Team description RFC Uppsala – Argus

N. Brunsberg[1]
L. Asplund[1], J. Bergsten[1], A. Carlborg[1], J. Gundemark[1], T. Hamplin[2], R. Kabagambah[2], M. Larsson[2], O. Rensfelt[1], D. Rosén[1], C. Strand[1], P. Södergren[1], P. Thorsélius[1], A. Tolfmans[1], J. Vesterlund[1], E. Welén[1], and M. Werkander[1]
argus-vt03@student.docs.uu.se
http://www.robocup.it.uu.se

[1] Department of Information Techonology, Uppsala University, Sweden
[2] Department of Computer Science, Mälardalens University, Sweden

Abstract. The Argus team presents redevelopment of the existing autonomous Argus robots. Research focuses on designing an ultrasonic vision system for environmental perception and object recognition, soft real-time communication properties for a non real-time operating system, and a robot architecture based on autonomous hardware modules. Further development areas are new camera vision systems, a multi-angled kicking device, omnidirectional driving devices, a new compass system, built in intelligence in the collision system and a photo sensoric line detection system.

1 Introduction

This year the Argus team is presenting the fourth generation of autonomous soccer playing robots developed at Uppsala University. In year 2001 the Argus robots were developed into their current design. Last year the team participated in the RoboCup2002 competition in Fukuoka, Japan. The 2002 construction was the first stable design but lacked stability in ultrasonic sensoring and speed in image analysis. Therefore, this year focus is put on developing a stable and powerful ultrasonic system and a new camera vision system. The development can be summarized into the following scientific researching areas:

- Ultrasonic vision system for environmental perception and object recognition.
- Digital camera vision system.
- Soft Real-Time communication properties based on a Non Real-Time Operating System.
- Autonomous hardware modules.
- Strategic worldview and teamwork.

Besides the research with scientific focus, development is performed within the following areas:

- Line sensoring positioning system.
- Multi-angle, compressed air driven kicking device.
- Driving mechanism honouring the Swedish inventor Hans Ilon.

Each robot is equipped with three vision systems; one front camera system, one omni-camera system and one ultrasonic vision system. Further the robots contains infra red collision detection, a compass sensoring system and an accelerometer based positioning system. Due to the development areas mentioned above, the robots are also equipped with a multi-angled kicking device, a line sensoring system with photo sensors and a driving mechanism consisting of three motors with omnidirectional wheels.

2 Ultrasonic vision system

The research involving the ultrasonic vision system focuses on developing environmental perception and object recognition using a directed beam created by an array of ultrasonic transducers. This research aims to develop a sensoring system able to complement existing vision systems on the robots by giving more accurate distance and angle vectors to identified objects. All research within this area is divided into the following three subsections:

- Mechanical layout.
- Design of reconfigurable hardware.
- Algorithm analysis and implementation.

Mechanical layout

Using one ultrasonic transmitter gives a short range, wide angled beam to analyze. The aim for the mechanical layout research is to construct an array of transmitters to maximize the transmitting range and to minimize the side lobes. This will be achieved by placing the transducers tightly, preferably by placing them with a centre-to-centre distance smaller than the wavelength of the beams. When positioning the transducers in such order we aim to be able to perform long range scanning and performing object identification in a desired direction, without interference from objects outside the desired scanning area.

Design of reconfigurable hardware

Currently, the hardware used consists of hard coupled modules which are somewhat difficult to reconfigure. The research within this subcategory aims to develop a single controlling hardware with high efficiency that can be easily reconfigured. This is, for example, to be able to vary the internal amplitude of the transmitters. By developing an FPGA-solution to use as the controlling hardware we aim to achieve parallelism which would lead to more efficient data analysis while at the same time transmitting, or performing concurrent analysis of multiple sample data.

Algorithm analysis and implementation

Within this subcategory our research aims to find and implement algorithms with lowest possible fault ratio for object recognition. We also focus on mapping possible algorithms to the underlying hardware infrastructure to identify the most suitable algorithms for object classification.

3 Digital camera vision system

The digital camera vision system consists of a front and an omni camera, each connected to a printed circuit board which communicates with the PC104 through a CAN-bus. This model contributes to the autonomous module system of which the robot is based on.

Hardware design

Argus' printed circuit board is a redesign of the 2001 circuit board for a digital camera. The board contains a fast SRAM in which every YUV-value from the camera forms an address in the memory where the object corresponding to that color is stored. The aim with the color mapping in the SRAM is to provide a fast image analysis. This solution also provides possible reprogramming for hardware calibration. All Can-bus communication, calibration and initialization of the camera will be handled by an AVR. This will speed up the communication and let the DSP, also situated on the circuit board, handle all signal processing.

Image analysis

The software solution of object-to-color mapping is designed to be based on quadratic discriminant analysis instead of the former box model approach. The aim with quadratic discriminant analysis is to provide a clearer mapping of objects. This can be achieved since the group of samples marking an object is more concentrated in 2 dimensions and thus less likely to merge. The object corresponding to the color mapped in the memory is sent to the DSP. The DSP's contributed by Analog Devices are used for all image analysis and information about the located objects is sent to the AVR. This information is then sent to the PC104 through the CAN-bus which manages all information handling in the robot.

4 Operating System

This research aims to redevelop a non real-time operating system to achieve soft real-time communication properties. Currently all scheduling and prioritization is handled through a standard Linux distribution. We aim to speed up scheduling by patching the kernel with pre-emptive scheduling and by developing a CAN-module which replaces task polling by asynchronous scheduling with dynamic prioritization. By developing such a module we aim to minimize the amount of jitter and the number of cycles for low priority tasks.

5 Autonomous modules

The research within autonomous modules aims to design robots consisting of modules, each being autonomous in its intended working area. Robots developed this way will be simulating the human internal communication structure, where each module works autonomously within its defined level and implements the required intelligence to do so. Communication will then be handled on a layered level through a CAN-bus, where an embedded PC104 represents the high level communication node. Through this sensor fusion, the PC104 gathers and analyzes all relevant information to form a strategic understanding of the surrounding environment, a strategic worldview. An example of this is the IR-collision system, where all data capturing, data analysis and possible movement decisions are handled within the IR module. Minimal strategic information is then passed on to the PC104 through the CAN-bus for strategic decisions.

6 Strategic worldview and teamwork

All autonomous modules of the robot gather and treat specific sensor information and data. When communicating information to the PC104, it forms a strategic worldview of the robot's state and its surroundings. This worldview is used to take strategic decisions on actions and behaviour. Each robot communicates its worldview through WLAN to the team coach for it to be able to form a complete view of the team, which then communicates this information back to each player. Currently the players communicate between eachother through the team coach. The reasearch within strategic worldview and teamwork aims to setup communication directly between the players. This is cruicial for team based strategic decisions such as one player backing up the player in posession of the ball, or for the player closest to the goal keeper to act as a defender.

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