
# UNIVERSIDAD FRANCISCO DE VITORIA

## ESCUELA POLITECNICA SUPERIOR

## Fundamentals of Computer Engineering

## Practical work I

Agriculture Robotics

GROUP 6

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# Abstract

In this practical work we explore in depth the use of robotics in agriculture as well as its possible future. Due to the importance of agriculture in today's society as well as the fast rise and advancements of robotics and technologies such as AI and IoT, it was only a matter of time before these two concepts merged into a new one.

This practical work aims to understand how robotics will play a key part in agriculture's development and future. In addition, this work will analyse various types of robots with different purposes, such as planting, picking and fertilizing, and cover the advantages and disadvantages of them in agriculture.

Furthermore, this work will dive into how these technologies cause debates or even concerns relating to the consequences of the use of agrorobotics. In particular, this work will focus on the possible job loss that awaits people who work in farms or fields, the environmental impact it could have and the privacy and protection of farmers data.

Finally, this work closes with a short reflection and conclusion regarding the possibilities agrorobotics bring as well as the challenges it presents for humans.

# Introduction

Agriculture robotics refers to automated machines used to perform farming tasks, such as planting, harvesting, and monitoring crops, often with minimal human intervention. These robots use technologies like AI, machine learning, and GPS to increase efficiency, precision, and productivity in crop and livestock management.

## 1.1 Motivation

For the search of the topic each member of the group proposed 4 options that made us want to explore about it. There was a topic that appeared in almost all four elections we each held as team members, so the election was quite easy, agriculture robotics.
This topic may seem something boring, but our interest comes from a movie everyone knows about: Interstellar. Cooper, the main character, works at an autonomous farm, where the manpower needed to keep the farm running is minimal compared to what we have nowadays. So we all agreed that if all the farms had the same technology that cooper had in his farm, the work would be much more efficient.
The motivation to do the research was to get to know more about the technology that will end the necessity to do simple and boring tasks by humans.

## 1.2 Objectives

The main objective of this paper is to analyse the current and future role of agricultural robots in the automation of farm work, exploring their applications, advantages, disadvantages, and ethical implications.
Among the objectives of the work, we find the following points:

1. Describe what an agricultural robot is and describe its main types.
2. Make an overview of the technologies and components that make their operation possible.
3. Evaluate the benefits and limitations of their use compared to traditional methods.
4. Analyze future trends, especially the integration of Artificial Intelligence (AI) and the Internet of Things (IoT).
5. Reflect on the ethical, social, and environmental consequences of using robots in agriculture.

## 1.3 Practical Work Outline

The paper begins with a general overview of agricultural robotics and its growing importance in modern farming. It first defines what a robot is and explains how these machines are applied in agricultural processes. Then, it describes the main types of agricultural robots and the technologies that enable their operation, such as sensors, GPS systems, and artificial intelligence. The work also examines the advantages and disadvantages of using robots in agriculture,

highlighting their impact on productivity, costs, and employment. Later, it explores future developments, focusing on the integration of AI and IoT for precision and sustainable farming. Finally, the paper includes an ethical analysis addressing issues of power concentration, data privacy, and environmental effects.

# 2 Agriculture Robots

This section should include a short introduction about why this technology or topic has been researched or built or discovered.

## 2.1 Description of Agriculture Robots

In order to give an accurate description of agriculture robots, its relevant to know what a robot is and what are the features that make an ordinary robot an agricultural one. When you ask two people about what a robot is, you may get different answers, because the reality is that robots can come in many different shapes and sizes, a robot doesn't have to be human alike, in fact, most don't. What defines what a robot is depends on their purpose, but we could make a definition that encompasses all these different types of robots: a robot is a machine capable of acting on its own through three essential components: sensors, actuators, and programs. And an agricultural one is defined by RootCamp1 as "any robotic device that can improve agricultural processes, by taking over many of the farmer's duties that are slow or labour intensive." (RootCamp, agricultural robot: how robotics is changing agriculture, 2022) So what makes a robot an agricultural one is self-explanatory, the one whose purpose is to facilitate or even substitute farmer's duties.
It may seem not so important if we compare it to other applications that robotics have, but nothing could be further from the truth, because according to Future Market Insights, the market grew from USD 6.6056 billion in 2019 to USD 12.6431 billion in 2023, which implies a Compound Annual Growth Rate (CAGR) of about 17.6% from 2019-2023. However, this is not the only aspect that makes agricultural robots relevant:

[1] Rootcamp is a German organization that supports start-ups related to the development of agricultural technology.

