AUTOMATION AND THE FARMER

John Billingsley

National Centre for Engineering in Agriculture,
University of Southern Queensland, Toowoomba, Australia.
Email: billings@usq.edu.au

ABSTRACT

A current problem in Australia is the shortage of human assistance for farmers. Automation and technological innovation are discussed as answers to this, delegating tasks to 'robot' systems. By way of example, projects are examined that have been conducted over the years at the NCEA, including vision guidance of tractors, quality assessment of produce, discrimination between plants and weeds and determination of cattle condition using machine vision. Strategies are explored for extending the current trends that use machine intelligence to reduce the need for human intervention, including the concept of smaller but more intelligent autonomous devices. Concepts of teleoperation are also explored, in which assistance can be provided by operatives remote from the process. With present advances in communication bandwidth, techniques that are common for monitoring remote trough water levels can be extended to perform real-time dynamic control tasks that range from selective picking to stock drafting.

Keywords: Automation, machine vision, robotics, teleoperation

INTRODUCTION

As its name implies, the National Centre for Engineering in Agriculture is concerned with exploiting engineering advances for the benefit of farming. Whereas the research stimulus has in the past arisen from the need to improve quality and efficiency, another factor is becoming prominent. The labour needed to perform the essential farming operations is becoming increasingly hard to find.

The focus of this paper is to consider ways in which a degree of autonomy can be introduced to farming, while observing the necessary limitations of safety and efficiency.

Over a distant historic perspective, migration of the workers from the land to the cities can be viewed as the result of 'push' by their replacements, first by the horse, then by the steam traction engine and more lately by the internal combustion engine. But now the cities have exerted their own attractions. The shortage of manpower is now well established and digital technology is experiencing a 'pull' to provide assistance to the few remaining workers on the land.

Tractors and farm machinery have grown increasingly larger, so that a single human operator can cover a maximum area in a day. Although there are still a few crops that are picked by hand, mechanical harvesting is taking over with increasing levels of automation. In some cases, crops have been adapted so that they can be gathered automatically for later sorting or processing in a controlled environment. For example, some varieties of tomatoes are harvested green and hard, being ripened and sorted on grading lines in a packing shed. The sorting and grading of apples is illustrated in figure 1.

Guidance of farm vehicles by GPS and machine vision is becoming more widespread (Figure 2). In addition to straightening the rows of crop so that measures such as 'controlled traffic' can be applied, automatic guidance reduces the burden on the driver, Nevertheless a driver must be present, if only to satisfy the needs of insuring the machine against the damage that it could inflict if it were fully autonomous.

The farming of beef holds romantic images of stockmen rounding up and tending herds of cattle, driving them along stock routes to new pastures or to the abattoir. But while the stockmen have been made more mobile with the quad-bike and the helicopter, there is pressure to replace as many of their functions as possible.

Wool is a labour-intensive product when it comes to shearing time. But efforts to replace the shearer with a robot to drive the clippers have not been successful. Could a change of objective from the present desire to keep the fleece in one piece lead to a breakthrough?

The objective of this paper is to view a number of developments in agricultural automation in the light of the present Australian climate of labour shortage. Some speculative ideas are also explored that may seem strange today but which might become commonplace.

Figure 1. A sea of apples queue up for grading

Figure 2. Machine vision and GPS can straighten furrows

THE AUTONOMOUS ROBOT FARMHAND

Some years ago a light-hearted story [1] extended Steele Rudd's chronicles of “Dad and Dave” beyond the present time. One theme explored the concept that large autonomous tractors had become illegal, on account of their danger to the public at large. They were to be replaced by small machines that although autonomous, were of a size that presented little threat.

Research on small machines can now be found in the literature, though not necessarily as a result of the story. When satellite guidance was first introduced, its price left little change from $100,000. Now we see GPS receivers with an OEM price of just a few dollars installed in modestly priced mobile telephones, even more cheaply than in the navigation aids for motorists. Although the intrinsic errors of the cheaper systems exceed the requirements for guidance within a crop row, a combination of 'codeless' techniques with machine vision can give the necessary precision [2]. The computer controller embedded in any simple appliance has far more processing power than that which is needed for the tasks of a small farming robot. If such robots became common, then with the economy of scale a complete command and guidance package could be put together for one quarter of the cost of the quad-bike style of mechanism that might convey it (Figure 3).

