Autonomous Robotic Soccer

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I am very pleased to introduce this issue of **it – Information Technology** to the journal readers. The articles in this issue provide a very good overview of the work done within the framework of the RoboCup initiative. The first RoboCup, the world championship in robotic soccer, was held in 1997 in Nagoya (Japan) as part of the International Joint Conference in Artificial Intelligence, IJCAI 97. Since then, RoboCup has been held every year in a different city. In July 2005, RoboCup was held in Osaka (Japan) and it will take place in Bremen (Germany) during June 2006.

Robotic soccer is a new benchmark and a laboratory for artificial intelligence. The late *Herbert Simon*, one of the founding fathers of AI, once said that it is more difficult to simulate a bus driver than a professor. A professor follows abstract logical rules, like a chess player, and arrives to a mechanical conclusion. However, a bus driver must process visual scenes in real time, must predict the movement and behavior of many objects, must operate the machine, and must guarantee the safety of the passengers. That is, it is much more difficult to build an autonomous vehicle, a driver-less car, than it is to prove geometry theorems.

Solving problems in the field of computer vision, multiagent communication, behavior control, top-down and bottom-up planning, etc. requires an appropriate laboratory. It is still too difficult (and too dangerous) to try to operate autonomous robots in an open environment such as a street or an office. Robotic soccer provides such a laboratory: a controlled yet non-trivial environment, where the main problems regarding autonomous robots can be dealt with. The possibility of comparing solutions, the tournament setting, has also mobilized many research groups from around the world, because it is not the same to test an algorithm than to test it against an adversary. More than 230 teams of roboticists were present during RoboCup 2005 in Osaka and played in the different RoboCup leagues: simulation, small-size, mid-size, AIBO, rescue, humanoid, and others.

The articles in this issue deal with interesting research aspects in the different RoboCup leagues. *Martin Riedmiller* and *Daniel Withopf* deal first with the simulation league. Here robots are simulated in a computer. Such a simulated platform makes possible to apply algorithms in which agents learn from repetitive experiments. Riedmiller's team, the Brainstormers, has been very successful in the last years because they have been able to avoid programming agent behaviors by hand. The simulated robots learn by doing, that is, by using reinforcement learning. How this can be done in the multiagent domain is explained in their contribution. *Alexander Gloye* et al. explain in their paper how to detect a malfunctioning robot using a video camera and how the control modules can learn to suppress hardware errors. We would like to build autonomous robots which can self-repair when they are far away from their basis and can finish a mission. The robots Gloye et al. use as example are from the small-size league (robots with 18 cm diameter) and the results are very promising. *Felix von Hundelshausen* explains in his paper how an autonomous robot can self-localize in a large arena using only a video camera. Visual features of the field are used to achieve localization and the problem is solved using computer vision algorithms. This is remarkable, since only a few years ago the best mid-size robots (50 cm in diameter) were still using laser scanners for localization. Now this can be done with the computer power provided by a subnotebook processing 30 frames per second. *Thomas Röfer* provides ample information in his paper about the AIBO robots used in the league of the same name. The AIBO is a commercial robot with many degrees of freedom. The main challenge when using such robots for robotic soccer is to program the computer vision and the correct control of the robotic limbs. The processing power is limited and the quality of the video images is compromised by the pose of the robot. Computer vision and control are intimately connected in this kind of robotic platform – Röfer explains how such problems have been solved by the "German Team" competing in RoboCup. The German Team has been world champion twice (in 2004 and 2005).

RoboCup is an artificial laboratory but has been trying to reach the "real world" of autonomous robotics through a set of initiatives. *Thomas Wisspeintner* and *Abheek*

Bose explain in their paper how they designed a generic robot for many kinds of applications. The "Volksbot" is a modular platform, a kind of construction kit from which soccer but also special robots can be built. Just recently, Wisspeintner could show a robot, built from Volksbot components, which can be used outdoors and can climb stairs. The mechanics of the robot was evolved in a computer. Surmann et al. describe the robots developed at the Fraunhofer Society for the RoboCup rescue competition. Here, autonomous robots have to move in difficult terrain, self-localize, build a map of the environment, and find victims. *Hartmut Surmann* et al. explain how this is done, the kind of sensors used, and open research problems in the field of rescue robotics.

The final goal of the RoboCup initiative is to build anthropomorphic robots, that is humanoids, which can eventually be competitive against human opponents. This is a kind of "Turing Test" for robots which will take decades to pass. However, the first humanoid robots which can swiftly move on a field and which can process images with small on-board computers are already being built. *Sven Behnke* gives an overview of this work in his paper, and also of the kind of robots he has been building.

I hope that the papers in this issue answer many of the questions I have heard from interested colleagues in the last years. It is important to realize that we are building soccer robots just as a first step towards other kinds of autonomous robots. In the future there will be robots everywhere: robots which can clean large spaces, security robots, robots which explore other planets or tough environments, even service robots at home. The form of the robots will be specialized to their function. A washing machine is, in principle, already a robot which only has to be made somewhat more autonomous. We will not see humanoids walking around in the streets, as science fiction films suggest. There will be an ecology of robots in which specialized niches require specialized form. But there will be also humanoids, just because we want to understand humans, and the best possible way to understand a human is by building one. This objective is probably unachievable, but provides a research horizon towards which we are progressing. We may never reach the horizon, but we will find and solve many interesting problems during our journey.

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