Field Robotics

We are developing technologies that allow robotic systems to assist or replace humans performing tasks that are difficult, repetitive, unpleasant, or take place in hazardous environments. These robotic systems will bring sociological and economic benefits through improved human safety, increased equipment utilisation, reduced maintenance costs and increased production.

Capabilities

- **Dynamics and Control** — For robots to operate effectively, they require not only a model of their environment, but also a thorough ‘understanding’ of their own range of motion. This requires the implementation of suitable control algorithms for each robot. We are investigating the dynamic modelling and intelligent control of robots, developing control algorithms that take full advantage of the robot’s form and provide consistent and reliable operation at the machine’s performance boundaries. This technology will allow robots to be used within tight operational constraints, performing tasks using minimum energy and in minimum time.

- **Engineering Support** — Our robotics research is supported by a team of engineers and technicians who are skilled in all aspects of robotics hardware design, construction and maintenance. The Engineering Support team is involved from the conceptual design stage though to the full integration of all the electrical, mechanical and electronic components of our robotics platforms. Our projects with industrial partners require the team to maintain up to date qualifications and knowledge of site operating procedures, safety standards, and maintenance schedules in mining and other industries. The team is experienced in working on-site with local technicians to ensure industrial-quality deployments of our automation technologies.

- **Mapping and Localisation** — Almost all applications of field robotics require the robot to be able to locate itself with respect to some coordinate system. Our research and expertise in this area includes laser scan matching, beacon-based localisation, visual odometry, and off-board vision-based localisation (using fixed cameras to track the robot). Another common scenario in field robotics occurs when a robot has no known map or accurate measure of its pose, so must simultaneously estimate and maintain both. This is known as Simultaneous Localisation and Mapping (SLAM). Our research focuses on solving the SLAM problem for applications involving long term autonomous operation of robotic vehicles.

- **Materials Handling** — We have significant experience with developing autonomous vehicles and systems for material handling both indoors and out. For these vehicles to be dependable, they need to be reliable, efficient, and safe in their operations. We have addressed these issues through the robust design and testing of algorithms, hardware and software systems that allow the vehicle to localise itself, navigate and operate in the presence of other vehicles and people, whilst conducting its end-to-end operations in varying weather conditions.

- **Outdoor Vision** — Using visual perception for robots in an outdoor setting requires algorithms that give reliable and consistent performance in lighting conditions ranging from bright sunlight, through overcast and rainy conditions, to darkness (in the case of 24 hour operations), and possibly poor visibility (such as underwater). Challenges for day-time operations include strong shadows and high-contrast scenes which necessitate intelligent exposure control. Practical vision algorithms must operate in real-time onboard the robot, which introduces additional challenges in cases where the processing computer is limited in terms of power consumption and physical size.

- **Robot - Sensor Network Interaction** — We are exploring ways of using robots to augment the capability of fixed sensor networks. Static nodes have a limited sensing horizon and typically a low-cost sensor, low-computational power and low energy budget. By contrast a mobile agent (robot) has more energy and computation available, and can carry larger and higher quality sensors. Further, since it is capable of returning to base the robot can recharge, download data over a high bandwidth link and recalibrate its sensors. Robots can also physically interact with the environment and with the static sensor network for tasks such as deployment, redeployment and repair of nodes. Meanwhile, the sensor network can act as a communications fabric for mobile agents, and can provide information beyond the range of a robot’s on-board sensors.

- **Shared Autonomy** — Shared autonomy describes the situation where control of a machine is shared between a human operator and a computer system. If the operator is located remotely, control can be compromised by the effects of communications latency and reduced bandwidth - meaning that the robot appears unresponsive and the operator has little knowledge of what is happening around the machine. It is therefore critical that the computer control system be designed so as to prevent the machine from causing unintended damage. Our research in this area is developing technology that will make the operation of remote machinery both safe and productive.

- **Situational Awareness** — In order for robots to interact with their environment, they need to be able to sense their surroundings and construct a useful world model from that sensory input. Our robots use a variety of sensor systems, including laser, radar, and sonar scanners, as well as mono and stereo vision and infrared cameras. The optimal choice of sensing apparatus for a given application is determined by factors such as the typical features of the environment, the presence of other moving objects, the size and speed of the robotic vehicle, and the type of tasks it must perform.

Platforms

**Unmanned Helicopters**

Unmanned aircraft (UAVs, RPAs, drones) are a rapidly growing sector of the aerospace industry. We are developing technologies enabling safe and cost-effective operations of unmanned helicopters through automation. Our long-term goal is operations of unmanned helicopters in non-segregated airspace without the need for human supervision.
Projects

1999-2004 Load Haul Dump (LHD) Automation — An LHD is a mid sized (up to 60 tonne) underground mining vehicle that loads, hauls and dumps (hence its name) metaliferous ore from an open stope (where there is broken rock) to a crusher or waiting truck to be transported to the surface. Since the roof of the tunnel in open stope areas is unstable, this type of operation presents a number of safety issues and provides a perfect opportunity for automation. Our aim in this project was to automate the haulage and dumping cycle for an LHD.

2000-2007 Blast Hole Charging Automation — The aim of this project was to automate the charging process in underground mining. This process involves placing primer and detonators into holes drilled into the roof and walls of development drives, and filling the holes with liquid explosives. The vehicle to be automated (referred to as the Mobile Charging Unit) carries an emulsion pumping system, a primer/detonator assembly system and a hydraulic arm. CSIRO’s role in the project was to develop a hydraulic arm that is able to insert the emulsion hose into the pre-drilled holes.

2004-2009 Shovel Loading Automation — With funding from the Australian coal industry’s research program ACARP, CSIRO is collaborating with the Cooperative Research Centre for Mining, to develop automated swing loading technology for electric mining shovels. Our contribution to this project is the development of a system which takes input from a variety of sensors (including lasers and a mm wave radar) and uses this to construct and maintain an accurate model of the shovel’s environment capturing the shape and form of the face, the position and location of the crusher-conveyor or truck and the shovel itself.

2005-2006 Excavator Guidance — This project developed and demonstrated a system that is able to simultaneously track the bucket of a mining excavator and map the terrain under the boom. Trials of a proof of concept system deployed on an excavator at the Blair Athol mine in central Queensland demonstrated that the system is able to generate dynamic Digital Terrain Maps (DTM) while tracking the location of the bucket teeth to within 10cm. Importantly, the trials also demonstrated that the sensors are able to survive over extended periods in the mining environment.

2007-2008 Rock-Breaker Automation — Together with colleagues from across the ICT Centre as well as CSIRO’s Division of Exploration and Mining, researchers from the Autonomous Systems Laboratory have developed technologies that will enable the effective and safe tele robotic control of mining equipment over distances of thousands of kilometers. Our technology has been proven on a Rockbreaker machine at Rio Tinto’s West Angeles iron ore mine, which was controlled by an operator over 1,000 km away in Perth.