The Attempto RoboCup Robot Team

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Abstract. This paper describes the hardware and software architecture of the Attempto RoboCup team. The different parts of robot, sensor and computer hardware which are used are presented.

1 Introduction

For building a good team of agents that can take part in the RoboCup-2001 contest, ideas and results from different fields of research, e.g. artificial intelligence, robotics, image processing, engineering, multi agent systems can or even must be used and tested [1],[2].
Since we are developing a team for the mid-size contest our main objective is to build a robot system, which is able to recognize the environment in a suitable way and to build a fast and reliable control system, which is capable of solving the given task of playing football. This control system must cope with the dynamics and adverse aspects of complex situations which are characteristic for the RoboCup contest.
The remainder of the paper is structured as follows: Section 2 describes the robot, sensor and computer hardware of the Attempto team. Section 3 describes the problems which are the motivation for our research work.

2 Hardware

2.1 Robot platform

As the basic robot platform for the field player we are using the Pioneer2 DX from ActivMedia Inc. These robots are equipped with a differential drive system with a free running caster wheel mounted at the back of the robot. The maximum achievable translation speed is about 1,5 m/s, the maximum rotational speed is $2\ \pi$/s. The robot can carry weights up to 20 kg and can be equipped with a maximum of three 7,2 Ah batteries, which allows an operating time with all additional hardware like PC and sensors of nearly three hours without recharging.
As the basic platform for the goal keeper we are using a Pioneer AT. Each of the four wheels of this robot is driven by its own motor. The wheels on each side are coupled with a belt. The battery with a capacity of 12Ah allows an operating time with our additional hardware of 1.5 hours.

2.2 Sensors and actuators

As we are convinced that better sensors will result in a better situation assessment and, ultimately, in better playing capabilities, we try to employ a diversity of sensors on the robot. Therefore we are considering the use of the following sensors: Sonars, 2d laser scanner, color camera, 360^0 camera.

Sonars: The Pioneer2 DX is equipped with eight, the Pioneer AT with seven Polaroid 6500 Ultrasonic transducers, which are mounted in front and at the front side of the robot.

Laser scanner: The employed laser scanner is a LMS200 from SICK AG. It has a 180^0 field of view and a maximum angular resolution of $0{,}25^0$. It can measure distances up to 15 m with an accuracy of 10 mm. With a resolution of 1^0 and a total field of view of 180^0 and 500 kbps data transfer rate over a RS422 serial device the achievable scan rate is nearly 40 Hz. Its main drawbacks are its size (137*156*185 mm), weight (4,5 kg) and power consumption (max. 17,5 W).

Color camera: For the task of object detection and classification we are using two vision systems. Both systems use a Siemens SICOLOR C810 CCD-DSP color camera, with a 1/3 inch CCD-chip and a resolution of 752x582 pixel. The output format is a regular CCIR-PAL signal with 625 rows and 50 half frames per second. One of the cameras is mounted at the front of the robot. This camera is equipped with a 2,8f wide angle lens. It is mainly for the detection of the ball and the objects, which lie in front of the moving robot.

360^0 camera: The second camera is mounted in an omnidirectional vision system, which is mounted at the top of the robot. A 4,2f lens is mounted at this camera, to achieve a large visual field. In contrast to most other omnidirectional vision systems this design has a paraboloid mirror instead of a conical mirror. This should give a better mapping of objects below the horizon ([3]).

Kicker: We developed two different kicking devices. A pneumatic one which consists of a pneumatic cylinder, an electric valve, and a tank for compressed air. The second kicking device is based on a spring mechanism wound up by a BMW car windshield wiper motor.

2.3 Onboard Computer

The onboard computer is a custom design based on standard PC parts with custom enclosure and is mounted at the rear top of the robot. Each PC has a 400 MHz AMD K6 CPU, 64 MB RAM and a 1,2 GB Hard Disk Drive. Additionally each computer is equipped with two PCI framegrabbers with a Booktree BT484 chip. These devices deliver images in YUV-format at 25 fps (PAL) and a maximum resolution of 768x576 pixels. For the connection to the laser scanner a high speed RS422 serial card was modified to achieve a data rate of 500 kbps, the highest data rate supported by the laser scanner. For the communication between the robots and to an external file server wireless PCMCIA Ethernet cards in PCMCIA to ISA adaptors are used. They were sponsored by ARtem Datentechnik, Ulm, and work at data transfer rate of 2 Mb/s.

