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The Role of Robotics at the Future of Modern Farming

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Abstract. Precision Farming has shown benefits of this approach but we can now move towards a new generation of equipment. Mowing grass, spraying pesticides and monitoring crops for example, instead of regularly dousing an entire apple orchard with chemicals, towed sensors find diseases or parasites with infrared sensors and cameras, and spray only the affected trees. Commercial farms of the future may be staffed by robots that will identify, spray and pick individual pieces of produce from plants, even when their targets are grapes, peppers and apples that are as green as the leaves that surround them. Just as the mechanical reaper transformed the economics of cereal farming, a new wave of agricultural automation promises to do the same in other areas of horticulture. Because picking apples is very different to plucking strawberries, the machines are taking various forms.

Keywords: Robotics, modern farming, future of agriculture.

1. Introduction

Until about four decades ago, crop yields in agricultural systems depended on internal resources, recycling of organic matter, built-in biological control mechanisms and rainfall patterns. Agricultural yields were modest, but stable. Production was safeguarded by growing more than one crop or variety in space and time in a field as insurance against pest outbreaks or severe weather. Inputs of nitrogen were gained by rotating major field crops with legumes. In turn rotations suppressed insects, weeds and diseases by effectively breaking the life cycles of these pests. A typical Corn Belt farmer grew corn rotated with several crops including soybeans, and small grain production was intrinsic to maintain livestock. Most of the labor was done by the family with occasional hired help and no specialized equipment or services were purchased from off-farm sources. In this type of farming systems the link between agriculture and ecology was quite strong and signs of environmental degradation were seldom evident [1]. But as agricultural modernization progressed, the ecology-farming linkage was often broken as ecological principles were ignored and/or overridden. In fact, several agricultural scientists have arrived at a general consensus that modern agriculture confronts an environmental crisis. A growing number of people have become concerned about the long-term sustainability of existing food production systems. Evidence has accumulated showing that whereas the present capital- and technology-intensive farming systems have been extremely productive and competitive; they also bring a variety of economic, environmental and social problems [2]. Modern agriculture uses a lot of energy. It comes in many forms from fertilisers and chemicals to tractors and fuel. The Phytotechnology approach tries to target the introduced energy to improve efficacy. [3] reported identified that a 70% energy saving can be made in cultivation energy by moving from traditional trafficked systems (255 MJ/ha) to a non-trafficked system (79 MJ/ha). This was for shallow ploughing and did not include any deep loosening. From this we estimate that 80-90% of the energy going into traditional cultivation is there to repair the damage done by large tractors. It would be much better to not cause compaction in the first place which is one of the reasons that leads us to consider using small light machines. Harvesting is the most labor-intensive activity for many crops, but even advocates say that no one has built a machine that comes close to matching the sensory motor control of humans. That is poised to change as sensors and software becomes cheaper and more advanced [4]. As scientists in Israel and Europe get closer to this goal, experts say the work has a number of potential benefits. Autonomous agricultural robots could protect human workers from the harmful effects of handling chemicals by hand. And through a system of highly selective spraying, robots could reduce a farm's use of pesticides by up to 80 percent. Robots could also offer a timely supply of labor in many places, where there simply aren't enough itinerant workers available at the right times in the harvesting cycle. Meanwhile, attempts to create robots that can see, grasp and learn could end up having widespread applications in medicine, video games and more. And while scientists have been working to develop robots for agricultural labor for more than 20 years, a new project is taking a more cerebral approach. The goal is to teach computers to see like humans do and to get better at their jobs as they work and learn [5]. Whatever shape they come in, agrirobots share several underlying technological advances which have their origins in factories. Automating factories is easier than automating farms, which are far less predictable environments: the weather constantly changes, the light alters, the ground can turn from grass to mud, and there are animals and people wandering around. Moreover, unlike car parts, fruit does not come in standard sizes. It moves around on branches in the wind, changes shape and color, and can be hidden by leaves. But improvements in vision and other sensing systems, coupled with the increase in the power of computing, have made robots cleverer, safer and more dexterous. Yet farmers, like factory owners, will want a return on their investment. “It is actually not hard to pick an orange, but it is very hard to pick an orange cost effectively,” says Tony Stentz of the Robotics Institute at Carnegie Mellon University in Pittsburgh. Because robots can work all day without a break, they have one advantage over manual labor. But it is their potential for accurate information-gathering that is proving to be an equally important talent. Greater mechanization may prompt farmers to change some of their ways and the varieties they grow. Crop-tending robots that use vision systems, laser sensors, satellite positioning and instruments to measure things like humidity can build up a database of information about each plant [6]. Therefore, the objective of this study was to evaluate the role of robotics at the future of modern farming.

