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Michael M. Richter (Eds.)

Case-Based Reasoning Research and Development

7th International Conference
on Case-Based Reasoning, ICCBR 2007
Belfast, Northern Ireland, UK, August 2007, Proceedings

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Rosina O. Weber
The iSchool at Drexel
College of Information Science & Technology
3141 Chestnut Street, Philadelphia, PA 19104, USA
E-mail: rweber@ischool.drexel.edu

Michael M. Richter
TU Kaiserslautern
Department of Computer Science
P.O. Box 3049, 67618 Kaiserslautern, Germany
E-mail: richter@informatik.uni-kl.de

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Preface

The International Conference on Case-Based Reasoning (ICCBR) is the pre-eminent international meeting on case-based reasoning (CBR). ICCBR 2007 (http://www.iccbr.org./iccbr07/) was the seventh in this series, presenting the most significant contributions in the field of CBR. The conference took place in Belfast, Northern Ireland, UK, during August 13-16, 2007. ICCBR and its sister conferences ECCBR (European Conference on Case-Based Reasoning) alternate every year. ICCBR followed a series of six successful international conferences previously held in Sesimbra, Portugal (1995); Providence, Rhode Island, USA (1997); Seeon, Germany (1999); Vancouver, Canada (2001); Trondheim, Norway (2003); and Chicago, Illinois, USA (2005). The European Conferences on Case-Based Reasoning (ECCBR) were held as European workshops in Kaiserslautern, Germany (1993); Chantilly, France (1994); Lausanne, Switzerland (1996); Dublin, Ireland (1998); and Trento, Italy (2000); and as European conferences in Aberdeen, UK (2002); Madrid, Spain (2004); and Lykia World, Turkey (2006).

Days one, two, and four comprised presentations and posters on theoretical and applied CBR research. In order to emphasize the importance of applications, the traditional industry day was converted into an Industry Program held on the second day, in the middle of the conference. Day three was devoted to five workshops: Case-Based Reasoning and Context-Awareness; Case-Based Reasoning in the Health Sciences; Textual Case-Based Reasoning: Beyond Retrieval; Uncertainty and Fuzziness in Case-Based Reasoning; and Knowledge Discovery and Similarity.

There were four distinguished invited speakers. Two speakers from the CBR community, David W. Aha (Naval Research Laboratory, USA) spoke about perceptions of CBR, while Eva Armengol (IIIA-CSIC, Spain) talked about usages of generalization in CBR. Hans-Dieter Burkhard (Humboldt University, Germany) described the use of cases in robotic soccer, and Larry Kershberg (George Mason University, USA) presented the role of XML databases in CBR. Thanks to their commitment and ideas.

The presentations and posters covered a wide range of topics, including adaptation, planning, learning, similarity, maintenance, textual CBR, and recommender systems. This volume includes 15 papers from oral presentations and 18 from posters. These were chosen from a total of 64 submissions originating from 25 different countries. In addition, the volume contains three papers from invited speakers. The accepted papers were chosen based on a thorough and highly selective review process. Each paper was reviewed and discussed by four reviewers and revised according to their comments.

There were many people who participated in making ICCBR possible. First of all, David W. Patterson (University of Ulster, Northern Ireland, UK) –the Conference Chair who had the initiative to propose ICCBR 2007. The organization team was very diverse, having David C. Wilson (University of North Carolina, USA) and Deepak Khemani (IIT Madras, India) as coordinators of the Workshop Program. Thomas Roth-Berghofer (DFKI, Germany) chaired a Steering Committee for the Industry Program that included Kareem S. Aggour (General Electric CRD, USA), Bill

Cheetham (General Electric CRD, USA), Mehmet H. Göker (PricewaterhouseCoopers, USA), and Kalyan Moy Gupta (Knexus Research Corp., USA).

Mirjam Minor (University of Trier, Germany) coordinated the contacts with CBR researchers who have published work outside ICCBR and ECCBR conferences. We invited those researchers because we wanted to bring to the ICCBR audience a complete view of recent advances in CBR.

