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A Review of the Use of Mechatronics in Agriculture

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ABSTRACT
There are a lot of practical uses for mechatronics in agriculture.
One of the oldest sectors, agriculture dates to the nomadic era and was formerly dependent only on human labor before being discovered to use animal labor. technical advancements like steam-engine and diesel tractors and hydrostatically powered mechanical tools that need control. To meet the demands for more autonomy in more uncertain and unstructured contexts, the solution to unsolved problems depends on further advancements that call for the replacement of the human brain. Our focus is on the development of irrigation systems, and promising fields within this framework include mechatronics, large-scale optimization, and complex system automation. To learn more about the state of the art, benefits, and drawbacks of various approaches used, a few mechatronics applications in agriculture and their procedures are examined.

Keywords: Agriculture, Automation, Application, Irrigation, Mechatronics

I. INTRODUCTION
Numerous industries and application domains, including consumer goods, lifestyle, health, automotive, and agricultural, use mechatronic systems. The technical advances needed to improve and ease human life and maintain the environment are the basis for the development of current and future mechatronics. In a demanding industrial setting, mechatronic systems aid in offering a competitive edge [1]. Consequently, there are a lot of practical uses for mechatronics in agriculture. With roots in the nomadic era, agriculture is among the oldest sectors of the economy. Before mechanical advancements like diesel/steam-engine tractors and mechanical equipment with hydrostatic power that required control, it was entirely dependent on human labor. Later, animal labor was discovered. To meet the demands for more autonomy in more uncertain and unstructured contexts, the solution to unsolved problems depends on further advancements that call for the replacement of the human brain. Within this context, the fields of mechatronics, large-scale optimization, and complex system automation show promise. Information technology integration into agricultural technologies is being driven by necessity; it may take the shape of a management and planning system, a machine, or a process controller [2].

Today, technology serves as agriculture's feeding hand [3], [4]. Actuators and sensors are examples of mechatronic components that are essential to our farms' cropping, cleaning, fertilization, seeding, and vegetation monitoring processes. Sensors are used to measure color, ambient light levels, moisture content, ripeness-indicating alcohol content, and hazardous chemical concentrations, such as pesticides and insecticides. A variety of devices have also been developed and built to support agricultural operations, such as rotating machines for seedling, gathering, and cleaning crops as well as soil regeneration and robot arms that tend to plant roots [5].

Many mechatronics and embedded technologies, including microcomputers and microcontrollers, are already in use in modern, multipurpose agricultural facilities. These independent components serve as the framework and fundamental units of a contemporary agricultural complex.

Precision agriculture (PA), which uses advanced control systems to increase crop productivity, is the foundation of contemporary agriculture. Precision agriculture's core A qualitative shift in the character of agricultural production was made possible by several of the breakthroughs that the scientific and industrial revolutions brought to agriculture. The use and integration of technology in agriculture has produced several beneficial outcomes. By generating enormous yields, it has not only reduced labor costs but also crop prices [7]. We examine several fields in which mechatronics systems have been used to learn about the benefits and drawbacks of technology for advancement and exploration. It is basically highly precise manuring and irrigation according to needs [6].

II. MECHTRONICS IN AGRICULTURE

2.1: Precision Agriculture

Precision agriculture, which involves the use of sensors, mechatronics, and automation to increase the effectiveness of monitoring and interference techniques, was initially implemented in industrial manufacturing in the 1980s. We can develop a new line of agricultural equipment based on small, intelligent technologies that improve economic capability, decrease waste and environmental impact, and promote food sustainability thanks to the development of mechatronics and autonomous systems. Additionally, to minimize waste and increase yields, robotic platforms on the plantation gather sensory data that offers extensive information and insights into yield optimization, better planning, the number of resources required, and when and where those resources are needed [8].

2.2: Animal Production

Production of Animals Many cutting-edge technology instruments have been added to animal production in the last ten years to help with decision-making, especially regarding management, feeding plans, animal health, and fertility. To handle the associated data and give the farmer the right instruments and warning signals, specialised electronic devices have also been developed. Biosensor technology has enormous potential to enhance animal welfare, health, and production efficiency as mechatronics advances [9].

