Team rUNSWift
University of New South Wales, Australia

RoboCup 2010
Standard Platform League

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Abstract. RoboCup continues to inspire and motivate our research interests in cognitive robotics and machine learning, particularly layered hybrid architectures, abstraction, and high-level programming languages. The newly formed 2010 rUNSWift team includes mainly final year undergraduate students under the supervision of leaders who have been involved in RoboCup for many years. In 2010 the team revamped the entire code-base and implemented a new integrated project management system. Several innovations have been introduced in vision and locomotion this year, and several other planned developments will be tied over to 2011.

1 The Team

The RoboCup Standard Platform League (SPL) has been and continues to be excellent training for the undergraduates who also make a significant contributions towards research. The UNSW SPL teams (and previously the Four-legged teams) have almost entirely been made up of final-year undergraduate students, supported by faculty and research students. The 2010 rUNSWift team includes undergraduate students: Brock White, Benjamin Vance, David Claridge, Adrian Ratter, Stuart Robinson, and Yanjin Zhu; research students Jayen Ashar and Hung Nguyen; faculty staff: Bernhard Hengst, Maurice Pagnucco and Claude Sammut; Development Manager Brad Hall (see Figure 1).

Fig. 1. *The 2010 rUNSWift team. Left to right, top to bottom: Brad Hall, Brock White, Benjamin Vance, Claude Sammut, Bernhard Hengst, Maurice Pagnucco, David Claridge, Adrian Ratter, Stuart Robinson, Hung Nguyen, Yanjin Zhu, Jayen Ashar, Nao Blue, Nao Red.*

The team has the financial support of the School of Computer Science and Engineering at UNSW and the Australian Research Council Centre of Excellence for Autonomous Systems. The School also provides a great deal of organisational support for travel. We have a competition standard field and a wealth of experience from our participation in the four-legged league, simulation and rescue competitions. Our sponsors include Atlassian Pty Ltd.

2 Project Management

For 2010 we reviewed our approach to team selection, project management, supervision and research and development. We embarked on a total rewrite of the code. We have found that part-time participation by large numbers of students does not lead to coordinated deliverables. The new 2010 team has been selected on the basis that core team members devote a significant amount of their time to research and development on the SPL project and count that effort towards either their final year thesis project or an approved special project. Students are selected on the basis of academic standing and some evidence of performance on larger projects.

A new project management system from Atlassian Pty Ltd has been configured by the students for use by the team. The Atlassian suite of products,