This diverse team together with the authors, the Program Committee, and additional reviewers are the stars of the CBR community in 2007. They made the conference happen and we want to thank them for their brilliant performances that are recorded in this volume.

We would also like to acknowledge the thoughtfulness of David W. Aha, whose constant leadership and concern for the community are crucial to the success of ICCBR and ECCBR conferences.

We gratefully acknowledge the generous support of the sponsors of ICCBR 2007 and their, partly long-time, sponsorship of ICCBR and ECCBR.

Additional help was given by doctoral students from the iSchool at Drexel University. Thanks to Caleb Fowler for serving as webmaster and to Sidath Gunawardena and Jay Johnson for their help with this volume. In support of local arrangements, thanks to the Local Arrangements Committee from the University of Ulster: Patricia Kearney, Niall Rooney, Mykola Galushka, and Juan Carlos Augusto.

The submission and reviewing process was supported with the use of Conf Master.net - The Conference Management System. We would like to express our gratitude to Thomas Preuss. Finally, we thank Springer for its continuing support in publishing this series of conference proceedings.

June 2007

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ICCBR 2007 was supported by these organizations: DFKI (http://www.dfki.de/web), Drexel iSchool (http://www.ischool.drexel.edu/), empolis (http://www.empolis.com/), University of Ulster (http://www.ulster.ac.uk/), and Zerosolution Inc. (http://www.zerosolution.com/).

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Cases in Robotic Soccer

Hans-Dieter Burkhard and Ralf Berger

Humboldt University Berlin
Institute of Informatics
D-10099 Berlin
{hdb,berger}@informatik.hu-berlin.de

Abstract. Soccer playing robots are a well established test bed for the development of artificial intelligence for use in real environments. The challenges include perception, decision making and acting in a dynamic environment with only unreliable and partial information. Behaviors and skills for such environments must be optimized by experiences. Case Based Reasoning provides an excellent framework for learning as discussed in this paper.

1 Introduction

Early AI was based on symbolic descriptions of problems using logics, theorem provers and search techniques for solutions. There was a common understanding that chess programs could be a milestone to understand and implement intelligent behavior. Now we have machines that can play chess, but these machines are not considered to be really intelligent. We have learned that acting in the real world is much more difficult for machines. Machines are still far away from performing daily tasks. Therefore, the development of soccer playing robots has become a new challenge. The competitions in RoboCup are used to evaluate scientific and technological progress, similarly to the role of chess in the past.

The key problem of AI is the knowledge about daily life, how it is like to ride bicycle or to climb a tree, or simply to walk. Such skills are necessary to understand language, to interpret a scene given by visual sensors, or to decide what to do next. Human beings do acquire this knowledge by learning, by experiencing the environment, by collecting cases about good and bad behavior. Therefore, Case Based Reasoning (CBR) can be used as a basic technology together with other methods from Machine Learning. At the same time, CBR meets again its roots in cognitive science. It is still a challenge to understand how the experience can be stored and organized for later use. The scenario of soccer playing robots provides a lot of different tasks in dynamic real environments. The tasks include perception, skills and deliberation.

Because lack of space, we cannot give a detailed introduction to RoboCup. There are recently five different leagues, introduced to tackle different problems on the base of the available hard- and software. Real robots are investigated in the

- **Middle Size League (MSL)** with robots not exceeding a 50 cm diameter.

R.O. Weber and M.M. Richter (Eds.): ICCBR 2007, LNAI 4626, pp. 1–15, 2007.

- **Small Size League (SSL)** with robots not exceeding 15 cm in diameter.
- **4-Legged League (4LL)** with Sony's AIBO robots.
- **Humanoid League (HL)** with robots of human shape.

The **Simulation League (SL)** was established in order to explore more complex strategic and tactical behaviors which cannot be realized with real robots up to now. Besides individual programs for the 11 players, each team has a coach program for directing the playing style (while analyzing an ongoing match).

More information about RoboCup can be found on the website [1]. Recent developments are discussed in the article [2].