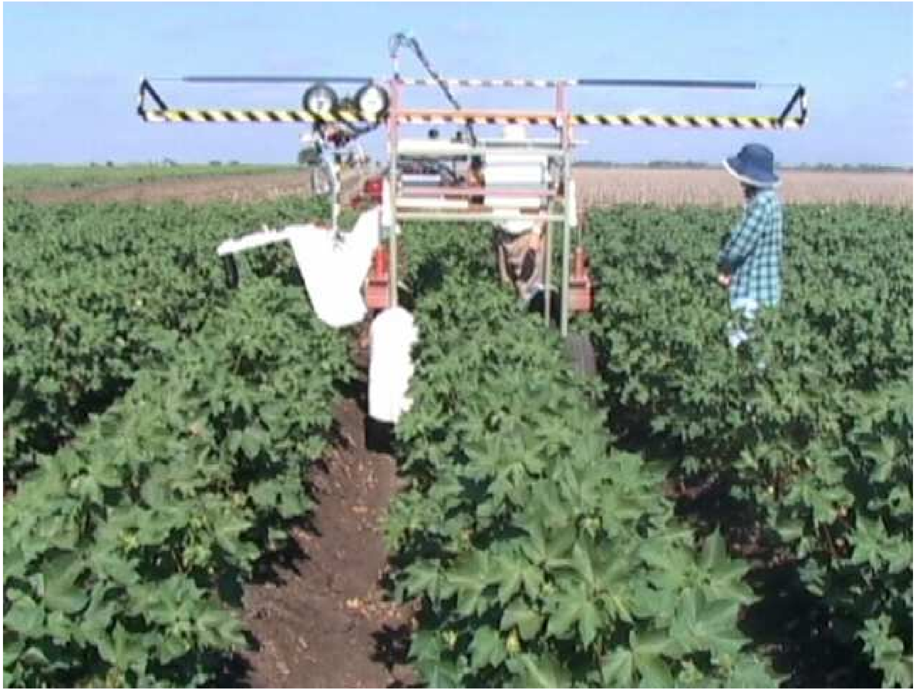

Figure 3. University of Southern Queensland's 'Autonomous Robot Farmhand' in action [3].

Without the pressure of labour shortage, the imperative of large machines does not apply. In the Philippines, in Central Luzon, the collection of implements and harvesters for rice shown in figure 4 would be dwarfed by machinery common to the most modest of property here in Australia. With ample labour, it is hard to justify any attempt to make the machines large or autonomous in a Philippine environment.

Figure 4. A display of the 'latest' machinery in a Luzon research facility.

Even in Australia, one of the factors impeding the uptake of digital technology would be any need for expert maintenance and repair. The mainframe installations of old required a data-processing manager commanding a team of technicians. Today, the High Street laptop has much greater computing power than those old mainframes, but if it becomes faulty it is much more likely to be scrapped than it is to undergo an expensive repair. In a similar way, maintenance of small robots can become less of a concern. Whereas the loss of the use of a large tractor could be a disaster for the farm, the failure of a small robot tractor from a team of a dozen is a mere inconvenience, while it waits to be returned to the dealer.

So what tasks could such a robot perform?

A clear candidate is selective spraying, either to control weeds or pest infestations. Sensors can be carried close to the growing crop. Speed is less of an imperative than with a large machine that employs a human driver. The small robot machines can work day and night, indeed night time is likely to offer advantages in the ability to control the lighting. The logic that interprets the images can then take detection to a high level of reliability.

Other potential tasks include those such as cultivation, tasks where large forces or loads are not involved. Seed planting can also be performed with great precision. Harvesting would require collaboration with a load-carrying vehicle onto which small robots could unload their produce. This would parallel the methods used until recently for the manual harvesting of broccoli, where pickers walk behind a vehicle, cutting broccoli heads and placing them on conveyor belts extending from the carrying vehicle. Indeed the use of a 'mother vehicle' could be of more general use for refuelling the robots, restocking them with chemicals or seed to apply, or acting as a hub for communications between the robots and a central command and control station.

HARVESTING CATTLE

Two recent projects have given insight into the way that beef farming is carried out. In many regions such as the dry centre, near Alice Springs, cattle can be relied upon to make regular visits to watering points [4]. These can be fenced, with access that requires the animals to pass close to an electronic reader that can identify them from the NLIS (National livestock Identification Scheme) tags clipped to their ears. These radio frequency tags have a range of only a metre or so, but as the animals pass through a narrow race they can be identified and also weighed, as shown in figure 5.

In an ongoing project their shape is also scanned by machine vision so that their condition can be estimated. The data system is already able to operate gates, so that automatic drafting is possible. Now, of the animals visiting the watering point, some can be released to roam free once again while others can be directed to a holding pen, their selection either being determined by tag number, by their size and condition or by detection of a calf that has not yet been tagged. With little or no intervention, data can inform the farmer of the rate of weight-gain for each animal and the value of keeping a beast longer or 'harvesting' it now.