2.3: Autonomous Tractor

The laborers of contemporary mechanized farms are tractors. Numerous agricultural operations include the usage of tractors. Tractors can till fertilizer, plant, spray, weed, mow, haul, and harvest when they have the right riggings. Tractors are a crucial piece of equipment for automation because of their versatility. These machines can now be automated thanks to mechatronics, which lowers costs, improves safety, and increases production for a variety of agricultural processes. [10] introduced a tractor automation system that uses driving the appropriate routes to program a task. A convoy of tractors that drive various sections of the routes are then given the assignment once it has been divided into smaller tasks. Every tractor has sensors built into it that can identify humans, animals, and other big things in its route. If an impediment is detected, the tractor will stop until a supervisor gives it an order via a wireless link.

2.4: Crop Seeding

One of the most important agricultural processes in crop cultivation is seeding. The ultimate yields are greatly impacted by the proper seed selection, the sowing procedure, and the recognition of the agricultural dates. Currently, automated tilling-and-sowing machines are available to do laborious tasks with the help of mechatronics. The machine enables simultaneous seeding of catch crops and grains, as well as ploughing and minimum tillage. This machine's use enables one pass for both soil preparation and seedling. Utilizing a machine that combines tilling and sowing will advance the agronomic and economic effects [11].

III. CROP MONITORING ANALYSIS

A wireless sensor network was suggested by Crop Monitoring and Analysis [12] as a means of developing an inexpensive agricultural remote monitoring and control system. Sensor nodes are tiny, self-sufficient devices that make up the sensor network. The main goal is to keep an eye on and manage each plant's unique environmental needs. Small, inexpensive wireless sensor nodes make up the Wireless Sensor Network. Every node periodically observes, senses, and collects data before transmitting it to the base station. Zigbee, a low-power wireless communication technology, serves as the foundation for the system. The brain of the system is a microcontroller, which manages all the sensors, turns them on, and coordinates their operation.

3.1: CROP WEEDING SPRAY

Crop Weeding and Spraying [13] demonstrated a robot that employs two vision systems—one gray-level and one color-based—for agricultural weed control. [14] suggested a multipurpose intelligent device that enables variable rate watering and automatically eliminates weeds. With this approach, weeds can be removed without endangering the crops that are being grown. It can be wasteful and bad for the environment to spray weed killers and insecticides into fields. The use of mechatronics results in a clever system that is significantly more effective [15].

3.2: CROP FERTILIZATION

A key determinant of soil quality is soil fertility, which indicates how well the soil can support crop life. The quantity of macro and micronutrients, water, pH, and other elements in the soil all affect how fertile the soil is. To maintain a high nutrient content in the event of a deficiency, fertilizers are supplied to the soil. To avoid having too much or too little fertilizer in the soil, [16] suggested and created an automated method for the metered addition of fertilizers.

The dispensary system, microprocessor, and sensors make up the three primary components of the system. Advanced application technologies for targeted crop fertilization are now undergoing development. Data on the condition of every area of the plantation is made available by decoding satellite photos of the property. After that, a plan for fertilizing the entire plantation will be developed, considering the crop type, soil condition, weather, etc. After that, the program will be loaded into the tractor's mechatronic dozing device control unit. The tractor will thereafter apply fertilizer with the use of GPS and auto-guidance [17].

IV. RELATED WORK ON FERTILIZATION

The process of artificially delivering water to soil or land is known as irrigation. It helps sustain landscapes, revegetate damaged soils in arid regions, support the establishment and development of agricultural crops, and help during dry spells [18]. One of the most important aspects of agricultural growing is irrigation. An automated irrigation system is necessary because irrigation has been an ancient practice that has undergone numerous stages of development over the years. Various techniques have been used to achieve proper irrigation, and the larger the farmland, the greater the need for an improved irrigation system [19].

Using soil moisture sensors to regulate irrigation is one way to achieve more effective water and irrigation utilization. This minimizes water waste and keeps the field well-irrigated [20].

An Arduino UNO microcontroller is combined with an automatic irrigation system, and it is configured and programmed to send a signal to the irrigation system in response to the soil's moisture level. A soil moisture sensor is used to measure the soil's moisture content. The Arduino (microcontroller) receives a signal from the sensor whenever the moisture level changes. The microcontroller uses a water level sensor to verify that there is enough water in the above tank before turning on or off the irrigating system as necessary. The system's design reduced labor costs, minimized water waste, increased plant growth, and decreased expenses [20].

