AUTOMATION IN AGRICULTURE : A STUDY

Dr. D.K.Sreekantha
Professor, Dept. of Computer Science and Engineering
NMAM Institute of Technology, Nitte, Udupi Dist. Karnataka,
sreekantha@nitte.edu.in

Abstract— The world population is expected to reach 9.1 billion by year 2050 says FAO (World Food and Agriculture Organization) and to feed this population food production should be increased by at least 70%. Developing countries have to double their food production. The traditional methods of farming and ever decreasing farm labour availability is making agriculture economically unviable and inefficient. In above context research on development of intelligent, autonomous machinery for carrying agricultural activities is essential to improve the quantity and quality of the agricultural produce. Today there is an urgent need to address the issues like indiscriminate use of agrochemicals, conservation of energy, control on environmental pollution and effects of global warming. Automation of farming practices has proved to increase the food production levels. This paper surveys the work carried out by various researchers to get a holistic picture on current state of implementation of automation in agricultural practices around the world.

Keywords— Mechanization, Automation,Farming, Sensor networks, and Agro chemicals

I. INTRODUCTION

Monitoring of the agricultural environment has become a major issue in recent years due to a range of factors including population growth, need for increased food production and the apparent onset of global warming. Population growth has led to environmental problems arising primarily from the pressure to produce more food from an essentially static or even diminishing food production land area. Modern agriculture depends heavily on engineering, technology, biological and physical sciences. Mechanization of agriculture activities have relieved much of the manual work and increased efficiency and productivity of farms.

II. INTERNATIONAL AND NATIONAL STATUS OF AUTOMATION

A. INTERNATIONAL STATUS OF AUTOMATION

America and Europe are leading the agricultural mechanization revolution followed by Japan, now the rest of the world is adopting aggressively agricultural mechanization. India has at present mechanization levels between 40-45 percent and lagging behind in comparison with other BRIC countries such as Brazil and China. By the year 2050, the annual food grain production is required to grow to 333 million tons from the current levels of 257 million tones recorded in 2014.

B. NATIONAL STATUS OF AUTOMATION

Agricultural machinery market in India is estimated to grow at a CAGR of over 10 percent during the period 2013-18. Indian states like Haryana and Punjab are having very high mechanization levels and negligible mechanization in north-eastern states. Rapid urbanization, growing population, promising employment and growth of other sectors are affecting the farm productivity. The market size of the farm equipment sector is estimated at approximately US$ 6.5 billion and has seen strong growth in recent years. Agriculture productivity can be increased up to 30 percent and input cost can be decreased by 20 percent approximately by automation of agricultural activities.

C. CHALLENGES FOR AUTOMATION OF AGRICULTURE

- Small and scattered land holdings
- Affordability and financing of farm equipment
- Poor quality levels of equipment procurement
- Mechanism and poor after sales service
- Over dependency on tractors compared to other kinds of machinery
- Agri sector is expected to employ approximately 205 million people by 2019-20
- In rural India, about 60 percent people working for agriculture and allied activities.
- The estimated reduction in farm labour is about 26 percent by 2050.
Majority of farms are smaller in size and unsuitable for operating large farm machineries

III. REVIEW OF LITERATURE

The researchers have carried out a preliminary study of the automation in agriculture literature from IEEE digital library, reputed international journals and conferences. Authors have presented some of the most relevant papers as way illustration.

Paul B. McNulty and Patrick M. Grace [1] discuss the automation of agricultural activities around the world. The rate of growth of automation of agriculture should be on par with growing world population. Today machines have partially replaced the human energy and animal power. The authors stated that first America and Europe are leading the agricultural automation revolution followed by Japan. Now the other part of the world also started adopting automation aggressively. Agricultural automation is the primary area of research to improve the food quantity and quality, use of appropriate quantity of agro chemicals, energy conservation and environment.

Agricultural Machinery Industry India report [2] presented the growth market structure and business strategies facts about availability of farm power decade wise from 1952- 2016 and tabulated facts about animal, mechanical and electrical power utilization for agricultural activities. This paper has also tabulated the Indian agriculture machinery stocks comparison with that of countries such as Japan, UK, Germany and France. The growth of different agricultural machines from 1992 to 2003 is also presented. This paper gives a holistic picture about the agriculture machinery availability in India with comparison to developed countries.