The paper is organized as follows: In Section 2 we start with a very short overview on the programming of soccer robots. It is the basis for the discussion of the Machine Learning tasks in Robotic Soccer in section 3. A discussion of the CBR related general problems is given in section 4, and section 5 gives short overviews about existing work using CBR in RoboCup.

2 Programming Soccer Robots

The robots in RoboCup have to act autonomously, no human interaction is allowed. In the so-called sense-think-act cycle they have to recognize the environment, to decide about their next goals and related actions, and to perform the actions using their skills.

The robots have to gather all needed information using their sensors. They have to process the sensory input to obtain a picture about the situation, the localization of the robot itself, of the other robots, and of the ball. Today, visual sensors are widely used to perceive the environment. Sophisticated algorithms for picture processing and scene interpretation are needed. Statistical methods like Kalman filters or particle filters are used for localization tasks. Not only the place but also the the direction and the speed of the ball are very important. Latency modeling (a good team in SSL has a latency of approx. 110ms) and prediction methods are important as well.

Especially the biped (humanoid) and quadruped robots (AIBO) need various proprioceptive sensors for observing and controlling their movements. Sensors for joint angles, forces, and torques measure the positions, directions and movements of different parts of the body.

Having a belief (not necessarily a true knowledge) about the environment, the robot has to decide for its next goals and actions. This means to check and to evaluate the own chances in comparison to the opportunities of other robots (team mates and opponents) on the playing ground. Therefore the robot needs knowledge about his own skills and about the results it can hopefully achieve.

There are different levels of control. On the lowest level, the robot has to control its body movements. In the case of humanoid robots it has to keep balance while walking or kicking. This needs a continuous interaction between sensor inputs and appropriate actions at the related joints. The compensation of an unexpected force by an adjustment of the heap is an example. It is still an open problem in the worldwide research on humanoid robots how this can be achieved best: how to couple sensors and actors, which sensors to use and where to place them, how to program the control etc. Recent efforts try to implement some kind of a spinal cord inspired by solutions from nature. Because of the lack of complete models, methods from Machine Learning are tested for the development of efficient (distributed) sensor-actor loops.

Having such basic skills like dribbling, intercepting or kicking the ball, the next level of control concerns the choice of an appropriate skill for a given goal. While the skill is performed, the robot has continuously to check the performance of the skill, e.g. maintaining control over the ball while dribbling. Again, a close interaction is necessary between sensors, control, and actuators.

On the highest level(s), tactical and strategic decisions can actually take place. Related reasoning procedures are especially studied in the simulation league because it is the only league which already uses 11 players per team.

3 Machine Learning Tasks in Robotic Soccer

As discussed in the previous section, a soccer program consists of modules according to a "horizontal" structure regarding the sense-think-act cycle, and a "vertical" structure of the levels (layers). The related modules can cooperate in different ways depending on the architecture in use. Visual perception, for example, is performed vertically starting with primitive image operations on the lowest level up to the scene interpretation using background knowledge (physical properties, design of the playground etc.) at the higher levels. Horizontal cooperation is necessary for the sense-think-act cycle.

Many of the processes inside the modules as well as the interconnections of the modules are subject to Machine Learning. Available data are incomplete and unreliable such that programming by hand leads to sub-optimal solutions. Moreover, optimal solutions are often too costly because of real-time requirements. Hand crafted systems in RoboCup were sufficient only during the first years. Now, all the good teams in simulation as well as in the real robot leagues use various Machine Learning techniques to a great extend. RoboCup has become an important scenario for development and evaluation of Machine Learning. The scenario of keep away soccer [3] has become a standard evaluation test bed for Machine Learning.

It is not possible to train all aspects of successful soccer playing in a single learning process. The overall learning task (how to win) has to be decomposed into smaller tasks. Up to now, the most scenarios investigated for Machine Learning in RoboCup are rather granular, but because of the interdependencies of the processes, the scenarios for learning are depending on each other. Actually, the pioneering work for multi layered learning came from the RoboCup community [4]. We will give some examples in section 5.

3.1 Perception

The players need to have beliefs about the movement of the ball, about their own position and the position of other players. In the early days of RoboCup teams