Implementation of robotic technologies in agriculture

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Abstract. Agrobots are technological innovations that raise agricultural processes to a completely new level of development. In agriculture, robotic units replace the labor of numerous working teams, facilitate, speed up and simplify the picking of fruits, spraying of soil and crops, supply of feed, and transportation of crops. Keywords: robots, agro-industrial complex, productivity, digitalization, mechanization, crop production, green agriculture.

1 Introduction

Robotization in the agricultural industry is a cutting-edge solution that boosts productivity and sustainability in today's farming sector. By incorporating new robotic technologies, numerous benefits can be realized. These include enhanced task accuracy, reduced physical strain on workers, optimized resource usage, faster task completion, and a decrease in environmental impact. Examples of robotics utilized in agriculture encompass unmanned tractors and combines, automated fruit and vegetable harvesting and packaging, plant care tasks such as pruning, weeding, and irrigation, as well as milking cows and monitoring grazing land.Challenges of robotization: the need to adapt technologies and robots to different types of soil and climatic factors; lack of qualified personnel capable of effectively operating machines and maintaining automated systems [1-7].

Robotization of the agro-industrial complex is very relevant in today's rapidly developing technological environment. By incorporating robotics and automation into agriculture, there is high potential to improve efficiency, productivity and sustainability.

Robots can perform tasks such as planting, weeding, harvesting, and even monitoring crop health with precision and prediction. This can help optimize the use of natural resources, reduce labor costs and minimize environmental impact through the targeted use of resources such as water and fertilizers [8-10].

There are several problems in the development of robotization in agriculture. These include the high initial costs of acquiring and implementing robotic technologies, the need for specialized training of personnel to operate and maintain these systems, and the potential displacement of human labor in rural areas. Additionally, there are concerns about data security and privacy issues with the growing use of digital technology in agriculture.

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Although there are significant benefits that can be gained from robotics in agriculture, careful consideration must be given to address these challenges and ensure the successful and sustainable integration of robotics into agriculture [4-7].

Robotization in agriculture includes the use of robots for planting, monitoring crop health, harvesting, and other tasks traditionally performed by humans. However, successful implementation of robotization in the agricultural sector requires careful planning, investment in technology and consideration of the potential socio-economic impacts on rural communities.

2 General characteristics

Using robotics, farmers can automate tasks such as planting, weeding and harvesting, which in turn leads to increased efficiency and productivity. Robots equipped with sensors and artificial intelligence algorithms can also help monitor crop health, optimize resource use and reduce the need for chemicals. Overall, the integration of robotics into agriculture has the potential to revolutionize farming practices, making them more sustainable and environmentally friendly.

Artificial intelligence (AI) is increasingly found in agriculture, revolutionizing the industry in various ways.

1. Precision Agriculture: AI is used for precision agriculture, which involves optimizing field-level control through navigation technologies. This includes using drones, sensors and AI algorithms to monitor crop health, soil conditions and optimize yields.

2. Predictive Analytics: AI algorithms can analyze various data points such as weather conditions, soil quality and temporal data to provide information and make predictions for the future. This helps farmers make informed decisions regarding planting, harvesting and pest management.

3. Crop Monitoring and Management: AI tools can monitor and manage crops by analyzing images of fields using drones or satellites. By identifying areas that need more attention, such as pest infestations or water stress, farmers can quickly take corrective action.

4. Weed and Pest Control: AI can help in the effective detection of weeds and pests, thereby reducing the need for the use of harmful herbicides and pesticides. Machine learning models can differentiate between crops and unwanted plants, providing targeted treatments.

5. Optimization of the supply chain. Predictive analytics can help in better planning and distribution of agricultural products.

6. Robotics and Automation: Robots and AI-enabled automation tools are used for various tasks such as planting seeds, harvesting and sorting food. This reduces the manual labor required and increases efficiency.

7. Climate Change Adaptation: AI can help farmers adapt to changing climate conditions by providing data and recommendations. This includes adjusting planting schedules, irrigation practices and crop varieties based on predicted weather conditions.

The application of AI in agriculture is helping farmers increase productivity, reduce costs and make more sustainable and environmentally friendly decisions. It plays a critical role in shaping the future of agriculture and ensuring food security for a growing world population.

The use of robots in the agricultural market is expected to continue to grow as technology advances and the demand for sustainable and efficient farming practices increases.

Over the past few years, agricultural robots have begun to be actively introduced into agricultural activities around the world. Figures 1-4 show the best agrobots currently available.

