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Automation in Agriculture: Agribot the Next Generation Weed Detection and Herbicide Sprayer–A Review

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Abstract—*Agriculture is humankind's oldest and crucial economic activity providing the food, fiber, feed and the fuel necessary for the survival of human race. With the India's population expected to reach 1.6 billion by 2050, agricultural product must double if it is to meet the increasing demands for bioenergy and food. India has many factors which affects the productivity, mainly includes inadequate irrigation system, seed quality, labor shortage and inefficient farming practice. To raise the productivity while limiting growing pressure on environment, automation will help in attaining sustainable agriculture via large scale robotics and micro robots to examine and preserve crops at the plant level. The objective of this review paper is to highlight the beginning of a revolution in the field of agriculture, international competition in agricultural sector, advancement in technology and wide spread application of intelligent machines in agriculture, which will become inevitable in future.*

Keywords*: Agro-technology, image-processing, machine vision, robotics, sensors.*

1. INTRODUCTION

Recent developments in the field of digital technology have opened new scenarios about automation and robotics in agricultural system. The objective of this review is to highlight the fields of farming where control and sensing are essential. Ultimately the objective will remain to attain sustainable agriculture. *Sustainable agriculture* is the production of food, fiber, feed or other animal or plant productivity using divergent agricultural techniques that preserves and conserves the nature, human communities and animal welfare. For decades robotics and automation have played a significant role in increasing the efficiency and reducing the cost of industrial production and products. With the proliferation of GPS and vision-based system, self-manoeuvre tractors and harvesters are already available commercially in industrialized countries. Recently, countrymen have begun to experiment with autonomous systems such as pruning, thinning, trimming, spraying, harvesting and weed removal.

To outline the latest advances in these areas, and to talk about becall and opportunities which have to be considered by the engineers to realize automation where every task in the farm is carried out by robot [1]. Before now, in our history, man power began to substitute with animal power. Later, mechanical power replaced animal power when stream engines became common in 1890. By 90's farm machinery began making transition to large-scale farming [2]. Even then, the humans are source of intelligent to control and manage the machinery. If intelligent machine or robots can be manufactured that will make his operation more profitable and comforting, then farmers will use it. Many of the world's technologically sound countries have been working in incorporating robotics and intelligent machine in agriculture. Many experiments have been conducted, and few models have been launched commercially like AgBot 1 and AgBot 2 etc.

Automation increases the productivity and safety of operator. Automation technology have grown rapidly in virtually every sector of human activities such as manufacturing, construction, household, communication, warfare, offices, exploration and space travel. Automation in agriculture is still under research stage due to the complex nature of unstructured and realistic environment. The robot demand autonomous navigation, environment adaption and large amount of data processing. As the complexity and uncertainty of environment exist, the environment mathematical model is not easy to establish, and single sensor cannot provide complete information. Multi-sensors information combined with other technologies such as signal processing, control theory, probability, statistics and artificial intelligence together can provide technical solution for agricultural robot to work in dynamic and unknown environment [3]. Precision autonomous farming is defined as an operation, control and guidance of autonomous machines to perform agricultural tasks [4]. The most significant abilities of automatic agricultural vehicles and their interrelation can be stated as from the block diagram (Fig. 1) for the understanding of robotization in agriculture industry.

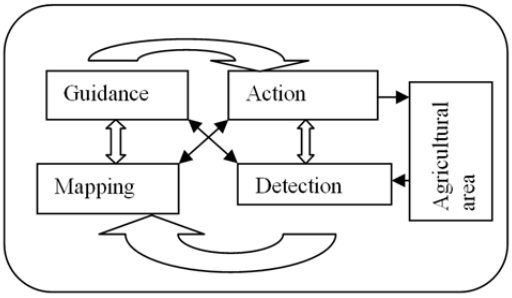

Fig. 1: Relation between the Abilities of Service Unit.