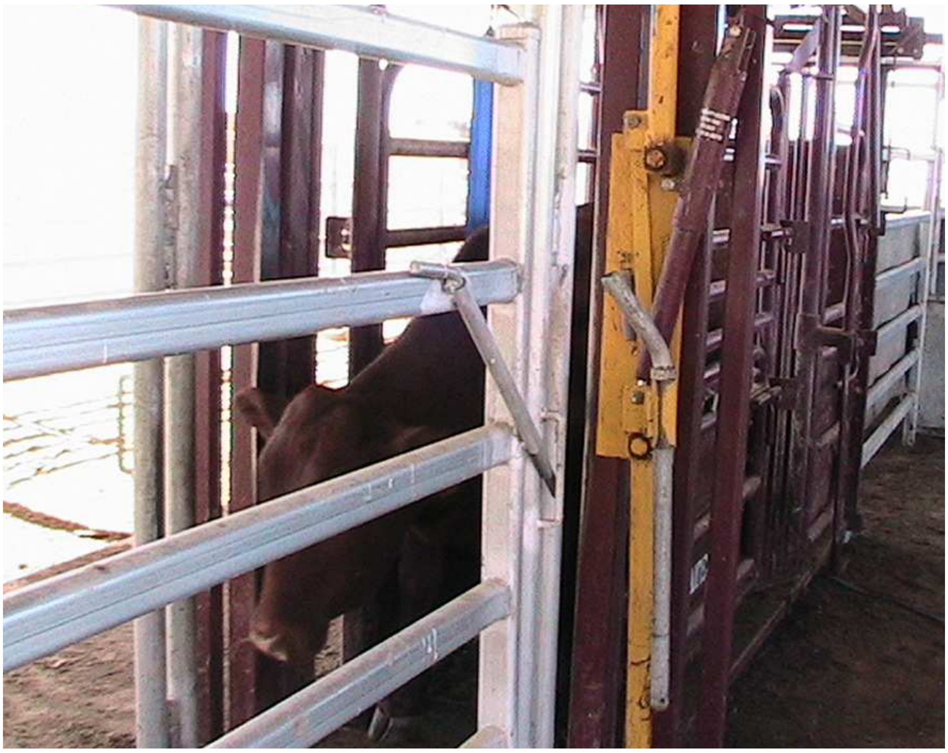

Figure 5. A steer walks over a weighing platform

The ultimate collection purpose is for gathering the animals to be moved on to the next stage in the production chain. Until this point, the animals have largely been allowed to roam naturally, breeding and increasing their numbers with very little human intervention. Now they are collected for finishing. They are taken to feed-lots where they are fattened for the abattoir.

There is an interesting similarity between this and the harvesting of hard, green tomatoes by bulk collection, to be ripened and sorted in more controlled circumstances.

THE VIRTUAL BACKPACKER

There has been considerable research into the use of machine vision for identifying the ripeness and location of fruit for automatic picking, so far without great commercial success. The recognition task can be demanding, as shown in figure 6. Meanwhile farmers are dependent on an itinerant labour force of backpackers, visitors from other countries who make a holiday of casual farm work. A Google search with the words ‘backpacker’ and ‘farm’ yields over a million hits.

However these workers are becoming harder to find. With the world recession resulting in a reduction of travel, they will become increasingly scarce. A photograph of backpackers leaning precariously from the back of a truck to pick mangoes suggested an alternative semi-automatic way to achieve the harvest.

A ‘robot arm’ manipulator can be made from a lightweight open frame with pneumatic actuation. This can perform the gathering operation, perhaps using a small net to scoop the fruit from the tree, if only it can be directed correctly. Advances in communication bandwidth will allow webcam links to convey images to a television screen at sufficient frames per second that a remote observer can identify each fruit to be picked. Games consoles such as the Wii allow the user to interact with a screen image, which in this case is the image of an actual manipulator.

While backpacker numbers may be reducing, Australia has a plentiful supply of retirees. Perhaps we will see retirement homes holding sessions in which residents sit in front of a large-screen television set while bringing home the harvest.

Figure 6. Fruit may be hard to detect for robot picking

ROBOT SHEARING

Twenty years ago, a Western Australia research centre was attempting to automate sheep-shearing. An ingenious hydraulic robot arm manipulated the clippers in an imitation of the actions of a human shearer. The objective was to remove the fleece in a single piece. To enable the process to proceed, a human had to immobilise the sheep on a table. The machine was not a commercial success, though the immobilising table has found some favour with human shearers.

But was this really the approach most likely to succeed? The process has been likened to one of making an automatic dishwasher by putting a dish mop into the gripper of an industrial robot that stands in front of a sink. Does the fleece really have to be kept in one piece, or could a simpler and more specialised machine harvest the wool from the flanks of sheep that file through a narrow passageway? A second machine could then shear the back, another the wig, leaving the final task of tidying up the more sensitive regions to a human.

On-line quality detection could direct the harvested wool to one of several bins, according to its measured 'micron' rating, perhaps achieving the objective that was intended when keeping the fleeces individual.

IN CONCLUSION

Agriculture is just one step in the supply chain that leads to the table of the consumer. Just as automation has brought down the price of electrical goods by reducing the manpower involved, so the price of agricultural production is reducing. But whereas electronic games are a luxury, food is a necessity that must be produced at all costs. We therefore need either more farmers or more ways to produce food with limited manpower. The robots are coming to the rescue.

ACKNOWLEDGEMENTS

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