Agrobots - Today and Tomorrow

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Agrobots - Robots in Agriculture

1. Introduction

Agriculture involves the systematic production of food, feed, fiber, and other goods. In addition to producing food for humans and animals, agriculture also produces cut flowers, timber, fertilizers, animal hides, leather, and industrial chemicals.
Food is anything made up of carbohydrates, fats, water or a protein that's eaten by animals or people for nutrition or pleasure.
Fodder is food made from vegetable or animal bi-products that is for animals including livestock, pigs, sheep, and chicken.
Fiber is a class of material including cloth, cotton, linen, jute, flax, ramie, and sisal.

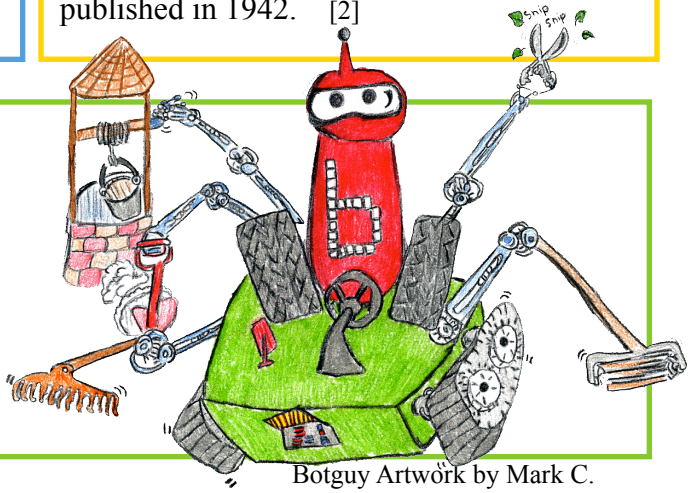
Agriculture comes from two Latin words:
ager which means a field
culturia which means cultivation, the tillage of the soil.
A lot of the world's workers (42%) are involved in agriculture in some way. [2]

A robot is a machine that can be programmed and reprogrammed to do certain tasks and usually consists of a manipulator such as a claw, hand, or tool attached to a mobile body or a stationary platform.
Autonomous robots work completely under the control of a computer program. They often use sensors to gather data about their surroundings in order to navigate.
Tele-controlled robots work under the control of humans and/or computer programs.
Remote-controlled robots are controlled by humans with a controller such as a joystick or other hand-held device.
The word 'robot' came from the Czech word 'robota', which means forced labor, or work. It was first used in the play R.U.R., Rossum's Universal Robots, written in 1921 by a Czech playwright named Karel Capeck.
Isaac Asimov was the first person to use the term 'robotics' in "Runaround," a short story published in 1942. [2]

Put agriculture and robotics together and you get:

AGROBOTS

Machines programmed to do agricultural tasks and farm assignments.



Botguy Artwork by Mark C.

2. The Current State of Agricultural Robotics

Today agricultural robots can be classified into several groups: harvesting or picking, planting, weeding, pest control, or maintenance. Scientists have the goal of creating 'robot farms' where all of the work will be done by machines. The main obstacle to this kind of robot farm is that farms are a part of nature and nature is not uniform. It is not like the robots that work in factories building cars. Factories are built around the job at hand, whereas, farms are not. Robots on farms have to operate in harmony with nature. Robots in factories don't have to deal with uneven terrain or changing conditions. Scientists are working on overcoming these problems.

2.1 Uses for Agricultural Robots

The number or agricultural robots, agrobots, is increasing each year. The jobs they can do are also increasing with new technology in hardware and software. Robots are milking cows, shearing sheep, picking fruit, weeding, spraying, and cultivating, They use GPS and sensors for navigation. The new robots are getting smaller and smarter.