S.N.Asoegwu and A.O.Asoegwu [3] overviewed agricultural mechanization and environmental management in Nigeria. Authors have identified the agricultural inputs such as land, capital, labor, research, education, communication, information, and engineering technology. All these inputs are required for development of agricultural mechanization and in turn for enhanced agricultural production. This paper states that the bio-chemical, socio-economic and engineering factors are integral part of agricultural development.

M.S.Rahman, M.A.Monayem Miah, Moniruzzaman and S. Hossain [4] have studied the influence of farm automation on man power requirements for growing wheat crop in Northern Bangladesh. This study revealed that the yield of wheat crop under automation is increased to 2.65 t/ha from 2.57 t/ha using conventional farming practices. Traditional forms have higher variable cost (Tk.10,102) and whereas the mechanized farms have higher gross margin (Tk. 14,168) compared to traditional farm. The power tiller spares cost have increased and have been identified as a major hindrance of automation. The results indicated that farm mechanization will significantly reduce the man power requirements.

Uday B.Desai, B.N.Jain, S.N.Merchant [5] applied wireless sensor networks (WSN) technology for assessing the chemical contamination of water bodies and environment. The parameters of soil, atmosphere, fertilizers and pesticides are measured by the deployed sensor nodes on the field. This sensor network can be used for detecting intruders, plant disease, pests and fire. This constant crop monitoring helps farmers to increase the crop yield.

James F. Thompson and Steven C Blank [6] stated that mechanization of agriculture helps to remain competitive. Automation of agriculture has helped farmer to enhance their crop production and decrease the cost in California and they are ahead of the competition in the global marketplace. The authors have conducted a study of rice and tomatoes cultivation and discovered that manpower requirement has been decreased by 92% to 97% and total input costs decreased by 20%.

Nick Sigrimis, Panos Antsaklis and Peter P.Groumpos [7] have discovered that computer based systems and robotics are immensely contributing the green revolution. The farmers are more depending on these machinery for carrying out routine and laborious activities. Managing increasingly complex agricultural systems demand most sophisticated systems. Agriculture produce is
feeding the world population, bio industries and energy sector driving the transition.

S.S.Katariya, S.S.Gundal, Kanawade M.T and Khan Mazhar [8] have designed a prototype robot for automation of agriculture activities such as water supplying, dropping of seeds accurately and automatically, plugging, pesticide spraying. The echo-friendly solar power system installed in the field supplies power to robot. Tracking system guides the movement of the robot in a pre-defined path only for fruit crops. The pesticide spraying mechanism avoids direct contact between farmer’s body and poisonous pesticides. This system also maintains a standard level of pesticide quantity which improves the fruit quality and soil quality standards. The water supply system provides accurate water to a particular crop and saves the wastage of water. On the outset fully automated system saves money, time and also improves the quality of production. This robot can play a big role in promoting green evolution.

J.Farrington [9] reviewed the mechanization policy and the impact of tractors in South Asia. Associating mechanization with modernization was first adopted by People’s Republic of China in the 1970s and considered mechanization as an indicator of agricultural development of the country. Mechanization substitutes directly for labor and is socially undesirable, given the high population density and limited employment opportunities in most of the Asian countries. Mechanization is more likely improve timeliness, irrigation, and agrochemical use. Bangladesh lacks an agricultural frontier with virtually all agricultural land already exploited and only 68% of its land cultivated. India has a wide range of mechanized and non mechanized agricultural equipment. Tractorization varies from one state to another and its association with irrigation. For instance, the Punjab has more than 12 4wts/1,000 ha and around 75% of its area is irrigated.

Knowledge paper on transforming agriculture through mechanization [10] has published the facts about agricultural equipment sector of India. India has a significant contribution in global top countries for agriculture production. The major crops grown are rice, sugarcane, wheat, vegetables and fruits. There are many proven cases to show that automation increases the agricultural productivity by 30% and decreases the cost by 20%. Indian tractor industry accounts for 30% of total global production and the largest consumer in the world.


Application automation technology in agriculture, horticulture, Greenhouse and forestry, which is termed as of agriculture robotics. Many researchers are working in this area and designed for the farmer robot, mobile robot, flying robot.

Authors have reviewed the research work on agricultural vehicles carried out for last twenty years. This study revealed that there are significant developments and improvements robots performance, but at same time there are some limitations which are causing the delay in commercial application of robots. GPS and machine vision technologies may be used in designing vehicle guidance systems. Authors propose to use swarm of small machines in agriculture rather than using few large ones. The farmers demand smaller machine which are cheaper and easier to operate. Many of the tasks in agriculture are repetitive in nature, require intelligence and quicker action, dangerous for humans, hence robots can replace humans in this cases. The robots can perform the activities more accurately and thus enhancing productivity.