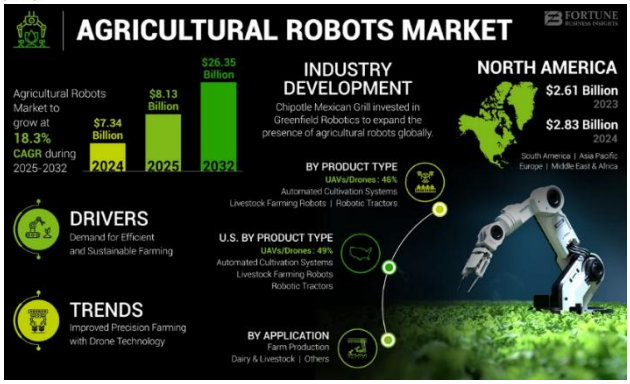


*Figure 1- Agricultural Robots Market of 2023-2024 and predictions for the next years*
*Source here*

In this infographic we can observe it is expected that the agricultural robots market increases an 18.3% during 2025-2032. But why this sudden growth of agricultural robots market? The reason it's simple, the innovation is born out of necessity. "The challenges facing growers have never been as big as it is today. And it's about labour expenses, it's about other expenses, whether it's the tariffs or trade wars and whatnot … So, growers are looking for anything to make their operations more efficient. And the only way out is to innovate our way out." said Tim Bucher, the CEO & Co-founder of Agtonomy in an article by Euronews (Euronews,"Are self-driving tractors the key to tackling agriculture's labour crisis?"-2025) "Either we get that cost of labour down by moving the agricultural operation to where the labour is cheaper, or we automate it with robots". Said by Walt Duflock, vice president of innovation at the Western Growers Association, on the same article.
Basically the global population growth doesn't stop, but the available farm workers decrease every year. According to the Food and Agriculture Organization (FAO, 2024), the agricultural sector needs to increase productivity by at least 60% by 2050 to meet global food demand. So agricultural robots, or "agribots," have emerged as a solution to reduce human dependence, to avoid moving to countries where labour is cheaper and exploit them, improve efficiency, and promote environmentally friendly production.
So once the importance of agrobots is settle, let's see the 8 most used of agricultural robots according to Escatec, a company that design and manufacture these robots.

## Different types of agriculture robots

| Name | Overview | Visual reference (Picture) |
|---|---|---|
| **1. Planting and seeding robots** | Its purpose is to automate the sowing of seeds with precision placement and spacing. They can dig soil, plant seeds, and add fertiliser and water. |  *Figure 2- Oz by Naïo Technologies, seeding robot.* *Source here* |

| | | |
|---|---|---|
| **2. Harvesting and picking robots** | They pick fruits, vegetables, or grains automatically, often using vision systems to detect ripeness. The only thing that is limiting this kind of robots is the delicate nature of some of this food. |  <br>*Figure 3- Fruit-Picking Robots*<br>*Source here* |
| **3. Drones** | The principal function of the drones is to be the eyes of the farmers, so they don't have to travel long distances of field to monitor or exterminate crops with pesticides. It was one of the first agrobots to be used. |  <br>*Figure 4- Agras T40 drone used in farms*<br>*Source here* |
| **4. Crop sprayers** | We have discussed the importance of exterminating crops, and drones can either detect them or exterminate them, but drones are not as precise as it is required. That's why crop sprayers gain popularity. By using intelligent land-based robots, pesticides can be delivered only where they are required and in very precise quantities. Avoiding most problems that supplying wrong quantities of pesticide involves, such as food contamination, air pollution or toxic exposure. |  <br>*Figure 5- Solix Sprayer Robot (crop sprayer)*<br>*Source here* ~~5~~ |
| **5. Weeding and mowing machines** | They detect and remove weeds using mechanical tools, lasers or herbicide micro-dishing. They started in private gardens and now are being employed on an industrial scale. |  <br>*Figure 6- SCARABAEUS mowing and mulching robot*<br>*Source here* ~~6~~ |
| **6. Sorting and grading robots** | Sorts fruits or vegetables by size, colour, or quality using cameras and sensors. In the past this was one of the most labour-intensive tasks, but the use of intelligent |  |