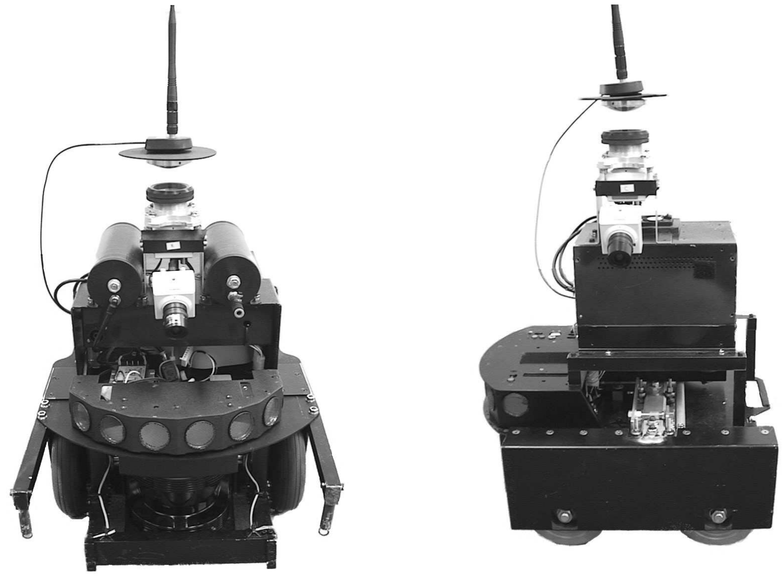

Fig. 1. The Attempto-Team robots

3 Research Topics

Our main research interests includes the accurate and robust modeling of the dynamic RoboCup environment since in our opinion this is the foundation for a effective operation in dynamic environments [5]. In contrast to the paradigms of strict behavior based approaches we think it is necessary to have such an internal representation of the surrounding world as the basis for a suitable robot action selection process. Using only an actual "snapshot" of raw sensor data without taking into account previous recorded data or the prediction of object properties like position and velocity leads to several problems:

1. An object can temporarily be hidden by another object and therefore not longer be detected by the sensors, though it is still there, since physical objects do not tend to disappear.
2. It is not possible to derive any information about the dynamic properties of a moving object. Therefore it is not possible to predict the further behavior of this object for e.g. obstacle avoidance or ball following reasons.
3. Usually raw sensor data are used to extract more complicated features. If this extraction is not stable the sudden appearance or disappearance of a certain feature can lead to an undesired behavior of the robot. If for example a robot in a RoboCup environment is moving with the ball and suddenly by changing lighting conditions the ball is not longer detected as a ball but as

an unknown object the robot should try to avoid this object since it is not preferable to collide with it.

To solve the mentioned problems we are developing a probabilistic based representation of dynamic objects. The task of modeling a dynamic object in this representation comprises the following steps: sensor data processing to extract features representing an object, association of the features to certain object tracks, track maintenance, i.e. track initiation for newly detected objects, track confirmation for existing objects and track deletion for objects which could not be confirmed for a defined time. The filtering and prediction of the object tracks is the last step and closes the loop, i.e. the next step is again the association of derived features to object tracks.

4 Summary and Discussion

This paper described the hardware of our RoboCup team and the interesting and challenging problems of modeling dynamic aspects of the RoboCup scenario which we want to address in our work. Our approach so far has been hardware oriented: we tried to find the most capable robot platform within our budget and tried to maximize the number, diversity and the quality of our sensors. At the moment we are using sonars, a wide angle color camera, an omnidirectional camera, a compass and a 2d laser range finder. Our underlying assumption is that at the current state of RoboCup play, improving the sensing and prediction capabilities will give a higher payoff than raising the speed of the robots or the onboard processing power or the "intelligence" of the robots. This is in contrast to the simulator or small size league, where all robots nearly have the same sensing capabilities. Our choice of sensors dictated the use of our pneumatic kicker and also the use of a larger PCI bus PC system with two frame grabbers. We use heavily specialized and optimized vision algorithms to keep the vision processing requirements low.

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