A Review on Agricultural Robots

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Abstract: This paper reviews the design, development and applications of a multipurpose agricultural robot designed for soil ploughing, irrigation and fertilizer spraying based on real time data inputs from the various sensors attached to it. Powered by batteries or solar energy or sometimes both, the agri-bots are generally controlled via Bluetooth, allowing user-friendly interaction. Given that 40% of the global population engages in agriculture, the interest in autonomous agricultural vehicles has surged. These robots offer hands-free operation and quick data input, potentially outperforming traditional large tractors by using multiple light, compact autonomous machines. This study aims to demonstrate how such robots can enhance productivity and reduce labor costs in farming.

Keywords: Multipurpose Agriculture, Robot, Autonomous bots, Farming, Bluetooth, Plough, Sowing, Irrigation, Fertilizer, Solar, Mechatronics

1.Introduction

In India, the agricultural sector is vital, employing a significant portion of the population and contributing substantially to the economy. Robots in agriculture present numerous benefits and applications, including enhanced produce quality, reduced production costs, and minimized manual labor for tasks such as weeding and spraying, especially in difficult environments where traditional machinery poses risks. Agricultural robots are automated systems equipped with multifunctional manipulators designed to perform a range of activities through programmed motions. These robots can operate autonomously or semi-autonomously, executing complex sequences of actions guided by external control or embedded systems.

Robots are increasingly utilized for repetitive tasks and in dangerous conditions, offering higher accuracy, speed, and endurance compared to human labor. This reduces production time and material waste, ultimately lowering costs. The Indian agricultural sector faces challenges such as an aging workforce, labor shortages and environmental uncertainties. Robotic solutions are being developed to address these issues, offering a promising future for the industry.

In India, agricultural robots are employed during harvesting to reduce produce waste and for tasks like weed control, seed planting, environmental monitoring, and soil analysis. These advancements, part of the high-tech agricultural revolution, include robots and drones that introduce precision farming techniques. This research highlights the essential

role of robots in agriculture, demonstrating their ability to enhance productivity, ensure quality, reduce costs, and operate in hazardous environments, making them indispensable tools for modern farming in India.

2.Literature Review:

Shamshiri, et. al. [1], explore advancements and challenges in agricultural robotics, emphasizing weed control, field scouting, and harvesting. It suggests solutions like swarm robotics and simpler manipulators for optimization. It underscores the significance of digital farming technologies.

Kushwaha, Sahoo, et. al. [2], discuss agricultural robotics' rise due to a demand for goods amidst resource and labor limitations. It categorizes agricultural robot systems and highlights key technologies, emphasizing a global market surge projected to reach $10 billion by 2023.

Cheng, C. et. al. [3], examine agricultural robots' rising importance, this paper highlights academic interest and technological advancements. It categorizes agricultural robots and discusses

Tang Q, et. al. [4], explore agricultural robots in the context of IoT and smart agriculture, this paper proposes an evaluation method integrating user requirements classification and solution ranking to enhance design practicality.

Khadatkar, et. al. [5], discuss advancements in robotics and AI revolutionize agriculture, addressing labor shortages and enhancing efficiency. Integration with IoT and machine learning enables precise field operations, with drones aiding crop management. Future research should focus on developing advanced robots for labor-intensive tasks.

Prakash S, et. al., [6] has detailed the design and development of an autonomous agricultural robot that digs soil, plants seeds, levels the ground, and sprays water. Powered by batteries and solar energy, it uses relay switch control with IR sensors. Key features include plowing, automated

Namburi Nireekshana, et. al., [7] discuss how India, a leading agricultural producer, faces high costs, labor shortages, water scarcity, and crop monitoring issues. Automation, hindered by small landholdings, addresses these challenges. A proposed robot can plough, sow, cut grass, spray pesticides, and detect leaf diseases, boosting efficiency and safety. Development requires coordination between electrical and agricultural experts.

P. K. Paul, et. al., [8] discuss how robotics, driven by AI, automates tasks in various industries, including agriculture. In farming, robotics handles tasks like weed control, planting, and monitoring. Technologies like cloud computing and big data are integrated into agriculture, fueling rapid growth in the robotics market. This paper discusses robotics basics, focusing on agriculture, exploring applications, challenges, and issues.

2. Overview of Agricultural robots

Future agriculture is set to undergo a transformative shift by integrating advanced technologies such as robots, temperature and moisture sensors, aerial photographs, and GPS technology. These innovations will collectively contribute to making farms more profitable, efficient, safe, and environmentally friendly. Precision agriculture, a practice that utilizes these advanced technologies, will enable farmers to monitor and manage their crops with unprecedented accuracy.

3.1 Autonomous Seeder and Planter:

Autonomous seeders and planters are driverless tractors with advanced navigation systems that can plant seeds with precision and efficiency. They can be self-propelled and traverse previously planned lines on a computer as shown in figure 1.

Figure 1 :Autonomous Seeder and Planter [10]
[Courtesy: www.futurefarming.com]

3.2 Paddy Autonomous Weeding Robot:

Moondino, as show in figure 2 is a rice paddy weeding robot capable of automatically performing weeding and padding tasks. It can manage its own plot of land and operate continuously in the rice field. The robot features a wheel that propels it and serves as a weeding tool. Equipped with precision GPS, Moondino can be used for mechanical weeding shortly after seeding on both dry and flooded terrain.