| | | |
|---|---|---|
| | robots is much more efficient and economical. | *Figure 7- Sorting and grading conventional robot*<br>*Source here*~~7~~ |
| **7. Autonomous tractors** | The tillage was always one of the most time-consuming activities on a farm. So, by using autonomous tractors, the time can be used in other more important tasks that requires a person to do. Also, it has saved a lot of money to farmers. |  <br>*Figure 8- fully autonomous tractor.*<br>*Source here*~~8~~ |
| **8. Livestock management robots** | And to end this section, livestock management robots. They automate tasks such as feeding, milking dairy cows or collecting eggs, it increases efficiency and profitability while improving animal welfare. |  <br>*Figure 9- DairyRobot R9500 intelligent automated milking*<br>*Source here* |

It is interesting also to see what the three most important specific agrobots are. (not in order, because it's very difficult to know exactly which is above the others in popularity)

**Lely Astronaut**

This milk collecting robot (Livestock management robot) has over 50,000 installed robots and with user insights from thousands of dairy farmers from more than 40 countries. It is leading edge in automatic milking systems. This robot comes with the most efficient and modern operating system (AOS-2), an automatic filter, ear tag id…
The reason why this model is being used above the rest is because it's the most tested, integrated, and welfare-focused milking robot, which explains its dominance in the livestock automation market.

*Figure 10- Lely astronaut*
*Source here*

A common mistake is to think that agrobots only includes agricultural robots, but this term includes all types of automation technologies used in farming activities, in different occasions farming robots like the one we just see, are mentioned as agrobots. We can confirm it in sources

like fortunebusinessinsights, the same source and article where we got the infographic at the beginning, saying "*Agricultural robots are autonomous vehicles used in agricultural practices and animal husbandry, such as weeding, seeding, harvesting, pesticide-spraying, milking and other livestock farming applications.*"
Or in Lucintel a global market research and consulting company based in the United States that focuses in providing market intelligence, data analysis, and strategic insights. In the report about trends, forecast and competitive analysis to 2030 of agrobots they mention the livestock monitoring, and more specifically the milking.
So yes, milking and other farming robots are included in the category of agrobots.

**FarmWise Titan FT-35 (Autonomous Weeding Robot)**

The leader of commercial weeding robots, it manages thousands of hectares of vegetables crops every season, and the company responsible for making this robot appeared every time in reports about agricultural robots, we are talking about the well-known Titan Ft-35, made by FarmWise.
The popularity of the weeding robot falls on its Ai and the continuous learning system.
First, the Titan FT-35 uses an advanced AI system for computer vision and machine learning model, which is trained with a lot o images (millions) to make its task the most efficient way.
This is the feature that makes the difference with his principal competitor Naïo Oz.
Because the continuous learning system gives the robot an adaptive capability that can't be found in other models.
To sum up, this robot it's the top one because it's de most precise, scalable and accessible weeding robot of the market.

*Figure 13-FarmWise FT35 Robotic Weeder*
*Source here*

**Blue River Technology – See & Spray (John Deere)**
Last but not least important because of that, Blue River Technology – See & Spray, it has de see & spray system one of the most used vision-based and selective spraying platforms in all robotics agriculture. In large scale farming it is the most used worldwide
One of the most attractive features these robot has is the capacity of making 2100 images per second. It really has a lot of opposition in terms of competitors on the market, because minimum the system is integrated in similar robots.

