# A Review of "Towards Autonomous Robotic Systems" TAROS 2005

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***Abstract:*** *This contribution gives a brief review of the proceedings and activities of the 6th "Towards Autonomous Robotics Systems" conference held at Imperial College London, September 12-14th, 2005.*

The "Towards Autonomous Robotics Systems" series is fast becoming the premier venue for the UK robotics community to meet and discuss robotics topics drawn from and inspired by a range of diverse ideas such as Artificial Intelligence, biological and materials sciences, computer science, mechanical and electronic engineering, new materials, autonomy and energy considerations, and more. TAROS 2005 was hosted jointly by the Cognitive Robotics group and the Biologically Inspired Autonomous Robotics Team (BioART) of the Department of Electrical and Electronic Engineering at Imperial College London.

The TAROS series has always sought to be a fully inclusive venue for the robotics community, not only welcoming contributions from experienced researchers but also encouraging younger researchers wishing to participate in the activities of the community. The series began with the TIMR (Towards Intelligent Mobile Robots) conferences. The name was changed to TAROS at the 2003 event to reflect the full breadth of interests within the UK robotics community.

The 34 papers presented, either orally or as posters, and published in the main proceedings [Nehmzow *et al*, 2005] reflect the state of contemporary research in the U.K. and beyond, with the majority of established U.K. robotics research sites represented at the conference. The significant degree of international participation this year also serves to highlight the broader context in which that research is placed.

TAROS is a multi-themed conference, its content necessarily reflecting current research. Several topics were well represented: robot design, swarm and cooperative behaviours, communication, imitation, and scientific methods in robotics research. Much robotics still takes place in the laboratory, but robotics for space, terrestrial and undersea exploration were all present.

Aspects of robot design remain a key issue. In the opening session the University of West England (UWE) team described a new mechanical and control design for a haptic sensor array modeled on the vibrissae (whiskers) of a rat, (Pearson *et al*., p.189 and this issue). From the same team, Ioannis Ieropoulos (Ieropoulos *et al*., p. 89 and this issue) describe both the technology and an extensive series of experiments with their EcoBot II, claimed to be the first robot powered by a Microbial Fuel Cell, in which electrical energy is extracted using bacteria from commonly available biological substrates such as plant or insect matter. Power outputs are low, but power self-sufficiency represents a key step on the road to true robot autonomy.

Dario Floreano's keynote address on the Tuesday morning was notable both for highlighting long standing work at EPFL on evolutionary cooperative working between robots and his video demonstrations of co-operative working between many "swarm-bot" robots; small mobiles that visually identify the state of others in the group and form cooperative chains by gripping each other about the midriff with specially adapted clamps. The flexible configurations created allow connected groups to complete tasks clearly impossible for individual robots, such as gap crossing. In a separate "search and rescue" scenario, swarm-bots located and attached themselves to a "victim", then attracted further robots to form long chains together developing sufficient traction to pull the person to "safety".

Several TAROS papers also took up the challenges presented by swarm and cooperative working between multiple robots. Mark Ayre (Ayre *et al*., p. 1) (European Space Agency) adopts behaviour based clustering algorithms to explore the potential for forming configurations of autonomous vehicles in space for robust self-assembly of complex structures. Alan Winfield (Winfield *et al*., p. 243 and this issue) presented exciting new work from UWE and Manchester using temporal logics to specify the formal properties of swarm behaviour. Gil-Pinto *et al*. (p. 65) adopt a control theoretic approach to follow-the-leader allowing each follower robot compute a trajectory to best maintain its position

relative to the leader. Schneider *et al*. (p. 205 and this issue) compare metrics for evaluating the quality of formation maintenance during leader-follower robot behaviours.

Kalantar and Zimmer (p. 135 and this issue) of the Australian National University, Canberra, describe a control strategy for multiple underwater vehicles to form along gradient isoclines. From the same ANU team, Schill, Zimmer and Trumpf (p. 197) provided a theoretical analysis of a many-to-many "omnicast" strategy for communication between swarms of submersibles, and Webers and Zimmer, (p. 235) considered the issues of real-time modeling of advanced dynamical systems, applicable to underwater vehicles.