Fungicides: Robots can be used to combat plant diseases that cause a lot of damage to crops. Fungi are the most common causes of crop loss in the entire world. To kill a fungal disease you need a fungicide, a kind of pesticide. Fungal diseases interfere with the growth and development of a crop. They attack the leaves which are needed for photosynthesis and decrease the productivity of the crop and cause blemishes on the crops which makes them worth less on the market. After the crops are harvested fungi can grow and spoil the fruits, vegetables, or seeds. Robots can treat plants that have been infected or destroy them if necessary. They could treat just the plants that need it, instead of covering the entire crop with fungicide. [6]

Herbicide: Another use for robots is in weeding. Robots can pull weeds from around the plants or just cut the tops off. All of the material can be collected by a robot and brought to a composting site limiting the need for herbicides, chemicals that destroy or inhibit the growth of plants. Herbicides are intended to kill weeds but many times also damage the crops.

Pesticide: Pesticides are used to control insects that can be harmful to crops. They are effective but have many side effects for the environment. Insects also adapt to the toxin in a pesticide and the survivors breed and pass the resistant trait on to the next generation making stronger insects that are harder to kill. Robots could solve this by removing pests from the crops without using chemicals. They might suck them up with a vacuum. A bellow base air system makes a vacuum that doesn't require the large amount of power of regular vacuum systems. There are ways to kill the insects without chemicals. The robot could submerge them in a container with water or into one closed up to produce extreme heat in the sun. Microbial fuel cells could be used to reduce the insects to electrical power with bacteria. Pesticides kill everything. Robots could be programmed to rid particular pests and not harm anything else. [12]

2.2 Examples of Actual Agricultural Robots

Mushroom Picking Robot

Mushrooms are a very difficult crop to grow. There is a lot of labor involved. Many mushroom farms are becoming extremely high tech. They use computerized systems and monitor all production phases.

Botguy Artwork by Mark C. [20]

The robot mushroom picker is an ongoing research project at the University of Warwick in the UK. See Figure 1. Their goal is to develop farm machinery that can reduce the labor costs of producing farm crops, in this case, mushrooms. The robot picks the mushrooms using a small suction cap on the end of its robotic arm. The robot has a charged coupled camera on board to tell which mushrooms to pick in a tray or bed, since mushrooms mature at different times during a six to ten week period. It uses the camera to tell the exact size of the mushroom and only pick the correct ones. Mushrooms grow in dark, damp places that are often inhospitable to humans. This makes the robot a perfect choice to work on a mushroom farm. The robot can only work half as fast as a human, but it doesn't mind working in the dark, or for 24 hours a day. [10]

"There are many advantages to robotics as well as removing the high cost of labour. One is that it will do a job very repetitively and very much the same every time, so you can get some huge quality improvements in a number of areas. One of the key advantages in agriculture is that robots can work 24 hours a day - often when there's no light, which can be a big factor with certain crops." Dr. Ken Young; Dr. Ken Young works in the manufacturing engineering section of the University of Warwick, the Warwick Manufacturing Group. [11]

Figure 1: Mushroom Picking Robot

[19]

Mushroom Statistics
2005-6 U.S. Crop

843 Million Pounds
881 Million Dollars
305 Growers
Ave. Price $1.05 Per Pound

[13]

Mushrooms In History

2600 B.C. - Egyptians held mushrooms as food for royalty.

400 B.C. - Hippocrates mentioned mushrooms as medicine.

1652 - Mushrooms cultivated as cure for boils, not for eating.

1780 - French cultivated mushrooms in underground quarries near Paris.

1866 - After the Civil War, mushrooms were grown underneath greenhouse benches by gardeners in North America.

1891 - The first book on mushrooms was published - *A Practical Treatise on Mushroom Culture for Profit and Pleasure* [7]

Figure 2: Kinds of Mushrooms

There are over 2500 different kinds of mushrooms. A few of the most popular are Portabellas, Shitakes, Criminis and White. See Figure 2.

