DEVELOPMENT OF A SOCCER ROBOT

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Abstract: Introduction, technical parameters and rules of soccer robot game are described. A developed soccer robot is presented. Control system of a Soccer robot is described. Soccer robot as an example for "Multi-Agent Systems" is discussed. Market potential of Entertainment robot is introduced.

Keywords: Soccer Robots, “Multi-Agent Systems“, Entertainment Robot, Mobile Robot.

1. Introduction

Robot soccer is the implementation of well-known soccer game using intelligent mobile robots. There are several game categories, which can be divided by the form, number of players as well as the size of playground and other criteria.

Our soccer robot in the category of MiroSot, is a two wheel driven mobile robot whose size is limited by the rule - 7.5 cm * 7.5 cm * 7.5cm (Length*Width*Height). An orange golf ball shall be used as the ball. Three human team members, a "manager", a "coach" and a "trainer" shall only be allowed to make competition (see Fig. 1).

In order to identify the robots and the ball on the playground, a vision system can be used.

The duration of a game shall be two equal periods of 5 minutes each, with a half time interval for 10 minutes. An official timekeeper will pause the clock during substitutions, while transporting an injured robot from the field, during time-out and during such situations that deem to be right as per the discretion of the timekeeper. Normally a game takes about 45 minutes.

The manager, the coach or the trainer may transmit certain commands directly from the remote host computer to their robots. It is not allowed to transmit commands such as reset signals to stop any/all of the robots or restart signals, without the permission from the referee. Any other information, such as game strategy, can be communicated to robots only when a game is not in progress. While a game is in progress the host computer can send any information autonomously.

A goal shall be scored when the whole of the ball passes over the goal line. The winner of a game shall be decided on the basis of the number of goals scored.

A foul can be called by the referee. After each interruption the robots should be positioned automatically or by hand of a team member in the distinct position defined by the rule according to the situation. For more details for the rules, please visit FIRA.

Our robots of the MiroSot game category are a kind of computer remote-controlled cars. In order to detect the position of robots and ball a color-CCD-Camera is mounted above the playground (approx. 2 m) which delivers 60 pictures per second of the field to the computer.

Using pictures the vision system calculates the position and orientation of his own and the opposite robots. To calculate the position of objects on the playground, color markers are attached on the top side of the robot. In the team computer - a standard PC - the software for image processing, strategies, path planning and communication is implemented. The computer communicates with the own robots of by radio communication and sends them the motion commands.
A robot soccer team has three human members;

- Manger - determining game strategies
- Coach - working at computer
- Trainer - arranging the robots on the playground.

The tasks of the host computer are in general:

- a vision system to calculate robot position and orientation
- generation of motion commands according to predefined game strategies
- communication with the robots (motion commands)

Another important point is the game strategy. In real word soccer if a team wins the players are heroes. If they loose the match the trainer is blamed. At robot soccer the situation is almost same. In order to win a real soccer game each player should be fast and strong, the game strategy should be good, the player should follow the command of the trainer. In the robot soccer the robot should be able to rapidly and exactly move, the team has to have good game strategies, like to pass the ball and to make set plays and robust communication between computer and the robots.

