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Role of AI in Agriculture: Applications, Limitations and Challenges

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Abstract: *Increase in the world's population as well as decrease in the availability of agricultural labour are demanding a smarter way to fulfill the global supply chain. Defining human intelligence in such a way that a machine can easily mimic it and can execute tasks which are simplest and those that are even more complex is known as artificial intelligence (AI). Recent advances in electronics offer vast opportunities for research, development and innovation in agriculture. India is facing scarcity in labour due to people moving into urban areas as daily wage workers and also due to agriculture being unproductive now a days. As a result there is always a scope to introduce new technologies like robotic platforms, plant health detection sensors, robotic harvesters, unmanned aerial vehicles, soil nutrient mapping using MATLAB etc., which can change the phase of agriculture. Present study was undertaken to summarize all the available technologies in agriculture from sowing to post harvesting. Although there are many applications, implementing an AI based technology on Indian fields is a difficult task because of the limited land holdings and different soil types. Repair and maintenance of these systems require a technical authority who should be available now and then for quick assistance.*

Keywords: Artificial intelligence, GPS, NDVI, Remote Sensing, VRT System, Robotic Harvesting

I. INTRODUCTION

Agriculture is in the race of acquiring advanced technologies in order to increase the productivity and improve input use efficiency. Agricultural productivity has increased significantly over the years as a result of intensification mostly aided by mechanization and automation (Bechar and Vigneault, 2016). As agriculture is suffering from the lack of trained workers, the problems can be addressed by the use of artificial intelligence techniques such as robotics and automation. Automation has considerably increased the productivity of agricultural machinery by increasing efficiency, reliability and precision simultaneously and reducing the need for human intervention (Bechar and Vigneault, 2016). These techniques have a favorable impact on the quality of life of the farmer and attract the younger generation due to its reduction in drudgerous operations under harsh conditions.

Till age depth plays an important role in crop growth and should be well managed during cultivation. Traditionally, tillage depth is determined by manually measuring the soil layer with steel rulers, which is labour intensive and time consuming. Recent advances in tillage depth monitoring mainly focus on the technologies employed to achieve automatic real-time measurements of depth.

Traditional sowing or broadcasting of seeds demands more seed rate with less seed to plant germination rate and incurs more cost. Seed meters of conventional precision corn planters are usually driven by ground wheel and chain and sprocket system and as a result, planting accuracy cannot be ensured because of the existence of ground wheel slippage and chain vibration, especially at higher forward speeds.

The traditional method of application of fertilizer is to apply fertilizers uniformly throughout the field, according to average demand of the soil or crop. The constant rate of fertilizer application is inefficient and leads to overfertilizing certain regions (Shruthi *et al*., 2018) and under-fertilizing others, not meeting the actual nutrient demand. Increase in rate of fertilizer application in general increases crop yield up to an optimum level, but extra fertilizer is left unused in

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the field. The application of fertilizers can be varied based on the analysis of information collected from the field. On the other hand variable rate technology (VRT) is a method for improving input use efficiency by applying near-optimum rates based on soil conditions and crop requirements.High value crop harvesting mostly relies on skilled and seasonal farm workers. However, there's a great concern of increasing labor cost and uncertainty in labor availability in the near future. These reasons greatly motivate research in robotic harvesting technology.

Various steps involved in agriculture from tillage to post harvest technologies

1. Crop monitoring and analysis
2. Soil manipulation
3. Seeding and planting
4. Fertilizing and Irrigation
5. Wedding and spraying
6. Autonomous tractors
7. Picking and harvesting
8. Sorting and packing

II. LITERATURE SURVEY

Recent advances in agriculture as well as the scarcity in labour are offering a vast opportunities in research and development of AI based equipment that will change the phase of agriculture. Hence study was undertaken to review various research works based on AI in agriculture carried out in and outside the country. Research work was done as a part of course work in Dr. NTR College of Agricultural Engineering, ANGRAU, Bapatla in the year 2020-21. Inclusion of AI provided a way to overcome the traditional practices which are discussed below in detail (Table 1).