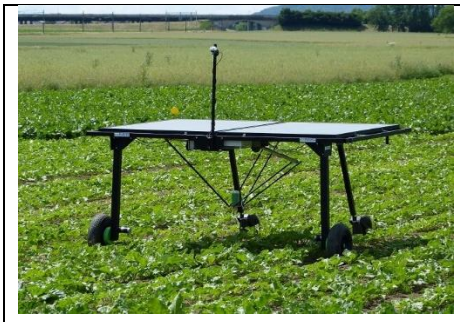

Fig.1. Ecorobotix robot weeder (Ecorobotix company, Switzerland)

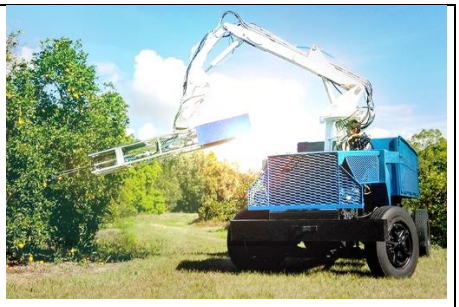

Fig.2. Energid citrus harvesting system (Energid Technologies, USA)

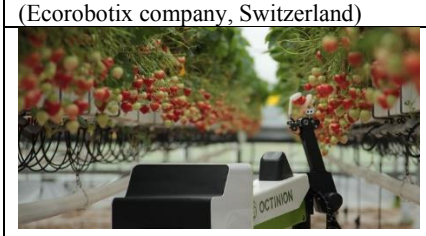

Fig.3. Strawberry picker Rubion (Octinion company, Belgium)

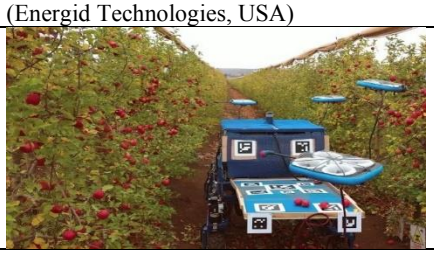

Fig.4. Flying autonomous robotic gardeners FAR (Tevel Aerobotics, Israel)

1. Ecorobotix robotic weeder - An autonomous machine capable of effectively weeding row crops, meadow crops and cover crops, meeting all environmental requirements. Due to the fact that the weight is only 130 kg, it can work in sunlight for 12 hours without human intervention. The autonomous drone uses a lightweight GPS tracker and several sensors on board. To determine the target, the robot uses sophisticated cameras mounted on its body. Micro-injections can reduce herbicide consumption by 90%, while they are 30 percent cheaper than traditional tillage methods. The machine is capable of cultivating up to three hectares of land per day. There are photohalogen solar panels on the top of the robot to ensure a stable power supply.
2. The robot is equipped with a simple and intuitive control interface, which makes its use accessible even to unqualified personnel. In addition, it can work autonomously, independently moving around the garden and collecting fruits. Using a robotic citrus picker also helps reduce the risks associated with traditional manual picking, such as worker injuries, falls from ladders, or damage to trees. The robot handles plants carefully and does not harm them. Due to its high productivity, cost-effectiveness and safety, the citrus picking robot is becoming increasingly popular in the citrus industry. It allows farmers to optimize the harvesting process, reduce costs and increase the profitability of their business.
3. Innovative Rubion Robot for Highly Efficient Strawberry Picking Belrobotics, a progressive Belgian robotics company, introduces a revolutionary fully autonomous strawberry picking robot called Rubion. This breakthrough mechanism is designed to optimize harvesting and eliminate problems associated with labor shortages and ensure consistent strawberry quality. Autonomous Navigation and Precise Detection Rubion is capable of navigating autonomously through greenhouses and agricultural tunnels, without

the need for human intervention. Its advanced computer vision system allows it to accurately detect ripe strawberries using algorithms based on deep learning and machine vision. Thanks to this, the robot can recognize the ideal degree of ripeness and distribute pressure evenly, preventing damage to delicate berries. Seamless Picking, Weighing and Sorting Once ripe strawberries are found, Rubion carefully picks them using its carefully designed robotic arm. The vibration mechanism minimizes the impact on the berries, maintaining their pristine freshness. The system also weighs each strawberry, ensuring accuracy and consistency in packaging. Intelligent Analysis and Prediction Rubion is more than just a harvesting machine. It is an intelligence that learns as it goes. By analyzing current harvest data, it is able to predict future harvests, allowing farmers to optimize their planning operations, anticipate demand and reduce losses. Sorting and categorizing by size and maturity In addition to harvesting, Rubion also sorts strawberries by maturity and size. This process ensures that the best quality berries reach the shelves in optimal condition. The robot uses multiple categories, allowing farmers to meet different market needs and add value to their crops.

4. A system of interconnected drones - flying autonomous robots - is “tied” by cables to a ground-based wheeled module. The module (the energy source for the drones) moves along the fruit plantings, and the drones themselves, using artificial intelligence and machine vision, recognize individual fruits, assessing their ripeness. The system is not only capable of harvesting tree-grown fruit, but also performs other tasks, such as pruning, that would normally require active human intervention. This is an excellent alternative to ground robots with a mechanical arm, not to mention manual harvesting: tests have shown that FAR (Flying Autonomous Robots) collects fruits without damaging them. The system is configured for both apples and stone fruits - peaches, nectarines and plums.