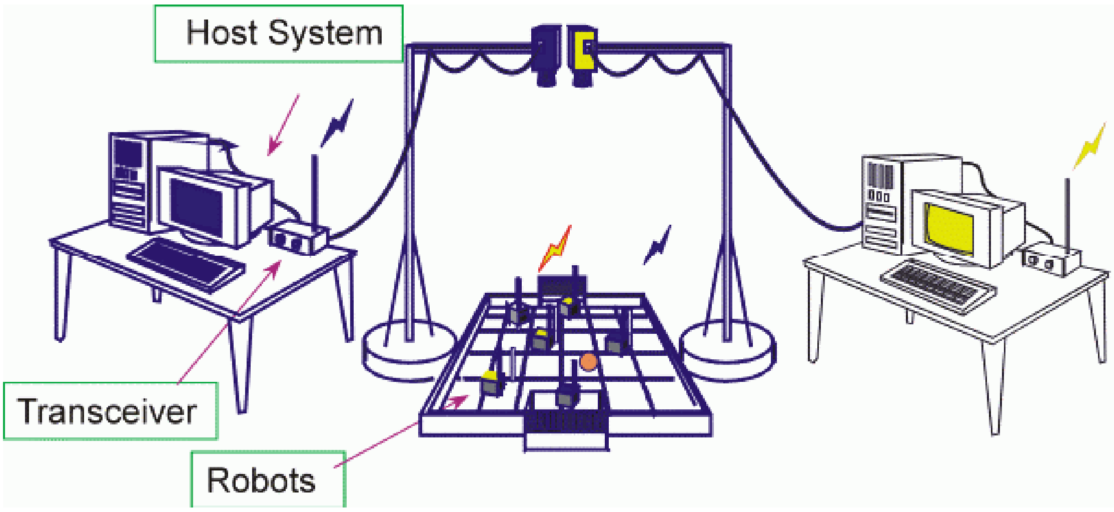

Fig. 1 Typical Robot Soccer Game Configuration

2. Mechanical system

Soccer robots consist of 2 wheels driven by gear-motors and driving belt mechanisms, robot body, microprocessor controller, RF module and batteries.
The expected technical performances of the soccer robot are presented in Table 1

Parameters	Soccer robots
Size	7.5x7.5x7.5 [cm]
Rotation Speed	Up to 215 rpm
Gear ratio	10:1
Maximum torque	1.5 Ncm
Weight	App. 325 g

Table.1 Technical Parameters of Soccer Robots

Using CAD software program SOLIDWORKS 2007 we have made a 3D model of the soccer robot (see Fig. 2).

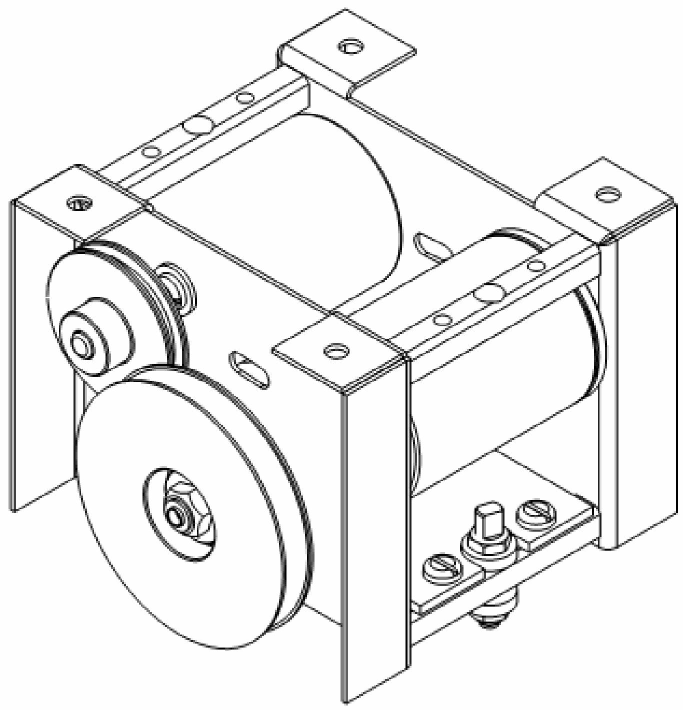

Fig. 2 3D Model of Soccer Robot

Calculating the stability of our Soccer robot, we have to know the mass properties of the robot (Density, Mass, Volume, Surface area etc.).
The most modern way to do so is to use one of the existing computer programs for modeling of the soccer robot.
Mass properties of Soccer robot
Output coordinate System: Coordinate System1
Density = 0.00 grams per cubic millimeter
Mass = 325.71 grams
Volume = 86644.02 cubic millimeters
Surface area = 62341.51 square millimeters
Center of mass: (millimeters)
X = 0.00
Y = -0.01
Z = 12.31
Principal axes of inertia and principal moments of inertia: (grams * square millimeters)
Taken at the center of mass.
Ix = (0.33, -0.95, -0.00) Px = 172490.05
Iy = (0.95, 0.33, 0.00) Py = 239838.33
Iz = (0.00, -0.00, 1.00) Pz = 267286.90
Moments of inertia: (grams * square millimeters)
Taken at the center of mass and aligned with the output coordinate system.
Lxx = 232695.54 Lxy = -20737.28 Lxz = -12.47
Lyx = -20737.28 Lyy = 179632.85 Lyz = 38.24
Lzx = -12.47 Lzy = 38.24 Lzz = 267286.88
Moments of inertia: (grams * square millimeters)
Taken at the output coordinate system.
Ixx = 282050.17 Ixy = -20737.28 Ixz = -4.84
Iyx = -20737.28 Iyy = 228987.47 Iyz = 14.85
Izx = -4.84 Izy = 14.85 Izz = 267286.89

3. Control System

The general structure schematics of the system for control of our robot is realized by use two hierarchical levels (see Fig. 3).

