INTERNET OF AGRICULTURE THINGS

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***Abstract*—The paper includes a study of various types of robots that are used and developed to ease the agriculture process. This paper also deals with the software technologies that are used for development of agricultural robots, challenges in implementing the use of agricultural robots in real world.**

Keywords—Coupled Layer Architecture for Robotic Autonomy, Microsoft Robotics Developer Studio Introduction ,Agrobots

I. INTRODUCTION

A major problem world is facing is of food in present era. But still in most of the countries people practicing agriculture depend on old techniques. To feed the increasing population of the world the most important thing is to increase the production of grains, which can be achieved with modern machinery and automated agricultural robots. This paper covers a review of different types of agricultural robots, the software and methodology to build them and their functions.

II. LITERATURE REVIEW

Bosilj et.al.[2018] This research paper describes the methodology of classification of different types of crops by their image processing. Different types of morphological characteristics are collected with high definition camera and based on the image collected the crops are classified to their respective category and also describes the soil required for it, different types of weeds that can infect the plant. [1]

Ramin Shamshiri et.al.[2018] This research paper has mentioned the use of IOT in collection of data about crop, then analyse and visualise the data and then predict the type of resources which are required and at what time i.e will help with the better planning of steps of cultivation by analysing the current climatic conditions. This paper has also proposed future scope by analysing the failure of predicted results.[2]

Behmanesh et.al [2017] This research paper has proposed an algorithm to estimate the fruit count on a tree with the help of smartphone camera. This will be cheaper and more easily used as compared with the expensive sensor-based system of counting fruits on a tree, and will help farmer to predict the quality of his harvest and thus can predict his/her profit.[3]

Fred E. Sistler [1987] *In t*his research paper author proposed various advance technologies that can be implemented in field of agriculture like advanced mechanisms for grain drying, irrigation scheduling, weedicide and pesticide use predictor, which will help the farmer to reduce its production cost and provide with more harvest. Maintaining the Integrity of the Specifications.

David Ball et.al. [2017] In this research paper author proposed to use different small robots who would be autonomous in doing the field activities. It came with robot made of integration of sensors and cameras who could detect the. A monitoring interface to monitor the working of these robots and a docking system to fill liquid to these robots.[4]

Fernando A. Auat Cheein et.al.[2013] has presented the basic four features required in unmanned vehicle used in agricultural field. Which includes: guidance about the task to be performed; proper mapping of the dimensions and various obstacles in the fields; feed proper information about biological factors (soil, pests, etc); Actions the machine need to take in execution of task.[5]

Avital Bechar and Yael Edan[2003] proposed methodology to develop a robot which has interaction with man, this robot collects the image from various parts of the fields and show various recommendations to farmer and the farmer can than manually can ensure the recommendations provided by the machine. It also compares the work (ex: harvesting the crop or plucking a fruit) by a robot and man.[6]

Jensen et.al [2013] This is a research on analysis of the local way of agriculture along with the climatic factors at that place and the diseases in the crop at a place, and then proposing if the method used in the process if cultivation is worth or not.[7]

T Redmond Ramin Shamshiri et.al.[2018] The author in this research paper describes about the different types of robots like for harvesting crops, for weed detection and also discusses the basic algorithm used in this type of robots. Like object identification algorithm, task planning algorithms in this way author proposes a shift from traditional framing methodology and to digital farming.[8]

Mohammad Behmanesh et.al[2017] in this research paper has categorized robots used in agriculture in four different categories and has categorized the robots on the basis of: harvesting robots-used for harvesting crops; navigation robots—to guide +to correct path and detect obstacle; crop disease detecting robots—which study the crop tissue and predict the disease. Weed detector—which detect the harmful weeds.[9]

III. MEASURES APPLIED IN BUILDING AGROBOTS

Designing of agricultural robots which are agrobots are highly dependent on modern technologies like- sensor technology, sensors are the major tool which is required in collecting the real time data and using this data we train the robots to perform the activities we want it to do.

Most of the agrobots are based on the image processing techniques these agrobots may include the fruit picking robots which process the image of a fruit and then decide if it is ripen or not. After processing that the fruit is ripened scans the path of the robotic arm to pluck the fruit. Vision based processing also plays a major role in in the process of seedling, weeding and target spraying.