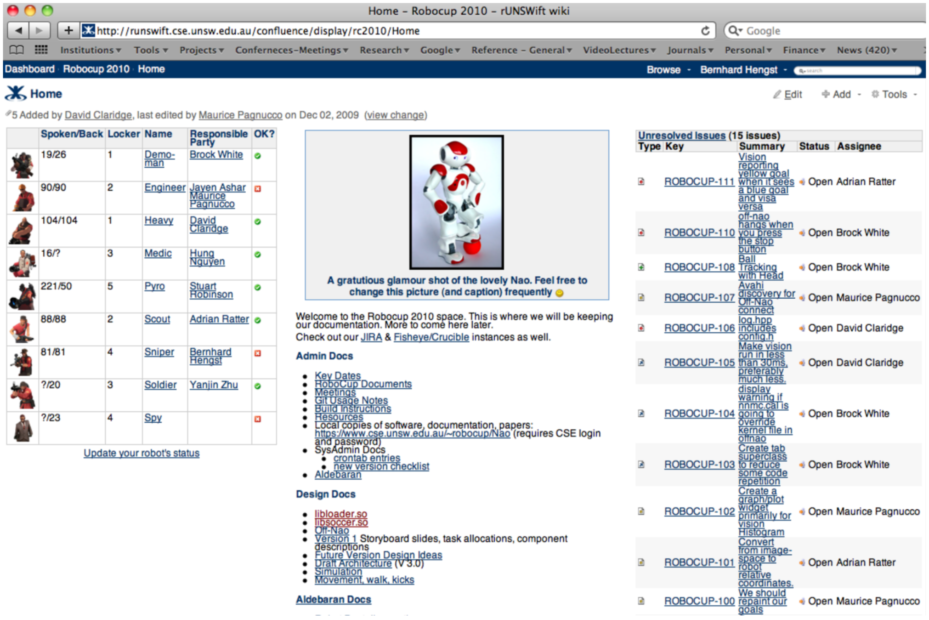

Fig. 2. *JIRA Studio - Confluence.*

called JIRA Studio, has three components: an enterprise wiki, Confluence, is a web application that facilitates collaboration and knowledge management (see Figure 2); JIRA, that combines issue tracking, project management, customisable workflow to increase the velocity of software development by the team; and FishEye, that opens the source code repository to help you understand the code, facilitate code reviews and keep tabs on the team members who write it.

While many successful innovative ideas from previous years have been used to fast-track the new code, we have continued our development of a more robust vision system and non-beacon localisation. We have made some innovations in bipedal walking and the use of the foot sensors to help stabilise omni-directional locomotion.

3 Research Interests

The vision of many robotics researchers is to have machines operating in unstructured, real-world environments. Our long term aim is to develop general purpose intelligent systems that can learn and be taught to perform many different tasks autonomously by interacting with their environment. As an approach to this problem, we are interested in how machines can compute abstracted representations of their environment through direct interaction, with and without human assistance, in order to achieve some objective. These future intelligent systems will be goal directed and adaptive, able to program themselves automatically by sensing and acting, accumulating knowledge over their lifetime.

We are interested in what Cognitive Robotics can contribute to the specification of flexible behaviours. Languages such as Golog (see Levesque and Pagnucco, 2000 for an application of Golog), allow the programmer to create highly reactive behaviours and the language incorporates a planner that can be invoked if the programmer wishes to be less specific about the implementation of a behaviour.

Traditional programming languages applied to robotics require the programmer to solve all parts of the problem and result in the programmer scripting all aspects of the robot behaviour. There is no facility for planning or deliberation. As a result programs tend to be complex, unwieldy and not portable to other platforms. High level robotic languages provide a layer of abstraction that allows for a variety of programming styles from deliberative constructs that resort to AI planning in order to achieve user goals through to scripted behaviours when time critical tasks need to be completed.

Our general research focus, of which the RoboCup SPL is a part, is to:

- further develop reasoning methods that incorporate uncertainty and real-time constraints and that integrate with the statistical methods used in SLAM and perception
- develop methods for using estimates of uncertainty to guide future decision making so as to reduce the uncertainty
- extend these methods for multi-robot cooperation
- use symbolic representations as the basis for human-robot interaction
- develop learning algorithms for hybrid systems, such as using knowledge of logical constraints to restrict the search of a trial-and-error learner and learning the constraints
- develop high level symbolic robotic languages that provide abstractions for a large range of deliberation, planning and learning techniques so as to simplify robot programming

3.1 Humanoid Robots

Research in our group includes applications of Machine Learning to bipedal gaits. PhD student Tak Fai Yik (a member of the champion 2001 four-legged team) collaborated with Gordon Wyeth at the University of Queensland to evolve a walk for the GuRoo robot (Wyeth, et al, 2003), which was entered in the humanoid robot league. This method was inspired by the gait learning devised for the Aibos. For the humanoid, the same philosophy is applied. Starting from a parameterised gait, an optimisation algorithm searches for a set of parameter values that satisfies the optimisation criteria. In this case, the search was performed by a genetic algorithm in simulation. When a solution was found, it was transferred to the real robot, working successfully. Subsequently, the approach we used was a hybrid of a planner to suggest a plausible sequence of actions and a numerical optimisation algorithm to tune the action parameters. Thus, the qualitative reasoning of the planner provides constraints on the trial-and-error learning, reducing the number of trials required. Tak Fai developed and implemented this system for his PhD (Yik, 2007). It has been tested on a Cycloid II robot. It is our intention to continue this work as part of the development for the Nao, Bioloid and Cycloid robots.