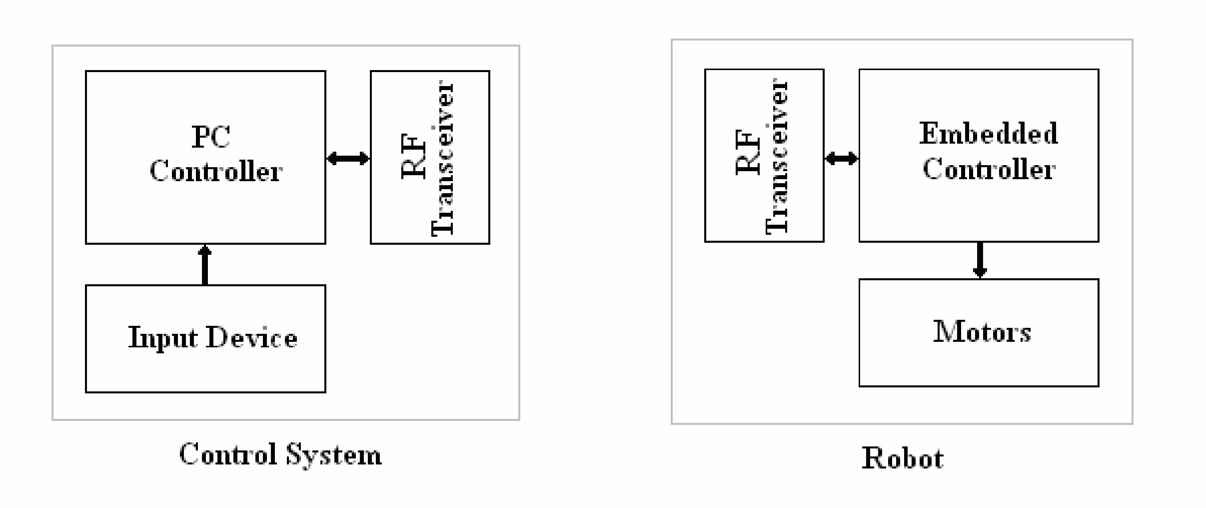

Fig. 3 Soccer Robot Control System

The PC is to be used at the High-level while the low level is to be designed on the basis of identical modules which use Atmel's ATtiny2313 MCU microcontroller. The Interface between PC (High-level) and controlling modules (low level) can be made by using a standard RF interface.
The system allows for precise positioning and monitoring of robot coordinates. The user interface allows for convenient human interfacing. Most components are standard and RF communication is very common in the field of short-distance remote control.

- Functional description

The control system consists of a PC (Main Controller), a RF Transmitter and an Input Device.
PC Controller is common-purpose computer, which performs main functions of accepting user commands and passing them to the robot through the RF interface.
RF Transceiver may be internal or external to the PC.
The Input Device is appropriate Human Interface Device (HID).
The Robot has an embedded controller which accepts user commands through RF module and controls the DC motors for performing the requested operations.

- Embedded controller description

The embedded controller module is implemented with Atmel's ATtiny2313 MCU. This microcontroller, being cheap and small in resources, is very fast for its class (up to 24 MIPS at 24 MHz clock), and has several special features that make it ideal for the given application. It's fast speed helps to implement simple firmware-only RF communication stack that minimizes the number of external parts, reduces the EMF (Electro Magnetic Field) noise and improves stability. The built-in PWM (Pulse Width Modulation) block makes it easier to control the speed of DC motors.

4. Robot soccer

Robot soccer is an example for "Multi-Agent Systems" (MAS) - intelligent robots working together cooperative and coordinated. They can split a task between them, communicate with each other and act autonomous. All the "players" have the common objective, to win as high as possible.