K. Subbulakshmi and A. Geetha [12] authored the paper microcontroller based fuzzy controller for an agricultural robot which can be used to ploughing the field, seeding and soil moisture sensing. Agricultural robots can be used to reduce manpower and can be operated using remote controls from a distant place becomes advantageous and cost-effective. Authors have designed an agricultural robot with internet based remote control
by using LAB VIEW. The position and speed controls are discussed. Fuzzy controller is designed to change the steering angle and the speed of the robot according to the desired reference position. The control was implemented using Atmega16 Microcontroller and the results are documented. This agricultural robot control reduces the manpower and. Authors proposes the use of GPRS transmission of data which is very fast, enables long distance communication and transmits the information about multiple number of robots.

Pedersen S.M, Fountas.S and Blackmore.S [13] have discovered that robots have been successfully used in many industries and warehouses in a controlled environment which have enhanced productivity and accuracy to a great extent. This success has inspired researchers to apply robots in agriculture. Research on autonomous vehicles in recent decades has resulted in commending results. Developed countries are about try them on their roads in real time. Researchers are applying a bunch of technologies like wireless sensors, communication technologies, GPS and GIS in designing autonomous vehicles for in the agriculture and horticulture. Many autonomous prototypes have tried in controlled and structured environments like orchards and horticultural crops such as tomatoes, strawberries and oranges. These automated systems are employed for high value crops. Robots can be used in dairy industry in indoor environments for automated feeding and cleaning. Safety is the major concern in using robots in real life. The robots safety system should ensure operate autonomously and unattended to be reliable and dependable. Robots can work round the clock, if it is be attended by humans then operational time is limited.

G. Belforte, R. Deboli, P. Gay and A. Giglio [14] analysed the agricultural operations such as precise fertilization, spraying, detection of crop diseases and selective harvesting could be carried out through robots. Authors presented results on design and implementation of multipurpose low cost robot designed for agriculture and green houses. The robot is a reliable and structurally simple which can operate greenhouses. This paper also discusses the mechanical design of the robot vision control. Authors are of the opinion that automation of agricultural activities is challenge in near future. The robot are successfully working in controlled environments like green houses. The robots can perform operations in greenhouse like spraying of toxic substances which is a valuable addition to prevent human operator’s health hazards.

V.Arguenon and A.Bergues Lagarde [15] proposed the simulation of prototypes for different agricultural robots using multi-agents system. These prototypes can be used in the harvesting of a vineyard. The system comprising several robot can also use these prototypes. This paper discusses the behavior of each robot, their interactions and some scenarios for the testing of the system. Cooperative behavior of robots in performing a task is studied. The simulation results are very useful in the development of various options for harvesting. These options are taken in to consideration while designing and development of prototype. This paper presented a method for the design and development of an agricultural robot using simulation and modelling for grapes. Authors have chosen multi-agent system to achieve their goal. Simulation is used for performance evaluation robots. Authors have presented the details on basic problems and desired behavioral roles for some of the system’s objects. The various behaviors of the robots like role based policies, protocols, cooperation issued are to be tested. The efficiency, speed and handling displacement required for harvesting in a given situation are taken in to consideration while deciding the actual number of robots required. The produce quality control and cost also determines the number of robots required. This supervisor would assign harvesting and transport robots to process any location in the vineyard. Another interesting point concerned is tele-operations. For many reasons, it may be necessary to enable human operator to manipulate any of the robots from a distance (e.g., in case of problems or emergencies). Lastly, the multi-agent system could also be used to take into account human and machine interactions for the prototyping of the system, focused on the displacement aspect of robots is tested based on the potential field method. Preliminary results of this paper indicated that the approach does provide a
number of interesting insights in to the design and development of the system.

Obviously, there is so much work to be done and case studies to experiment with and learn from. Many perspectives can be derived from this study.

