Austrian-Kangaroos 2013
Team Description Paper (TDP)

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Abstract. The Austrian-Kangaroos are a joint team of Vienna University of Technology and University of Applied Sciences Technikum Vienna. After successful participation in the years 2009 to 2012 we are participatingin RoboCup 2013 within the Standard Platform League again. Our team is a joint effort of researchers, lecturers and students of the University of Applied Sciences Technikum Vienna (UASTW)[1], and of the Vienna University of Technology (VUT) [2] with two directly involved institutes: The Automation and Control Institute (ACIN)[3], and the Institute of Computer Languages (Compilers and Languages Group, COMPLANG)[4].

1 Team Constitution

Our team is a joint effort of researchers, lecturers and students of the University of Applied Sciences Technikum Vienna (UASTW)[1] , and of the Vienna University of Technology (VUT)[2] with two directly involved institutes: The Automation and Control Institute (ACIN)[3] , and the Institute of Computer Languages (Compilers and Languages Group, COMPLANG)[4] . The team is led by Dietmar Schreiner, Markus Bader, and Alexander Hofmann.

RoboCup, especially humanoid robotic soccer, provides an excellent platform for research on a wide field of topics. Consequently, the research groups of all institutions participating in the Austrian-Kangaroos are applying their specific research questions and expertise to the league's standardized platform. In the following sections we provide a brief overview of ongoing research conducted by the involved working groups.

1.1 Concurrent and Embedded Real-Time Systems

One of the emphases of the *Compilers and Languages Group (COMPLANG)* is that of robust embedded systems. Within this context research is conducted for analyses and certification of dependable software, as much as for the development of new programming methodologies and languages that simplify the development of mission-critical embedded system applications.

Our current focus is set on evolutionary and nature inspired computing [1]. In more detail, our over all goal is the development of an artificial immune system for robotic devices. Traditional techniques in software development that typically handle a precisely enumerated set of faults do not scale well with the increasing system complexity and the real world's non-determinism. Hence, we think that a nature inspired approach similar to the concept of a biological immune system could be able to provide a sound and robust solution for this robotic issue. Assuming that there exists no complete enumeration of faults that should be detected and handled over the lifespan of a system within an indeterministic environment, classical error handling techniques quickly reach their limits in terms of development cost and technical capability. An immune system can overcome the problem of unknown and unexpected faults by detecting anything that is not a sane system state, and by utilizing adaptable rules on how to (re)establish a sane system. This concept was

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[1] University of Applied Sciences Technikum Vienna: http://www.technikum-wien.at

[2] Vienna University of Technology: http://www.tuwien.ac.at

[3] ACIN: http://www.acin.tuwien.ac.at

[4] COMPLANG: http://www.complang.tuwien.ac.at

developed by evolution over millions of years, and is a promising approach for robust autonomous dependable systems within non-deterministic environments.

To achieve the goal of nature inspired fault-tolerant self-healing software research has to be conducted at the intersection of five major scopes like depicted in Figure 1. Affordable devices that fulfill all necessary dependability constraints like safety or robustness can only be built by joining results from all denoted domains: (i) Model Driven Development as a basis for code generation as much as for system verification, (ii) Static Analysis as a methodology to derive system properties from program codes as much as to guide compilation and code generation tasks, (iii) Programming Languages to provide proper means of abstraction and semantically enriched specifications, (iv) Reflective Computing as a methodology for run-time monitoring and supervision, and (v) Nature Inspired Computing as promising way to handle the systems' increasing complexity.
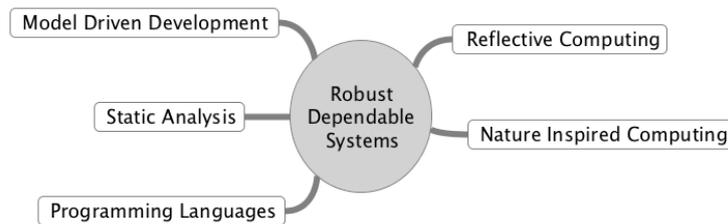

Fig. 1. Research Scopes

Building on our expertise on static analyses in particular aiming at the calculation of code properties like worst-case execution times (WCET) [2, 3] and translation validation for optimizing compilers, the design and synthesis of middleware for distributed real-time embedded systems, and model driven development methodologies [4–7], and programming languages for reactive and concurrent systems, we have implemented our artificial immune system iRIS (Inert Robotic Immune System) [8] for the league's NAO.

1.2   Vision for Robotics and Nonlinear Controls

Research of the *Automation Control Institute's* (ACIN) is gathered by two working groups. The working group *Vision for Robotics (V4R)*[1] utilizes the Austrian-Kangaroos as a test bed for their research towards robots that see and interact with the real world [9]. Research in object detection, localization, grasping and their affordances are crucial parts in this group [10, 11]. Work done in these fields is reflected in the techniques used within the teams' software.

Knowledge on nonlinear control systems is gathered by the *Complex Dynamical Systems Group (CDS)*[2] [12–15] involving bipedal walking algorithms. Ongoing research of the CDS group aims at combining traditional control systems with classical learning algorithms [16].

1.3   Robotics in Education

The UASTW has been in RoboCup since 2003, Padua/Italy [17], with successes in the Small Size League, and since 2009 in the Standard Platform league and the Rescue Virtual Robot League. In addition the UASTW is highly involved in the Austrian RoboCupJunior community [18] on a grounding level by hosting events like the Austrian-RoboCupJunior competition. One goal of the involved institute's working group is to teach students in a motivating environment. This is achieved by participating at RoboCup, which is a challenging environment in a committed community.