Figure 2: Autonomous paddy weeding robot [11]
[Courtesy: www.futurefarming.com]

3.3 Siberian Tiger

Through a collection of cameras and sensors, this robot, as shown in figure 3 is also known as a Russian agricultural robot, navigates fields, monitors crops, and soil conditions for plant disease control. For additional processing, the acquired data might be fed into a neural network. This innovative robot has the potential to improve disease control in crops while also increasing yields by 10% to 30%. [9]

Figure 3: Siberian Tiger [12]
[Courtesy: www.futurefarming.com]

3.4 LettuceBot

LettuceBot, shown in figure 4 is an advanced agricultural robot designed for precise weeding and thinning in lettuce fields. Using computer vision and machine learning, it identifies and targets weeds with high accuracy, minimizing the need for manual labor and chemical herbicides. This technology improves crop yield, reduces environmental impact, and enhances overall farming efficiency. [9]

Figure 4: LettuceBot [13]
[Courtesy: www.inc.com]

3.5 Robotriks Traction Unit (RTU)

The Robotriks Traction Unit (RTU) shown in figure 5 is an affordable "farm assistant" designed to perform various specialized and everyday tasks in agriculture, horticulture, and fruit-growing. Its adjustable chassis allows it to handle a range of activities. It can function as a load-carrying assistant under manual remote control, transporting bales, mineral blocks, fencing supplies, and equipment where heavy vehicles are unsuitable. On a livestock farm, the RTU can be programmed to perform light field tasks independently, such as harrowing or topping grass pastures. [9]

Figure 5: Robotriks Traction unit [14]
[Courtesy: www.futurefarming.com]

3.6 Fruit Pickers Robot

There is a growing need for automation in agriculture, but fruit cultivation mechanization has lagged. This study presents a method for detecting and harvesting fruit using a robotic arm as shown in figure 6. It uses a Single Shot MultiBox Detector for accurate fruit positioning and a stereo camera for 3D detection. The robotic arm moves to the fruit's position using inverse kinematics and harvests it by twisting its hand axis. Experimental results show over 90% detection accuracy, with the robot harvesting a fruit in 16 seconds. [11]

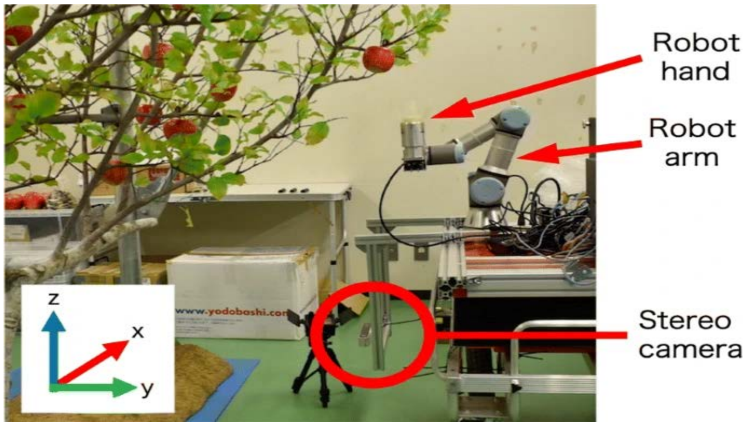

Figure 6: Fruit Pickers [15]
[Courtesy: An automated fruit harvesting robot by using deep learning]

3.7 Agribot Krishi Drone

The Agribot Krishi Drone, shown in figure 7 is India's first agriculture drone that has been approved and certified by the DGCA (Directorate Gerneral of Civil Aviation). It's a multi-rotary drone that can be used for spraying, broadcasting, and monitoring the health of crops and soil. The drone can cover up to 25–30 acres per day and is known for its precision when spraying pesticides and fertilizers. [10]

Figure 7: Agribot Krishi drone [9]
[Courtesy: iotechworld.com]

4. Research Gap

Agricultural robots have unique characteristics and are gaining importance globally, including in India. However, several challenges need to be addressed to enhance their adoption and effectiveness:

1. High Costs: The initial and operational costs of agricultural robots are high. To facilitate their use in India, support from government bodies, agricultural firms, NGOs, and charitable trusts is crucial.

2. Crop Suitability: Current agricultural robots may not be suitable for all types of crops, particularly certain fruits. Increased research and development are necessary to adapt these technologies to a wider range of produce.

3. Skilled Manpower: Developing, maintaining, and upgrading agricultural robots requires skilled professionals. There is a need for more formal education and training programs in this field to support future advancements.

4. Farmer Training: Farmers must be adequately trained to use these advanced machines. Workshops and training sessions should be organized to educate cultivators and agro-industry professionals on operating and maintaining agricultural robots.

5. Regular Maintenance: For optimal performance and productivity, agricultural robots require regular maintenance. Establishing support systems for ongoing maintenance can help ensure their effectiveness in the long term. [8]

By addressing these issues, the adoption of agricultural robots in India can be significantly improved, leading to enhanced productivity and efficiency in the agricultural sector.

Conclusion

Agricultural robots are practical machinery and devices designed for various farming tasks, offering precise accuracy in planting, seeding, weeding, transplanting, monitoring, watering, inspection, and harvesting, while also reducing farm waste. These innovations underscore the substantial benefits of robots in enhancing mechanized farming techniques. In summary, agricultural robots are essential tools for performing repetitive tasks more quickly, affordably, and accurately than humans in farming practices, inspections, harvesting, and post-harvest processing.

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