Ryszard Kowalczyk
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Advances in Artificial Intelligence

PRICAI 2000 Workshop Reader

Four Workshops held at PRICAI 2000
Melbourne, Australia, August/September 2000
Revised Papers

PRICAI 2000

Springer

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Preface

The Pacific Rim International Conference on Artificial Intelligence (PRICAI) is the leading conference in the Pacific Rim region for the presentation of research and the latest developments in Artificial Intelligence, including the application of AI to problems of social and economic importance. PRICAI 2000 was the sixth in the biennial series of conferences and was held in Melbourne, Australia, August 28–September 1, 2000.

The PRICAI 2000 workshops were designed to provide a forum for researchers and practitioners to present and exchange the latest developments at the AI frontier. Workshops are more specialized and on a smaller scale than conferences to facilitate active interaction among the attendees. They encourage AI theories to meet reality, AI researchers to work with practitioners, and vice versa. Through workshops, both sides get exposure to evolving research and tools, and to the practical problems to which AI can be applied. As an excellent indicator of the current level of active research and development activities, PRICAI 2000 included a total of seven workshops: *AI and the Internet*, *Intelligent Information Agents*, *Applications of AI in Industry*, *Multi-Agent Systems*, *Text and Web Mining*, *AI in E-Commerce*, and *Teams with Adjustable Autonomy*.

The work from four of the seven workshops has formed this unique collection of four parts. *Part I* reports on Applications of AI in Industry; *Part II* covers AI in E-Commerce; *Part III* details Intelligent Information Agents, and *Part IV* discusses the issues of Teamwork and Adjustable Autonomy in Agents. Each workshop paper was accepted after review by at least two experts. Further improvements were included in many papers in preparation for this collection. Readers can find diverse topics and careful discussions centered around the four important themes in our ever changing world. This collection plays an important role in bridging the gap between AI theory and practice, to emphasize the importance of AI in the research and development of Agents, E-Commerce, and in many real-world applications, and to publicize and extend AI technology to many domains in this fast moving information age.

The chairs of the workshops did an excellent job in bringing together many AI researchers and practitioners from the Pacific-Asia region and from all over the world. The well received workshops at PRICAI 2000 and the publication of this collection have convincingly shown the significance and practical impact of the work presented in this collection. Professor Nancy Reed's great effort in producing this special, fine collection will be applauded and appreciated by many. I am certain that this collection will stimulate more AI research and applications, influence many graduate students to conduct research and development in AI, and have a positive impact toward making our future better by creating an increasingly intelligent world.

June 2001 Huan Liu

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Part I

Applications of Artificial Intelligence in Industry

Artificial Intelligence in Industry

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Abstract. The Symposium on the Application of Artificial Intelligence in Industry was held in conjunction with the Sixth Pacific Rim International Conference on Artificial Intelligence (PRICAI-2000), Melbourne Australia, August 2000. It was the second of the Symposium series aiming to highlight actual applications of Artificial Intelligence in industry and to share and compare experiences in doing so. The Symposium brought together researchers and developers of applied Artificial Intelligence systems. The symposium is the leading forum in the Pacific Rim for the presentation of innovative applications of AI in industry.

1 Introduction

Artificial Intelligence techniques represent mature technology that have widespread application in many areas of industry. The application of Artificial Intelligence technology to industry has been happening, often quietly, for several decades. Success is often in making the techniques "disappear" into the functionality of the delivered system. Consequently, we do not always appreciate the wide application of AI.

In common with other computer systems, important issues related to building and deploying AI based production systems include: the development of domain-specific knowledge bases and ontologies; the development of domain specific tools, techniques and methods; systems architecture, systems and software engineering techniques and methodologies that are practical and effective; integration of AI systems with conventional database applications and legacy systems; the validation and verification of the functionalities and systems tuning for speed and efficiency. Other factors play a key role in determining the success of projects, including project, client, and management expectations, project planning, and social and cultural issues.