G.Aravinth Kumar, M.Ramya and C.Ram Kumar [16] studied the trends of green revolution and discovered that the industries and IT sectors have occupied most of the fertile cultivated land and hampering the growth for the green revolution. Authors proposed to implement the robotic operations in agriculture to increase the agricultural productivity. This paper deals with the project on green revolution using robotics. Traditionally cultivation does not have the knowledge of DNA characteristics of the each crop. This paper proposes an application of DNA knowledge in cultivation. The main advantage of this cultivation is based soil nutrients, climatic conditions and seed topology. A micro-controller checks the DNA status of the plant against the templates. These techniques propose better solutions to green revolution. This paper has presents a version of what aspects of crop production could be automated. Authors are of the opinion that this development process may be incremental but the overall concept requires a paradigm shift in the way people think about mechanisation for crop production that is based more on plant needs and novel ways of meeting them rather than modifying existing techniques.

Kentaro Kameyama, Yuta Umeda and Yuki Hashimoto [17] have developed an autonomous weeding robot for the paddy field. This robot has small two-wheels which weeds by running around the paddy field by using the information given from the direction sensor and the GPS receiver. Robot traveling model takes into account the parameters of the soil and the GPS. The process is derived and the conditions are investigated by experiments. The behavior of the weeding robot is also investigated by some simulations. The behaviors of the robot under the noisy conditions are tested by numerical examples.

Andrew English, Patrick Ross and David Ball [18] worked on agricultural autonomous vehicles based a new vision guide and texture tracking. This system helps to identify the crop rows that are difficult to detect. The current methods of segmentation require significant visual difference between the soil, crop and knowledge about crop rows structure. This method uses simulated overhead view of the scene for extracting and tracking the direction and lateral offset of the dominant parallel texture. Robot abstracts spacing, colour and periodicity which are crop-specific details. This method is capable of tracking crop rows across fields during day and night with extremely varying appearance. Authors have successfully presented a method that can guide a robot along the crop rows autonomously.

Chunling Tu Barend Jacobus van Wyk, Karim Djourani, and Yskandar Hamaand [19] presented vision based on navigation method for agriculture robots to detect crop rows efficiently. This method does not need identification of low level features (such as middle lines and edges of the images). This method does not implements complex algorithms for detecting edges and matching, hence saves the computation overload to a great extent. This method defines a flexible quadrangle edges to detect the crop rows. This flexible quadrangle method moves, shrinks or extends to localise the crop rows in the captured frames. The proposed method results are shown to be very effective and highly efficient in detecting the crop rows. This paper uses the videos captured from farm fields to identify and trace the crop rows. This method has high time efficiency because neither complex edging nor segmentation methods are employed. The real world video is used to validate the performance of the proposed method.

Fernando Auat Cheein, Daniel Herrera, Javier Gimenez, Ricardo Carelli, Miguel Torres-Torriti, Joan R. Rosell-Polo, Alexandre Escol’a and Jaume Arn [20] studied productivity challenges for agriculture in Chile and Argentina. Recent earthquakes and volcanic eruptions have damaged farmable land. The climate changes are also destroying the water reserves and affecting the agricultural productivity. The farm labour is migrating to industries in search of stable and more lucrative jobs creating a labour problem for both the countries This shortage of farm labor in both countries forced to perform primary and secondary
tasks using agricultural automation and sensing technologies.

Daniel Herrera, Javier Gimenez, Ricardo Carelli, Miguel Torres-Torriti, Joan R. Rosell-Polo, Alexandre Escol and Jaume Arno, [21] recently agriculture and lawn mowing domain are also applying multi-robot systems theme. The multi-robot systems require appropriate techniques for coordination between the robots to keep the system of robots robust and perform efficiently the operations saving time, energy and cost. Coordination technologies should track individual robot failures and should be scalable in terms of number of robots. Multi-agent systems are providing a good number of solutions using multirobot systems. Authors are focussing on multi-robot task allocation and dynamic configuration of multi robots for multi-robot area coverage. Dynamic bids algorithm which is auction-based is used for multirobot task allocation. This algorithm that significantly enhances the performance of robot tasks and significantly decreases the communication overhead between them. This paper presents experimental and analytical results from simulations using Webots simulator tool as well as on physical robots. The authors concluded that their approach has the potential to improve the coordination accuracy among the robots.

Simon Blackmore, Bill Stout, Maohua Wang and Boris Runov [22] studied on agriculture activites in order to discover innovative ways to improve their efficiency. Designing more intelligent and autonomous machinery to improve the efficiency and save energy. Today, the precision farming is one of the approach in this direction.

