The NUbots' Team Description for 2011

Steven P. Nicklin, Shashank Bhatia, David Budden, Robert A.R. King, Jason
Kulk, Josiah Walker, Aaron S.W. Wong, and Stephan K. Chalup

Newcastle Robotics Laboratory
School of Electrical Engineering & Computer Science
Faculty of Engineering and Built Environment
The University of Newcastle, Callaghan 2308, Australia
Contact: `stephan.chalup@newcastle.edu.au`
Homepage: `http://robots.newcastle.edu.au`

Abstract. The NUbots, from The University of Newcastle, Australia,
have had a strong record of success in the RoboCup Standard Platform
League since first entering in 2002. This paper summarises the history
of the team, describes the roles and research of the team members and
addresses relevant research projects and programs within the University.

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 coach-
ing. Our mission is to contribute to a responsible development and application
of robotics. Some of our projects therefore emphasise anthropocentric and bio-
cybernetic aspects in robotics research [10]. This includes new aspects of human
robot interaction and perception. The Newcastle Robotics Lab host several post-
graduate 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 which from then on participated in the following international competitions of the standard platform league which was formerly called Sony Four-Legged League:

- *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 [32].
- *Robocup 2007 in Atlanta, USA:* In 2007 the NUbots achieved second place, beaten by the Northern Bites in the final.
- *Robocup 2008 in Suzhou, China:* In 2008 the NUbots joined with The National University of Ireland, Maynooth and formed the joint team the NUManoids. The NUManoids achieved first place in the first year of the Standard Platform League with the new Aldebaran Nao robot.
- *Robocup 2009 in Graz, Austria:* In 2009 the NUbots participated as a seperate team once again. In this year we made it to the quarter finals of the competition.
- *Robocup 2010 in Singapore:* In 2010 the NUbots won their first pool of the competition, however where knocked out of the second pool with two draws and a loss.

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

3   Background of the NUbots' Team Members

- *Dr. Stephan Chalup* is an associate professor in computer science and software engineering and coordinates of the Newcastle Robotics Lab. He is one of the initiators of the University of Newcastle's RoboCup activities since 2001. His research interests include autonomous agents, bioinformatics, computer vision, dimensionality reduction, machine learning, and neuroscience.

- *Shashank Bhatia* Is currently 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 in 2010.
- *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 the use of multiple hypothesis based filters to aid in localisation. He has been a team member of the NUbots since 2005.
- *Josiah Walker* is an computer science honours student. His project involves the use of reinforcement learning to build a system to generate music. He is applying similar methods to generate kicks.
- *David Budden* is an undergraduate student student studying a combined degree of computer engineering and computer science. He has been working on the optimisation of camera settings, and creating motion scripts for the robot.
- *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.

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 [1, 3, 6, 15, 24, 25, 27, 30–33, 35, 36, 7, 8, 16, 11].

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 [17, 1, 3, 13, 14].

Development of the Robot Bear: In a collaborative effort with the company Tribotix and colleagues in design a bear-like robot was developed [4]. It is a high quality robot with metal gears, substantial processing power and a range sophisticated sensors.

Biped Robot Locomotion: We have previously improved existing walk engines by modifying the joint stiffnesses, or controller gains, [21–23]. 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.

Manifold Learning: In several projects we investigate the application of non-linear dimensionality reduction methods in order to achieve a better understanding and more precise and efficient processing of high-dimensional visual and acoustic data [9, 26, 40, 41].

Using Machine Learning and Robotics in Architecture and Computer Vision: In several projects we collaborate with architects to increase our understanding how humans perceive the aesthetics of the built environment [10]. Some of the projects investigate pedestrian models and pedestrian behaviour analysis through video analysis [18, 19]. The results may be useful in future robotics project that aim at implementing an emotion module for a robot.

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 *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

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

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References

1. Jared Bunting, Stephan Chalup, Michaela Freeston, Will McMahan, Rick Middleton, Craig Murch, Michael Quinlan, Christopher Seysener, and Graham Shanks (2003). *Return of the NUbots! The 2003 NUbots Team Report.*

2. Stephan K. Chalup, Oliver J. Coleman, Michaela N. Freeston, Richard H. Middleton, Craig L. Murch, Michael J. Quinlan, Christopher J. Seysener, and Graham D. Shanks (2003). *The NUbots Team Description for 2003.* RoboCup 2003 Symposium.

3. Chalup, S., Creek, N., Freeston, L., Lovell, N., Marshall, J., Middleton, R., Murch, C., Quinlan, M., Shanks, G., Stanton, C., and Williams, M.-A. (2002). *When NUbots Attack ! The 2002 NUbots Team Report.* School of Electrical Engineering & Computer Science Technical Report, The University of Newcastle, Australia.