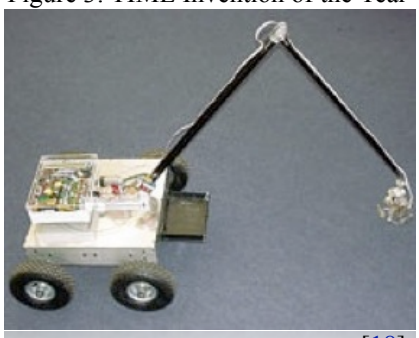
You can learn more about mushrooms at [14]
http://www.americanmushroom.org/growingmushrooms.htm

Botguy Artwork by Mark C.[20]

SlugBot - Big Idea In Development

Slugs are a nightmare for farmers. They eat leaves of growing crops like lettuce and put big holes in fruit like tomatoes. Ian Kelly and the University of West of England, Bristol, has invented a robot that will stop all of that. It is called Slugbot. It was TIME 2001 invention of the year. See Figure 3.

Figure 3: TIME Invention of the Year



[18]

The robot can track, capture and dispose of slugs. About the size of a lawn mower. Slugbot features a 1.5m long robotic arm, mounted on a turntable, which shines a red light that lets the robot detect the slugs. It is hard to see slugs in the daytime, but the red light makes them visible. Grass and vegetation appear dark under a red light, but the slugs show up as brightly lit. The robot has a CMOS image sensor that can detect the bright slugs. The arm then picks up the slugs and deposits them into a hopper where bacteria decompose the slugs. The robot uses a GPS system to find the station to deposit the slugs. Ultrasonic sonar and touch sensors are used by Slugbot to navigate and avoid obstacles.

Figure 4: Microbial Fuel Cell

[18]

The energy from the decomposing slugs is then used to refuel Slugbot. This is a practical use for the microbial fuel cell which is under development. See Figure 4.

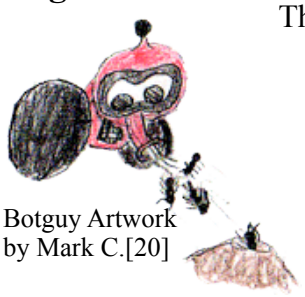
Slugbot is currently in the prototype stage. One goal of the project is to make a robot that is self-sufficient like an animal in both information and energy. Slugs were picked because they are a real problem for agriculture, they are soft without a shell or skeleton, they are large in comparison to many pests, and most of all, they are slow enough for Slugbot to catch. [9]

Figure 5: Ecobot II

[15]

Slugbot was just the first phase of the research being done. Now the university has moved on to the creation of Ecobot II. See Figure 5. The objective here is to create energetically autonomous robots. These robots would get all of their on board power from microbial fuel cells and carry no batteries. Ecobot I was a sugar eating robot and Ecobot II eats dead flies or rotten fruit. [9]

Ag Ants



Botguy Artwork by Mark C.[20]

The University of Illinois engineering department has developed several agricultural robots. One of them is Ag Ant. See Figure 6. The Ag Ant robots are small and are very inexpensive. They are designed to replace larger more expensive farm machinery. The Ag Ants are only 1 foot long and with most things (besides nanos) smaller is less expensive. They move around using mechanical legs. Ag-Ants are autonomous and can direct themselves down rows of corn using sensors. The sensor tells the robot when they reach the end of the row and need to turn around and move into the next row. Some common tasks that Ag Ant robots could do would include finding weeds, insects, or disease, sampling the soil for nutrients, and application of pesticides or herbicides.

Figure 6: Ag Ant

[16]

Tony Grift is a University of Illinois agricultural engineer. He is working on this project. See Figure 7. He says that the way they are solving farming problems is a "smaller and smarter" approach. The Ag Ant is about one foot long and has mechanical legs that it uses to walk through fields. [1]

The university wants to create a robotics ecosystem out of the robots. They pattern this after groups of bees. One bee goes out and finds a source of nectar and then comes back and tells the other bees where to go. The Ag Ants can do the same. One robot might find weeds and then transmit the location to other Ag Ants that would come to help attack the weeds. It's like creating an army of robots that can go out and survey a field, collect information, and send back data. Then a group of robots complete the necessary task.