4 Contributions to the Standard Platform and Four-Legged League

A UNSW team has taken part in every RoboCup competition since 1999. The year by year details are listed in the next section.

Locomotion In 2000, we introduced the UNSW walk, which became the standard across the league (Hengst et al, 2002). The key insight was to describe the trajectory of the paws by a simple geometric figure that was parameterised. This made experimentation with unusual configurations relatively easy. As a result, we were able to devise a gait that was much faster and more stable than any other team. Since then, almost all the other teams in the league have adopted a similar style of locomotion, some starting from our code. The flexibility of this representation led to another major innovation in 2003. We were the first team to use Machine Learning to tune the robot's gait, resulting in a much faster walk (Kim & Uther, 2003). In succeeding years, several teams developed their own ML approaches to tuning the walk. Starting from the parameterised locomotion representation, the robots are able to measure their speed and adjust the gait parameters according to an optimisation algorithm.

Localisation The 2000 competition also saw the initial use of a Kalman filter-based localisation method that continued to evolve in subsequent years (Pham et al, 2002). In the 2000 competition, advantages in localisation and locomotion meant that the team never scored less than 10 goals in every game and only one goal was scored against it in the entire competition. Starting from a simple Kalman filter in 2000, the localisation system evolved to include a multi-modal filter and distributed data fusion across the networked robots. In 2006, we went from treating the robots as individuals sharing information, to treating them as one team with a single calculation spread over multiple robots. This allowed us to handle multiple hypotheses. It also allowed us to use the ball for localisation information.

Vision Our vision system evolved significantly over our eight years in the four-legged league. From the beginning, in 1999, we used a simple learning system to train the colour recognition system. In 2001, we used a standard machine learning program, C4.5, to build a decision tree recogniser. This turned out to be very important since the lighting we encountered at the competition was very different from our lab and our previous vision system was not able to cope. Also in 2000, our vision system became good enough to use robot recognition to avoid team mates (Sammut & Hengst, 2003). In later years, we updated the vision system to be much faster and to recognise field markings reliably.

Software Engineering and Architecture Throughout the software development of the Aibo code, we have adopted a modular, layered architecture. The lowest layers consist of the basic operations of vision, localisation and locomotion. The behaviours of the robots are also layered, with skills such as ball tracking, go to a location, get behind ball, etc, being at the lowest level of the behaviour hierarchy, with increasingly complex behaviours composed of lower-level skills. Originally, all the behaviours were coded in C/C++ but in 2005 and 2006, as in 2010, the upper layers were replaced by Python code. We have also experimented with higher level functions coded in the experimental cognitive robotics language Golog.

One of the key reasons behind the UNSW team's success has been its approach to software engineering. It has always been: keep it simple, make the system work as a whole and refine only what evidence from game play tells us needs work. This practical approach has had a strong effect on our research because it has informed us about which problems are really worth pursuing and which ones are only imagined as being important.

5 Participation and Performance

A UNSW team has taken part in every RoboCup competition since 1999. Details of awards are as follows:

Standard Platform League/Four-legged league: 1999-2006, 2008-2009

- 1st place: 2000, 2001, 2003
- 2nd place: 1999, 2002, 2006
- 3rd place: 2005
- Quarter-finalists: 2004, 2008
- Challenges: 1st in 1999, 2000, 2001, 2002,
- Challenges: 2nd in 2003

Simulation soccer: 2001 - 2003

- 7th place: 2002

Rescue: 2005 - 2007, 2009

- 3rd overall: 2005
- Semi-finalists and 2nd in autonomous robot challenge: 2006
- Finalists: 2007, 2009.
- Best in class Autonomy: 2009
- 2nd in Mobility: 2009
- Award for innovative user interfaces: 2009

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