ISSN: 0974-5823 Vol. 7 No. 4 April, 2022

International Journal of Mechanical Engineering

Analyzing Implementation of AI, Robotics, and UAV Technologies in Agriculture to Boost Irrigation and Solve Crop Monitoring Challenges

Pragati Shah, B.Tech, M.Tech, Department of Computer Science and Engineering, School of Engineering and Technology, CHRIST (Deemed to be University), Bangalore

Dr. Manohar M, B.E., M.Tech, Ph.D., Associate Professor, Department of Computer Science and Engineering, School of Engineering and Technology, CHRIST (Deemed to be University), Bangalore

Abstract

Agriculture is a very important aspect of any country's economy. Automation is an emerging subject globally and it can further boost the economy. The food demand will also increase with the growing world population. Traditional irrigation methods are no longer sufficient for farmers to meet those needs. Hence, a lot of automated methods have been developed to meet food demands and also generated tons of job opportunities. AI has been revolutionary to the agriculture sector. This technology protects yield from factors like food security issues, unemployment, population, and climate changes.

This paper is aimed to analyze the use of AI, robotics, and UAV technologies to solve major challenges in irrigation and boost the agriculture sector. These technologies can prevent the overuse of herbicides, pesticides, and water and ensure the fertility of the soil with the proper use of the workforce. This study uses secondary data to review several previous works to have a brief insight into the existing status of automation in agriculture.

Keywords *– Agriculture, AI, robotics, UAV technologies, Irrigation, Crop Monitoring*

1. Introduction

The global population is supposed to cross the 10 billion mark by 2050 and boost a decent financial growth for agriculture by around 50% as compared to 2013 (FAO, 2017). Agricultural sector contributes 18% of the GDP of India and creates 50% of job opportunities for the nation's workforce. Developing the agricultural sector means empowering rural population, which further leads to rural growth and it eventually leads to structural transformation (Shah et al, 2019; Mogili & Deepak, 2018). AI is a growing technology in the agriculture sector. AI-based machines and equipment have redefined the modern agriculture system. A lot of high-end computer systems are made to determine various parameters like yield detection, weed detection, and crop quality inspection (Liakos et al, 2018).

The AI-based technologies can improve efficiency in all sectors and handle the challenges in the agricultural industry like irrigation, soil content, crop yield, weeding, crop monitoring, and crop establishment. Robots are also developed to provide valuable AI support to the agricultural sector. With the rise of the global population, the agricultural sector is going through tough times. But AI has all the solutions to help farmers enhance output and minimize input, while improving the output quality and ensuring a more rapid market for crop yields. There will be around 4.1 million data points daily on an average farm by 2050 (Kim et al, 2008).

1.1. Literature Reviews

According to Panpatte (2018), AI can enable farmers to assemble huge volumes of data from public and government portals, analyze all the data, and provide solutions to farmers to deal with a lot of ambiguous problems and come up with better irrigation techniques for higher yields. According to Lee et al (2007), there has been a growing interest in autonomous Unmanned Aerial Vehicles (UAVs) for surveillance and recognition, geolocation and body detection, forest fire detection, and search and rescue missions (Doherty & Rudol, 2007; Bhaskaranand & Gibson, 2011; Merino et al, 2006; Tomic et al, 2012).

Ferguson et al (1991) argued that seed quality and variety selection can define the optimum performance for all produce. The latest technologies are ideal for crops and also improved hybrid seed selection to meet the needs of farmers. Despite being last in digitalization, agriculture has seen impetus for the commercialization and development of technologies. AI has been pivotal in daily lives with the potential to change the environment (Gandhi et al, 2020; Kundalia et al, 2020, Ahir et al, 2020). A harvest planning approach has been proposed by Plessen (2019) on the basis of a combination of vehicle routing and crop assignment.

Jha et al (2019) gave a brief insight into the current status of automation in the agricultural sector and addressed a mechanism proposed for leaf and flower identification and watering with the implementation of IoT in a botanical farm (Albaji et al, 2010; Patel et al, 2020). AI is basically aimed to act as the human mind (Jani et al, 2019, Parekh et al, 2020). A lot of domains like deep learning and machine learning are important aspects of AI (Pandya et al, 2019, Patel et al, 2020, Sukhadia et al, 2020). Though AI is aimed to make smart programs and machines, machine learning is the skill to learn something without human intervention and deep learning refers to learning “deep neural networks” (Kulkarni & Deshmukh, 2013; Kodail & Sahu, 2016).

