Impacts of mechanisation and increasing automation in agriculture

Abstract

With the ever-growing human population combined with the ever-greater impacts of climate change the need for efficient and easily managed agriculture has never been greater. This work aims to study the historical methods and impacts of crop based agricultural mechanisation, highlight areas of automation advancement and assess the future impacts of these developments.

1. Historical mechanisation

The first form of mechanisation in agriculture started in around 4000 BC with the first horse drawn plough, however it would be many millennia until true mechanisation would be utilised. True mechanisation started in the early 1700s with the advent of a horse drawn machine to assist in the planting of crops. Jethro Tull's seed drill allowed for automatic sowing of seeds at a set depth and spacing. The next step in mechanising the growing of crops was the processing and harvesting. Invented in the 1790s, the threshing machine automatically separates the seeds from the stalks of the grain crop. This would be complemented by the introduction of Cyrus McCormick's reaper in the 1830s. The reaper cuts and collects crops for processing in a thresher. Over the next half century these two devices would be simplified into a single unit, the combine harvester. These device's horse based powerplant was the next feature to be mechanised with the introduction of steam powered equivalents in the late 1800s, however this replacement wasn't widespread. The true replacement for horse power came with the advent of the internal combustion engine at the turn of the century. Tractors and self-powered combine harvesters started to become truly widespread with the advent of the first world war, farm horses were needed for cavalry units and a mechanical replacement was needed to continue the work. However, it wasn't until the 1940s that internal combustion tractors outnumbered horses working in agriculture.

2. Automation

After the dominance of the internal combustion tractor was well established and crop-based agriculture had been heavily mechanised, the next goal was the automation of these existing methods. With the increase in widely available sensors and computational power in the past few decades one method of automation has become increasingly viable, Precision Agriculture.

Precision Agriculture is a method of accurately observing, comparing and responding to variations in conditions within crops to maximise yield. These could be adaptions to weather conditions, low soil fertility or any other sudden variations from the expected normality. Previously these variations could be sufficiently managed as "the very small size of fields and their delineation by natural boundaries, such as watercourses and change of soil type, may have enabled farmers to vary treatments manually" [1], however as fields grow larger and the amount of manpower working them decreases this becomes impossible.

The usage of GPS allows for partially or even fully autonomous driving of machinery, for instance combine harvesters are already semi-autonomously driven by following a lead human piloted tractor when harvesting [2] and with advances being made in control systems there are already fully autonomous tractors undergoing trials [3]. By allowing vehicles to know their exact location it allows for dynamic adaption to a nearby crops conditions, such as variable fertiliser blending and spreading to suit the requirements of nearby crops depending on the conditions returned by sensors within the field.

Combining the past decade's increase in drone capabilities [4] with the principles of Precision Agriculture allows for constant, instantaneous surveying of conditions without the need to wait for satellite imagery or a slower, less efficient, wheeled vehicle. By relying on drones for daily tasks such as fertilising and crop dusting, the need to arrange crops to allow for easy access of wheeled vehicles is removed, greatly increasing the efficiency of

land usage. When harvesting crops, a wheeled vehicle will still be needed due to the greatly increased capacity compared to a drone.

Originally the crops able to be mechanically harvested were limited, requiring certain characteristics for machines to process them while not ruining the crop in the process. These difficult crops were generally soft and grew on bushes or trees. However, advancements have enabled the harvesting of many of these such as Apples [5] and Strawberries [6]. Raspberries are proving some of the most difficult to mechanise and automate due to them being “hard to pick, are more delicate and easily damaged than other soft fruits, and grow on bushes with complex foliage and berry distribution” [7] but trials of autonomous, rail based, analysis and harvesting are proving .

3. Impacts

Since the introduction of mechanisation to agriculture there has been a steady decline in the percentage of the population employed within it, with almost 60 percent of the UK population employed in agriculture 1500 to 32 percent in 1800 and only 1.5 percent in 2000 [8]. This is due to mechanisms reducing the quantity of people required to work the same area of land compared to previously. This reduction had a large impact on the available workforce at the time of the industrial revolution, allowing for the mass manufacturing of goods on an unprecedented scale that encapsulates the industrial revolution.

The reduction of the human element in agriculture continues further with the implementation of modern semi and fully autonomous farming machinery. If the human element can be reduced to solely maintenance of these machines, the costs incurred by the workforce will greatly reduce. A fully autonomously managed system can theoretically get full usage out of all its resources, be it water, seeds, or fertiliser. This reduction could then be passed onto the consumer, leading to greatly more affordable food prices and more available income for other expenses.

Historically as machines became more advanced and sophisticated the speed of harvesting and planting increased. This increase allowed for a greater number of crop rotations per year which in turn further increased the soil fertility and food variety available [9]. This increases land usage efficiency continues with ever increasingly effective analysis and autonomous management tools, it is one of the major points behind implementing Precision Agriculture [1].

Conclusion

If historical trends will continue to be followed and technology continues to advance at its current rate then the increasing automation of agriculture, as with all economic sectors, is inevitable. Reduction of the human element in the crop based agricultural sector has had and will likely continue to have wide reaching impacts on society. If land usage efficiency can be increased, the impacts of an increasing population combined with climate change can be offset, if only temporarily.

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