Authors are aiming at designing advanced equipment that provides an opportunity to design a completely new range of agricultural machinery. The small and smart machines are to be designed to do right things, in the right place, at the right time in the right way. This paper outlines the need for advanced technologies to design innovative machinery to automate the crop production in near future. Authors emphasised the potential for reducing the scale of treatments with autonomous machines even though existing manual operations are efficient over large fields.

Luis Emmi, Mariano Gonzalez-de-Soto, Gonzalo Pajares and Pablo Gonzalez-de-Santos [23] studied mobile robots empowered with global positioning systems, machine vision, computer and laser based sensors and actuators. These mobile robots are designed with a vision to automate agricultural tasks and shifting operator activities to machines. Embedding many electronic devices in robot increases complexity and decreases reliability and increases its cost. Minimization of hardware, software and integration are essential to design viable robots. Application of fleets of robots is the step forward towards automatic equipment in agriculture. The numbers of specialized robots collaborate among them to perform one or several agricultural activities. This paper attempts to design system architecture with aiming to reduce complexity, enhance reliability, decreasing costs for both individual robots and robots working in fleets. This architecture also facilitates the integration of software from different vendors. This integrated architecture hosted on central computer to run all processes. This research also explores various topologies for controlling fleets of robots and successfully implemented in the RHEA fleet, which comprises three ground mobile units based on a commercial tractor chassis.

Ankit Singh, Abhishek Gupta, Akash Bhosale and Sumeet Poddar [23] have designed a robot for agricultural activities with nick name Agribot. The design and development of automated and intelligent robot for agriculture activities is the trend in 21st century around the world. This Agribot is designed to perform basic operations like planting, picking, weeding, pruning, harvesting and grafting. The authors aim at automation of crop production. Autonomous robots can enhance the efficiency of agricultural operations compared to humans. The design and development of fully autonomous robot may take long time, but incremental progress in fully autonomous robot requires a paradigm shift in the way people perceive automation of crop production.

Martin Holm, Pedersen Jens and Lund Jensen [24] designed model of four wheeled agricultural robot based on (Fault Detection and Isolation) FDI scheme to detect and isolate faults. This model is
called an API (Autonomous Plant care Instrumentation system). The authors presented a number of different techniques for deploying various FDI strategies for preliminary testing on a pre-existing non-linear model of the robot. This paper highlights the efforts to make the API a robust platform and more reliable with the design and implementation of new sensors to enable the robot to diagnose itself. The various FDI schemes were implemented successfully on the non-linear model. The system could detect and isolate some of the selected faults. An old inclinometer was replaced by a new design and implemented on this robot. Two more new proximity sensors are designed and implemented. The AFI scheme steering part was able to detect a false alarm, when the baseline test was performed. The steering part detects and isolates all faults as well and the propulsion actuator faults were also detected and isolated.

Gholap Dipak Dattatraya, More Vaibhav Mhatardev, Lokhade Manojkumar, Shrihari and Prof. Joshi S.G [23] presents an advanced agriculture process that includes cultivation on robotic platform. The robotic system is based on electromechanical (conveys a sense that it has agency of its own) and artificial agent that is steered by DC motor and has four wheels. This farm is cultivated by the robot, depending on the crop considering particular rows and specific columns. The infrared sensor detects the obstacles in the path and also senses the turning position of vehicle at end of row. The seed block can be detected and solved using water pressure. The solar panel is used to power DC battery and machine can be controlled remotely. Microcontrollers are programmed using in assembly language. The motion of vehicle is controlled and monitored by a microcontroller and DC motor. This paper presents the specifications and progress achieved in design of precision farming. Authors claim that their project increases the efficiency and accuracy. This project has high speed operation and no human intervention, can be further improved to make it a commercial product.

Tony E. Grift and Yoshisada Nagasaka [24] have designed two autonomous robots as platforms for crop/soil scouting and future robotic field operations. AgBo is a flexible industrial style robot with a sophisticated steering, sensing and communication arrangement. Ag Tracker, in contrast, was built with ruggedness, simplicity and low cost in mind. Its features simple skid steering and an arrangement of eight low-cost infrared sensors, two ultrasonic sensors and an electronic compass were used for crop guidance. AgTracker’s simplicity and ruggedness make it a strong candidate for a generic platform for scientists to develop autonomous crop scouts and field operation machines. These two robots have differing technological philosophies. AgBo has independent four-wheel steering, four steering modes (including crabbing and spinning) and inclination control. A SICK laser range finder, combined with an electronic compass and used for crop guidance. The main communication among sensors, actuators and controllers was implemented using a Controller Area Network (CAN). All of these functions, including remote control were implemented using a single microcontroller and no communication network was applied. This could refocus the research emphasis from the robots themselves to the truly important development of small, reliable, no-calibration, real-time sensors for the detection of stresses, diseases, weeds, pests and soil parameters to investigate what type of robot is most suitable for field applications, two robots were built with differing philosophies. In conclusion, AgTracker was found to be the most promising agricultural robot. It’s performance to price ratio was superior, its fewer parts proved more reliable and like AgBo, its negotiated corn crop rows autonomously without damaging any plants. In addition, its physical layout made it more rugged and easier to mount sensors and actuators for future development.