The game runs in a very dynamic environment. Every robot must complete his task between fixed (field border) and moving (other robots, ball) obstacles.
Robotsoccer is a very good test-bed and tool for following applications, like:

- Navigation of a mobile robot
- Multi-Agent System (MAS)
- Robots for entertainment, leisure and Hobby
- Education

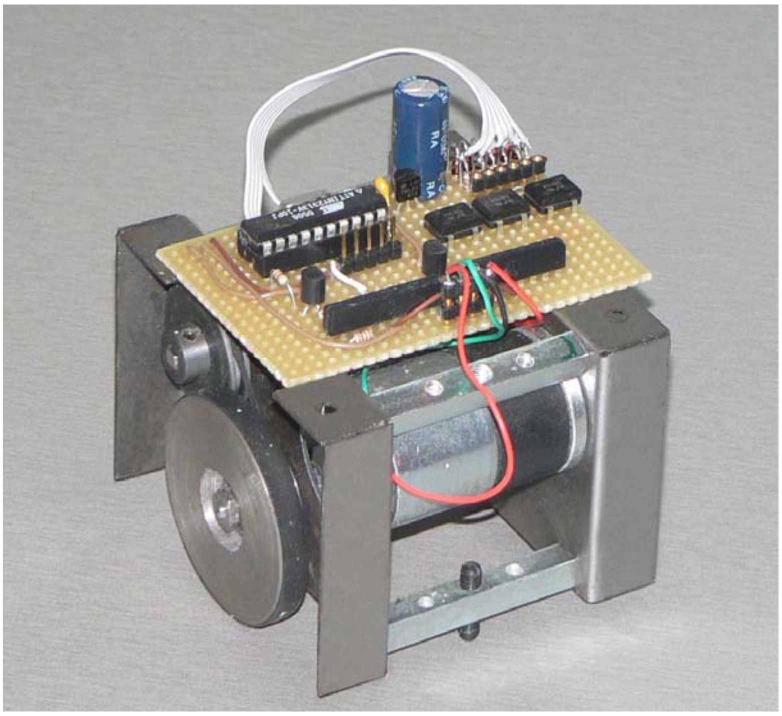

Fig. 4 Soccer Robot

Behind the playful application of Multi-Agent Systems as robot soccer there already are industrial applications. Driver-less transportation systems in today's production can be replaced. They can only move on pre-defined routes - induction rings in the floor - which can lead to well known traffic jams. With future transportation the robots can not only move freely, they can also split the tasks in an optimal way.
Robot soccer is also a good tool for education, because robot soccer is an interdisciplinary research subject. Like the mathematic or chemistry olympiad there is a robot olympiad in which kids from elementary school up to students can participate. Requirements are of course knowledge in the areas of programming, electronic, communication etc.
For robot soccer game, following components are necessary:

Hardware

- Mobile Robots
- Color-CCD Camera and Frame grabber card
- Computer
- Communication modules

Software

- "Graphic User Interface (GUI)"
- Image processing
- Communication protocol
- Game strategies

Robot soccer is a classic mechatronic system - an integration of fine mechanics, electronics, control techniques and information techniques. Therefore many known theoretical methods from these research areas like

- Navigation
- Image processing
- Intelligent control
- Sensor
- Communication
- Mechatronics

are applicable. At robot soccer you soon reach the limits of such methods which creates the need for new developments.

5. Conclusion

The importance of robotics for the development of the world economy was understood by the United Nations quite in time and this field is monitored yearly. A study made by the experts of the United Nations together with the International Federation of Robotics (IFR) is covering the statistics, market analysis, case studies and profitability of robot investment. According to these studies at least 919725 entertainment, toy and hobby robots are estimated to have been sold up to the end of 2004. About 2.5 million units are forecast for 2005-2008. The sales value is estimated at over 4.4 billion.

These data are showing the large market potential of robots for entertainment, leisure and hobby.

Behind the playful application of robot soccer, there already are industrial applications with intelligent robots working together cooperative and coordinated.

Robot soccer is also a good tool for education, because robot soccer is a classic mechatronic system including integration of hardware electronics, software and fine mechanics.

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