Currently, about 20 companies are developing various types of agricultural robots and their implementation in the agricultural sector. These companies include: (1) Company: ISO Group, a Flier Systems company, Gameren, the Netherlands (Product: RoBoPlant - flower planting robot and semi-autonomous plant replanting robots.); (2) Company: Autonomous Tractor, Fargo, North Dakota (Product: modular robotic tractor without control cab); (3) Blue River Technologies, Sunnyvale, CA (Product: LettuceBot2 (2nd generation) for lettuce thinning); (4) Company: Agrobot, Huelva, Spain (Product: Agrobot SW6010 and AGSHydro, hydroponic strawberry growing and harvesting system); (5) Company: Agribotix, Boulder, Colorado (Product: Agribotix Hornet Drone); (6) Company: Wall-Ye, Macon, France (Product: Wall-Ye 1000 mobile — pruning robot); (7) Company: ecoRobotix, Eser-Piete, Switzerland (Product: lightweight autonomous weeding robots; ecoRobotix field robot); (8) Company: Energid, Cambridge, MA (Product: Citrus Harvest Robot — Multi-Arm Harvester with Tug); (9) Company: Harvest Automation, North Billerica, MA (Product: HV-100 Mobile Robot); (10) Company: Vision Robotics, San Diego, California (Product: Vision Robotics 6-Line Lettuce Thinner and Grapevine Pruner); (11) Company: F Poulsen Engineering ApS, Hvalso, Denmark (Product: ROBOVATOR thermal and/or hydraulic cultivator); (12) Company: Kinze Manufacturing, Williamsburg, Iowa and Jaybridge Robotics, Cambridge, Massachusetts (Product: Automated Row Crop Harvest System — Autonomous Tractor and Grain Cart); (13) Company: Agrobotics, Little Rock, Arkansas (Product: AutoProbe, soil sampling system); (14) Company: Amazone-Werke Gmbh, Hasbergen, Germany (Product: Amazone-Bosch BoniRob – lightweight field robot); (15) Company: Helper Robotech, Gimhae, Republic of Korea (Product: BoniRob – field robot for grafting fruits and vegetables); (16) Company: Conic Systems, Barcelona, Spain (Product: EMP-300 plant grafting robot); (17) Company: Robotic Harvesting, Simi Valley, California (Product: Berry harvesting machine, information gathering machine and mobile platform); (18) Company: senseFly, Chezeau-sur-Lausanne, Switzerland (Product: eBee Ag); (19) Company: Rowbot, Minneapolis,

Minnesota (Product: Rowbot is an unmanned multi-function platform and is capable of moving between rows of corn. Used to: Apply nitrogen fertilizer according to the needs of corn plants. It can also collect sensor data for current and future work. GPS and several sensors allow the robot not to harm the plants); (20) Company: AGCO Fendt, Daluth, Georgia (Product: GuideConnect, SectionControl and VarioGuide).

The main advantages of introducing robotic technologies:

Increased quality of tasks performed: robots have a high degree of accuracy and minimize errors.

Reduce human stress and improve working conditions: Many agricultural jobs require physical strength and monotonous, repetitive movements, which can lead to injury and fatigue to workers.

Optimization of resource use: robotization of the agricultural sector allows you to accurately dose the amount of fertilizers and pesticides, which leads to a reduction in both material costs and the negative impact on nature.

Reduce task completion time: Automated machines operate continuously and provide high productivity.

Reducing environmental harm: technologies allow precise control of the use of water, fertilizers and pesticides, which reduces their consumption and minimizes emissions into the environment.

However, robotization of agriculture also has challenges:

New developments are expensive, as is further maintenance of equipment.

The introduction of robotics will give rise to ethical and legal disputes.

Robotization may cause a shortage of qualified personnel capable of effectively operating machines and maintaining automated systems.

The need to adapt technologies and robots to different soil types and climatic factors.

3 Conclusion

The agricultural robot market is expected to reach $11.58 billion by 2025, according to verified market research.

In Russia, the predominant use of robots in agriculture is concentrated on dairy and livestock farms, with minimal application in crop care, harvesting, and soil cultivation. The adoption of robotics in agriculture has significantly slowed due to the reliance on imported robotic technologies. Fluctuating exchange rates and increasing costs of robots have hindered access to these technologies for local farmers.

Globally, the field of robotics in agriculture is rapidly evolving, driven by the integration of intelligent systems to manage technological processes and enhance decision-making within production processes. Key applications of robotics in agriculture include milking animals, cleaning barns, shearing sheep, monitoring grazing livestock in livestock farming, as well as seeding crops, spraying plants, weeding, monitoring crop growth, and harvesting in crop production. Additionally, robots are used in auxiliary tasks such as monitoring land conditions and sorting and packaging agricultural products.Advantages of using agrobots: saving financial investments.; improving the quality and accuracy of agricultural operations; improving product quality; ensuring prompt execution of large-scale seasonal work; saving on consumables (fuel, chemical solutions) due to the automation of transportation routes and the accuracy of the dosage of sprayed chemicals.

In the future, with the development of technology and artificial intelligence, we can expect an even larger-scale implementation of robots in agriculture, which will give the agricultural industry a new impetus for development.

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