1.2. Research Objectives

- To analyze the use of AI in advancement of agricultural sector
- To evaluate robotic systems to mitigate irrigation problems
- To explore emerging UAV technologies solving crop monitoring challenges

1.3. Research Questions

- How AI can help in automation of agricultural processes?
- What robotic systems can do to mitigate irrigation problems?
- What are the latest UAV technologies used in the agro-based sector?

2. Methodology

To fulfill the above research objectives, this study is based on secondary data collected from various previous studies and research related to agriculture industry and emerging technologies used in the agro-based sector.

3. Data Analysis

Q. How AI can help in automation of agricultural processes?

AI-based technologies are helpful to make all fields efficient and manage all the challenges in the agriculture industry like irrigation, crop yield, crop-monitoring, soil content detection, crop monitoring and weeding (Kim et al, 2008). Agricultural robots can deliver highly valuable AI applications in this sector. With the rise in global population, the agriculture sector is going through a tough crisis but AI can deliver better solutions. AI solutions can help farmers produce more yield with less input while improving output quality and yield can go to the market faster. AI has great contribution to the agriculture industry, such as –

Image Recognition – There has been a great interest in Unmanned Aerial Vehicles (UAVs) and their uses like surveillance and recognition, geolocation, human body detection, forest fire detection, and search and rescue (Doherty & Rudol, 2007; Bhaskaranand & Gibson, 2011; Merino et al, 2006; Tomic et al, 2012). From delivery to photography, these imaging technologies are very versatile and they can be controlled with remote and dexterous devices in the air. One can make the most of these drones, devices, or UAVs which are very popular to cover vast distances and heights for several applications.

Biological and technical skills – AI can make it easier for farmers to assemble big data from public and government websites, analyze all the data, and provide ambiguous solutions to farmers and smarter ways for irrigation which helps in increasing yield for farmers. Farming can have a blend of biological and technological skills in the future thanks to AI. It will minimize workloads and losses and improve the quality of yields (Panpatte, 2018).

Chatbots dedicated to farmers – Chatbots are simply virtual assistants to provide automatic responses to the end-users. Powered by machine learning and AI techniques, chatbots understand natural language and respond to the users in a personalized manner. They are usually designed for travel, retail, media, and agriculture. In agriculture, they assist farmers by responding to their queries and giving advice, and recommendations.

Enhanced output – Seed quality and variety selection have achieved maximum performance in all plants in the work of Ferguson et al (1991). Latest technologies have been helpful in crop selection and also improved hybrid seed choices to meet farmers’ needs.

Q. What robotic systems can do to mitigate irrigation problems?

“Robotics and Autonomous Systems (RAS)” have been very helpful in leading economic sectors and sectors like Agri-Food which receive relatively low productivity. From farming to retail, the Agri-Food chain in the UK generates up to £108 billion per annum, with exports of £20 billion in 2016 in an international industry with 3.7 million employees (Duckett et al, 2018). Robotics has been very important in agricultural management and production. The researchers have focused on designing autonomous tools for the agriculture sector as the traditional farming machinery is no longer sufficient (Durson & Ozden, 2011).

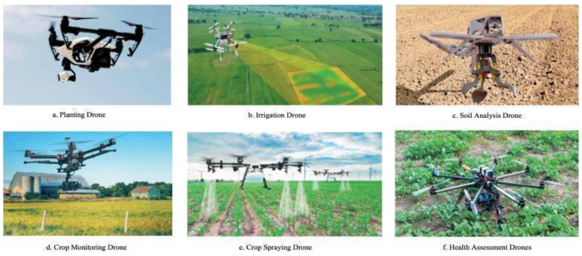
This technology is mainly aimed to produce greater benefits and replace human labor in large- and small-scale production (Manivannan & Priyadarshini, 2016). Robotics technologies have expanded further in productivity in the agriculture sector (Pedersen et al, 2008). The robots are engaged in several autonomous agricultural operations, for example, irrigation, weeding, protecting the farms from delivery of better reports, etc. It also ensures that extreme environmental conditions improve the precision and manage plants in several extreme conditions, without affecting production. The concept of bringing this technology emerged from a cotton gin invented by Eli Whitney (1765-1825), based in the US. This device has brought a revolution to cotton production by boosting the extraction of seeds out of cotton fiber. It was capable of producing 50 pounds of cotton per day. Autonomous agricultural robots were the inspiration for this machine.

