The NUbots' Team Description for 2010

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Abstract. The NUbots are the robot soccer team of The University of Newcastle in Australia. They have participated in the RoboCup Standard Platform League since 2002. They achieved world-champion titles in 2006 and as part of the joint NUManoids team in 2008. This paper summarises the history and composition of the team and describes associated research projects in the Newcastle Robotics Lab.

1 Introduction

The NUbots, from the University of Newcastle, Australia, have been a part of RoboCup since 2001. Competing in the Four Legged League from 2002-2007, and subsequently the Standard Platform league since 2008. The NUbots have had a strong record of success twice achieving a first place; in 2006 in Bremen, Germany, and, again in 2008 as part of the NUManoid team in Suzhou, China.

The central goal of the NUbots is to be a high performance competitive robot soccer team in the standard platform league at RoboCup. The vision of the research projects associated with the NUbot team is to develop and program robots that can support humans not only for routine, challenging, or dangerous tasks, but also to improve quality of life through personal assistance and coaching. Our mission is to contribute to a responsible development and application of robotics. Some of our projects therefore emphasise anthropocentric and biocybernetic aspects in robotics research [14]. This includes new aspects of robot perception and human robot interaction. The Newcastle Robotics Lab host several postgraduate and undergraduate projects that are associated with the NUbots.

The following sections describe the history of the team, the roles and research of the team members and addresses associated research projects and relevant aspects of the study and research environment of the University of Newcastle, Australia.

2 History of Achievements in Previous Competitions

The University of Newcastle's RoboCup initiative started in 2001. After the introduction of new robotics and machine learning related courses and projects

two undergraduate students participated in RoboCup Junior in Seattle and won the world title. After their return the NUbot team was founded in 2002 which from then on participated in the the Standard Platform League (SPL) which was formerly called Sony Four-Legged League. The following list describes the history of achievements of the NUbots since 2002:

- *RoboCup 2002 in Fukuoka, Japan:* The new NUbot team entered the Sony Four-Legged League and instantly achieved a third place.
- *RoboCup 2003 in Padova, Italy:* The NUbots achieved third place. They were only beaten in the semi finals by the team of the University of Pennsylvania 3-4 on penalties. The NUbots achieved the most goals for (83), and fewest goals against (3). It was noticed that they matched the previous record for the highest score in a legged league game at RoboCup by winning a match 16-0 against one of the other competitors.
- *RoboCup 2004 in Lisbon, Portugal:* The 2004 NUbot team again achieved a 3rd placed finish. Again the NUbots were undefeated in round-robin competition with the only loss in the tournament coming in the semi final match at the hands of the eventual world champions, The German Team.
- *RoboCup 2005 in Osaka, Japan:* 2005 saw the NUbots finish in second place at RoboCup 2005. The team went undefeated until the final, where we were beaten 4-3 in a penalty shoot-out.
- *RoboCup 2006 in Bremen, Germany:* 2006 was the year of the NUbot. The NUbots did not concede a goal until the final when we won 7-3 in an all Australian contest against rUNSWift [35]. The year 2006 can be seen as the peak of the Four-Legged League because Sony announced the end of the production of the AIBO robot.
- *Robocup 2007 in Atlanta, USA:* In 2007 the NUbots achieved second place in the fading-out Four-Legged League, beaten by the Northern Bites in the final. Oliver Obst from the Newcastle Robotics Lab achieved a first place in the 3D Soccer Simulation Developer League. Two new quadruped robots (bear and dog) were developed by some of our researchers and presented at RoboCup's tender proposal presentation [3, 8].
- *RoboCup 2008 in Suzhou, China:* In 2008 the NUbots joined with The National University of Ireland, Maynooth and formed a joint team, the NUManoids [1]. The NUManoids became the first world-champion in the Standard Platform League (SPL) with the new Aldebaran Nao robot.
- *RoboCup 2009 in Graz, Austria:* In 2009 the NUbots made it to the quarter finals of the competition.

More details on the history including a list of team reports is available from the NUbots homepage.

3 Background of the NUbots' Team Members

- *Shashank Bhatia* Is a postgraduate research student at the University of Newcastle, Australia. His research interests include autonomous vehicle navigation, probabilistic robotic techniques and machine learning. He joined the team for 2010.