But how can all these robots navigate through all the fields? or know which path to take? Well, according to specialist on this field as Riccardo Bertoglio, Matteo Matteucci, and more people that make the research we are going to talk, agricultural robots can navigate fields autonomously using LIDAR sensors and wheel encoders. The system allows the robot to move between crop rows, turn, and continue to the next row without human help. It proves that

autonomous navigation makes farming more efficient and precise, reducing costs and time. This connects with the idea of using AI and IoT to create smarter, more sustainable farms in the future.

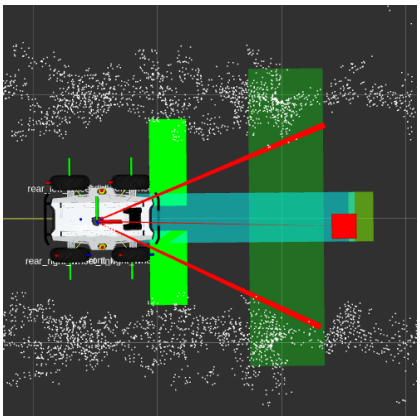

*Figure 11- robot navigating inside a row in the simulated environment Spurce*
*Source here*

*Figure 12- robotic platform navigating a real vineyard.*
*Source here*

# 2.2 Advantages and limitations

Advantages:

**Increased efficiency and productivity:** Agricultural robots can operate continuously (24/7) without needing breaks, enabling faster completion of tasks such as planting, irrigation, fertilising, monitoring and harvesting. This contributes to higher returns and improves overall productivity

**Precision and consistency**: Robots work with greater accuracy and repeatability than many manual processes. For example, they may apply fertilisers or pesticides only where needed, thereby reducing waste and improving crop quality.

**Enhanced sustainability**: By optimising resource usage (fertilisers, pesticides, water) and minimising idle labour, robotic systems support more sustainable farming practices and can help reduce the environmental impact of agriculture.

Limitations:

**Farmers don't know how to fix the robots**: Most farmers are not trained in robotics or programming, so when machines break down, they cannot repair them on their own. They must wait for specialised technicians, which can delay farm work.

**Maintenance is complicated and expensive**: Robotic systems require regular maintenance that many farmers are not able to perform. Professional servicing and spare parts are costly, making upkeep difficult for small farms.

**Potential job losses**: As robots take over tasks traditionally performed by human labour, there is a risk of reduced employment opportunities within farming and rural communities, which could have broader social and economic consequences.

## 2.3 The future of the technology

In the recent year, humanity has seen a significant growth in technology related to agriculture. From autonomous tractors from companies like John Deere, Kubota and AgXeed to drones that are used for monitoring and spraying crops.

All these advancements, while exciting, raise an important question: where could the future of agricultural robotics be headed? Have we reached the peak of what technology and robotics can do for agriculture, or are we just getting started?

To fully comprehend where agricultural robotics is headed, it's important that we look and understand what technologies could be a key part of its future. Especially regarding artificial intelligence and connectivity through the Internet of Things.
Why do I make emphasis on these two (AI & IoT)? Well for starters, AI will open the door for robotics to be much more beyond automation, not only repeating programmed sets of actions but also learning from the data and experiences. This could help in detecting plant diseases quickly and even recognizing patterns in crop growth, thus also determining the best time to harvest.

As for IoT, it's how it connects every single part of a farm into a single smart ecosystem. From sensors in the soil to irrigation systems, from weather stations to drones. All of these will constantly exchange information, and this will greatly help in a robot making real-time decisions such as adjusting the amount of water and fertiliser depending on the weather.

Still, smart and connected robots are really just one part of the future that awaits agriculture. Realistically, the most important aspect will be how these technologies could make farming more sustainable, environmentally friendly and even more precise.

Having the capabilities to determine the exact amount of water, fertiliser or pesticide every single plant need will be a game changer. This will lead to reduction in waste, and it will also protect the environment since it can prevent the overuse of chemicals. Not only this, but sensors and/or could also monitor the soils and crop's condition, helping farmers make faster and better decisions.

Even so, there is the fear of robots replacing farmers and leaving millions out of jobs. In reality, the future of agricultural robotics will be centred around collaboration, not replacements. Robots will take on the repetitive and physically demanding activities and tasks so that people can dedicate themselves to planning and supervising. Thus, will this "collaborative-robots" make farm work more efficient and even safer for people.