The objectives of the symposium were: to provide a forum for the discussion of innovative applications of AI in industry; to provide practising engineers exposure to and an evaluation of current research, tools, and practises in industry;

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to provide the research community a forum for exposing them to the problems of the practical applications of AI in industry; and to encourage the exchange of practical AI technologies and experience.

The selection of papers included in this volume brings together a collection that record varying degrees of application. Some propose techniques that are applicable to building industrial applications, while others report on industrial projects that are at various stages of implementation. Of particular interest are those that describe successful deployment in government and industry.

We trust you will find this selection of papers from the Symposium an interesting read and provide insights that you may be able to take advantage of in applying Artificial Intelligence solutions to real world problems.

2 Program Committee

We owe a considerable debt to the active members of the program committee for their efforts in carefully reviewing the papers and assisting the symposium chairs in their task of selecting papers that will be of interest to industry. The program committee consisted of:

- Leila Alem (CSIRO, Australia)
- Andrew Blair (BT Financial Group, Australia)
- Shu Heng Chen (National Chengchi University, Taiwan)
- Sung-Bae Cho (Yonsei University, Korea)
- Vladimir Estivill-Castro (Newcastle University, Australia)
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Applying Behavior-Oriented Robotics to a Mobile Security Device

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Abstract. The paper describes an industrial application of behavior-oriented robotics, the so-called RoboGuard. It is a mobile security device which is tightly integrated into the existing surveillance framework developed and marketed by Quadrox, a Belgian SME. RoboGuards are semi-autonomous mobile robots providing video streams via wireless Intranets to existing watchguard systems. RoboGuards fill several market-niches. Especially, they are a serious alternative to the standard approach of using Closed Circuit Television (CCTV) for surveillance. Low production cost and user friendliness were two important design targets for the actual mobile base of the RoboGuard, which were achieved by following the AI paradigm of behavior-oriented robotics.

1 Introduction

The RoboGuard allows remote monitoring through a mobile platform using onboard cameras and sensors. RoboGuards are supplements and often even alternatives to standard surveillance technology, namely Closed Circuit Television (CCTV) and sensor-triggered systems. The RoboGuard is a joint development between Quadrox [QUA], a Belgian security SME, and two academic partners, the AI-lab of the Flemish Free University of Brussels (VUB) and the Interuniversity Micro-Electronics Center (IMEC).

RoboGuards are tightly integrated into the existing range of products of Quadrox. This is an important aspect for the acceptance of any novel technology in well-established markets as customers are usually not willing to completely replace any existing infrastructure. For efficiency and security reasons, the RF-transmitted video-stream of the on-board cameras is compressed using a special wavelet-encoding [DC97]. The IMEC is the responsible partner for this feature of RoboGuard. The mobile base and its control, which are the main focus of this paper, are at the hands of the VUB AI-lab. The VUB AI-lab has a long tradition since the mid-1980s in basic research in the domain of behavior-oriented robotics. The expertise of the VUB AI-lab in this domain includes conceptual aspects as well as technological know-how, which are both incorporated in the RoboGuard system.

In accordance with recent interest in service robotics [Eng89], there has also been previous work on security robots. This work is widely scattered, ranging from unmanned gunned vehicles for military reconnaissance operations [AHE+90] to theoretical research on reasoning within decision-theoretic models of security [MF99]. Our approach deals

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with a system operating in semi-structured environments under human control and which is a product, i.e., it must be competitive to existing alternative solutions for the task.

The rest of this paper is structured as follows. In section two, a short introduction to the field of behavior-oriented AI is given and its relation to the RoboGuard project is explained. Section three presents the hardware aspects of a RoboGuard. In section four, the software side of the RoboGuards is introduced. Section five concludes the paper.

2 AI and Robotics

"Classical" robots as we find them today in industry rely very much on precise mechanics. This is necessary as these robots rely on exact models, for example to describe and compute their kinematics. The need for extreme precision puts high demands on the parts, the assembling, and the maintenance of these robots. The field of behavior-oriented robotics or the "artificial life road to AI" [Ste94a] on the other hand has come up with robotic systems which are much less demanding in this respect. The model-based control schemes are substitute by reactive ones [Bro86,Ste91], which establish close, dynamic couplings between sensors and motors. Instead of using complex models, sensor information is exploited as, as Rodney Brooks put it, "the world is its best own model" [Bro91]. In addition to the much lower need for precision, there is a lower need for computation power as well, as reactive control schemes are usually computationally much cheaper than model-based control schemes like for example inverse kinematics.