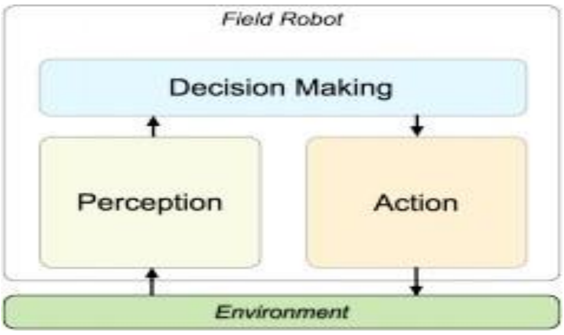

Fig 1. Measures applied in building agrobots[14]

IV. SOFTWARES THAT ARE USED FOR DEVELOPING AGROBOTS

- CARMEN: It is a Robot Navigation Toolkit. It is a modular software the main reason of making it modular is to divide the tasks which contains library for controlling the mobile robots. It has features like collection of data from sensors, algorithms for path mapping, 2d simulators.
- CLARAty It provides a software which can work as a laboratory to and can ease the process of testing and developing the robot. Provides a platform where on can develop local as well as remote acess robots.
- MRDS: It is an environment developed by where development and simulation of robots takes pace. It has its own language Visual Programming Language and also support other languages.
- Orca: Components of software is developed as building blocks and in later stage combined together to make a complex robot and is open-source.
- Orcos: It uses advanced version of C++ libraries for advanced machine and software control. Made to control robots and develop robotic operating system.
- Player: It a software which provides interface to support and control variety of robots. It is based on network-client interface system. Provided network between different robots with the help of TCP protocol. The client system collect the data through various samples.
- Robot Operating System (ROS): It a software which dispense a framework where one can write software for developing robots. It contains a strong library and provides various services. Examples are: inter-process communication, hardware abstraction.

	Agricultural Applications	Multiple Platforms	Multiple Users	Open Source	Updated Recently
CARMEN	Yes	Yes	Yes	(Yes)	No
CLARAty	No	Yes	Yes	(Yes)	No
Agriture	No	No	No	No	No
Agroamara	Yes	No	No	No	No
AMOR	No	No	No	No	No
Mobotware	Yes	Yes	Yes	No	Yes
SAFAR	Yes	Yes	No	No	No
Stanley	No	No	No	No	No

Fig2. Comaprision table for softwares for building agrobots [14]

V. STUDY OF EXISTING AGROBOTS

4.1 Weed control and targeted spraying robots

The main reason to build agrobots is to reduce the involvement of humans in agriculture field. Introduction of robots for weed control is both effective for time and labor. (a)BoniRob this robot can create a detailed map of field and is effective for spraying weedicides for the row crops. (b)Agbot is another robot which is made to detect the weeds and is emancipated in application of fertilizers. It has algorithms for classification of different weeds and then manually or chemically removing it.(c) Tertill is an agricultural robot that uses solar energy for its operation and is made for weed cutting. (d)Kongskilde Rootti is a based on FoboMind and is capable of doing fully or semi-autonomous precision seedling system, weed control and also has furrow opening and cleaning.

a. BoniRob b. Agbot

c. Tertill (d)Kongskilde Rootti Fig 3. Weed control and targeted spraying robots[13]

4.2 Field scouting and data collection robots

These robots have sensors attend to them to collection of data which is vey tedious task and has a lot of reliability issues. The devices used for data collection must provide veracious information. If these robots are accurately assembled than will prove its worth in terms of flexibility and multipurpose use and thus will proved to be very cost effective. The devises needed to be equipped with advanced imaging sensors which work with 3d point clouds and also with GPS navigation system.

(a) Trimbot is an autonomous navigation and monitoring robot which is specifically used in rose plantation area. Being equipped with robotic arm these robots are designed for rose cutting and trimming of rose bushes. (b)Wall-Ye is an agrobot specially built for vineyards. It is designed for mapping the grapes through camera and sensors, pruning and harvesting the grapes. (c)Ladybird is used for multiple purposes and is also an autonomous robot used for monitoring, have sensors or mapping objects detected during surveillance and uses advanced classification algorithm for distinguishing between different varieties of vegetables. (d) MARS (Mobile Agricultural Robot Swarm)It consists of swarm of few small and sleek robots. The main idea of designing such robots is to minimize soil compaction and also to reduce energy consumption. These robots can be customized for farm specific use.