Water waste is a major issue in agriculture since the sector needs and utilizes a lot of water. A few techniques, including sprinkler systems, rotary systems, drip irrigation, terraced irrigation, ditch irrigation, and drip irrigation, are employed to manage the surplus water from agriculture, according to [2]. Drip, sprinkler, and surface irrigation are the three main methods of irrigation. Using gravity to apply water to the soil's surface is known as surface irrigation, or flood irrigation. It is the most often used irrigation technique. Sprinkler irrigation uses water droplets to apply water to the soil. Water is applied to plants by drip irrigation, also known as trickling irrigation, which involves gradually dripping water into the roots of the plants. It is carried out by means of tubes that supply water straight to the plant's roots. In addition to saving water, this technique keeps soil nutrients from being lost.

4.1: Surface Irrigation

Surface irrigation, which is a widely used technique for crop irrigation in fields, entails introducing and spreading water on the field's surface and depends on the water's gravitational movement through the soil to the crops' roots [15]. In addition to storing water, the soil serves as a conduit for water as it percolates and spreads. When water is transferred and reduced to the soil surface, irrigation water typically seeps into the root zone. Additionally, a pipe at the field's greater elevation can be used to apply water during surface irrigation. Long parallel strips, smaller rectangular basins, or tiny waterways between crop rows can all be used to distribute water to the crops. There are two types of surface irrigation techniques: flooding and furrowing. The water used in the furrowing method only covers a section of the soil surface, whereas the flooding method uses water to cover the entire soil [16]. Surface irrigation is the simplest and least expensive technique; however, it is typically quite ineffective because plants only use 10% of the water that is spread out, according to [17]. Surface irrigation can frequently be labor-intensive in addition to using water inefficiently. Unfortunately, the most widely employed irrigation techniques worldwide are surface irrigation systems [18].

4.2: Sprinkel Irrigation

Sprinkler irrigation is a type of irrigation where water is applied similarly to how it would naturally rain. Water is pumped and sprayed into the air through sprinkler heads in this arrangement. As a result, the water can be broken up into tiny droplets that fall to the ground like rain. The technique is effective for covering small to large land areas since the sprinkler heads evenly distribute water across the soil's surface [19] divides the numerous sprinkler types into the following categories: Depending on how water is applied Turning around Sprinkler-Impact sprinkler, perforated pipe system, gear-driven, reaction-type, and fixed-head sprinkler Considering portability Systems that are semi-permanent, semi-portable, and portable Long-term system Considering the rates of precipitation Three types of sprinklers: low, medium, and high volume based on the operational premise Mini-sprinkler, propeller sprinkler, turbo hammer sprinkler, and whirling sprinkler Considering movement Move the irrigation system. Gun type, side roll, tow move, and hand move Constant move system, solid set system, Linear movement, centre pivot, Passenger Both small and large cities and individuals have embraced the sprinkler irrigation technology. This is due to the system's great water efficiency, ease of installation, and accessibility. However, a significant barrier is the high investment costs and high fuel expenses needed to operate the pressure pumps. This is the typical explanation for why using this system is ineffective and is abandoned [11].

4.3: Drip Irrigation

One irrigation technique used to reduce water use in agriculture is the drip system. Drop by drop, water is supplied to the plant roots using drip irrigation, maintaining a steady supply of water. This is crucial because it minimizes water consumption, guarantees crop survival, and prevents crop damage from over-irrigation [12]. Drip irrigation is therefore the most sophisticated irrigation technique with the highest application efficiency. The reason for this is that water is exclusively supplied to each crop's root zone, which is where it is most required [13]. Drip irrigation is used for crop cultivation in two main ways: surface drip and subsurface drip. When using surface drip irrigation, the pipe or tubing is positioned either directly beneath the soil's surface, in a groove, or on top of it. Subsurface drip irrigation, on the other hand, uses pipes or tubing that are buried just beneath the ground. This lessens the tubing or pipe's sideways movement brought on by temperature changes or wind. Thick-walled pipes or tubes that are buried in the ground below tillage machinery are used in subsurface drip irrigation. The irrigation installations are more permanent with a subsurface drip system [14].

