discussed here and the interested readers should consult [1]. The goalie uses two behaviors: blocking and waiting. When the goalie sights the ball, the robot moves sideways to attempt to intercept the ball before it reaches the goal. When waiting the goalie returns to the center of the goal mouth and attempts to realign its position in preparation for the next block. When the robots are not actively kicking or blocking, they perform localization where they estimate their position using the goals and walls as landmarks. The current implementation uses a simple mechanism where the path integrated, or dead-reckoned, coordinates are updated whenever they appear to be substantially in error.

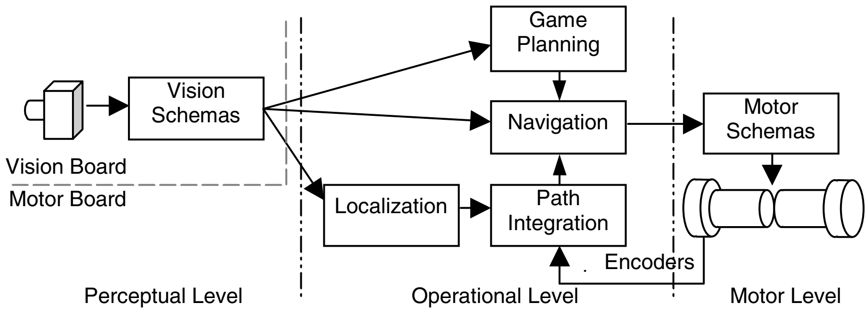

Fig. 3. The major components of the ViperRoos software control system.

5 Conclusions and Future Work

In summary, this paper has described the debut implementation of the ViperRoos on-board vision robot soccer team. Despite the disadvantages of using local vision against global vision, we believe that the overall performance of the ViperRoos at their debut RoboCup competition was satisfactory and that their strong performances against other local-vision teams demonstrated the potential of the system for further development.

There are a number of issues that we will be addressing in the coming year. In particular, we wish to develop:

1. Hardware upgrade to improve the frame rate and quality of visual system.
2. Inter-robot communication strategies that enable the team to both cooperate and overcome their perceptual and actuation limitations. Redesign of the communication hardware to improve latency and bandwidth.
3. Special kicking hardware to improve the accuracy and effectiveness of kicking thereby making the team more competitive.

References

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