Griepentrog et al (2005) introduced a basic automated model to figure out the actual seed position. They also established the placement of seeds with very high precision. They found zero ground velocity in planted seeds with certain mechanisms. The automated machines recorded the growth of the plant. A lot of biosensors were built to detect diseases and track plant growth (Tothill, 2001). Laser weeding has then replaced manual weeding, where a portable infrared light disrupted weed cells and computers have controlled this beam (Griepentrog et al, 2006). Automated irrigation systems are used for making the most of water.

Q. What are the latest UAV technologies used in the agro-based sector?

Also known as unmanned aircraft, automatons, or "unmanned ethereal frameworks (UAS)", the "unmanned aeronautical vehicles (UAVs)" are the vehicles that are remotely controlled. They work with GPS and other sensors on them. They are widely used for crop monitoring, weed identification, wildlife, and herd monitoring, disaster management, and irrigation equipment monitoring in agriculture (Ahirwar et al, 2019; Veroustraete, 2015; Natu & Kulkarni, 2016). They have been used as pesticide sprayers for decades by farmers and they are effective in cloudy weather. In tall crops, they have solved the issue of inaccuracy, such as corn (Simelli & Tsagaris, 2015; Sugiura et al, 2005). Uncontrolled use of pesticides may be harmful or insufficient to the yield. Figure 1 illustrates different types of drones used in the agro-based sector -

Figure 1 – Types of Drones in Agriculture



Source: Talaviya et al (2020)

4. Results

The cutting-edge imaging technologies and sensors have enabled farmers to minimize crop damage and enhance yields. UAVs have been very practical over the years. They are equipped with high-end cameras and sensors as the eyes for the users on the ground. They have been helpful for ground surveys, data analysis, and acquisition. Aerial surveys are not rare these days. Satellites are widely used to inspect large forest lands and crops but UAVs are widely used for added levels of flexibility and precision. There is no need to rely on ideal weather conditions and satellite positioning as pictures taken around 500 feet above the ground result in precision and better quality.

The AI technology will further boost the agriculture sector by predicting weather and other conditions like groundwater level, land quality, pest infestation, and crop cycle. AI, with accurate prediction or projection, will further reduce most of the farmers' concerns. AI-based sensors can extract major agriculture data to boost production.

5. Conclusion

There are several crop monitoring challenges in the agriculture industry, for example, weeding, lack of proper irrigation solutions, plant monitoring issues because of extreme weather and crop height, etc. But AI, UAV, and Robotics technologies combined can boost performance and eradicate all these problems in the agricultural sector. Soil moisture detection, automated irrigation, and remote sensors can improve various AI-based techniques. Precision weeding is one of the biggest challenges for farmers. But AI can help them overcome the loss of large amounts of crops during the process.

These autonomous robots are not just efficient, but they also mitigate the need for unwanted herbicides and pesticides. Additionally, farmers can spray herbicides and pesticides properly on the farms through drones and plant monitoring is not an issue anymore. Artificial intelligence can help mitigate the lack of resources in agribusiness. For inspecting crop characteristics like soil texture, soil content, and plant height, ample labor was needed in traditional strategies. Manual testing was tedious in this manner. With advanced systems, safe, quick, and high yield has been possible with the upscaling of adaptable practices.