The above abilities are incorporated into agricultural vehicles irrespective of their application scope. These abilities can be defined as follow [4]:

- Guidance: The way vehicle precedes the defined path within the agricultural field.
- Mapping: building a visual presentation of agricultural area.
- Detection: Finding out of a biological feature with means of a specific device (sensors) or method.
- Action: Execution of the task with the help of end-effectors for which vehicle is designed for.

The scope of this review paper is focused on the areas in agricultural field that can automate mainly the weed detection and its removal techniques. Section II of this paper deals with application areas of robotics and automation in agriculture. Section III includes the different types of weed detection and removal techniques. Section IV covers the conclusion and future scopes of robotics in agricultural domain.

2. ADVANCES IN AUTOMATION AND ROBOTICS FOR AGRICULTURAL APPLICATIONS

The main occupation for Indian people is agriculture and it contributes 13.9% of GDP share during 2013-14, for increasing the productivity automation in agricultural area will help a lot. There are many reasons that justify the other sectors like manufacturing industries and mining which have ready accepted these technologies more quickly than agriculture [2], it mainly includes the use of machinery throughout the year, but agriculture is a seasonal sector. It has a fixed annual cost and investment is high and many tasks are performed on rough territory, in ambient temperature, humidity, dust, mud etc. and machine environment is difficult to control as it is dynamic in nature. The agricultural areas which can be automated are grouped into different categories as follow:

2.1 Automation in Harvesting

Harvest is a process of gathering ripe crop form the field. Automation in harvesting is an interesting area of research. In papers [5], robotic melon harvesting is described. A Cartesian manipulator installed over a moving platform drawn by a tractor. Image processing (grey level imaging) and intensity levels of reflectance and texture and shape analysis algorithm is used for detecting the melon location. Task, motion and trajectory planning algorithm is used with an intelligent sensing, planning and control system. According to [6], for harvesting purpose, a pneumatic robotic arm controlled by an on-off valve with vision feedback system mounted on the top of end-effector can be used for harvesting purpose. The on/off valves are driven by pulse width modulation (PWM) signals. The whole system was realized in LabView software.

According to the paper Robot Farmers [7], the ken and navigation systems for a family of autonomous grove vehicles are presented. The perception system includes GPS (global positioning system), laser scanner, steering and wheel encoders and algorithms for processing the data. It also includes the hindrance detection system for averting collision. The developed vehicle can be operated in three modes and can perform the functions such as harvesting, tree tending and tree maintenance, mowing, spraying and scouting for ailment, insects and crop yield evaluation. Similarly [8] shows a multi-purpose robot used for ploughing, sowing and covering seeds with soil and another multipurpose robot that can perform tasks such as picking, harvesting, pruning, planting, weeding and grafting is stated in paper [9]. The controller used here is ARM7/ARM9. Motors are activated with the help of relays. Vision based row guidance technique is used to guide robot along the rows. In [10], an electromechanical robotic system is proposed for automatic sowing process. The machine consists of seed storage hopper, sensors like IR sensor, block sensor, empty sensor and proximity sensor for various detection purposes. For data processing and control action microcontroller 89C51 is used. The path of robot is controlled by remote. The energy for motion and action is provided by solar cells mounted onboard. Another harvesting robot is designed for harvesting cucumber [11]. It consists of visual sensor to discriminate cucumber from stems and leaves, manipulator, end-effector for grasping the cucumber and cutting it and traveling device for making the robot movement from one plant to another. An agricultural operation is highly dependent on tractor wheels. Soil compaction is produced by the pressure exerted by wheels on their contact with the ground, which results in downward stress transmission which results in change in soil structural attributes This problem can be overcome by adopting the design as shown in paper [12] or we can design a legged robot. In [13], high relative positioning, robust and anticipating control techniques are proposed for motion control on rough territory and dynamic environmental conditions. In paper [14], design of multi-function agricultural robot which can perform tasks such as ploughing, seeding and sensing of soil moisture is proposed. It has used fuzzy controlled logic for steering angle and speed control of robot. Microcontroller 89C51 is used for implementing the mentioned logic. The robot can be remotely controlled and for this internet and web publishing toolbox in

LabView is used. The robot designed is cost effective as the hardware complexities are reduced by using sophisticated software programming.