- *Dr. Stephan Chalup* is the director of the Newcastle Robotics Lab and a Senior Lecturer in Computer Science and Software Engineering. He is the initiator of the NUbots and one of the academic team mentors since 2002. His research interests include machine learning, human-robot interaction and anthropocentric robotics.
- *Naomi Henderson* is studying for a Doctor of Philosophy. Her research involves automating the classification process including soft colour decisions, together with a detailed analysis of camera quality, settings and lighting and the effect on recognising colours and shapes. Her PhD topic is "Integrated Image Detection Algorithms for Robust Object Recognition". She has been a team member of the NUbots since 2005.
- *Dr. Robert King* is a lecturer in statistics at the University of Newcastle with particular interests in flexibly-shaped distributions, statistical computing and Bayesian knowledge updating. He joined the NUbots in 2004.
- *Jason Kulk* is studying for a Doctor of Philosophy. Jason has been working on the locomotion system. His research involves the application of a human-like reflex control system to bipedal stance and locomotion. His PhD title is "Anthropomorphic biped locomotion for complex topologies". He has been a team member of the NUbots since 2008.
- *Steven Nicklin* is studying for a Doctor of Philosophy. Steven has been working on localisation and modelling of the robot. His research involves stabilising a biped robot using model predictive control. His PhD title is "Biped locomotion using MPC". He has been a team member of the NUbots since 2005. Steve is the NUbot team leader for 2010.
- *Joshua Wilson* is an undergraduate student studying a computer engineering / computer science combined degree. His project involves research in the area of machine vision. He joined the team for 2010.
- *Aaron Wong* is studying for a Doctor of Philosophy. Aaron has been working on communication, line detection, application development and software architecture. His research is in the areas of communications, machine learning and acoustics. His PhD topic is "Sound-scape visualisation through dimensionality reduction". He has been a team member of the NUbots since 2008. Aaron is the NUbots' deputy team leader for 2010.

There are several other students, research assistants, and academics who are members or associates of the Newcastle Robotics Laboratory and the Interdisciplinary Machine Learning Research Group (IMLRG) in Newcastle, Australia. Details are linked to the relevant webpages at `www.robots.newcastle.edu.au`.

4 Research Areas

Robot Vision: Vision is one of the major research areas associated with the Newcastle Robotics Lab. Several subtopics have been investigated including object recognition, horizon determination, edge detection, and colour classification using ellipse fitting, convex optimization and kernel machines. Publications are

available e.g. from [2, 7, 9–12, 19, 20, 27, 29–33, 35–39].

Localisation and Kalman Filters: Research on the topic of localisation focused on Bayesian approaches to robot localisation including Kalman Filter and particle filter based methods. We are particularly interested in further modifications of the Kalman Filter to handle non-ideal information from vision and also incorporate information from multiple agents. Furthermore we are also interested in the use of machine learning to improve the models used by localisation. For information about our current approach see [2, 7, 17, 18, 21].

Development of the Robot Bear: In a collaborative effort with the company Tribotix and colleagues in design a bear-like robot was developed [8, 26]. The idea of the bear was first proposed at a seminar at Schloss Dagstuhl in 2006 [3]. A protoype was presented at RoboCup 2007 in Atlanta. The current model is called Hykim and is produced by Tribotix. It is a high quality robot with metal gears, substantial processing power and a range of sophisticated sensors.

Biped Robot Locomotion: We have previously improved existing walk engines by modifying the joint stiffnesses, or controller gains, [24, 25]. The stiffnesses are selected through an iterative process to maximise the cost of transport. We intend to develop a new walk engine to incorporate the idea of varying joint stiffness at its foundation. We also investigate the application of Support Vector Machines and Neural Networks to proprioception data for sensing perturbations during pseudo quiet stance. A related project investigates how spiking neural networks can be employed to control bi-ped walk [40–43].

Manifold Learning: In several projects we investigate the application of nonlinear dimensionality reduction methods in order to achieve a better understanding and more precise and efficient processing of high-dimensional visual and acoustic data. [4, 5, 28, 44, 45].

Anthropocentric Biocybernetic Computing: The Newcastle Robotics Lab is engaged in interdisciplinary research projects that address human information processing on different levels and in interaction with the environment. One of the projects investigates computational concepts that can model how design of the built environment evokes complex perceptual and emotional responses in people that see or use buildings. Software that implements the underlying response mechanisms could be used to control robot behaviours associated with emotional artificial intelligence [10, 11, 14, 15, 22].

5 Related Research Concentrations

The *Interdisciplinary Machine Learning Research Group (IMLRG)* investigates different aspects of machine learning and data mining in theory, experiments and applications. Particular emphasis is put on interdisciplinary projects. The

IMLRG's research areas include: Dimensionality reduction, vision processing, acoustics, robotics control and learning, neurocomputing, evolutionary computation, reinforcement learning, and kernel methods.

The *ARC Centre for Complex Dynamic Systems and Control (CDSC)* provides significant industrial and manufacturing performance advances by working on approaches to control and scheduling. These approaches aim to unify the use of disparate technologies, namely, mathematical modelling through to computer systems, electromechanical machinery, scheduling systems and chemical processing. For more details see `http://cdsc.newcastle.edu.au/cdsc`

6 Robotics Education

The School of Electrical Engineering & Computer Science offers a range of undergraduate courses which are an excellent preparation for postgraduate research studies in the area of machine learning and robotics. Details are available at
`http://www.newcastle.edu.au/school/elec-eng-comp-sci/`
Information about Masters and PhD studies at the University of Newcastle are available from `http://www.newcastle.edu.au/research/rhd/`
For enquiries about scholarships or exchange arrangements please contact the school's office: School of Electrical Engineering and Computer Science, Faculty of Engineering and the Built Environment, The University of Newcastle NSW 2308, Australia Phone: +61 2 492 15330, Fax: +61 2 492 16929.

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Links to publications can be found at the NUbots' webpage

`http://robots.newcastle.edu.au/`

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