> Grift said, "Instead of applying all of this spray that might drift everywhere, a robot could actually 'spit' chemical at the plant with great precision, using a very small amount of chemical." [1]

Figure 7: Working with Ag Ant

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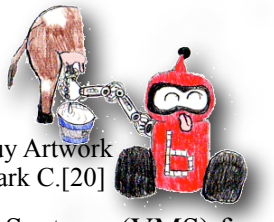
[16]



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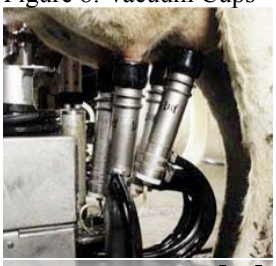
Cow Milking Robot
VMS Voluntary Milking Systems

Figure 8: Vacuum Cups



[17]

Many companies have developed Voluntary Milking Systems (VMS) for automated cow milking. How does it work? Cows can decide that they want to be milked and walk into the milking parlor. A tag on the cow which contains electronic information about the cow is read by the computer, and if enough time has passed since the cow's last milking, the cow is allowed to enter. First the cow is given a food supplement. While it is eating, a robotic arm moves under the cow and uses lasers and photo sensors to find the teats. The computer has images of each cow's teats and how they are positioned. This helps the laser to find each teat and guide the robotic arm. Each teat is cleaned and then vacuum milking cups are attached. See Figure 8.

Figure 9: Robotic Arm

[17]

Information about the milking is sent to a computer for analysis. The machine can keep track of how much milk, the milk flow and milking time not only for each cow but also for each of the cow's teats. This information can be used to tell how healthy the cow is and indicate disease. After the cow is milked, the robotic arm moves away and then applies a disinfectant solution to the cow's underside. See Figure 9. The cow is then allowed to leave. The VMS then cleans itself before another cow is allowed to enter the system. There are several advantages to the VMS. The cows can decide to be milked more than the twice a day routine used in most dairies. Some dairies have seen an increase in milk production. Dairy farmers are free to do other things around the farm instead of having to be locked into the twice a day routine. [8]

What the Farmer Has to Say About VMS

Have you heard of the robot milking systems? Do you use them?

"Yes, most dairy farmers know about the robot systems. We don't use the robot milking systems at our dairy, but I do know that they are very popular in other states, especially in the midwest."

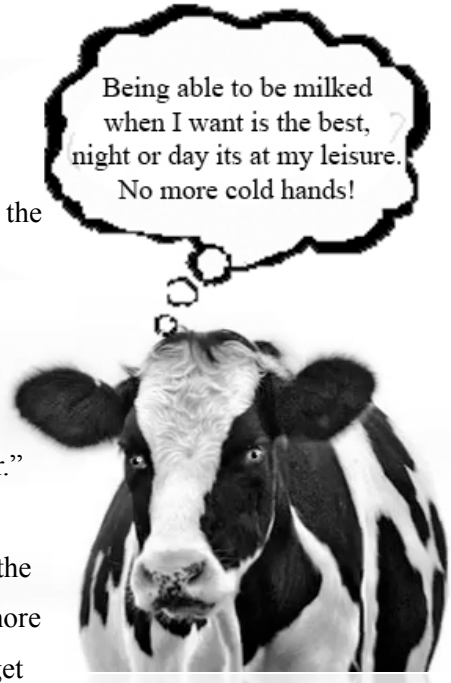
Why don't you use the robots?

"We have a lot of money invested in our milking machines and changing over would just be too expensive right now. But maybe later."

What kind of things have you heard about the VMS?

"The farmers that use them seem to like them. They say that because the cows can choose when they are milked, the cows are choosing to go more than twice a day and that has increased the quantity of milk that they get from each cow."

An Interview With a Texas Diary Farmer at the Texas State Fair in Dallas, Oct. 2006



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Specialists:

11. Jim Rowley BEng (Hons) MSc, Reserach Engineer
    Dr. Ken Young, Warwick Manufacturing Group,
    The University of Warwick, UK
12. Terry Fidler, Engineer, Australia
13. National Agricultural Statistics Service

Photos:

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Botguy artwork: Mark Cieslikowski

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