2.2 Fruit Picking Robots

In [15], near-minimum-time fruit picking robot algorithm is projected which is derived by solving Traveling Salesman Problem (TSP).The algorithm defined is used for cylindrical robot. The paper deals with the two main problems: trajectory planning and path planning. The main difference between the both is that path following do not have time constraints in executing the task whereas trajectory planning includes. In paper [16], an automatic or semi-automatic robot for harvesting artichoke is presented. The designing and simulation were done on 3D CAD environment with Matlab® interfacing. For detecting the artichokes on the herbage, an artificial vision algorithm has been engendered satisfyingly. In the paper two machines are proposed, first is having 3DOF and another is having 2DOF and each DOF is pneumatically or hydraulically actuated.

Another paper by Christopher [17], designs an image guided citrus fruit picking robotic arm. The concept is inspired by 'frog tongue' mechanism. The system uses flexible tubes with cutting tools at the end which is pneumatically actuated and steered robotically, with machine vision cameras as feedback system. The cutting and fruits picking is done by manipulator and not by the vehicle as shown in paper [17], [18] and [6]. Different types of end-effectors and cutting tools can be used for these purposes. In [19], a multipurpose vineyard agricultural robot is proposed. The robot used four different end-effectors for different applications: harvesting, berry thinning, bagging and spraying. Application based end-effectors can be developed and program can be changed accordingly in robot. It consist of manipulator which is a robot body or chassis, a vision sensor for image processing and identifying the target, a traveling device and the end-effectors which make the robot market valued.

3. AUTOMATION IN IRRIGATION

For increasing the productivity automation in irrigation is an effective way. With the scarcity of water resources and ecological environment irrigation system must be efficient and intelligent. Researchers around the world have worked and developed many great irrigation systems such as: Irrigation Control System Based on an FPGA [20], Sensors for Data Collection and Irrigation supervision done by operating Smart Phone and Wireless Network [21] and so on. An automatic drip irrigation technique is designed and implemented using sensors control system network in [22] and wireless sensor network in [23] and [24]. In the above systems sensors like soil moisture, water flow and water level sensors are used. Different controllers such as AVR ATMEGA or ARM microcontroller is used for controlling and decision making task of opening and closure of pump for irrigation. An intelligent irrigation (Fig. 2) system includes basically three blocks: data acquisition process, decision making method and control system technique. It can be illustrated as follow:

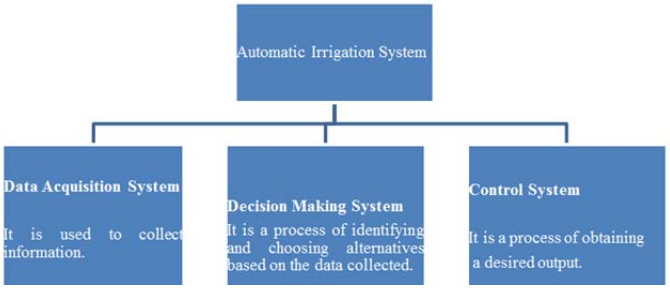

Fig. 2: Blocks of Automatic Irrigation System

Researchers have developed many sensors and devices for data acquisition [4, 1, 25, 26 and 27]. Decision making method can be performed using suitable software and control system involves the use of micro controllers or FPGA or any other suitable device.

4. WEED DETECTION AND REMOVAL TECHNIQUES

In India, the privation caused by weeds overshoot the losses from any other genre of agricultural pests like insects, nematodes, rodents, diseases, etc. According to the survey the yield losses due to weeds in different systems of rice cultivation ranges from 15-90%. Losses due to weed in India approximately cost Rs 1,980 crores. The productivity of agro products cannot be increased by simply doubling the inputs (land, water, labours, seeds, chemicals etc.) because many of them are limited and overstretched. We need a sustained rise in production efficiency from better farming practices, new hybrid seeds, and improved pest management. Robotics and automation will be a part of this equation.