(a) Trimbot (b)Wall-Ye

(c)Ladybird (d) MARS Fig 4. Field scouting and data collection robots[13]

4.3 Harvesting robots

Harvesting is an intensive, time-consuming and expensive process of farming. Harvesting is one of the most censorious phases of agriculture, and it poses different challenges. Besides that agricultural harvesting process largely depends on labor availability. So there's a big demand at the process to move to using some autonomous machines. Few of the robots harvested are:

a. Harvey b. CROPS

c. SWEEPER d. Energid citrus picking system Fig 5. Harvesting robots[13]

Most of these robots are emanate on the principle of detect and move. These robots are equipped with high quality of sensors, camera and a robotic arm. The robots detect fruits through camera and sensors. The next step is to move the robotic arm to the fruit so as to pluck it. The algorithms are designed so scan the shortest path between the fruit and robotic arm considering the fact that the branches should be always at the back of the fruit.

VI. DIGITAL FARMING WITH THE HELP OF AGOBOTS

Agriculture sector is facing colossal problem of declining profit. If we take example of country like India whose 60% population is engaged in agriculture yet share only 18% share in GDP. With the help of digital framing and introduction of robots in agriculture there a very good chance of reduction of labor cost and earning more profit.

Digital farming comes with the concept of collecting real-time data of field with the help of integrated technologies than transferring this data to control and processing unit and then advising the farmers to take necessary steps. There are various aspects of digital farming including thermal imaging to check crop and soil health. Digital farming also includes the use of emerging technologies like Big data, cloud computing, data science, Internet of Things, GPS, virtual farms, UAVs, mobile devices and robotics.[13]

Introduction computer to robot communication system involves collection of data than sending it to cloud system and then give the processed results. The cloud based results are more reliable as they include analysis considering both historical and real-time data. With the help of UAV digital framing involves reconstruction od a 3D orchard, using this concept people can connect their farms and provides better data collection and make better decree and predictions.

If we compare this with the traditional methods which used heavy machinery like tractors which caused soil compaction and thus reduces the nutritional values of the soil and takes years to recoup its fertility.

One solution to the above problem proposed by the researchers is using multiple small robots. These robots are devised using high level machine learning and genetic algorithms along with the concepts of artificial intelligence. One such example is construction of nutrient map by a group of robots who collect soil at different field location. But in making multirobot coordination system the primary goal is to find out the design algorithms for obstracle detection, navigation using GPS and coordination between them. These can collect information like: temperature, luminous intensity, presence of carbon dioxide and other harmful gases.