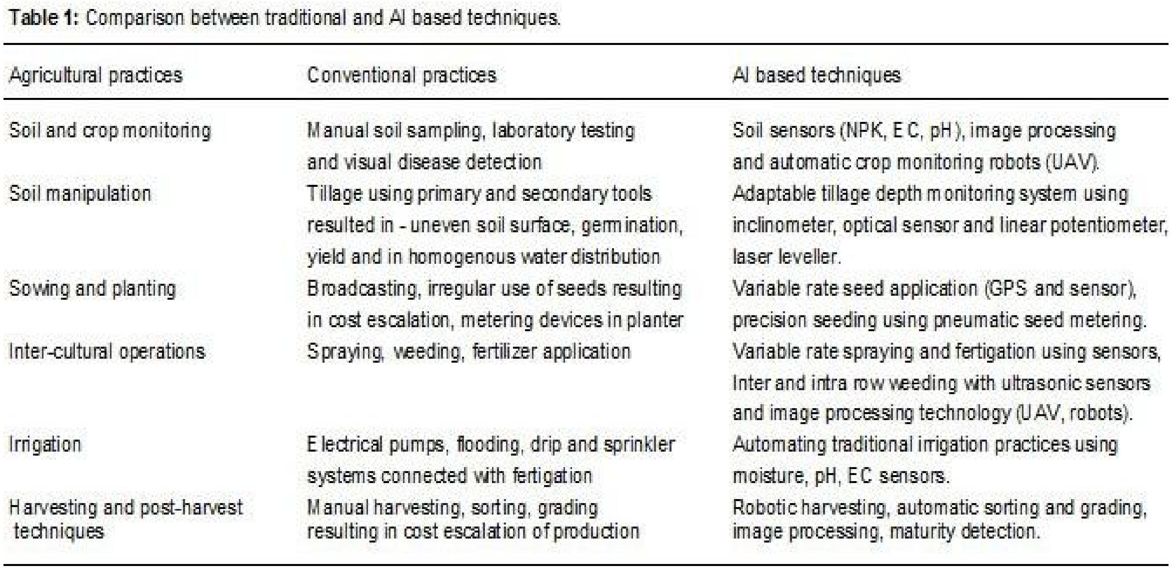

Table 1: Comparison between traditional and AI based techniques.

Agricultural practices	Conventional practices	AI based techniques
Soil and crop monitoring	Manual soil sampling, laboratory testing and visual disease detection	Soil sensors (NPK, EC, pH), image processing and automatic crop monitoring robots (UAV).
Soil manipulation	Tillage using primary and secondary tools resulted in - uneven soil surface, germination, yield and in homogenous water distribution	Adaptable tillage depth monitoring system using inclinometer, optical sensor and linear potentiometer, laser leveller.
Sowing and planting	Broadcasting, irregular use of seeds resulting in cost escalation, metering devices in planter	Variable rate seed application (GPS and sensor), precision seeding using pneumatic seed metering.
Inter-cultural operations	Spraying, weeding, fertilizer application	Variable rate spraying and fertigation using sensors, Inter and intra row weeding with ultrasonic sensors and image processing technology (UAV, robots).
Irrigation	Electrical pumps, flooding, drip and sprinkler systems connected with fertigation	Automating traditional irrigation practices using moisture, pH, EC sensors.
Harvesting and post-harvest techniques	Manual harvesting, sorting, grading resulting in cost escalation of production	Robotic harvesting, automatic sorting and grading, image processing, maturity detection.

Table 1: Comparison between traditional and AI based techniques.

III. SOIL AND CROP MONITORING

Boni rob is an Agribot which monitors crops in the field, checks soil moisture, fertilizer levels and scan for weed and pest infestations. It integrates with airborne drones and crop management software's so that farmers can keep track of what's happening in their fields. Bonirob identifies weeds in a crop by the shape and color of their leaves and has the ability to destroy weeds without using toxic chemicals. When Bonirob identifies a weed, it extends a mechanical probe and precisely pulverizes it. Bonirob stores and shares data about the types of weeds it finds and their geographic distribution, cross referencing that information with all the other data it collects about soil moisture, weather and fertilizer.