Michael A. Goodrich and Alan C. Schultz [25] have developed Human–Robot Interaction (HRI) that has recently received considerable attention in the academic community, in labs, in technology companies, and through the media. Authors described the HRI story from multiple perspectives with an eye toward identifying themes that cross applications. The survey attempts to include papers that represent a fair cross section of the universities, government efforts, industry labs and countries that
contribute to HRI. HRI comprises a cross section of the disciplines that contribute to the field, such as human, factors, robotics, cognitive psychology and design. Human–robot interaction is a growing field of research and applications. This field includes many challenging problems and has the potential to produce solutions with positive social impact. Its interdisciplinary nature requires that researchers in this field understand their research within a broader context. In this survey authors have tried to present a unified treatment of HRI-related problems, identify key themes and discuss challenging problems that are likely to shape the field in the near future.

Rubens A.Tabile, Eduardo P. Godoy, Robson R. D. Pereira, Giovana T. Tangerino, Arthur J. V. Porto and Ricardo Y Inamasu [26] have studied the parameters such as tolerance, scale and agility utilized in data sampling used in precision agriculture. This paper highlighted the employment of methodologies in remote sensing used to couple to a Geographic Information System (GIS) applied to agricultural field. The application of agricultural mobile robots is a strong tendency in European Union, USA and Japan. In Brazil, there is ongoing research on development of robotics platforms, serving as a basis for semi-autonomous and autonomous navigation systems. The main aim of this work is to describe the project of an experimental platform for data acquisition in field for the study of the spatial variability and development of agricultural robotics technologies to operate in agricultural environments. The proposal is based on a systematization of scientific work to choose the design parameters utilized for the construction of the model. The kinematic study of the mechanical structure was made by the virtual prototyping process, based on modeling and simulating of the tension applied in frame. The study showed the possibility of the robot application for carrying out remote sensing in agricultural environments. Initially the possible areas of activity and the main consumer markets have been identified. The operations that could be performed as well as the most important features that make up the agricultural environment have been defined. This data and the technical options available have been selected, in view of the set of parameters of operations which best fits the prerequisites of the project. The simulation and validation of the structure designed by specific software have been performed. The design of the platform enabled to develop agricultural robot which is efficient and meets all specified requirements.

Shiva Prasad B.S, Ravishankar M.N and B.N Shoba [26] have designed a prototype agriculture robot for seeding and fertilizing robot using microcontroller. The robot also senses the soil ph, humidity, temperature and moisture. The remote controls the robot. The remote controller is used to move the robot to the destination and perform the above functions. The robot is internet enabled. DC motors are used to navigate the robot to required position and its speed is controlled by the remote.

Sachin V Pathak and NRNV Gowripathi Rao [27] studied agricultural mechanization in India. Agriculture sector provides about 65% employment and provides livelihood to about 70% of the population. Agriculture produce contributes to about 18% of Gross Domestic Product (GDP). Modern agriculture is benefited by advanced technology and restricted to farmers with large landholdings. Small farmers are using tractor mounted implements which are popular and being commercialized. Harvesters, elevators, threshers for cereal crops and crop specific machines have been developed, commercialized and used on a large scale. A future requirement for farm equipment and technologies include rota-tiller for seedbed preparation, till planter, strip till drill, pneumatic precision planter, sugarcane sett cutter planter, vegetable trans planter and check-row planter, for sowing and planting. Power weeder and equipment for chemico-mechanical weed management, electro-static spraying and tall tree spraying are required. Harvesting equipment for sugarcane and cotton are required to be developed. R&D institutions in the country have developed a number of useful technologies for mechanizing farm operations.