According to paper [28], Kargar and Shirzadifar have developed a weed detection and classification method that can be use for weed control robot in corn fields. They used machine vision algorithm to classify plants as weeds or crops according to their properties. Finally, based on position of weeds, herbicides are sprayed on desired spot. For actual-time in-field objective whole algorithm is executed in LabView software. According to [1], organic matter or color sensors are used for finding the rate of organic matter in soil and recommend the herbicides rate. These sensors can be used in controlled herbicide spraying. Stefan [9], proposed a stereo visual odometry system for mobile robot equipped with cameras mounted on carriage for capturing images which can be used for weed detection.

According to [29, 30], weed detection is done using feature extraction using discrete wavelet analysis and navigation of mobile robot is done with the help of PIC16f788 microcontroller and ARM LPC2148 respectively. The data

transferring between PC and controller is carried out using Zigbee technology. Similarly in paper [31], an aerial pesticide sprayer is developed. The advantage of an aerial robot is that it need not have to worry about the obstacles and rough territories. But the drawback of this technique is that there is no control on the amount pesticides sprayed. As in paper [32], the movement and pesticides quantity can be controlled by remote controller but its range is limited due to RF transmitter and receiver usage in communication. Instead of controlling robot by remote we can design an automatic steering control and adaptive smart car [33]. The Paper [34], uses the size features for demonstrating weed detection and in paper [35], texture based weed detection is used for differentiating weeds and crops in the field. There are many properties used for detecting weeds in agricultural field such as size, spectral reflectance, shape, texture features etc. [36]. Gulam and malik in their paper [37], designed an Agribot which is operated via wifi communication. It has move working range than the RF and Zigbee operated controllers. It is a multipurpose robot designed for activities like seeding, weeding, and spraying pesticides and herbicides. For movement of robot in crop rows machine based vision and GPS system is developed in [38]. We can incorporate obstacle avoidance system [3] in our robot to make it more automatic, safe and environment friendly robot. In paper [39], automatic system for spraying in greenhouse is developed. AVR microcontroller is used for operating it. In paper [40], genetic algorithm is used to optimize decision making for classifying crops and weeds. It is an intelligent vision system and it also gathers the geographical field information for creating a field map.

5. CONCLUSIONS

Automation in agricultural field is under research stage and is continuously developing. Most of the self-governing agriculture vehicles are used for agrochemical dispersal, irrigation; harvesting, weed detection, terrain leveling, etc. are manned and are not fully automatic in functioning. The projects studied in this review paper can substitute blanket energy over usage of targeted inputs and thus decreasing the cost of inputs and simultaneously increasing the amount of superiority. This will improve the economy as well as will lead fewer burdens on environmental resources. The overall application requires dynamic, real time environmental interpolation and control of multi sensors operation. Inclusion of fuzzy logics and neural techniques and artificial intelligence can help a lot in solving nonlinear and dynamic agricultural system and will fulfill our foremost target of enlarging the yield.

REFERENCES

[1] Takoi K. Hamrita, E. W. Tollner and Robert L. schafer, “Towards the Fulfilling the robotic Farming Vision: Advances in Sensors and Controllers for Agricultural Apllications”, IEEE transactions on industry applications; vol.36, no. 4, July/August 2000.

[2] Fred E. Sistler, “Robotics and Intelligent Machines in Agriculture”, IEEE journal of robotics and automation; vol. RA-3, no. 1, February 1987.

[3] Liu Pingzeng, Bi Shusheng , Zang Guansheng, Wang Wenshan, Gao Yushu and Deng Zhenmin, “Obstacle Avoidance System for Agricultural Robots based on Multi-sensor information Fusion”, IEEE, December 2011; pp. 1181-1185.

[4] Fernando A. Auuat Cheein and Ricardo Carelli, “Agricultural Robotics, Unmanned Robotic Service Units in Agricultural Tasks”, IEEE; September 2013, pp. 48-58.

[5] Yael Edan, Dima Rogozin, Tamar Flash and Gaines E. Miles, “Robotic Melon Harvesting. IEEE transactions on robotics and automation”, vol. 16, no. 6, December 2000, pp. 831-834.