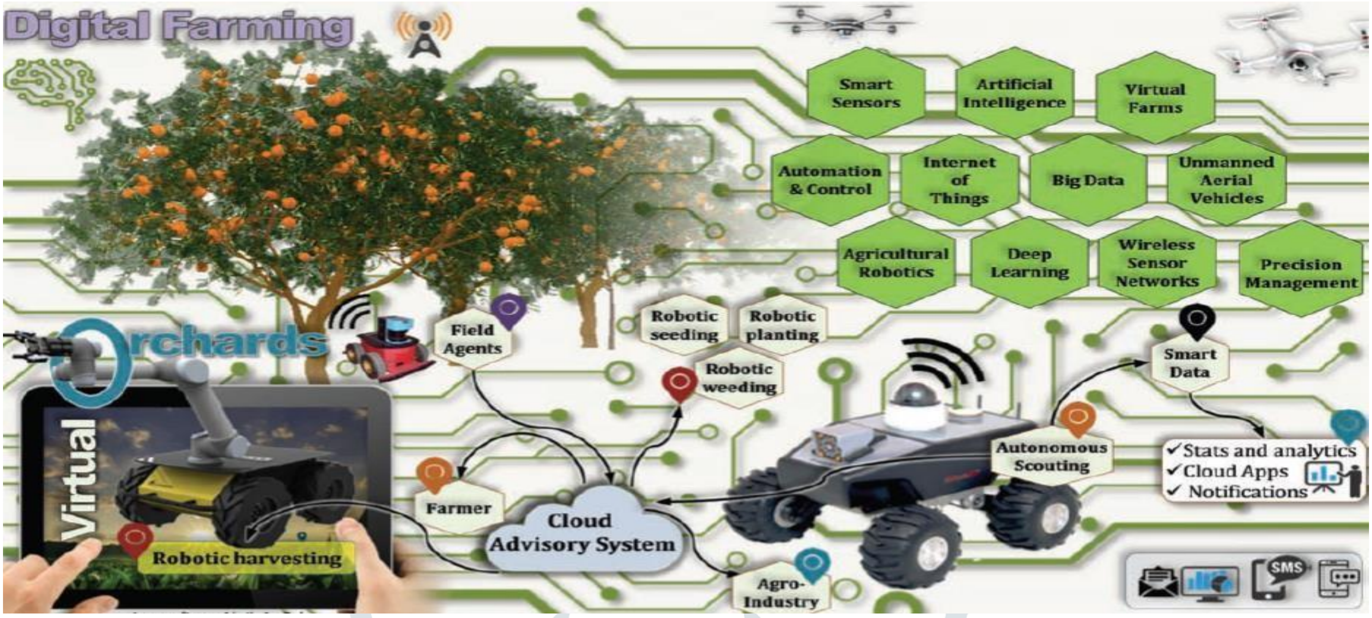

Fig 6. A conceptual illustration of digital farming and virtual orchards with emphasize on the role of agricultural robotics[13]

VII. CHALLANGES IN IMPLEMENTING AGROBOTS

After several years of research now scientists have been able to develop advanced and efficient sensors for collecting information. But data collection is not always ample, it only helps in making better analysis and decision making. Which only reduces our decision making time but can only provide profit if it is supported by efficient management technologies.

One another challenge of using networking in this process is the threat of network being compromised. If the network is being compromised it will cause catastrophic loss for farmers as will create ambiguity in data collected by the farmer. When algorithms are applied on these ambiguous data will abviously produce wrong decisions and predictions and thus will cause a great loss to the farmer.

The next problem in implementing is huge investment these technologies are very beneficial but often benefits come with a cost. Installing robotics equipment in fields comes with a heavy on time investments because the designing of such efficient robots requires a obligatory skill and expertise and also the software used in these robots are very expensive.

Sometimes the system may confuse about the output and may give a wrong output. One of such example is analysis of color of leaf and detecting the disease in plant. The color of leaf may turn yellow due to normal leaf shedding process by a healthy plant or due to lack of nitrogen content in soil or because of lack of moisture. This situation requires machine to interact with human to produce a correct output. But interaction with the humans is not desirable for developing fully automated system.

The other problem with its implementation in developing countries like India is connectivity as the agricultural fields are located in the village areas of the country. The village areas have very poor wireless connection. The main problem with the wireless connectivity signals. We cannot think of robotics system like MARS to be implemented in such interior village areas of a country.

The other challenge is withstanding the wrath of nature some robots might work appropriately in test conditions in laboratories but the things may not work when it comes to a real-time situation. Some of the sensors may even get damaged due to heat or not work appropriately work in excessive cold weather. Withstanding in rain is another a tough task. Robots designed need to be waterproof and be light so that it can be taken out of the field during rain from the marshy soil or need to be implemented with the wheels that could drive robots out of the marshy area.

Maintenance is also a big challenge for the robots because in country like India most of the farmers lack technical knowledge required for the maintenance of the robots. They need either to depend on authorized company for its maintenance or need to hire some technical expert for its maintenance. This will again add up to the cost of total agricultural production.

There has been oodles of research taking place about developing advanced agricultural robots in past few years. The introduction of robots in agriculture has greatly reduced the dependence of framers on labors and helped to overcome the labor shortage problem. With more advanced tools it provides correct decision steps like accurate detection of diseases or find the requirement of fertilizers in plant, detection and removal of weeds. Robots also involve human interaction to come-up with a fully correct outcome. Example of such system is; if a fruit is missed by a robot than human can detect and direct the machine to pluck it.

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