It is also equipped with a soil penetrometer which helps in measuring surface soil moisture *i.e*., irrigation requirement, soil pH *etc*., while traveling in the field. It consists of an on-board GPS such that measurements relative to its location can be made.

Soil manipulation

Tillage or mechanical manipulation of soil is done to provide favorable conditions for crop production. It is a laborious process which involves breaking the compact surface of earth to a certain depth and loosen the soil mass to destroy the weeds and increase the water absorbing capacity of the soil. Tillage depth plays an important role in crop growth and should be well managed during cultivation. Traditionally, tillage depth is determined by manually measuring the soil layer with steel rulers, which is labour intensive and time consuming. Recent advances in tillage depth monitoring mainly focus on the technologies employed to achieve automatic real-time measurements of depth and can be classified into two main categories, namely contact and non-contact type.

Uneven soil surface has a major impact on the germination, stand and yield of crops due to inhomogeneous water distribution and soil moisture. Even the best levelled fields using traditional land levelling practices are not precise and this leads to uneven distribution of irrigation water. One of the advanced method to level or grade the field is to use laser-guided levelling equipment. Laser land levelling is defined as levelling the field within certain degree of desired slope using a guided laser beam throughout the field. The system consists of a laser-transmitting unit that emits an infrared beam of light in a straight line by rotating the laser beam 360°. The receiver is arranged on the implement that senses the IR beam of light and converts it to an electrical signal. The electrical signal then actuates the hydraulic valves that controls the leveler blade. Operations from beginning to ending are accomplished automatically without the operator touching the hydraulic controls.

Honglei *et al*., (2016) designed and developed an adaptable tillage depth monitoring system with an adjustable swing arm and an optical encoder. A lab view program, which is able to achieve adaptable measurement on different terrain morphologies, has been developed based on different cases and corresponding mathematical models. The process of uphill travel on different terrain morphologies has been analyzed in five stages, with the same analysis conducted on the process of downhill travel. It has been found that a maximum absolute error of 11.3 mm and a maximum relative error of 7.40% for the field experiments on regular surface about different depths. A maximum absolute error of 12.8 mm and a maximum relative error of 8.53% for the field experiments on slope surface about different depths. The results demonstrated good accuracy for both in- house and in-field measurements under both horizontal and sloping conditions. Hence, such a measuring system holds good potential to be applied in real tillage depth monitoring, particularly in the case of covered ground as found in conservation farming.

Sowing And Planting

Sowing is an art of placing seeds in the soil by random scattering or by maintaining row to row/plant to plant spacing in the field. More than one seed may be dropped at selected rates in this method. Planting is used for seeds which are larger in size such as potato, sugarcane, onion *etc*. and not more than one seed is dropped in the field.

Precision seeders and planters have to be used more and more widely which have the ability to save seeds and keep uniform seed spacing (Chauhan *et al*., 2017). Seed meters of conventional precision corn planters are usually driven by ground wheel and chain and sprocket system, and as a result, planting accuracy cannot be ensured because of the existence of ground wheel slippage and chain vibration, especially at higher forward speeds. Moyer *et al*., (1994) reported that planters lost their efficiency and planting accuracy in rugged fields due to the inappropriate interaction between ground wheel and soil which resulted in non-uniform seed placement.

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Yang *et al*., (2015) developed a mechatronic driving system for seed metering on conventional precision corn planter. To improve the planting performance of precision planters, a mechatronic driving system was designed and its field working performance was evaluated in this research. A two-row pneumatic precision planter was modified to allow simultaneously using two different driving systems, *i.e.*, with one row unit equipped with the newly designed mechatronic driving system and the other row unit equipped with conventional mechanical driving system and used for planting at three forward speeds (9, 11 and 12 km/h) on no-tillage and rotary-tillage lands. The result indicated that planters equipped with the mechatronic driving system was more suitable for high speed planting. As compared to the mechanical driving system, the advantage of the mechatronic driving system is more noticeable especially when the forward speed is more than 11 km/h.