To sum it up, if we look ahead, agriculture appears to be moving toward a future of autonomous farms. In that future it's drones, sensors and robots the ones in charge of coordinating almost

every step of the process. But even so, humans still play a crucial part in that future. Setting goals, analysing data and ensuring that technology benefits the planet and the people.

So, have we reached the peak of agricultural technology? Most likely no. Realistically we are barely getting started. What we see today is only the tip of the iceberg. An iceberg which involves robots producing more food, with less effort and in a safer way for the environment.

## 2.4 The ethical view

As many papers and news articles say: "We are facing the 4º agricultural revolution", and with the revolution, there are always problems that rise and suppose a serious ethical issue for the people.

**Centralization of the power**

The implementation of this more expensive and more efficient machinery will lead to the centralization of the power in the big Farming Companies (wholesales).

The independent farmers that won´t have enough money to purchase this new machinery will be displaced in the market by the big companies with a huge number of resources. These new robots, many times more productive than the farmers, will reduce the price of the products in the market, which will help the consumer, but harm the farmer

This centralization will lead to an inevitable monopoly of the market, that, if not regulated by the government, will oppress even more the independent farmers and increase the food prices.

**Data and privacy of the farmers**

It is not unknown to many that technological companies use the data of their userbase. In agriculture, this usage of data of farmers could lead to a war of stock exchanges.

Knowing the productivity of the farming land would be an unfair advantage. Companies could use this information to make profit in the stock market, and that would definitively ruin farmers.

**Cybersecurity Concerns**

The agriculture robots connected to the internet can be attacked by hackers, that could obtain data or pirate the machinery to, for example: guide an autonomous tractor towards a road and have an accident. Their employment would be a serious security risk

**Sustainability**

Robots would also reduce the emissions of greenhouse gasses, because they run with electricity, that can be obtained from renewable sources, unlike fossil fuels used in modern farming machinery.

But in contrast, the materials used to build these robots are no renewable, the lithium for their batteries, or the silicon for their circuits are not infinite

**Environmental Impact**

"Field crop robots may contribute to more efficient use of pesticides, fuel and labour, provide better prevention of crop threats such as fungal disease, and allow for more precise and site-specific application of chemicals as desired by consumers increasingly aware of and concerned about traces of chemicals in food" [4.1]

The use of these robots would end with real life concerns about products in agriculture, especially the way they are treated with chemicals that are harmful for humans.

But it will also be harmful to the environment in many ways: The use of heavy machinery will compact the soil, making it harder for many plants to grow. It would also be a threat for wildlife animals and would cause a high number of accidents, that would be especially dangerous to endangered species.

**Job displacement**

Like with any other implementation of a new technology, the initial use of agriculture robots would make many farmers lose their job due to the robots automating the process. This initial series of layoffs would augment the amount of unemployed.

But with the time, those people would be absorbed by the market into new jobs, and the agriculture robots would also create new jobs (engineers, mechanics …)

These 6 are the main ethical problems faced by agriculture robotics.

# Conclusions

Agrorobotics brings huge possibilities for agriculture that is more efficient, precise and friendly with the environment. It could change completely how we produce food while the world population keeps growing and there are less people to work in the fields. The robots can do planting, picking, weeding, spraying and even take care of animals 24 hours a day, 7 days a week, without wasting water, fertiliser or pesticides.

The market is growing fast (almost 18 % every year) and this shows that soon many farms will use this technology to make food in a sustainable way.But there are big challenges too. The robots cost a lot of money and need special people to fix them, so only the big farming companies can buy them. This will push small farmers out of the market and give all the power to a few companies.

Many workers will lose their jobs at the beginning, even if later new jobs for engineers or technicians appear. The data that the robots collect can be used in a bad way, and hackers could attack the machines. Also, the heavy robots compact the soil and can hurt animals or plants, and the materials to build them (like lithium) are not infinite.

To make it work, we need rules from the government, good ethical ideas and collaboration between humans and robots – not just robots doing everything. People will still be needed to plan and watch.

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