Min Hyuc Ko, Kyoung Chul Kim, Beom Sahng Ryu, Abhijit Suprem and Nitaigour P Mahalik [28] have presented a study on vision
based autonomous driving of a four-wheel-drive platform for agricultural applications. The driving platform can be autonomously driven on any path pattern. The key contributions to this paper are development of unique navigation pattern to train the mobile robot to follow any kind of path pattern. Authors have demonstrated how speed, steering angle per pixel and camera angle play an important role in developing navigation algorithm for a four-wheel drive (4WD) type mobile robot for moderately low speed applications. This paper demonstrates FWD and RWD of a 4WD mobile robotic platform intended for weed monitoring application. Initially a path pattern is defined for testing and learning of the driving constraints. The robotic platform was experimented in a greenhouse. The vision-based autonomous driving algorithm was developed and validated.

The image processing was achieved using a single camera. In this paper, autonomous driving platform among the many factors that affect the driving characteristics was comprehensively studied. The important parameters to be considered for 4WD system are camera mounting angle, steering angle per pixel and driving speed. Cornering and straight line driving principles were studied. In a narrow space like greenhouse, the rear-wheel steering with excellent driving characteristics can be the future work.

Drishti Kanjilal, Divyata Singh, Rakhi Reddy and Prof Jimmy Mathew [29] stated that the world is getting automated with advancement of technology. Manual labor is substituted by automated systems because of advantages like energy efficiency, safety and speed of operations and promotes agriculture growth. Agriculture is the primary economic sector of India and other developing countries. The concept of automation is extended to the agricultural farms and farm houses. Many activities of the farm like auto-irrigation cycles, secure temperature controlled enclosures for livestock and farm products are automated. This paper discusses the implementation of automatic lighting system, auto-sprinkler system, in-house temperature control and security for farm houses. The temperature and motion sensitive devices will only work on demand based to conserve the energy effectively. The paper also presents the features to enhance the security of the farm. Energy efficient farm automation is the need of the hour in an agro-based economy. This project has attempted to introduce an efficient smart farm system. It has incorporated automation into various aspects of the farm. Manual labor can be reduced by an innovative design for animal enclosures that provide improved living conditions of livestock by automated light, temperature, humidity and sprinkler control system. The animals feel comfortable in the enclosures under controlled conditions of humidity and moisture and control settings may set as per requirement. The system is made secure through a password protected digital lock which ensures the safety of animals in their enclosures. The incoming and outgoing movements of livestock are enabled by the auto lock and release doors. The loss of livestock and valuable resources can be prevented by smoke detectors which will prevent fire hazards. The automated feeder control system feeds the animals and reduces the human labor in the process. The system is powered by solar and bio gas and thus the system can be made energy efficient. A GSM module is interfaced to connect all aspects of the modern automated farm. The farm owner can control and access the automated system using his smart phone. This paper outlines the use of automated technology to the farm environment, systems and appliances that are able to communicate in an integrated manner. This will conserve energy efficiency and results in convenience, quality and safety benefits.

Francisco Rodríguez, Manuel Berenguel, José Luis Guzmán N, Sebastián and N Dormido [30] shared the experience of developing a virtual course on modern automation of agricultural systems. This course is taught using classical teaching tools and novel teaching methods, taking advantage of new information and communication technologies (ICT). This virtual course is based on the WebCT platform and includes interactive tools and both a virtual and a remote laboratory for greenhouse climate control and fertirrigation teaching/learning. The authors presented a virtual online course on automation and robotics applied to agricultural systems, specifically, to greenhouses.
This course uses ICT technologies for teaching and access to remote laboratories by the students from different geographical areas. The theoretical part of this course was developed using hypertext systems, and it was complemented with several exercises. Laboratory experience (real or interactive) is extremely important as a part of control learning. The hypertext systems, interactive tools, and remote labs are very powerful elements, helping the students to enhance their motivation, skill, and ability to understand and solve engineering problems.

IV. CONCLUSIONS

Authors have carried out a review of agriculture automation with an aim to understand the latest developments around the world. These researchers would like to design low cost, and efficient small robot to automate the agricultural activities of small farmers in Western Ghats region.

This paper concludes that the automation of agriculture is partially successful in structured and controlled environments and lot of research is in progress to full automation of agriculture activities and some significant progress is also achieved. Instead of using one sophisticated and high cost machinery, it is recommend using a fleet of small scale, special purpose robots in collaborative approach.

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