Behavior-oriented robotics profits mainly from recent advances in sensor technology as there are more and more mass-produced, inexpensive sensors available for a multitude of different applications. Especially, advances in vision related hardware allow for some various sensing tasks at low cost. In combination with the tremendous savings at the mechanical part of the device, a behavior-oriented robot can be produced much cheaper than its classical counterpart [Bir98]. This cost effectiveness is an important feature for RoboGuard.

In addition, RoboGuard needs several functionalities which are directly related to artificial life (Alife) [Lan89] and research on animats (= animal + robot) [Wil91]. For example, RoboGuard has to be self-sufficient, i.e., it has to be able to sustain itself over extended periods of time in respect to energy [Pfe96]. In this context, basic research in an artificial robotic ecosystem [Ste94b,McF94,Bir97,BB98] turned out to be very useful for this practical application.

A further advantage of employing behavior-oriented concepts in RoboGuard is the facilitation of semi-autonomy. In contrast to the naive intuition, including a human operator in the control loop of the base can make the task more complex. It is very difficult, if not impossible for a human teleoperator to efficiently steer a mobile base with video-streams from a on-board camera only. Operators do not take the current speed and momentum of the base into account, they neglect possible delays, they have difficulties to develop a feeling for the size of the base, and so on. In addition, the mobile base has to be protected from accidental or malicious misuse.

Shortly, the mobile base needs an advanced system for navigation and steering support including obstacle avoidance. The fusion of operator steering commands, autonomous drive and navigation functionality, as well as domain-specific plausibility and safety checks is a non-trivial task. For this purpose, the modular approach of using behaviors is especially suited. It also turned out that we could strongly benefit in this respect from insights gathered in the domain of robot soccer [BKW00,BWBK99,BWB+98].

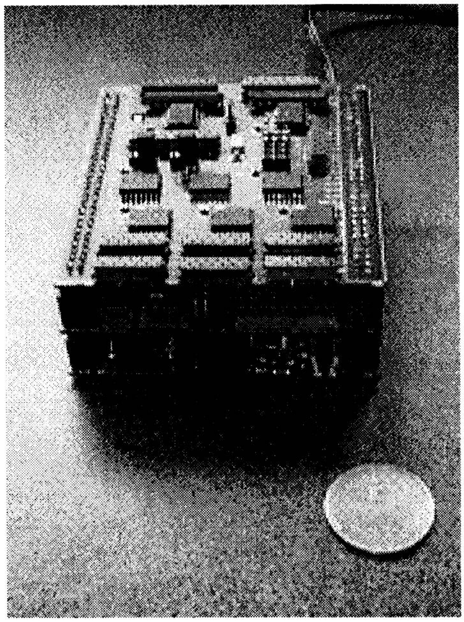

Fig. 1. A picture of the RoboCube, an extremely compact embedded computer for robot control.

3 The Implementation of the Mobile Base

3.1 The RoboCube as Controller-Core

The basic Sensor-Motor-Control of RoboGuard centers at the side of electronics around the RoboCube, a special robot control hardware developed at the VUB AI-lab. The VUB AI-lab has quite some tradition in developing flexible robot control hardware. Various experimental platforms have been build in the lab starting from the mid-eighties up until now. They were used in basic research on behavior-oriented architectures as well as for educational purposes. In all applications it was important that researcher or students could easily add, change, and replace components. Over the years, experiences with approaches based on embedded PCs and different micro-controllers were gathered and lead to the *Sensor-Motor-Brick II (SMBII)*[Ver96]. The SMBII is based on a commercial board manufactured by Vesta-technology providing the computational core with a Motorola MC68332, 256K RAM, and 128K EPROM. Stacked on top of the Vesta-core, a second board provides the hardware for sensor-, motor-, and communication-interfaces.