Edge driving mechanism is noted to be most efficient metering in delivering single seed at prescribed spacings. An edge-driving mechanism mainly consisted of four parts, *i.e.*, a motor, a small gear, a gear ring and a seed plate. When the motor works, it will drive the seed plate to rotate through the gear set. The reduction gear ratio from the small gear to the gear ring was set at 5 according to the structure of the seed plate.

Jin *et al*., (2019) developed and tested an electric precision seeder for small size vegetable seeds. The seeder was driven by electric power during the sowing process and sowing condition was monitored using fiber sensor technology. It can quickly adjust row spacing and sowing depth during sowing process to meet the requirements of agricultural planting. Field test was carried out for coriander, pakchoi and radish on the accuracy and monitoring of the system, respectively. The results showed that during the field operation, the sowing precision of the sowing machine was 95%. When the seeder worked at the speeds of 3 km/h and 4 km/h, the relative error of the monitoring precision of the system was less than 6%. This system can meet the real-time monitoring requirements of the seed metering device and improve the quality of the sowing work.

Combining geo-mapping and sensor data detailing soil quality, density, moisture and nutrient levels takes a lot of the guesswork out of the seeding process. Seeds have the best chance to sprout and grow and the overall crop will have a greater harvest. As farming moves into the future, existing precision seeders will come together with autonomous tractors and IoT-enabled systems that feed information back to the farmer. An entire field could be planted this way, with only a single human monitoring the process over a video feed or digital control dashboard on a computer or tablet, while multiple machines roll across the field.

IV. INTER-CULTURAL OPERATIONS

Intercultural operations such as spraying, fertilizer application, weeding, inter-row weeding *etc*., are carried out between sowing and harvesting. Manual intercultural equipment's are easy to work with in between the rows compared to tractor mounted equipment's but are time consuming and involves drudgery. Farmers practice traditional methods to apply fertilizers uniformly throughout the field. This uniform and constant rate application of fertilizer is inefficient and mostly leads to over-fertilizing certain areas and at the same time, under-fertilizing others, not meeting the actual nutrient demand (Mohan *et al*., 2021).

Autonomous robotic weed control systems can replace the labour and can also reduce the current dependency on herbicides, which can improve the sustainability of agriculture and reduce its environmental impact (Slaughter *et al*., 2008). Detection of weeds based on its characteristics and guiding the robot to the detected weeds are the major challenges in the research area of robotic weed removal techniques. Increasing range of weeds as well as crops has enhanced these challenges to work on detecting different varieties of weeds for all types of field crops.

Rekha *et al.* (2020) developed a real-time robotic weed knife control system for tomato and lettuce based on geometric appearance of plant labels. Automated weed management tools in vegetable crops are needed to reduce or eliminate hand-weeding because of labour shortages and cost. Distinguishing crop plants from weeds in complex natural scenes of crop-weed mixtures remains a challenge for weed management automation. The paper presents a novel solution to the weed control problem by employing crop signalling technology: A novel systems approach that creates a machine-readable crop plant. A robot-vision-based weed-knife control system with a novel three-dimensional geometric detection algorithm was developed to automate weed control for tomato and lettuce crops. The system successfully detected the crop signal from occluded crop plants while traveling at speeds up to of 3.2 km/h. The in-field experiments show that the system is able to reduce the number of weed plants by 83% in the seedling area. Crop detection accuracy was measured at 97.8% with a detection time of 30 ms/f.

Xiong *et al*., (2017) developed and tested a novel laser weeding prototype robot equipped with a dual-gimbal that can work in parallel. The robot was able to detect weeds in the indoor environments, to carry lasers with which to target the weeds, and also controlled the platform in real-time realizing weeding continuously. Three subsystems of the prototype robot were developed: a platform, machine vision and dual-gimbal laser pointers. Finally, two performance tests were conducted in the indoor environments such as positional error test and weeding efficiency test. The weeding positional error test showed that the weeding mean positional error was 1.97 mm, with a 0.88 mm standard deviation. Another test indicated that with a laser traversal speed of 30 mm/s and a dwell time of 0.64 s per weed, the robot displayed a high hit rate of 97%.

