

Application to Participate Sony Legged Leagues in RoboCup 2003

1. Team Information

Team Name: Essex Rovers

Team Web Page: http://cswww.essex.ac.uk/staff/hhu/Essex_Rovers/ER_team.html

Team Leader:

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Expected number of team members: 3

2. Team Description Paper (in pdf)

2.1 Research Interests

The RoboCup Sony legged robot league is an excellent forum to promote research in many areas such as artificial intelligence, robotics, sensors, and agent technology. Funded by the Royal Society and the University RPF awards, we are currently building a firm research platform on which future work on multi-agent systems can be carried out toward many real-world applications.

In general, RoboCup (the Robot World Cup) is an international research initiative to foster Robotics and Artificial Intelligence using football as a common task. It shares many characteristics of real football games and makes the competition very challenging. Its ultimate goal is "By mid-21st century, a team of fully autonomous humanoid football robots should win over the World Cup champion team." This is another landmark project aiming to achieve significant advance in science and technology similar to other landmark projects such as the IBM Deep Blue project.

Our Essex research team will work closely with other teams together, step-by-step toward the realisation of our dream. We welcome anyone who is interested in making his/her contribution to join this challenging project, especially the talented students who are willing to do research degrees.

1.2 Proposed approach to address the RoboCup challenge

Our research efforts have been put on the construction of a multi-agent system for cooperation and learning of multiple legged robots in the RoboCup domain. The architecture is based on a modular design, which will allow flexible implementation and future extension. A Neural Network based color detection algorithm and a fuzzy logic based controller are investigated. An evolutionary approach to learning in the fuzzy logic controller is employed for reactive behavior control of the Sony legged robots.

We have also focused on developing an interactive software environment for the design of real-time control algorithms in AIBO football playing robots. The software environment consists of three modules such as state reflector, gait generation and vision. It gives a variety of useful features for gait generation and development. By using a mouse or keyboard commands, an operator is able to record a sequence of movements that can be replayed. It is also a very useful tool for debugging and evaluating quadruped gaits.

We also developed an interactive tool by using Microsoft Visual C++ to generate the GCD Table for image thresholding. It provides the ability to simulate image processing with the same C++ code employed in real robots. The most beneficial characteristics of using the GCD method is its flexibility. The system can recognize up to 255 colors with a single table and achieve high accuracy color detection. With the non-rectangle threshold, there is nearly no confusion between two colors.

An important issue in the design of the *Cognition* module in the agent architecture was to synthesis low-level basic behaviors and high-level cooperative behaviors of multiple Sony legged robots. Low-level behaviors enable individual robots to play a role in a specified task or game. High-level behaviors enable a team of robots to accomplish missions that cannot easily be achieved with an individual mobile robot.

Behavior construction and vision processing are two key aspects of focus in our team. Behaviors serve as basic building blocks for our modular software system. The use of two levels of behaviors is to decompose the task into contextually meaningful units that couple perception and action tightly. Fuzzy logic implementation further enhances the abilities of the system in the face of uncertain.

Using this system, both robot's learning and evolving abilities will be focused for the next competition, particularly in the vision system and cooperative behaviors. Inaccurate visual tracking and inefficient kicking will be addressed as well.

2.3 Background of the principal investigator

Huosheng Hu is a Professor in Computer Science at the University of Essex. Prior to this, he was a Lecturer in the Department of Cybernetics at the University of Reading for one year and a senior

researcher in the Department of Engineering Science at the University of Oxford for 9 years, working on 3 successful EPSRC research projects directed by Professor Mike Brady in the area of autonomously guided vehicles (AGVs) for manufacturing in collaboration with industry. He has developed different sensor systems and data fusion algorithms for mobile robots to navigate in both indoor and outdoor environments with dynamical changes. Bayesian decision theory has been adopted to reduce uncertainty for mobile robots to handle unexpected situations in real time. He has also developed statistical models for mobile robots to implement global path planning in manufacturing environment, which are based on Bayesian learning by integrating prior information and new information gathered by multiple sensors.

Prof. Hu has published 6 book chapters and over 100 papers in the area of sensor fusion, autonomous navigation, RoboCup and mobile robotics. He received a number of best paper awards, and successfully completed a number of research projects as a principal investigator funded by the Royal Society, EPSRC and industry. He is a founding member of IEEE Society of Robotics and Automation Technical Committee of Internet and Online Robots since 2001 and a member of the IASTED Technical Committee on "Robotics" for 2001-2004. He was a Conference Chairman for the 1st European Embedded Systems conference in Paris, 1996, and a member of the Program Committees for a number of international conferences such as IASTED Robotics and Applications Conferences between 2000 and 2003, RoboCup Symposiums 2000, 2001, 2002 and 2003.