6. References

1. FAO, I. F. A. D., & UNICEF. (2017). The state of food security and nutrition in the world 2018. *Building climate resilience for food security and nutrition*.
2. Mogili, U. R., & Deepak, B. B. V. L. (2018). Review on application of drone systems in precision agriculture. *Procedia computer science*, *133*, 502-509.
3. Shah, G., Shah, A., & Shah, M. (2019). The panacea of challenges in real-world application of big data analytics in the healthcare sector. *Journal of Data, Information and Management*, *1*(3), 107-116.
4. Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. *Sensors*, *18*(8), 2674.
5. Kim, Y., Evans, R. G., & Iversen, W. M. (2008). Remote sensing and control of an irrigation system using a distributed wireless sensor network. *IEEE transactions on instrumentation and measurement*, *57*(7), 1379-1387.
6. Panpatte, D. G. (2018). Artificial intelligence in agriculture: An emerging era of research. *Anand Agricultural University*.
7. Lee, J., Wang, J., Crandall, D., Sabanovic, S., & Fox, G. (2017). Real-time, cloud-based object detection for unmanned aerial vehicles. *2017 First IEEE International Conference on Robotic Computing (IRC).*
8. Doherty, P., & Rudol, P. (2007, December). A UAV search and rescue scenario with human body detection and geolocalization. In *Australasian Joint Conference on Artificial Intelligence* (pp. 1-13). Springer, Berlin, Heidelberg.
9. Bhaskaranand, M., & Gibson, J. D. (2011, November). Low-complexity video encoding for UAV reconnaissance and surveillance. In *2011-MILCOM 2011 Military Communications Conference* (pp. 1633-1638). IEEE.
10. Tomic, T., Schmid, K., Lutz, P., Domel, A., Kassecker, M., Mair, E., ... & Burschka, D. (2012). Toward a fully autonomous UAV: Research platform for indoor and outdoor urban search and rescue. *IEEE robotics & automation magazine*, *19*(3), 46-56.
11. Merino, L., Caballero, F., Martínez-de Dios, J. R., Ferruz, J., & Ollero, A. (2006). A cooperative perception system for multiple UAVs: Application to automatic detection of forest fires. *Journal of Field Robotics*, *23*(3-4), 165-184.
12. Ferguson, R. B., Shapiro, C. A., Hergert, G. W., Kranz, W. L., Klocke, N. L., & Krull, D. H. (1991). Nitrogen and irrigation management practices to minimize nitrate leaching from irrigated corn. *Journal of Production Agriculture*, *4*(2), 186-192.
13. Gandhi, M., Kamdar, J., & Shah, M. (2020). Preprocessing of non-symmetrical images for edge detection. *Augmented Human Research*, *5*(1), 1-10.
14. Ahir, K., Govani, K., Gajera, R., & Shah, M. (2020). Application on virtual reality for enhanced education learning, military training, and sports. *Augmented Human Research*, *5*(1), 1-9.
15. Kundalia, K., Patel, Y., & Shah, M. (2020). Multi-label movie genre detection from a movie poster using knowledge transfer learning. *Augmented Human Research*, *5*(1), 1-9.
16. Plessen, M. G. (2021). Freeform path fitting for the minimisation of the number of transitions between headland path and interior lanes within agricultural fields. *Artificial Intelligence in Agriculture*, *5*, 233-239.
17. Jha, K., Doshi, A., Patel, P., & Shah, M. (2019). A comprehensive review on automation in agriculture using artificial intelligence. *Artificial Intelligence in Agriculture*, *2*, 1-12.
18. Albaji, M., Shahnazari, A., Behzad, M., Naseri, A., BoroomandNasab, S., & Golabi, M. (2010). Comparison of different irrigation methods based on the parametric evaluation approach in Dosalegh plain: Iran. *Agricultural water management*, *97*(7), 1093-1098.
19. Patel, D., Shah, D., & Shah, M. (2020). The intertwine of brain and body: a quantitative analysis on how big data influences the system of sports. *Annals of Data Science*, *7*(1), 1-16.
20. Jani, K., Chaudhuri, M., Patel, H., & Shah, M. (2020). Machine learning in films: an approach towards automation in film censoring. *Journal of Data, Information and Management*, *2*(1), 55-64.
21. Parekh, V., Shah, D., & Shah, M. (2020). Fatigue detection using artificial intelligence framework. *Augmented Human Research*, *5*(1), 1-17.
22. Pandya, R., Nadiadwala, S., Shah, R., & Shah, M. (2020). Buildout of methodology for meticulous diagnosis of K-complex in EEG for aiding the detection of Alzheimer's by artificial intelligence. *Augmented Human Research*, *5*(1), 1-8.
23. Sukhadia, A., Upadhyay, K., Gundeti, M., Shah, S., & Shah, M. (2020). Optimization of smart traffic governance system using artificial intelligence. *Augmented Human Research*, *5*(1), 1-14.
24. Kulkarni, A., & Deshmukh, G. (2013). Advanced Agriculture Robotic Weed Control System. *Int. J. Adv. Res. Electr. Electron. Instrum. Eng*, *2*(10).
25. Kodali, R. K., & Sahu, A. (2016, December). An IoT-based soil moisture monitoring on the Losant platform. In *2016 2nd International Conference on Contemporary Computing and Informatics (IC3I)* (pp. 764-768). IEEE.