Xinyu *et al*., (2016) developed an unmanned aerial vehicle based automatic aerial spraying system to perform plant protection operations. The system used a highly integrated and ultra-low power MSP430 single-chip micro-computer with an independent functional module. This allowed route planning software to direct the UAV to the desired spray area. The test results of route precision showed that in a 3-4 m/s crosswind, route deviations were around 0.2 m. The result of multiple-spraying swath uniformity tests showed a minimum coefficient of variation of 25% when flying at a height of 5 m with a spraying swath of 7 m and a wind speed of 0-2 m/s. When the spraying swath was 9 m or 5 m, the coefficients were 34% and 41%, respectively. Spray uniformity for these UAV tests were superior to the standard requirement for ultra-low volume spraying variation coefficient, 60%.

Srivastava *et al.* (2019) developed an UAVs technology for precision agriculture and environmental research. Information gap between the farmers and information about the location of the crop under stress in the given area was addressed by using a unique application called as vegnet (Vegetative Network). It aims to provide the necessary tools to detect stressed crop locations using the spectral images obtained from UAVs and provide location and area covered under those stressed crops. Solar panels were installed on the drone itself to eliminate the charge during the day when it is operating on the field. This GUI based platform will work with satellite datasets such as Landsat and other images.

Kim *et al*., (2008) developed a variable-rate granule applicator with a 10 m long boom. This system consisted of soil property map of 10×10 m grid size. The pneumatic applicator was equipped with simple blow heads and a metering system. The reported CV values regardless of the working speed ranged from 2.9% to 15.3% and 11.2% to 13.1% in the longitudinal and transverse directions respectively. Tola *et al.* (2008) modified a mechanical fertilizer application system for automatic setting of target fertilizer application rate. The system could maintain uniform application rate by performing real-time adjustments with on-the-go monitoring application.

Alameen *et al*., (2019) developed and evaluated a control system for variable rate granular fertilizer applicator. The developed VRA system was basically composed of two main units. These two units were the fertilizer flow rate control unit and the map-based control unit. Fertilizer flow rate control unit main responsibility was to control the flow rate by adjusting lever. Double acting pneumatic cylinder was attached to the handle of the lever to facilitate the movement of the lever either forward or backward based on the desired fertilizer application rate. Variable rate control unit consists a microcontroller (Arduino MEGA 2560) uploaded with a developed program code was utilized to integrate the functions

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of the developed system components. Automatic adjustment of the desired granular fertilizer application rate was achieved successfully. The developed system can be used efficiently for VRA of granular fertilizers with an overall error of ± 2.6%. The response time of the developed control system to adjust to a higher fertilizer application rate was 0.0062 s kg^{-1}. However, the response time was calculated at 0.0110 s kg^{-1} when adjusting to a lower application rate.

Chattha *et al*., (2014) modified variable rate (VR) fertilizer spreader to control each pair of nozzles for spot application of fertilizer in blueberry field. The system consisted of cameras, solenoid valves, pneumatic cylinders, VR controller and custom software. The modified system was capable of using prescription maps and automated sensing and control system which simultaneously detect foliage/bare spots in real time to avoid fertilization in bare spots/weed patches. The μeye cameras and controller was tested and calibrated for target detection and fertilizer application. The ACCU-RATE controller performed reliably and efficiently to control the fertilizer application rate through each pair of nozzles with 5% difference from manual measurements. The results of response time revealed that the maximum of 2.38 s and 2.25 s was taken to dispense clay filler and fertilizer respectively.

