Robots in Agriculture

American consumers have a strong demand for unblemished fruits and vegetables. Satisfying the demand requires hundreds of thousands of workers who have the skills to plant the fields, tend the crops, harvest the produce, and pack it and prepare it for shipment to markets in the United States and abroad. Unfortunately, we have a huge shortage of workers with these skills.[71]

The problem is even bigger in Japan where the number of people working in farms dropped from 2.2 million in 2004 to 1.7 million in 2014.[72] Small farmers are retiring and, in many cases, not being replaced. To improve productivity, the government has encouraged farm consolidation by larger companies. Larger companies can apply additional business skills to the industry. The consolidation is happening but is limited by the availability of farm workers. The current labor shortage is more than 70,000 full-time employees but experts predict the unmet demand will rise to 130,000 over the next five years.[73] The European agriculture sector is experiencing similar labor shortages. The root cause of the labor shortages around the world is older farmers are retiring and young people are not finding farming an attractive or lucrative career opportunity.

Compounding the problem of labor shortages is the increased demand for food. The UN estimates the world population will rise from 7.3 billion today to 9.7 billion in 2050.[74] In addition to labor shortages and increased demand, a third factor is the need to increase yields for farmers to meet the demand.

Agricultural robots can help increase production yields and fill the labor gap. Robotic solutions range from autonomous tractors to robotic arms. Agricultural robots can automate boring and repetitive tasks. They can also enable farmers to focus more on managing and improving the overall production yields. Some of the specific tasks robots can fulfill in agriculture include:

- Harvesting and picking
- Controlling weeds
- Autonomous mowing, pruning, seeding, spraying and thinning
- Sampling and categorizing genetic characteristics
- Sorting and packing

Harvesting and picking is one of the most widely adopted robotic applications in agriculture due to the precision and speed of robots. The results are improved yields and reduced waste from crops left in the field. However, these applications can be difficult to automate. The RIA Robotics Online Marketing Team explained,

> A robotic system designed to pick sweet peppers encounters many obstacles. Vision systems have to determine the location and ripeness of the pepper in harsh conditions, including the presence of dust, varying light intensity, temperature swings and movement created by the wind. It still takes more than advanced vision systems to pick a pepper. A robotic arm has to navigate environments with just as many obstacles to delicately grasp and place a pepper. This process is very different from picking and placing a metal part on an assembly line. The agricultural robotic arm must be flexible in a dynamic environment and accurate enough not to damage the peppers as they're being picked.[75]

Indoor Farming

Farming is not limited to outdoor fields. Indoor farms now represent 2.3 million square feet globally and growing. Brooklyn, NY based Agrilyst, Inc. predicts expansion of indoor farming will reach 22 million square feet, which amounts to roughly 505 acres of land.[76] Although this represents a very small fraction of the 900 million acres of farmland currently cultivated in the U.S., indoor farms offer major yield advantages over outdoor farms. Indoor farms occupy much less space and require fewer human resources. Another advantage comes from the average yield per acre. Indoor farms for vine crops like tomatoes and leafy greens yield more than ten times outdoor farms.[77]

A new startup in Somerville, MA called Root AI, thinks they can increase yields even higher. The company explains their mission,

> We believe tomorrow's farms won't look like the endless outdoor crop rows we remember and that the security and quality of our food will no

> longer be limited by an increasingly unpredictable climate or access to land. Instead, hyper efficient indoor farms will grow delicious and chemical free produce. At Root AI, we are on a mission to create the intelligent robots that will help growers build the farms of the future.[78]

Root AI's robot, called Virgo, can pick things as delicate as tomatoes and strawberries. Two young robotics entrepreneurs from Harvard and the University of Pennsylvania have been highly innovative at the difficult task of picking tomatoes, strawberries, and lettuce without squishing them. Josh Lessig, Co-Founder and CEO at Root AI, said,

> The technology is being used heavily in the food industry. What you would buy a soft gripper for is making a delicate food gripper very easy to deploy that would help you maintain food quality with a mechanical design that was extremely easy to manage. Like inflatable fingers that could grab things.[79]

The Virgo robot does more than harvesting and picking. As it picks tomatoes at indoor farms, it also inspects the crops to assess their health and prune vines where needed. It observes and updates ripening profiles so the robot can cultivate crops continuously and more effectively than people.[80]

Root AI's robots have a camera on the robot's arm to get a close view of the fruit or vegetable. An additional camera beside the robot collects color images and 3D depth information to provide a larger perspective on the vegetation. The company uses artificial intelligence to detect any irregularities in the plants and label the images for human review. Root AI uses proprietary vision processing technology to measure fruit ripeness, size, and quality.

Investors are buying into Lessig's and Root AI's vision. Lessig sums it up as follows,

> There are many roles at the farm and we're looking to supplement in all areas. Right now, we're doing a lot of technology experiments with a couple of different growers on assessment of ripeness and grippers ability to grab the tomatoes. Next year we're going to be doing the pilots. On a personal level I have concerns about how much food we're going to have [in the future] and where we can make it. Indoor farming is focused on making food anywhere. If you control your environment, you have the ability to make food. Satisfying people's basic needs is one of the most impactful things I can do with my life.[81]

As a result of the labor shortage and anticipated demand for food, the market for agricultural robots has grown rapidly. The market was valued at $3.42 billion in 2017 and is expected to grow at 21% per year.[82] Farming automation technologies are emerging in numerous areas beyond harvesting and picking. For example, one of the most widely adopted dairy farming robot systems is used for milking cows. According to the International Federation of Robotics, milking robots represent an 85% share of field robots. Nearly 20,000 dairy farms have installed robots in Western Europe, Canada, United States, China, and Japan. The adoption is being driven by increased milking frequency and increased flexibility in deploying human labor.[83]

Research and Markets, one of the world's largest online market research companies, cites some other major agricultural projects including GARotics (Green Asparagus Robotics Harvesting System), GRAPE (Ground Robot for vineyArd Monitoring and ProtEction), and MARS (Mobile Agricultural Robotic Swarms) funded by the European Commission to replace manual labor with automation technologies.

The MARS system includes use of multiple small robotic vehicles which operate as a "swarm". The robots are coordinated through a cloud computing infrastructure and precise GPS technology. The result of this precision farming is reduced planting of seeds, fertilizer, and pesticides while achieving higher crop yield.[84] Another MARS advantage is the small size of its tires which reduce soil compaction and energy consumption compared to traditional heavy farm machinery. Visit the Robots Videos section at robotattitude.info to see MARS (Mobile Agricultural Robotic Swarms) in action.

Summary

By 2050 the world's countries will need to feed two billion more people than today.[85] Labor shortages in farming are challenged by immigration restrictions and generational shifts into other forms of work. Farming will need to optimize where they grow, what they grow, and how they grow. Greater efficiency will be needed for outdoor and indoor farming. Robots can play a significant role in meeting the challenges. In the next chapter, I will discuss robots in manufacturing.