IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 07-12

Robo-bees: Intelligent Farmers for the Next Gen Agricultural Technology

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Abstract: *India is an agriculture based country and its development lies in the advancement of agricultural techniques. This paper discusses the framework for next gen framing based on a combination of precision agriculture and robotic systems. The work focuses on making agriculture domain tech savvy using robo-bees leading to improvement in the yield. Robo-bees are advancement in the field of drones. These Robo-bees are being used to monitor and take necessary decision based on the input provided by the sensor based fields. Robo-bees are of two types; Queen Bee and the Worker bees. The queen bee plays an important role in the decision making process for next gen farming. Queen bee performs the major functionalities like in farming decisions, yield prediction, crop cycle decision etc. and instructs the worker bees to carry out the necessary operation. A farm has a variety of crops planted around and to monitor the environment, numerous sensors are attached to the ground. The sensors are useful in the data acquisition phase; which will help to accumulate the environment parameters such as the fertility of the soil, soil moisture, and weather conditions. This data is sent to the queen bee to identify the matching scenario and to suggest appropriate actions for it. Queen bee informs the worker bees about the decision i.e. whether to spray water or fertilizers as per the need. The robo-bees (worker bees) capture images from various parts of the farm to monitor the plant growth. Pesticides are required or not are identified by analysing the texture of the leaves. Based on the weather conditions, fertility of the soil, plant growth etc. the Queen bee helps to generate an outcome values/ expected yield. Based on above obtained values the Queen bee can also identify which crops can be planted for the next season cycle. The paper identifies problems of system adaption, usability, and feasibility, health of plants and users and energy consumption using literature review. The precise implementation and use of the model will make agriculture more profitable, efficient, environmental friendly and help make the most appropriate decisions.*

Keywords: *Agricultural technology, data analysis, decision making, robo-bees, sensor based system*

I. Introduction

In India agricultural sector accounts is about 16% of GDP. Its impact on the development of the country is huge. The agricultural land comprises arable land, permanent crops, permanent meadows and pastures. Currently, 37.6% of the area in the world is classified as agricultural land by the Food and Agriculture Organization. After the United States, India ranks second in the world with respect to largest arable land with 159.7 million hectares of land. The following fig. 1 shows percentage of land under agriculture over the years in India.

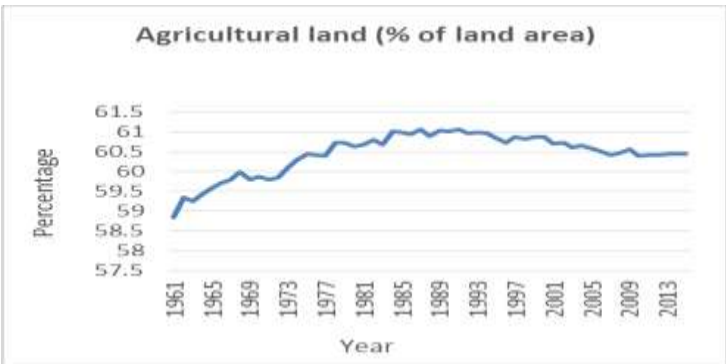

Fig. 1: Percentage of land under agriculture in India

The farmland distribution over various states differs drastically. The reason for the same are due to weather conditions, financial assurance, etc. The farmland distribution under principle crops is displayed graphically below in Fig. 2.

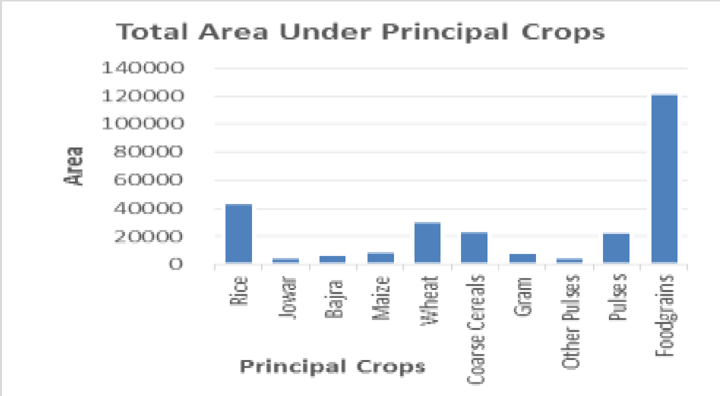

Fig. 2: Farmland distribution vs. principle crops.