Zhang *et al.* (2014) developed a variable rate fertilizer system based on optical sensor to control the fertilizer amount by optical sensor measured NDVI of crop. The study analyzed the input and output conditions of control system, designed a hardware, algorithm and control system for fertilizer, mainly software flow and a feedback control way. It consisted of 6 optical sensors mounted on a boom, interface module, micro controller, speed sensor, rotation sensor, PWM valve and hydraulic motor. It relies on sensors to provide real-time crop detection information which is used to dispense fertilizer amount for the crop need. A CV ranging from 0.35% to 2.67% with a maximum relative errors of 5.17% was observed. The fertilizer response time of controller system was less than 0.875 s.

Ishola *et al*., (2013) developed a RFID-based variable rate technology fertilizer applicator for tree crops. The applicator consisted of a long-range Radio Frequency Identification (RFID) reader to detect the stored tag ID on the available passive RFID tags attached on the trees. The Tag ID was used by the control program of the VRT system in triggering the rotary valves which are the metering units for the system. The control program receives the RFID tag ID on the tree, it relates the tag ID to the information in the database and triggers the VRT fertilizer applicator system to apply precise amount of fertilizer to that particular area. The results showed that the response time of the VRT applicator was found to take 2-3 seconds. It has a field capacity of 7.60 ha/h and 8.10 ha/h with field efficiencies of 0.55 and 0.57 at the travelling speed of 4.43 km/h and 4.92 km/h, respectively.

V. IRRIGATION METHODS

Irrigation in rainfed areas is an important operation to avoid poor yield and crop failure due to delayed rainfall. Electrical pumps supply water for farm irrigation in required quantity at desired time. So it is difficult to maintain water supply and nutrient contents in the field whenever necessary. But these practices can be automated using automatic soil moisture and nutrient measuring sensors. The information otherwise called moisture readings, nutrient contents, PH value, EC *etc*., obtained from this sensor is further processed and irrigation systems are activated whenever needed.

Vellidis *et al*., (2007) developed and evaluated a prototype real-time, smart sensor array for measuring soil moisture and soil temperature that uses off-the-shelf components for scheduling irrigation in cotton. The array consists of a centrally located receiver connected to a laptop computer and multiple sensor nodes installed in the field. The sensor nodes consist of sensors (up to three Watermark soil moisture sensors and up to four thermocouples), a specially designed circuit board and a radio frequency identification (RFID) tag which transmits data to the receiver. The smart sensor array offers real potential for reliably monitoring spatially variable soil water status in crop fields. The relatively low cost of the system allows for installation of a dense population of soil moisture sensors that can adequately represent the inherent soil variability present in fields. Integration of the sensors with precision irrigation technologies

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will provide a closed loop irrigation system where inputs from the smart sensor array will determine timing and amounts for real-time site-specific irrigation applications.

VI. HARVESTING AND POST-HARVEST TECHNIQUES

Harvesting is the operation of cutting, picking, digging or a combination of these operations to remove the useful part from plants. Post-harvest techniques involve improving the quality of farm products or storage, processing, packaging, transportation and marketing. Harvesting is a highly drudgerious and tedious operation. It is a costlier and time consuming operation due to increasing shortage of man power. Hence automation in harvesting is considered to be of critical importance.

Heng *et al*., (2018) carried out designing and evaluating a robotic apple harvesting system. High value crop harvesting mostly relies on skilled and seasonal farm workers. However, there's a great concern of increasing labor cost and uncertainty in labor availability. These reasons greatly motivate research in robotic harvesting technology. Simulation is a necessary tool in designing robotic systems. It simulates the robot behavior in a simplified and controlled environment, which can save time and cost in robot development.

Because of the unstructured environment of the apple orchard the robot needs the ability to adjust to the fruit space to maximize the overlap. By incorporating an adjustment algorithm that accounts for changes in the environment, the 5' DOF configuration's performance is increased by 81% without any increase in the actual workspace volume. The increase is less significant in the other configurations tested but any increase in efficiency is important to make the system more economical. Using these simulations to drive design modifications for additional field testing will greatly improve the actual robot performance.