26. Kim, Y., Evans, R. G., & Iversen, W. M. (2008). Remote sensing and control of an irrigation system using a distributed wireless sensor network. *IEEE transactions on instrumentation and measurement*, *57*(7), 1379-1387.

27. Lee, J., Wang, J., Crandall, D., Šabanović, S., & Fox, G. (2017, April). Real-time, cloud-based object detection for unmanned aerial vehicles. In *2017 First IEEE International Conference on Robotic Computing (IRC)* (pp. 36-43). IEEE.

28. Bhaskaranand, M., & Gibson, J. D. (2011, November). Low-complexity video encoding for UAV reconnaissance and surveillance. In *2011-MILCOM 2011 Military Communications Conference* (pp. 1633-1638). IEEE.

29. Doherty, P., & Rudol, P. (2007, December). A UAV search and rescue scenario with human body detection and geolocalization. In *Australasian Joint Conference on Artificial Intelligence* (pp. 1-13). Springer, Berlin, Heidelberg.

30. Tomic, T., Schmid, K., Lutz, P., Domel, A., Kassecker, M., Mair, E., ... & Burschka, D. (2012). Toward a fully autonomous UAV: Research platform for indoor and outdoor urban search and rescue. *IEEE robotics & automation magazine*, *19*(3), 46-56.

31. Merino, L., Caballero, F., Martínez-de Dios, J. R., Ferruz, J., & Ollero, A. (2006). A cooperative perception system for multiple UAVs: Application to automatic detection of forest fires. *Journal of Field Robotics*, *23*(3-4), 165-184.

32. Duckett, T., Pearson, S., Blackmore, S., Grieve, B., Chen, W. H., Cielniak, G., ... & Yang, G. Z. (2018). Agricultural robotics: the future of robotic agriculture. *arXiv preprint arXiv:1806.06762*.

33. Dursun, M., & Ozden, S. (2011). A wireless application of drip irrigation automation supported by soil moisture sensors. *Scientific Research and Essays*, *6*(7), 1573-1582.

34. Manivannan, L., & Priyadharshini, M. S. (2016). Agricultural robot. *international journal of advanced research in electrical, electronics and instrumentation engineering*, *5*(1), 153-156.

35. Pedersen, S. M., Fountas, S., & Blackmore, S. (2008). Agricultural robots—Applications and economic perspectives. In-Service *robot applications*. IntechOpen.

36. Griepentrog, H. W., Nørremark, M., Nielsen, H., & Blackmore, B. S. (2005). Seed mapping of sugar beet. *Precision Agriculture*, *6*(2), 157-165.

37. Tothill, I. E. (2001). Biosensors developments and potential applications in the agricultural diagnosis sector. *Computers and Electronics in Agriculture*, *30*(1-3), 205-218.

38. Griepentrog, H. W., Noerremark, M., & Soriano, J. F. (2006, September). Close-to-crop thermal weed control using a CO2 laser. In *Proceedings: CIGR World Congress, Agricultural Engineering for a Better World, Bonn, Germany, 3rd–7th September*.

39. Talaviya, T., Shah, D., Patel, N., Yagnik, H., & Shah, M. (2020). Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. *Artificial Intelligence in Agriculture*, *4*, 58-73.

40. Ahirwar, S., Swarnkar, R., Bhukya, S., & Namwade, G. (2019). Application of drone in agriculture. *International Journal of Current Microbiology and Applied Sciences*, *8*(01), 2500-2505.

41. Veroustraete, F. (2015). The rise of the drones in agriculture. *EC agriculture*, *2*(2), 325-327.

42. Natu, A. S., & Kulkarni, S. C. (2016). Adoption and utilization of drones for advanced precision farming: A review. *International journal on recent and innovation trends in computing and communication*, *4*(5), 563-565.

43. Simelli, I., & Tsagaris, A. (2015, September). The Use of Unmanned Aerial Systems (UAS) in Agriculture. In *HAICTA* (pp. 730-736).

44. Sugiura, R., Noguchi, N., & Ishii, K. (2005). Remote-sensing technology for vegetation monitoring using an unmanned helicopter. *Biosystems Engineering*, *90*(4), 369-379.