Rigorous scientific investigation of robot technologies represents an important step in the development of the field. Theocharis Kyriacou (Kyriacou *et al*., p. 143 and this issue), University of Essex, described a method of encoding the behaviour of a mobile robot in a high-order polynomial function that may be used to identify the essential properties of the system, and provide a means to transfer behaviours easily and compactly between dissimilar robots. Also from University of Essex, Vieira Neto and Nehmzow (p. 227 and this issue) compare two approaches to visual novelty detection in robots. Gunstone and Lee (p. 73) describe a calibrated robot tracking method; Cassinis *et al*. (p. 27) a robot localisation method utilising active beacons.

Klaus Schilling's keynote address

Wednesday's keynote address by Klaus Schilling (University of Würzburg) developed the space theme and described his work towards the descent control systems of the NASA/ESA Cassini/Huygens space mission to land on Titan, one of Saturn's 30 or more moons. The talk combining insight into the technologies and techniques required to overcome the severe problems of long mission times and far remote autonomous operation with findings from the mission science, revealing a strange world of rivers and lakes of liquid methane.

Mike Rose's (British Antarctic Survey, NERC) invited talk both introduced the work of the British Antarctic Survey and considered the opportunities and not inconsiderable challenges for robotics and the robotics community in another remote, cold and inhospitable – but at least comparatively accessible – environment.

Rachel Gartshore and Phil Palmer, University of Surrey (p. 57 and this issue) were awarded the Springer Best Paper Award for their paper "Exploration of an Unknown 2D Environment using a View Improvement Strategy" describing Rachel's doctoral thesis work on an area-mapping algorithm that explicitly identifies under-explored areas for further investigation.

The Springer Best Paper Award, presented by Ulrich Nehmzow

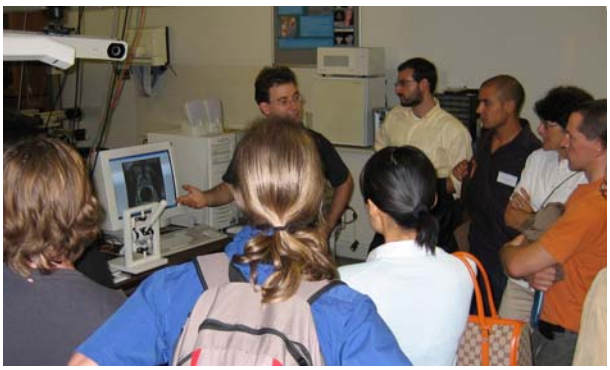
This year TAROS directly incorporated papers from the Biologically Inspired Robotics Network (Biro-Net) autumn symposium as a fully integrated session. Funded by EPSRC, Biro-Net has been established to foster working links between biologists and robotics researchers. This integrated session reflects the growing extent to which the UK robotics community is influenced and inspired by the biological sciences.

Combining the biologically inspired with a space theme, Yang Gao (Gao *et al*., p. 51 and this issue) presented a design for a biomimetic drilling and sampling system for extraterrestrial deployment inspired by the reciprocating motion of the ovipositor of the wood wasp. Also in this session, Theodoros Damoulas (Damoulas *et al*., p. 35) presented work at IPAB, University of Edinburgh, considering the role of valency (sensations arising from changes in internal physiology) in balancing evolved and adaptive agent behaviours. Meng and Lee's (University of Aberystwyth) paper (p. 157 and this issue) described a robotic model of early stages in sensory motor learning, inspired by Jean Piaget's theories of child development. Matt Johnson (Johnson and Demiris, p. 119 and this issue) from Imperial College London presented his latest work on imitation in robots, using forward and reverse visual models to simulate and interpret actions and intentions from the visual perspective of other robots; imitation in robots was also addressed by Bart Jansen's (p. 111) paper.

Language and communication amongst robots and between people and robots remain important topics. Pejman Iravani and Jeffrey Johnson (p. 95) considered

how teams of robot footballers might establish a form of visual communication to help team strategy by observing formations of players within the teams. Stanislao Lauria (p. 151) described how a robot's perceptive abilities can be used to improve speech recognition rates for specific tasks. Joerg Wolf and Guido Bugmann (p. 251) considered the problems of language corpus collection in a robotics context.