Zhonghua *et al*., (2020) developed a smart camera for quality inspection and grading of food products using machine vision technology. Evolutionary learning process was developed for simplicity and for visual inspection of food products which was not only capable of automatically learning unique information from training images, but also improving its performance through the use of boosting techniques. Smart camera equipped with a Cortex-A57 processor showed a processing time of approximately 10 milliseconds per prediction or 100 frames per second. And algorithm was proved to be efficient for very high frame rates even with a small ARM-processor.

Three simple application cases are included to demonstrate the operation of this unique solution. Two datasets of more challenging cases were created to analyze and demonstrate the performance of our visual inspection algorithm. One dataset includes infrared images of Medjool dates of four levels of skin delamination for surface quality grading. The other one consists of grayscale images of oysters with varying shape for shape quality evaluation. The algorithm achieved a grading accuracy of 95.0% on the date dataset and 98.6% on the oyster dataset, both easily surpassed manual grading, which constantly faces the challenges of human fatigue or other distractions.

Manuela and Alphus (2015) studied electronic nose applications for fruit identification, ripeness and quality grading. Fruits produce a wide range of volatile organic compounds that impart their aromas and contribute to unique flavor characteristics. Fruit aroma and flavor characteristics are of key importance in determining consumer acceptance in commercial fruit markets. Fruit producers, suppliers and retailers traditionally utilize and rely on human testers or panels to evaluate fruit quality and aroma characters for assessing fruit salability in fresh markets. The current and potential utilization of electronic-nose devices (with specialized sensor arrays) are very effective in discriminating complex mixtures of fruit volatiles and efficient fruit aroma analyses to replace conventional expensive methods used in fruit aroma assessments.

Developing technology capable of delicate harvest work, like picking fruit from trees or vegetables such as chillies, is where high-tech farms will really shine. Engineers are working to create the right robotic components for these sophisticated tasks which incorporates sophisticated cameras and algorithms to identify colour, shape and location to determine its ripeness. These are only a few of the dozens of upcoming robotic designs that will soon take over harvesting from human labour. With the robust IoT system, these AGbots could continuously patrol fields, check on plants with their sensors and harvest ripe crops as appropriate.

VIII. LIMITATIONS AND CHALLENGES OF AI IN AGRICULTURE

The problem with encouraging machine learning and AI in agriculture is not the lack of capability in agriculture scientists but mainly the variance in physical environments that is making testing, validation and rolling out of this technologies more difficult. Practically speaking, a man can address a situation more accurately than AI. But since the primary goal is to overcome drudgery, AI and machine learning has a vast application from tillage to post harvest technology.

In farmers perspective, AI is something that applies only to digital world and might not be helpful to them in the field. Lack of understanding and unreasonable expenses clearly fail to explain the usefulness and how they should be implemented. Small land holdings and irregular field elevations limit the usage of precision agriculture implements. A small farmer practices conventional farming as he cannot afford an AI or unmanned ariel vehicle (UAV) or drone. Hence people holding community farming with more than 5 ha of land can easily practice precision agriculture and can also rent it for custom hiring.

VIII. CONCLUSION

This review article on the role of AI in agriculture has summarized the current challenges in traditional farming and explained the modern strategies to overcome these challenges:

1. Soil and crop monitoring systems helps in checking soil moisture, fertilizer levels and scan weeds and pest infestations.
2. Advanced techniques to overcome uneven soil surfaces like laser land levellers and automatic depth controlling systems to level or grade the field for homogenous water distribution and soil moisture.
3. Precision seeders and planters have to be used more and more widely which have the ability to save seeds and keep uniform seed spacing.
4. Autonomous robotic weed control systems can replace the labour and can also reduce the current dependency on herbicides, which can improve the sustainability of agriculture and reduce its environmental impact.
5. Unmanned arial vehicles (UAV) technology provides information about the location of the crop under stress and applies chemical sprays if necessary.
6. Variable rate technology (VRT) is a method for improving input use efficiency by applying near-optimum rates based on soil conditions and crop requirements. More the variability in yield within a field, it is more likely that site-specific input management will be needed.
7. With greater concern of increasing labour cost and uncertainty in seasonal farm workers in the near future, robotic harvesting will be an emerging technology.

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