2. The Use of Agricultural Robotics

2.1. Crop Scouting

One of the main operations within good management is the ability to collect timely and accurate information. Quantified data has tended to be expensive and sampling costs can quickly out weigh the benefits of spatially variable management. A high clearance platform is needed to carry instruments above the crop canopy and utilise GPS [7].

Fig 1. (Left) Portal crop scouting platform (Madsen and Jakobsen 2001), (Right) Sub canopy robot ISAAC2 built by a student team from Hohenheim University (www.fieldrobot.nl)

2.2. Robotic Weeding

Controlled biodiversity is an opportunity that could be realised with robotic weeding. Non-competitive weeds can be left to grow when they are at a distance from the crop. This is part of the design parameters for the Autonomous Christmas Tree weeder being developed at KVL [7].

Fig 2. The autonomous Christmas tree weeder

2.3. Smart Gardeners

Developed for a robotics class at MIT, autonomous gardeners use equipment mounted on the base of a Roomba. Sensors in the soil alert the robot, which waters plants and can use an articulated arm to pick any fruit it sees. MIT staff has no immediate plans for commercialization, but they are continuing to create more autonomy in the bots. Future systems could compare earlier images of the same plants over time to detect diseases or parasites [4].

Fig 3. MIT (Smart Gardeners)

2.4. Inspecting A Tomato Plant

IN THE early 1830s, spurred on by his hatred of sweaty field work, Cyrus McCormick took an idea his father had been working on at the family farm in Virginia and produced a mechanical reaper. Others devised similar machines. Despite initial scepticism, farmers eventually bought them in droves. With one person riding the horse that pulled the reaper, and another raking the cut stalks off the back, the machines could harvest as much grain in a day as a dozen men breaking their backs with reaping hooks [6].

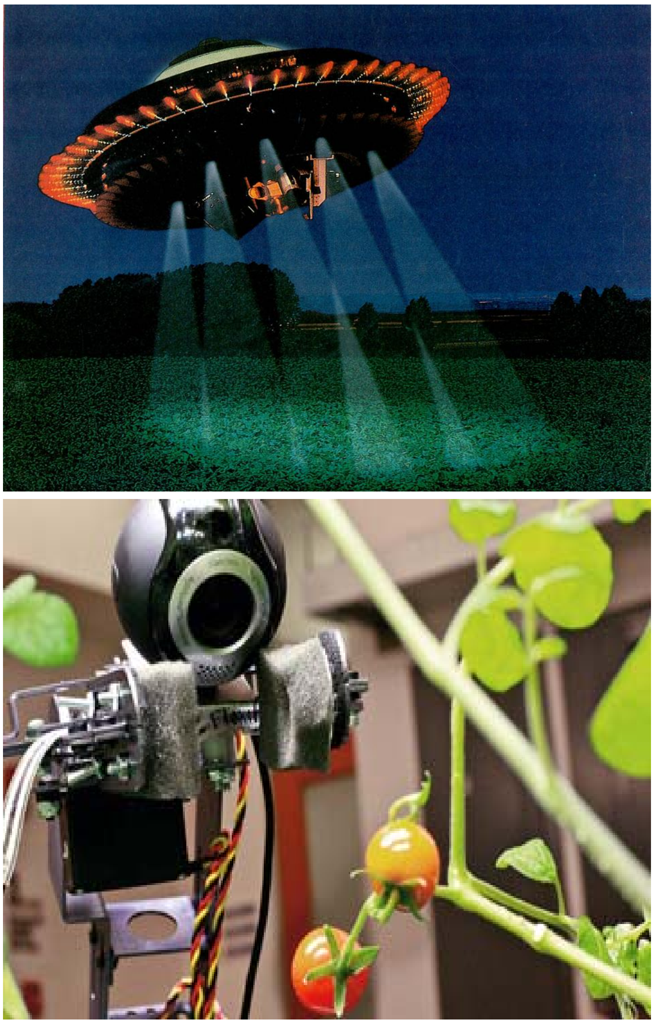

Fig 4. Inspecting a tomato plant at MITJason Dorfman

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