Tours were organised of two of the main robotics laboratories at Imperial College London. Postgraduate and undergraduate students of the Cognitive Robotics and BioART groups (Electrical and Electronic Engineering) were given the opportunity to present their current work. Paschalis Veskos demonstrated his use of synchronised neural oscillators for walking control using the lab's miniature humanoid robots Flip and Flop, Tim Guhl his application of Bernie Baars' "global workspace theory" to visual perception, Georgios Sakellariou his technique for image skeletonisation inspired by robot navigation techniques and Varol Kaptan his work on pursuit behaviours in robot swarms. Imperial undergraduates Vidula Vinayagamoorthy and Adam Rae, both completing summer internships under Imperial's Undergraduate Research Opportunities Program (UROP), demonstrated visual tracking with the group's upper torso humanoid robot, LUDWIG.



The Mechatronics in Medicine Laboratory

Also on show were recent advances in surgical robotics at the Mechatronics in Medicine laboratory (Mechanical Engineering). The MiM's world leading robotics developments include the *Acrobot*, assisting surgeons in knee replacement operations by providing a stable and controlled platform for bone removal, *Roboscope* for endoscopic surgery of brain tumours and *Probot* for transurethral resection of the prostate (TURP). Demonstrated was the group's *TURP trainer/monitor* system for surgical training.

Conferences such as TAROS are not just about the technology. The Monday reception hosted by the organising committee gave everybody a chance to meet and talk over a Sri Lankan style buffet meal and drinks. The formal conference dinner presented a second opportunity to discuss issues and socialise in the rather more grandiose surroundings of the Ognisko Polish Club restaurant in Exhibition Road.

A special "robotics in the arts and education" session introduced the participants to the work of the EPSRC funded Creative Robotics Research Network (CRRN). In the arts section, Paul Granjon (Z-productions) described his "sexed robots" installation, then on display at the Venice Biennale arts festival. Alex Zivanovic (Imperial College London) spoke on Edward Ihnatowicz's early computer controlled sculpture, the Senster, which was displayed for several years from 1970 at the futuristic Evoluon in Eindhoven. The Senster's fluid and lifelike responses to visitors using sound and movement sensors made it a great favourite with visitors. At the end of the conference the CRRN organised independent trips to the National Science Museum and to the "Machine Shop", a company specialising in use of animatronics and robotics for special effects.

The work of many individuals and the support of many organisations are required for a successful conference. Thanks, then, to the members of the program committee for providing their time and expertise in reviewing the papers submitted. As conference local organiser, I would particularly like to record my thanks to Mercedes Lahnstein, Matthew Johnson, Adam Rae, Fabienne De Swardt and Shahareen Hilmy of the Department of Electrical and Electronic Engineering of Imperial College, to Dr. Alex Zivanovic of the Mechatronics in Medicine laboratory, and to Janet Thomas of Biro-Net for their help and support with the conference organisation.

The organisers are grateful to Biro-Net for their help and support, including sponsorship for the invited speakers and in the provision of bursaries for the young researchers speaking in the Biro-Net session. We are also grateful to Springer, London, for their continuing sponsorship of the best paper prize and to the Engineering and Physical Sciences Research Council (EPSRC) for financial support of TAROS 2005, directly through research grant EP/C530683/1 ("Abductive Robot Perception: Modelling Granularity and Attention In Euclidean Representational Space") and through their support for Biro-Net.

The 7th in the series "Towards Autonomous Robotic Systems", TAROS 2006, will be held at the University of Surrey in September 2006 and we look forward to another stimulating meeting then. You can keep up to date with news about the conference, paper submission deadlines and the like at the website, www.taros.org.uk.

Unless otherwise indicated, all page numbers in this review refer to articles in:

Nehmzow. U., Melhuish, C. and Witkowski, M. (Eds.) (2005) Proceedings of Towards Autonomous Robotic Systems (TAROS-2005), Imperial College London, September 12-14th 2005; ISBN 0-905247-03-5