He is a member of EPSRC Peer Review College. He served as a member of Editorial Advisory Board for International Journal of Industrial Robot during 1997 to 2000, and currently is a reviewer for a number of international journals such as IEEE Transactions on Robotics and Automation, Automatic Control, Neural Networks and International Journal of Robotics Research. He is a Guest Professor at both Central South University and Northeast Normal University, China, between 2000 and 2005. Also, he is a Chartered Engineer, a senior member of IEEE, and a member of IEE, AAI, IAS, IASTED and ACM.

2.4 Description of the team organization and effort to be spent

- Dr Dongbing Gu is currently working on the development of hybrid control architecture, fuzzy control and learning algorithms for Sony robots.
- Mr Dragos Golubovic is working on low-level motion control, including wheel-like gait generation and motion control. Genetic algorithms have been adopted to optimize the control parameters for optimal control of the robots.
- Mr Bo Li is working on real-time visual navigation, including color table and color segmentation, object recognition and tracking.

2.5 Some relevant publications

- B. Li, H. Hu and L. Spacek, An Adaptive Colour Segmentation Algorithm for Sony Legged Robots, Proceedings of IASTED International Conference on Artificial Intelligence and Applications, Innsbruck, Austria, 10-13 February 2003
- D. Gu and H. Hu, Reinforcement Learning of Fuzzy Logic Controller for Quadruped Walking Robots, Proceedings of 15th IFAC World Congress, Barcelona, Spain, July 21-26, 2002
- D. Golubovic and H. Hu, An Interactive Software Environment for Gait Generation and Control Design of Sony Legged Robots, Proceedings of the 6th International Symposium on RoboCup, Fukuoka, Japan, 24-25 June 2002
- D. Gu and H. Hu, GA-based Automatic Acquisition of Fuzzy Rules for Controlling Quadruped Walking Robots, Proc. Conference of Institute of Automation, Beijing, China, 21 September 2002
- B. Li, H. Hu and L. Spacek, A Hybrid Experimental Platform for Sony Legged Robots, Proceedings of CACSCUK'2002, UMIST, England, ISBN 0 9533890 5 9, 21 September 2002
- D. Golubovic and H. Hu, A Hybrid Evolutionary Algorithm for Gait Generation of Sony Legged Robots, The 28th Annual Conference of the IEEE Industrial Electronics Society, Sevilla, Spain, Nov. 5 to 8 2002

- H. Hu and D. Gu, Reactive Behaviours and Agent Architecture for Sony Legged Robots to Play Football, *International Journal of Industrial Robot*, Vol. 28, No. 1, pages 45-53, ISSN 0143-991X, January 2001
- D. Gu and H. Hu, Evolving Fuzzy Logic Controllers for Sony Legged Robots, *Proc. of the RoboCup 2001 International Symposium*, Seattle, Washington, 4-10 August 2001
- H. Hu, D. Gu, D. Golubovic, B. Li and Z. Liu, Essex Rovers 2001 Team Description, *Lecture Notes on Artificial Intelligence 2377: RoboCup 2001*, A. Birk, S. Coradeschi and S. Tadokoro (Eds.), pp. 679-700, 2001
- D. Gu and H. Hu, Fussy Behaviour Learning for Sony Legged Robots, *EUSFLAT 2001 - European Society for Fuzzy Logic and Technology Conference*, De Montfort University, Leicester, UK, September 5-7, 2001
- H. Hu and D. Gu, A Multi-Agent System for Cooperative Quadruped Walking Robots, *IASTED International Conference Robotics and Applications (RA 2000)*, Honolulu, Hawaii, USA, August 14-16, 2000
- Huosheng Hu, Kostas Kostiadis and Zhenyu Liu, Coordination and Learning in a team of Mobile Robots, *Proc. of the IASTED Robotics and Automation Conference*, Santa Barbara, CA, USA, 28-30 October 1999

2.6 Statement of commitment to enter RoboCup-2003 in Padova

We are currently seeking financial support from our university, industry and funding organisations to cover our registration fee and travel expenses.

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