A smart phone soccer robot for the AMiRESot League

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Abstract—After a brief summary of the motivation for the AMiRESot robot soccer league and its origins, this short article describes the low cost Smart Phone Autonomous Mini Robot (AmRo-SP) suitable as a player for the AMiRESot league.

I. THE ROBOT SOCCER GRAND CHALLENGE

The idea of using the soccer game played by robots as a Grand Challenge problem in Artificial Intelligence, at par with other landmark problems such as computer chess, arose in 1992 (RoboCup.org 2012). Robot Soccer was to provide a platform for research into design principles of autonomous agents, multi-agent collaboration, strategy acquisition, real time reasoning and sensor fusion (Kitano, Asada, Kuniyoshi, Noda, and Osawa 1995). Yearly international robot soccer championships in various leagues have been held since 1996.

Later, in 1998, Kitano and Asada (Kitano, Asada, Noda, and Matsubara 1998) formulated the grand challenge as follows:

By mid-21st century, a team of fully autonomous humanoid robot soccer players shall win the soccer game, comply with the official rule of the FIFA, against the winner of the most recent World Cup.

H. Kitano and M. Asada IROS 1998

In contrast to the abstract computer challenge, where the IBM Deep Blue team defeated world champion Garry Kasparov in 1997, the robot soccer challenge is grounded in the real world by sensing the environment and acting on it to fulfill a purpose. Winning a soccer game is a collaborative task requiring fast decisions by the players in a highly uncertain environment strongly dependent on the actions of the all the players on the field. Robot soccer in its various leagues provides a benchmark for fast moving multiple robots that collaborate on a collective task. Once science and technology have met the robot soccer grand challenge, a very large portion of the obstacles on the path to building useful autonomous machines for a wide range of tasks, such as mobile factory robots with the versatility of human workers, personal robot assistants, care robots, rescue robots and many more, will have been overcome. Many of the technical and scientific challenges on the road to these goals are present in the soccer game. Just imagine having at your service a machine that has the speed and dexterity of a human soccer player and its ability to quickly react to a fast changing external situation!

The robot soccer game has made astounding technical advances since its introduction in the mid 1990s, and has spurred many lines of robotics research (see for example the work by Manuela Veloso). Despite its advances there is still a long but promising road ahead. The surface has barely been scratched. The robot soccer grand challenge poses an ambitious goal. We can expect many technical spin-offs along the road to its achievement. The robot soccer game, or for that matter any similar physical team game, provides a well defined, yet evolving benchmark problem, that by lacking any direct commercial value is on neutral ground for private and industrial players to collaborate.

II. THE AMiRESOT LEAGUE

As by 2013, robot soccer championships are played in two main leagues: RoboCup and FIRA (Federation of International Soccer Associations). RoboCup is the one that aligns more closely with the robot soccer Grand Challenge. The participant teams mainly come from tertiary institutions and are run by groups of research students. The FIRA league focuses predominantly on the educational benefits of robot soccer to high school and undergraduates. Consequently the RobCup is the one that needs more resources for participation. Within each league there are several categories with their own degree of difficulty and cost. Robot soccer has benefitted from the worldwide popularity of soccer as a spectator sport. Thereby robot soccer has been a very successful motivator for students to learn about science and engineering. Robot soccer is open for wide participation at all levels of technical competency from primary to graduate school. This very positive characteristic of robot soccer has nevertheless overshadowed its unique features as a technological grand challenge.

In 2008 we wrote the rules for another league, the AMiRESot league, with the purpose to provide a lower cost entry into the robot soccer game while at the same time presenting significant technical and research level challenges that can grow over many years to come. The defining demand of the AMiRESot league is that the soccer robots be fully autonomous. The second defining demand is that the robots be small. The size limitation is intended to reduce cost and space requirement, but on the other hand it creates the challenge of packing the needed computational and sensing resources into a small space at the lowest possible cost. Efficient use of resources becomes a central issue. Despite the recent trend towards humanoid soccer robots we decided to stay with wheeled robots. For the time being we see the effort required in building fast walking robots as a distraction from the objective of developing collaborative behaviours. We see fast locomotion as an essential constraint within which collaborative behaviours have to function. It is simple to make wheeled
Autonomous mobile robots compliant with size restrictions and yet capable of playing a soccer game under the AMiRESot rules not available for purchase. Although their mechanical construction is not difficult the required electronics hardware requires advanced electronic design capabilities. In 2011 (Tetzlaff and Witkowski 2012), presented a prototype mini-robot for the AMiRESot league and Herbrechtsmeier et al. (Herbrechtsmeier, Rueckert, and Sitte 2012) described a full featured design, yet under construction, of an autonomous mini-robot for research and education suitable for the AMiRESot league. Both design required the fabrication of custom designed printed circuit boards (PCB). Thus the barrier for entering the AMiRESot soccer league remained still too high for the majority of interested teams.

A. AMiRo base for Smart Phones

In search for lowering the entry barrier to the AMiRESot league Ulf Witkowski’s group at the Technical University of South Westfalia presented the prototype mini-robot for the AMiRESot league shown in Figure 1 that consists of a mobile base that acts as an USB device to a smart phone. The smart phone is fitted on the AMiRo-SP (Smart Phone) base with the phone camera looking forward to capture the scene in front of the robot. Smart phones provide computing power, communication, camera and sensors in a small package at a low cost that a custom design cannot match. Google provides, free of charge, the Android Software Development Kit (SDK) that has all the necessary tools for writing application software for Android phones.

The AMiRo-SP base is cylindrical with 100 mm in diameter, as required by the AMiReSot rules, and provides two-wheel differentially steered locomotion. Each wheel is driven by its own motor equipped with optical shaft encoders. Two batteries power the motors and the main circuit board. The base has 8 infrared proximity sensors placed uniformly spaced around the periphery of the body. A single PCB board has a 32 bit micro-controller with an ARM Cortex-M core that runs the drivers for the motors, shaft encoders, IR proximity sensors and the USB client port. A server program executes the motor control and sensor reading commands issued by the client robot behaviour program running on the smart phone. The base give mechanical support for an Sony Xperia smart phone that connects to the base over an USB cable.

Vision, accelerometer, compass, gyroscope sensors and Wi-Fi and Bluetooth communication are all handled by the client robot behaviour program, written in Java, running on the smart phone. Everything for writing soccer playing apps for the smart phone is there.

REFERENCES