According to [15], drip irrigation is a useful technique for irrigating crop soil right at the root zone, which lowers traditional losses such runoff, soil erosion, and deep percolation. Drip irrigation is more suitable and economical than surface irrigation when used in arid regions with sandy, shallow soils and undulating terrain. Because of this, the drip irrigation system is now thought to be a way to improve the efficiency of irrigated farming and to address several issues with dry land farming. Applying drip irrigation technology has decreased the wasteful and inefficient use of water that results from surface irrigation. Additionally, drip irrigation eliminates the environmental issues that surface irrigation causes, like salinity and waterlogging. Increased crop yields, improved quality products, reduced tillage needs, and improved fertilizer use efficiency are all made possible by drip irrigation [16].

V. STATE OF THE ART IRRIGATION

There are typically two ways to measure the moisture content of soil: direct soil sample and indirect soil moisture detection. Because it takes a lot of work and cannot give immediate feedback, the direct method of evaluating soil water content is no longer typically used for irrigation. Advances in technology have made it possible to permanently install soil moisture sensors at key points inside a crop plantation to collect repeated moisture measurements that can be utilized for irrigation control over time [17]. To regulate irrigation, an automated decision support system was created. The system's primary characteristic is its accurate estimation of crop irrigation requirements based on continuous soil assessment and climate variables. The decision support system is highly flexible due to the use of real-time data from the soil in a feedback control system.

[18].suggest a method to maximize agricultural plantation water utilization. The system uses a wireless network of temperature, humidity, and soil moisture sensors to automate the watering process. By inserting the sensors into the plant's root zone, it is possible to precisely regulate and limit water waste in the field by determining the specific field condition. ZigBee and GSM are used to monitor the system, and an instantaneous intelligent sensor arrangement was created to measure the moisture content and soil temperature [4]. The setup consists of a central receiver that is connected to a laptop or computer and several sensor nodes placed around the countryside. To transmit data to the central receiver, the sensor nodes are composed of a specially constructed circuit board, thermocouples, soil moisture sensors, and an RFID tag. This is a closed-loop irrigation system in which the timing and amounts for immediate irrigation execution are determined by an intelligent sensor configuration.

created an autonomous irrigation system based on a microcontroller that can water areas of a field that require water while avoiding areas where appropriate moisture is recognized. There was at least one sprinkler head, a water dispenser, and a solenoid valve with an "on" and "off" state to regulate the flow of water in each area that needed irrigation. Moisture sensors were placed in the soil in these areas to measure and transmit the soil's moisture content to a microcontroller that was connected to the solenoid valves for control. On a particular irrigation day, the microcontroller, which consists of the circuitry and software, selectively activates each solenoid valve. This process begins at the pre-programmed start time and lasts for the pre-programmed amount of time, unless it is shortened because the moisture sensor for that area signals that the predetermined adequate moisture level has been reached. created a method to automatically deliver water for farm fields and household gardens. Temperature and moisture sensors that are positioned at the crop roots were used to conduct the study. The sensors' detected values are transmitted to a base station, where an ESP8266 Wi-Fi module is used to compile and post real-time field data to the internet.

Additionally, the station alerts the user to any anomalous conditions, such as high temperatures and low moisture. The irrigation system's valve opens whenever the detected value exceeds the predetermined threshold. The user may now continuously check the condition of the soil thanks to technological improvements as we move closer to the Internet of Things (IOT).

In areas with sufficient sunshine but insufficient water to carry out the necessary farming tasks, a SCADA-based system can be helpful. Programmable Logic Controller (PLC)-based automated SCADA systems are crucial for agriculture. A smart solar system with solar panels that focus on the sun's energy can power the system. Sensors for detecting soil moisture and level are used by the system. While level detection sensors measure the water level in the water tank, soil moisture sensors measure the moisture content. The fact that solar energy is a limitless, freely accessible source of energy is its greatest advantage [4].

VI. CONCLUSION

The agriculture sector is rapidly evolving into a crucial industry that requires increasingly sophisticated methods and modern control systems to manage the increasingly complex agricultural systems. Precision agriculture (PA), which uses advanced control systems to increase crop production efficiency, is the foundation of contemporary agriculture. Manuring and irrigating according to needs and with extreme precision is the fundamental component of precision agriculture. The use and integration of technology in agriculture has produced several beneficial outcomes. By generating enormous yields, it has not only reduced labour costs but also crop prices. A few benefits and drawbacks of popular irrigation techniques were outlined, along with suggestions for how to improve them and create more effective procedures.