4. S. K. Chalup, M. Dickinson, R. Fisher, R. H. Middleton, M. J. Quinlan, and P. Turner. *Proposal of a Kit-Style Robot as the New Standard Platform for the Four-Legged League*, In: Australasian Conference on Robotics and Automation (ACRA) 2006.

5. Stephan K. Chalup, Craig L. Murch, and Michael J. Quinlan. *Machine Learning with AIBO Robots in the Four-Legged League of RoboCup*, IEEE Transactions on Systems, Man, and Cybernetics C, Vol. 37, No. 3, pages 297-310 May 2007.

6. Stephan K. Chalup and Craig L. Murch (2004). *Machine Learning in the Four-Legged League.* 3rd IFAC Symposium on Mechatronic Systems.

7. Chalup, S.K., Henderson, N., Ostwald, M.J. and Wiklendt, L. *A Method for Cityscape Analysis by Determining the Fractal Dimension of Its Skyline*, ANZA-ScA 2008.

8. Chalup, S.K., Hong, K. and Ostwald, M.J. *A Face-House Paradigm for Architectural Scene Analysis*, CSTST 2008 ACM 2008.

9. Stephan K. Chalup, Riley Clement, Joshua Marshall, Chris Tucker, and Michael J. Ostwald. *Representations of Streetscape Perceptions Through Manifold Learning in the Space of Hough Arrays.* 2007 IEEE Symposium on Artificial Life, April 1-5, 2007.

10. Chalup, S.K. and Ostwald, M. J. *Anthropocentric Biocybernetic Approaches to Architectural Analysis: New Methods for Investigating the Built Environment.* . In Paul S. Geller, editor, Built Environment: Design Management and Applications. Nova Scientific, 2010.

11. Chalup, S.K., Henderson, N., Ostwald, M.J. and Wiklendt, L. *A Computational Approach to Fractal Analysis of a Cityscape's Skyline*, Architectural Science Review, (forthcoming).

12. Oliver J. Coleman and Stephan K. Chalup (2003). *Towards Matching Perception in Simulated and Real World Robot Navigation.* Australian Conference on Artificial Life (ACAL'2003).

13. Leonie Freeston (2002). *Localization and World Modelling,* project report, School of Electrical Engineering and Computer Science, The University of Newcastle.

14. Michaela Freeston (2003). *Localisation and World Modelling in Robot Soccer*, project report, School of Electrical Engineering and Computer Science, The University of Newcastle.

15. Henderson, N., King, R., and Middleton, R.H. (2007). *An Application of Gaussian Mixtures: Colour Segmenting for the Four Legged League using HSI Colour Space*, RoboCup Symposium, Atlanta, July 2007. Lecture Notes in Computer Science , Springer-Verlag Berlin/Heidelberg, 2007.

16. Henderson, N., King, R., and Chalup, S.K. *An Automated Colour Calibration System using Multivariate Gaussian Mixtures to Segment HSI Colour Space*, Proceedings of the 2008 Australasian Conference on Robotics & Automation (ACRA'2008).

17. Naomi Henderson and Steven P. Nicklin and Aaron Wong and Jason Kulk and Stephan K. Chalup and Robert King (2009) *The 2009 Nubots Team Report.* School of Electrical Engineering & Computer Science Technical Report, The University of Newcastle, Australia.

18. Arash Jalalian, Stephan K. Chalup, and Michael J. Ostwald. *Agent-agent interaction as a component of agent-environment interaction in the modelling and analysis of pedestrian visual behaviour.* In CAARDIA 2011. Circuit Bending, Breaking and Mending. The 16th International Conference of the Association for Computer-Aided Architectural Design Research in Asia, 2011.

19. Arash Jalalian, Stephan K. Chalup, and Michael J. Ostwald. *Architectural evaluation of simu- lated pedestrian spatial behaviour.* Architectural Science Review, 54(2), 2011.

20. Nate Kohl and Peter Stone (2004). Machine Learning for Fast Quadrupedal Locomotion. *The Nineteenth National Conference on Artificial Intelligence*, AAAI 2004.

21. Kulk, J.A. and Welsh, J.S. *A Low Power Walk for the NAO Robot*, Proceedings of the 2008 Australasian Conference on Robotics & Automation (ACRA'2008).

22. Kulk, J.A. and Welsh, J.S. *Autonomous Optimisation of Joint Stiffnesses over the Entire Gait Cycle for the NAO Robot*, Proceedings of the 2010 International Symposium on Robotics and Intelligent Sensors.

