Jay Katupitiya and colleagues at the University of Sydney have already developed a driverless tractor

Machines without men

Driverless machinery, is inevitable, but developing farming systems that need sophisticated technological solutions can be minimised.

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In broadacre agricultural operations, almost always there exists cooperation between a mobile element and a manipulative element. The mobile element is most commonly a tractor and the manipulative element an implement. In general, the tractor provides the propulsion and the implement carries out the task. In carrying out the task, the implement interacts with the ground and is subject to a wide variety of forces that more often than not, causes undesirable implement motions. As precision farming is becoming increasingly important, it is necessary to improve the precision of implement motion. This is in stark contrast to the precision of the prime mover motion.

Our proposed research aims to develop control methodologies to maximize the precision attainable in controlling agricultural equipment. There are two primary research goals.

Firstly, we will endeavour to develop a complete and accurate mathematical model of the tractor-implement combination. To date, all published works are aimed at developing controllers based on simplistic kinematic models. They ignore the dynamic effects and hence, perform poorly in practice.

Developing a complete mathematical model is a complex task. Having obtained the complete mathematical model, sophisticated control algorithms will be developed to suit the model. These algorithms will then be tried in simulation to choose an optimised algorithm.

Secondly, we will develop control strategies to be implemented on a fully instrumented agricultural tractor. GRDC funds will be used to build a seeding implement that can be pulled by the John Deere tractor described.

The instrumented and automated tractor is an excellent facility to carry out the proposed research. We have already developed a low level traction control system similar to the tractor's control hardware, and a steering control system that can accurately follow command signals delivered by a high level controller, such as the one based on the complete mathematical model. While the automated steering and traction control system make the tractor suitable for unmanned operations, the primary achievement is the elimination of human operator involvement that may contribute to down grading the precision of the tractor operation.

The final aim is to make the implement accurately follow the desired path

The tractor is equipped with two on-board GPS systems that communicate with a base station GPS system, so that RTK operation is implemented. The base station GPS system and one of the on-board GPS systems have 2cm accuracy, therefore a high precision read out of the tractor position is obtained. The second GPS system has 20cm accuracy. It is used in conjunction with the first on-board GPS system to obtain the tractor orientation, ie yaw and roll. The tractor pitch is obtained by a precision tilt sensor. These sensors are sufficient to obtain the position and orientation of the tractor even when it is stationary.

The tractor is fitted with an Inertial Measurement Unit (IMU) to measure short term dynamic movements. This device is particularly useful during the mathematical modelling of the tractor. As some of the modelling will be based on experimental system identification, the rate gyros and accelerometers of the IMU are extremely useful. A 3-D angle sensor mounted at the hitch point will deliver the global position and orientation of the implement, so the roll, pitch and yaw of the implement will also be known.

The final aim is to make the implement accurately follow the desired path. This requires a certain number of control inputs. Tractor steering and propulsion are two inputs currently used. However, they are insufficient and are unable to influence significantly the implement motion. Therefore, some means of generating lateral forces on the implement is necessary. One suggestion is to use trailing steered wheels at the implement. There are many other methods to generate such lateral forces.

At the same time as steering the implement on the desired path the system must be able to accommodate the requirements of current farming practices – no-till, controlled traffic, wheel track minimisation to avoid soil compaction etc.

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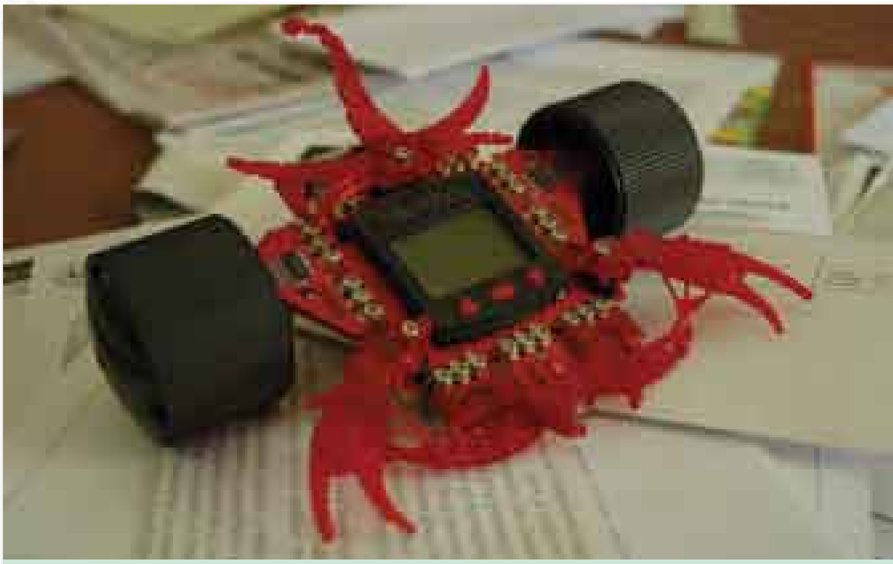

Today a homemade robot, tomorrow automated filing – everything can be on wish list.

Autonomous versus automatic

Autonomous systems are systems that can make decisions and do things without direct human intervention. Automatic systems carry out tasks without making decisions. Autonomous systems require a certain degree of artificial intelligence. Automatic systems do not require intelligence; if a system knows exactly what is going to happen and then no intelligence is necessary. Therefore, autonomous systems are meant to expect unexpected situation and must be capable of making the right decision.

Given the limited structure that can be achieved in agricultural operations, automatic systems are unsuitable. So, autonomous systems will form the backbone of the autonomous farming, 'machines without men'.

Intertwined with the autonomous systems are reliability and cost effectiveness. In general, simpler systems are more reliable and obviously cost effective. Broadacre agriculture is well poised to maximise reliability by achieving simplicity. Simplicity can be achieved by enforcing structured operations, as with these less sensing is required. So, the most vigorous autonomous operations must take place at seeding to ensure precision layout of plants, or even at the land preparation stage for new farms. Once this has been done, the follow up operations become even simpler to automate and manage.