REFERENCE

[1]. Dieterle, W. (2004). Mechatronic systems: industrial applications and modern design methodologies. IFAC Proceedings Volumes, 37(14), 1–5. https://doi.org/10.1016/S1474-6670(17)31071-6

[2]. Sigrimis, N., Antsaklis, P., & Groumpos, P. P. (2001). Advances in control of agriculture and the environment. IEEE Control Systems, 21(5), 8-12.

[3]. Tyagi, A., Gupta, N., Navani, J. P., Tiwari, M. R., & Gupta, M. A. (2017). Smart irrigation system. International Journal for Innovative Research in Science & Technology, 3(10).

[4]. Ramli, N. L., Mohd Yamin, N., Ab Ghani, S., Saad, N. M., & Md Sharif, S. A. (2015). Implementation of passive infrared sensor in street lighting automation system. ARPN Journal of Engineering and Applied Sciences, 10(22), 17120–17126.

[5]. Hessel, L., & Bar-On, D. (2003). U.S. Patent No. 6,508,033. Washington, DC: U.S. Patent and Trademark Office.

[6]. Erdélyi, V., & Jánosi, L. (2017). Mechatronics in Agriculture. Scientific Bulletin Series C: Fascicle Mechanics, Tribology, Machine Manufacturing Technology, 31, 31-35.

[7]. Imadi, S. R., Shazadi, K., Gul, A., & Hakeem, K. R. (2016). Sustainable crop production system. In Plant, Soil and Microbes, 103-116.

[8]. Duckett, T., Pearson, S., Blackmore, S., & Grieve, B. (2015). Agricultural robotics: the future of robotic agriculture. Arxiv preprint arxiv:1806.06762.

[9]. Stentz, A., Dima, C., Wellington, C., Herman, H., & Stager, D. (2002). A system for semi-autonomous tractor operations. Autonomous Robots, 13(1), 87-104.

[10]. Gore, T. H., Kote, M. P., Varpe, P. B., & Jagtap, M. T. (2016). Crop monitoring analysis and controlling system, 6(2), 138–141.

[11]. Åstrand, B., & Baerveldt, A. J. (2002). An agricultural mobile robot with vision-based perception for mechanical weed control. Autonomous robots, 13(1), 21-35.

[12]. Chang, C. L., & Lin, K. M. (2018). Smart agricultural machine with a computer vision-based weeding and variable-rate irrigation scheme. Robotics, 7(3), 38.

[13]. Amrutha, A., Lekha, R., & Sreedevi, A. (2016). Automatic soil nutrient detection and fertilizer dispensary system. In Robotics: Current Trends and Future Challenges (RCTFC), International Conference on (pp. 1-5). IEEE.

[14]. Grau, J. B., Antón, J. M., Packianather, M. S., Ermolov, I., Aphanasiev, R., & Cisneros, J. M. (2009). Sustainable agriculture using an intelligent mechatronic system, (1), 3452 3457. https://doi.org/10.1109/IECON.2009.5415192

[15]. Kumar, G. (2014). Research paper on water irrigation by using wireless sensor network.

International Journal of Scientific Research Engineering & Technology (IJSRET), 3–4.

[16]. Umeh, M., Njideka, M., Okafor, S. O., & Agba, F. C. (2015). Intelligent microcontroller-based irrigation system with sensors. American Journal of Computer Science and Engineering, 2(1), 1–4.

[17]. Van Iersel, M., Seymour, R. M., Chappell, M., Watson, F., & Dove, S. (2009). Soil moisture sensor-based irrigation reduces water use and nutrient leaching in a commercial nursery. In Proc. Southern Nursery Assn. Res. Conference, 54(5), 17-21.

[18]. Deo Kumar, B., Srivastava, P., Agrawal, R., & Tiwari, V. (2017). Microcontroller based automatic plant irrigation system. International Research Journal of Engineering and Technology, 2395–56.

[19]. Awati, J. S., & Patil, V. S. (2012). Automatic irrigation control by using wireless sensor networks, 1(6).

[20]. Oseko, F. O. (2016). Design of sprinkler irrigation system for a farm in menara (B.Sc. Project). University of Nairobi, Nairobi, Kenya.