[6] G. Carducci, M. Foglia, A. Gentile, N.I. Giannoccaro and A. Messina, “Pneumatic robotic arm Controlled by On-Off valves for Automatic Harvesting based on Vision Localisation”, IEEE international conference on industrial technology 2004; pp. 1017-1022.

[7] Marcel Bergerman, Silvio M. Maeta, Ji Zhang, Gustavo M. Freitas, Bradley Hamner, Sanjiv Singh and George Kantor, “Robot Farmer, Autonomous Orchard Vehicles Help Tree Fruit Productin”, pp. 54-63, March 2015.

[8] Akhila Gollakota and M.B. Srinivas., “Agribot- a Multipurpose Agricultural Robo”,. unpublish.

[9] Ankit Singh, Abhishek Gupta, Akash Bhosale and Sumeet Poddar, “Agribot: An Agriculture Robot”, IJARCCE; vol. 4, issue 1, January 2015.

[10] Gholap Dipak Dattatraya, More Vaibhav Mhatardev, Lokhande Manojkumar Shrihari and Prof. Joshi S.G., “Robotic Agriculture Machine”, IJIRSET; vol. 3, issue 3, April 2014.

[11] Seiichi Arima and Naoshi Kondo, “Cucumber Harvesting Robot and Plant Training System”, Journal of Robotics and Mechatronics; vol. 11, no. 3, 1999.

[12] M. Maza, J.G. Fontaine, M. Armada, P. Gonzalez de Santos, V. Papantoniou and M. Mas,“Wheel+Legs- a new solution for Traction Enhancement without Aditive soil Compaction”, IEEE robotics and automation amgazine, December 1997.

[13] Augrey Guillet, Roland lenain, Benoit Thuilot and Philippe Martinet, “Adaptable Robot Formation Control of Autonomous Vehciles”, IEEE robotics and automation magazine; vol. 21, issue 1, pp. 28-39.

[14] K.Prema, N.Senthil Kumar, S.S.Dash and Sudhakar chowdary, “Online Control of Remote Operated Agricultural Robot using Fuzzy Controller and Virtual Instrumentation”, IEEE ICAESM; March 2012, pp. 196-201.

[15] Yael Edan, Tamar Flash, Uri M. Peiper, Itzhak Shmulevich and Yoav Sarig, “Near-Minimum-Time Task Planning for Fruit-Picking Robots”, IEEE transactions on robotics and automation; vol. 7, no. 1, February 1991.

[16] Domenico Longo and Giovanni Muscato, “Design and Simulation of Two Robotic System for Automatic Artichoke Harvesting”, Robotics, December 2013.

[17] Christopher Aloisio, Ranjan Kumar Mishra, Chu-Yin chang and James English, “Next Generation Image guided Citrus Fruit Picker.”, IEEE – 2012, pp. 37-41.

[18] Baozeng Jia, Anmin Zhu, Simon X. Yang and Guari S. Mittal, “Integrated Gripper and Cutter in a Mobile Robotic System for Harvesting Greenhouse Products”, IEEE international

conference on robotics and biomimetics; December 2009, pp. 1778-1783.

[19] M.Monta, N.Kondo and Y.Shibano, “Agricultural Robot in Grape Production System”, IEEE; vol. 3, 1995, pp. 2504-2509.

[20] Zhiyong Lai and Yongli Dai, “An Irrigation Control system based on FPGA”, IEEE international conference on Instrumentation and Measurement, computer, communiction and control; 2012.

[21] Nattapol Kaewmard and Saiyan Saiyod, “Sensor Data Collection and Irrigation control on Vegetable crop using Smart Phone and Wireless Sensor Network for smart farm”, IEEE conference on wireless sensors; October 2014.

[22] Prashant S. Patil, Shubham R. Alai, Ashish C. Malpure and Prashant L. Patil, “An Intelligent and Automated Drip Irrigation System using Sensors network Control System”, IJIRCCE; vol. 2, issue 12, December 2014.

