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Hardware design and distributed embedded control architecture of a mobile soccer robot

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ABSTRACT

Designing robust, modular and fast mobile robots, operating in high dynamic environments is a challenging task. This includes design of the mechanics and the control system of the robot. This paper presents the modular hardware design of a mobile soccer robot platform, including the mechanics, electronic system and the low-level distributed control architecture of the robot. The basic idea behind this paper is not to introduce a new distributed control architecture, both at low and high levels of control, but to focus on a novel approach to manage the distributed control system of a single robot, consisting of a number of microcontroller based modules connected together through a data bus.

1. Introduction

RoboCup is an international research and education initiative. Its goal is to foster artificial intelligence and robotics research by providing a standard problem where a wide range of technologies can be examined and integrated. In RoboCup middle-sized league, robots with maximum area of 50 cm × 50 cm play soccer in teams of up to five robots with an orange soccer ball on a field the size of 12 × 18 m. Matches are divided in 15-min halves. All sensors of the robot are on-board and the robot communicates with its teammates via wireless networking [26].

Since 1999, the RFC Stuttgart, formerly known as the CoPS-Team, successfully took part in RoboCup tournaments. In the year 2003 the decision was made to develop a customized robot for RoboCup competitions in middle size league. The first model was designed from scratch and constructed for the RoboCup World competitions 2004 in Lisbon [2]. The team successfully participated in the competitions and achieved the third place. Since then, newer robot models have been designed and different improvements and modifications have been applied to the robot platforms. RFC Stuttgart participated with the second model in the RoboCup competitions in Germany in 2006 and achieved the second place in the competitions [11].

Based on the experiences, achieved in the last 10 years of RoboCup mid-size league participation, a new robot, named RFCBot, is designed and constructed in order to further enhance the performance of the robot. The new robot does not have the drawbacks of the former models, e.g., lack of modularity and ease of repair. Furthermore it has significant improvements in robot dynamic, stability and robustness. With this new robot the team participated in the RoboCup competitions 2009 in Graz and became the world champion of the middle-sized league.

The modular hardware design, including the mechanics and the electronic system of RFCBot, is introduced in this paper. The high robustness, high velocity and ease of maintenance let the robot to be an appropriate choice for the high dynamic environments like RoboCup scenario. The modular design of the robot lets it to be easily used in other robotic applications by removing some parts and adding extra components, e.g., laser scanners. The distributed control system of the robot, studied in this paper, is based on the usage of a number of microcontroller based units, connected together through a CAN bus. CAN protocol, originally developed by Bosch GmbH [3] for automobile industry, is used extensively in robotic applications. Distributed robot architectures, using CAN (e.g. due to its low price and its simple usability and reliability), is investigated in robotic applications by many researchers. In [8] a walking robot is investigated, in which the controller nodes communicate with each other over a CAN bus. In [28] a hybrid approach is shown, where centralized and local controls coexists and cooperate with a distributed approach for low-level control of a humanoid robot to provide robust and versatile operation using a CAN bus.

Managing the communication over the CAN bus is an important issue in the robotic applications, in which CAN bus is used as the data bus to connect together the microcontroller modules. A novel method for managing the CAN nodes of a mobile robot is introduced in this paper. The method points two significant targets. It manages the communication through different types of communication links in a distributed control architecture, e.g., communication with CAN nodes over a CAN bus or communication with other software modules over software pipes. On the other hand, the

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