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Autonomous Systems and Robotics at ACSE

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Abstract

The Department of Automatic Control and Systems at Sheffield University has three research groups around the topics of:

1. Complex systems – modelling and control
2. Intelligent control and monitoring
3. Autonomous control and robotics

Until early 2013 there have been only the first 2 groups covering the well-established fields of control science for engineering systems. Mid 2013 resulted in the formation of a new group, a third research group , known as Autonomous Control and Robotics has been formed due to the emerging industrial need for advanced control systems in autonomous operations. Since its formation, with 9 core members, the group has rapidly grown and it now makes for over one third of the academic members of the department and a few more who belong to more than one research group. Beyond the academic members, the number of researchers affiliated with the group is now over 30 which makes it one of the largest groups in the UK of its kind. The Autonomous Systems and Robotics Group – ASRG currently holds about £4.8M from EPSRC and around £1M from the EU, TSB and from direct industrial support. Consequently, ACSE, through ASRG, has a large presence in the Sheffield Centre for Robotics – SCentRo. This talk briefly outlines the research areas ASRG members are most interested in.

ASRG's professional interests can be approximately grouped around the following topics.

1. *Design tools for autonomy*

Research effort in this area covers topics such as how to build and programme easily reconfigurable and self-reconfiguring robots, software agent architectures to deliver autonomous capability in highly complex environments and we address problems of how to create a working, ongoing, anthropomorphic relationship between robots and their users. We develop design methods for autonomous control of ground and air vehicles (UAVs), for co-operative control, for mission planning, navigation, task allocation and for simultaneous localisation and mapping (SLAM).

2. *Cooperation between intelligent machines*

This deals with problems inducing development of robot cooperation in a team of robots. Methods are being developed where robots are observing and interpreting each other's intentions (robot empathy). We are doing research on pursuit and evasion policies by a team of robots, human swarm interactions, multi-vehicle cooperative trajectory planning. There is also research on robot cooperation based on distributed optimisation methods, optimisation-based islanding of power networks using piecewise linear AC power flow and cooperative distributed model predictive control systems with coupled constraints. We also pursue research on cyber-physical systems whose operations are monitored, coordinated, controlled, and integrated by a computing and communication core.

3. *Functional safety by formal verification*
Problems of how to synthesise correct-by design autonomous systems, capable of reliable decision making in complex environments. We address problems such as: given an autonomous robot for some application, how we can analyse and improve its reliability? How to cope with the safety, legal and ethical challenges in future use of autonomous robots? How can intelligent robots make decisions in an ethical way? We use formal verification methods on supercomputers to automate the process of analysing robot behaviour in complex environments.

4. *Robotic situational awareness from cameras and sensors.*

We develop new advanced methods for reasoning about many objects that evolve in a scene over time. Information about such objects arrives, typically in a real-time data feed, from sensors such as radar, sonar, LIDAR and video tracking in complex sensor systems. We also address the problem of architectures for dynamic heterogeneous information fusion to extract knowledge from large amounts of data.

5. *Autonomous power system solutions*

We develop methodologies for parallel operation of inverters to facilitate large-scale utilisation of renewable energy. Design of autonomously operating hybrid electric vehicles by optimisation of system components as well as their control systems is being delved into. We have also been doing research on integrating and automating airport operations.

6. *Assistive robotics*

We develop assistive techniques for mobility of disabled and the elderly, muscle and joint modelling techniques, intelligent techniques for gait restoration in paraplegia, robotic and functional electrical stimulation-assisted mechanisms for exercise, with benefits of rehabilitation, for paraplegia. These include rowing, cycling, treadmill walking, sit-to-stand manoeuvres, intelligent orthotic systems for mobility, manipulation and grasping for elderly and disabled in support of ambient assisted living.

This is a non-exhaustive list of our research limited by space and it does not cover, for instance, aspects of swarm robotics addressed by another talk at this conference.
Further information on the work of the Autonomous Systems and Robotics Group can be found at http://www.sheffield.ac.uk/acse/research/groups/asrg

Keywords Control Systems; Autonomous Systems; Robotics