23. Jason Kulk and James Welsh. *Perturbation Sensing using Proprioception for Humanoid Robots.* Proceedings of the IEEE Conference on Robotics and Automation, 2010.

24. McMahan, W. and Bunting, J. (2002). *Vision Processing*, project report, School of Electrical Engineering and Computer Science, The University of Newcastle.

25. Craig L. Murch and Stephan K. Chalup. *Combining Edge Detection and Colour Segmentation in the Four-Legged League.* Australasian Conference on Robotics and Automation (ACRA'2004), 2004.

26. Craig L. Murch. *Dimensionality Reduction on AIBO Robots.* Honours Thesis, Newcastle Robotics Laboratory, 2004.

27. Nicklin, S.P, Fisher, R., and Middleton, R.H. *Rolling shutter image compensation.* Lecture Notes in Computer Science 4434, pages 402-409, Spinger-Verlag Berlin/Heidelberg, 2007.

28. Michael J. Quinlan. *Machine Learning on AIBO Robots.* PhD Thesis, School of Electrical Engineering and Computer Science, The University of Newcastle, 2006.

29. Quinlan, M., Murch, C., Middleton, R., and Chalup, S. (2003). *Traction Monitoring for Collision Detection with Legged Robots.* pp. 374 - 384, In: Daniel Polani, Brett Browning, Andrea Bonarini, and Kazuo Yoshida. RoboCup 2003: Robot Soccer World Cup VII, Lecture Notes in Computer Science 3020, Springer-Verlag 2004 (received engineering challenge paper award).

30. Quinlan, M.J., Chalup, S.K., and Middleton, R.H. (2003). *Techniques for Improving Vision and Locomotion on the Sony AIBO Robot.* Proceedings of the 2003 Australasian Conference on Robotics & Automation (ACRA'2003).

31. Quinlan, M.J., Chalup, S.K., and Middleton, R.H. (2003). *Application of SVMs for Colour Classification and Collision Detection with AIBO Robots.* Advances in Neural Information Processing Systems (NIPS'2003).

32. Quinlan, M.J., Nicklin, S.P., Henderson, N., Fisher, R., Knorn, F., Chalup, S.K., Middleton, R.H. and King, R. (2007) *The 2006 NUbots Team Report.* School of Electrical Engineering & Computer Science Technical Report, The University of Newcastle, Australia.

33. Quinlan, M.J., Nicklin, S.P., Hong, K., Henderson, N., Young, S.R., Moore, T.G., Fisher, R., Douangboupha, P., Chalup, S.K., Middleton, R.H. and King. R. (2005). *The 2005 NUbots Team Report.* School of Electrical Engineering & Computer Science Technical Report, The University of Newcastle, Australia.

34. Quinlan, M., Murch, C., Moore, T., Middelton, R., Lee, Li., King, R, Chalup, S. (2004). *The 2004 NUbots Team Report.* School of Electrical Engineering & Computer Science Technical Report, The University of Newcastle, Australia.

35. Seysener, C. (2003). *Vision Processing for RoboCup 2003/2004*, project report, School of Electrical Engineering and Computer Science, The University of Newcastle, 2003.

36. Seysener, C., Murch, C., Middleton, R. (2004). *Extensions to Object Recognition in the Four-Legged League.* pp. 274, In: RoboCup 2004: Robot Soccer World Cup VIII, LNCS 3276, Springer-Verlag 2005.

37. Wiklendt, L., Chalup, S.K. and Middleton, R.H.. *A Small Spiking Neural Network with LQR Control Applied to the Acrobot*, Neural Computing and Applications 17, Springer London 2008.

38. Wiklendt, L., Chalup, S.K. and Seron, M.M. *Simulated 3D Biped Walking with and Evolution-Strategy Tuned Spiking Neural Network*, Neural Network World 19, pp. 235–246, 2009.

39. Lukasz Wiklendt and Stephan K. Chalup. *Balance Control of a Simulated Inverted Pendulum on a Circular Base.* Australasian Conference on Robotics and Automation (ACRA), 2009.

40. Wong, A. and Chalup, S.K. *Towards Visualisation of Sound-scapes Through Dimensionality Reduction*, 2008 IEEE World Congress on Computational Intelligence (WCCI), Hong Kong, June 1-6, 2008.

41. Wong, A.S.W. and Chalup, S.K. *Sound-scapes for Robot Localisation through Dimensionality Reduction*, Proceedings of the 2008 Australasian Conference on Robotics & Automation (ACRA'2008).