[23] Suraj S.Avatade and Prof. S.P. Dhanure, “Irrigation System using a Wireless Sensor Network and GPRS”, IJARCCE; vol. 4, issue 5, May 2015.

[24] Chaitali R. Fule and Pranjali K. Awachat, “Design and Implementation of Real Time Irrigation System using a Wireless Sensor Ntework”, international journal of advance research in computer science and management studies; vol. 2, issue 1, January 2014.

[25] Joaquín Gutiérrez Jagüey, Juan Francisco Vill-Medina, Aracely López-Guzmán and Miguel Ángel Porta-Gándara, “Smartphone Irrigation sensor”, IEEE sensors journal; vol. 15, no. 9, September 2015.

[26] Stefan Ericson and Björn Åstrand, “Stero Visual Odometry for Mobile Robots on Uneven Terrain”, Advances in Electrical and Electronics Engineering- IAENG special ed. Of the world congress on engineering and computer science 2008.

[27] M. Ramu and CH. Rajendra Prasad, “Cost effective atmoization of Indian agricultural system using 8051 microcontroller”, International journal of advanced research in computer and communication engineering; vol. 2, issue 7, July 2013, pp. 2563-2566.

[28] Amir H.Kargar B. and Ali M. Shirzadifar, “Automatic Weed Detection System and Smart Herbicide Sprayer Robot for corn fields”, IEEE february 2013.

[29] D.Durai Kumar, C.Vijaya and S.Jayashree Janani, “Autonomous Navigation of Mobile Robot for Automatic Weed Detection and Herbicide Sprayer in Agriculture”, International Journal of Engineering Science and Research Technology; March 2015.

[30] Snehal M.Deshmukh and Dr.S.R.Gengaje, “ARM-Based Pesticide Spraying Robot.”, International Journal of Engineering Research and General Science; vol. 3, issue 3, part-2, may-june 2015.

[31] P.D.P.R.Harsh Vardhan, S.Dheepak, P.T.Aditya and Sanjivi Arul, “Development of Automated Aerial Pesticide Sprayer”, International Journal of Engineering Science and Research Technology; vol. 3, issue 4, april 2014.

[32] Vijaykumar N Chalwa and Shilpa S Gundagi., “Mechatronics Based Remote Controlled Agricultural Robot”, International Journal of Emerging trends in Engineering Research; vol. 2, no. 7, july 2014.

[33] D.Sivaraj, A.Kandaswamy, S.Dinesh and J.Prithivira, “Design of Automatic Steering Control and Adaptive Cruise control of Smart Car”, International journal of computer applications 2011.

[34] Ashitosh K Shinde and Mrudang Y Shukla, “Crop Detection by Machine Vision for Weed Management”, International journal of advances in engineering and technology; vol. 7, issue 3, july 2014, pp. 818-826.

[35] R.S.Sabeenian and V.Palanisamy, “Texture based Weed Detection using Multi Resolution Combined statistical and Spatial Frequency (MRCSF)”, International journal of computer, electrical, automation, control and information engineering; vol. 3, no. 4, 2009.

[36] Rekha.S and A.Bhagyalakshmi, “A Survey on Weed and Pest Detection System’, International journal of advance research in computer science and management studies; December 2013.

[37] Gulam Amer, S.M.M.Mudassir and M.A. Malik, “Design and Operation of Wi-Fi Agribot Integrated System”, IEEE; May 2015, p. 207-212.

[38] Guoquan Jiang and Cuijun Zhao, “A Vision System based Crop Rows for Agricultural Mobile Robot”, IEEE international conference on computer application and system modelling 2010.

[39] Alireza Rafiq, Davood Kalantari and Hamid Mashhadimeyghani, “Construction and Development of an Automatic Sprayer for Greenhouse”, CIGR journal; vol. 16, no. 2, june 2014.

[40] Noboru Noguchi, John F.Reid, Qin Zhang, Lei Tian and Al C.Hansen, “Vision Intelligence for Mobile Agro-Robotic System”, Journal of Robotics and Mechatronics; vol. 11, no. 3, p. 193-199, 1999.