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[1] V4R `http://v4r.acin.tuwien.ac.at`
[2] CDS `http://cds.acin.tuwien.ac.at`

2 Research and Development

2.1 Past Achievements

The Austrian-Kangaroos successfully participated in the RoboCup WC 2009 in Graz [19] for the first time and reached the quarter-finals. After our first year we redesigned our software framework reflecting the team's experiences from the 2009 season. In 2010 we reached the 3rd place at the German Open and at the Mediterranean Open. At this time we were already using our first-generation framework as announced in the 2009 TQD [20], Section 2.1. At the WorldCup in Singapore our system was finally capable of detecting faulty system states and misbehaving software components, and hence was able to set counter measures at a coarse grained level [21]. These achievements enabled us to score the best time on the technical dribbling challenge in Singapore. In 2011 the team won the Mediterranean Open and participated at the WorldCup in Istanbul, adapting the well accepted B-Human framework to coexist with our own functional modules. In 2012 the team participated in the WorldCup in Mexico City. There for the first time our artificial immune system (iRIS) was successfully deployed and used under real tournament conditions.

Software Architecture: The software architecture developed and used during 2009-2011 consists of several loosely coupled components, each residing in its own address space:

- The **Communication** component is responsible for all network communication including sharing of each robot's world model with teammates, and receiving referee commands.
- The **Vision** component extracts information about recognizable objects (e.g. ball, goal posts) in the environment from the camera image.
- The **World Model** component combines the locally extracted world objects with the other robots' world models into a belief about the world's current state.
- The **Control** component is responsible for role selection based on the belief calculated by the word model component. It also sends commands to execute planned actions to the motion component.
- The **Motion** component is responsible for executing motions. It relies on the Aldebaran AL-Motion NaoQI[3] module to control the Nao's joints and the Aldebaran walking engine.
- The **Monitor** is responsible for detecting faulty or misbehaving components. Based on a simple rule set, it is able to set counter measures to different kinds of faults.

Component interaction is achieved via two communication facilities:

- **Shared memory** is used to propagate information to all relevant components. Our shared memory provides a full-fledged publisher-subscriber infrastructure. Hence, it triggers signals in all connected components, if a subscribed memory location is altered.
- **RPC calls** allow point-to-point communication between two components.

By start of season 2012 we decided to focus our efforts on our domains of expertise, in order to invest our resources even more efficiently. In consequence, our self-made base framework was abandoned and was replaced by the B-Human framework [22]. To integrate our know-how and hence our competitive assets (real-time communication, AI, vision and localization) into this framework, we replace corresponding modules and augment the system by so-long non existing ones. For 2013 we kept the B-Human framework as a base-line but intensified our efforts on additional "missing" components, like audible landmarks, and acoustic communication, but also improved low-level system drivers for the visual sub-system as much as for the WLAN part.

Team play: Over the last years, a role based goal driven behavior engine was implemented and was sufficient for a 4 vs. 4 soccer match. The roles a robot could be assigned to are (i) goalkeeper, (ii) defender, and (iii) attacker. Role assignment is dynamic (except the goal keeper), and worked well over the last seasons. In addition we successfully adopted the robots' sonar sensors to avoid pushing penalties. For 2011 we implemented a fail-safe real-time leadership election protocol to dynamically promote the team captain.

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[3] NAO SDK: `http://www.aldebaran-robotics.com/`

Robotics in Education: The Austrian-Kangaroo team is a learning environment for students that intrinsically motivates [23]. The rotation lifecycle [24] that was developed for UASTW's SSL team Vienna Cubes has been implemented for the Austrian-Kangaroos as well and enforces the keep of knowledge and increases the sustainability of the team. In the EU-project Centrobot a platform for exchange of learning material with robots was developed [25] to share digital content for teachers in robotic classes.

2.2 Improvements for the WC 2013

As stated above, we again will base on the B-Humans Code, and will integrate our assets from the fields AI, Real-Time Communication, and Sensing/Localization.

Sensing / Localization By season 2012 goal posts have become uniform in terms of color. As a result, participating teams must keep track of their playing direction during the game. For 2012 we implemented a method to use multiple color histograms to describe the background in different areas in order to overcome the uniform goal problem.

However, this approach turned out to be unreliable in typical tournament scenarios due to fluctuating audience, top lights etc. and led to one own goal during WorldCup 2012. Therefore, we decided to add audible landmarks as additional means of orientation. The tournament at RoboCup 2013 will provide an excellent test bed in terms of background noise and disturbance for audible landmarks.

Robust Robotic System Software To increase the robot's software robustness we are improving sophisticated real-time monitoring capabilities in ongoing research. Our research so far successfully covered a nature inspired robotic immune system, which includes automatic deployment of software sensors and derivation of counter measures from dependency trees and error models.

Team Coordination For state-of-the-art team play self-localization, object sensing and dynamic role assignment have to go hand in hand. Therefore, our vision system propagates beliefs from the low level sensing up to shared knowledge between robots. For the 2013 setup we had to reworked the role selector, integrated fall-back roles for broken communication, and completely reengineered our static as much as dynamic motion primitives.

Robotics in Education Within the next year a UASTW research group (Section 1.3) tries to present robots to children from kindergarten. In 10 sessions students and research members present different robot models and the children use a BeeBot for their first robot programming experiences. Because of the importance of documentation of scientific work the children use cameras to take pictures of the robots, print the pictures and place them into their personal lab book. Furthermore, first experiences in elementary schools are planned. After this, the activities in Robotics in Education will reach from kindergarten to university level. Currently some research at the UASTW are working on a new learning model for robots that will focus more on the motivation of children learning with robots.

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