The country's economy depends not on the farmland but the yield that is achieved after all those efforts. Yield is dependent on the agricultural techniques, technologies used, farming methods, etc. and may vary based on area as well. The following graph fig. 3 depicts average yield in India based on the production of the principal crops cultivated in our country.

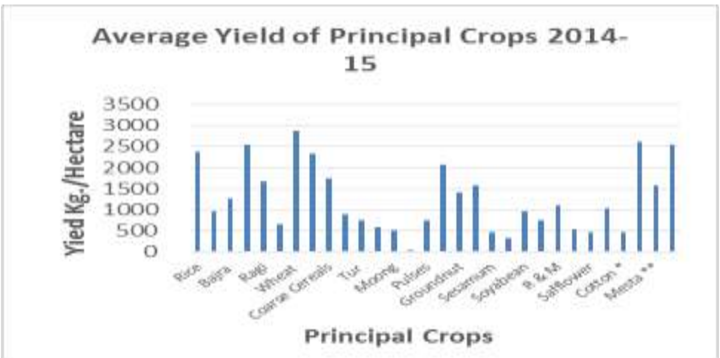

Fig. 3: Average yield of principal crops in India

Agriculture is one sector where technologies evolve at a faster rate for effective farming and better productivity of the crops or plants. Emerging technologies such as AI, robotics, etc. are being implemented in the agriculture sector as well turning heads of various tech giants as well as that of a common man.

II. Need For System

According to the Food and Agriculture Organization, there should be an increase of 70% in food production by 2050 to meet the needs of the ever increasing population. The population is increasing at a rapid rate compared to the production of food. The following graph figure 4 displays estimated population increase in millions from 2012 to the end of the year 2022.

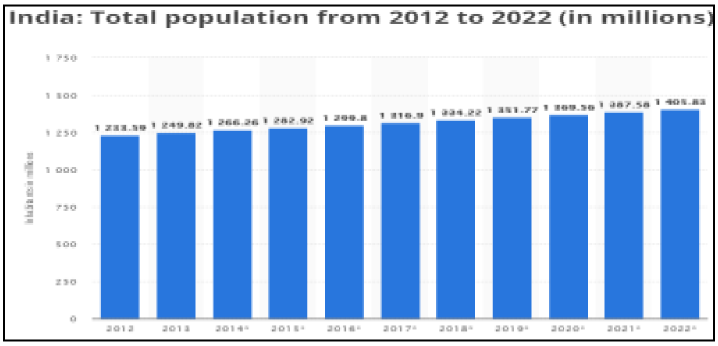

Fig. 4: Population of India

In order to meet these demands, technology including IoT, AI and big data combined can help attain the targets of production. Faster decisions need to be taken to act upon the challenges faced by the farmers to help obtain high yield. The farmers tend to take decisions assuming about certain parameters in the field or about the crops which may later affect the growth or the yield of the crop. For more accurate decisions sensor based inputs can be taken; which can be used to determine appropriate solution using fuzzy systems by the robo-bee (queen bee). Image processing techniques can be implemented using the robo-bees (worker bees) which can help to monitor plant growth and identify the need of pesticides in case of insect attack on the crops. The sensors can also monitor the water moisture in the soil, the fertility of the soil which can help in maintaining the water levels. This will improve the productivity with a reduced cost making agriculture more efficient and help in taking precise decision about planting crop cycle based on the seasons thus increasing the overall yield.

III. Research Objectives

The research objectives are as follows

1. To fulfil the growing demand of food and ensuring agricultural growth.
2. To find out effective and acceptable technological solution this is suitable for small farm lands.
3. To make farming less stress free so that farmers can adopt the technology.

IV. Literature Review

Environment temperature, humidity, CO2 level and sufficient light detection modules are used in wireless sensor network based polyhouse monitoring system. Automatic adjustment of polyhouse is provided in this polyhouse controlled technology [4].

An approach in development of crops monitoring system in real time to increase production of rice plants have been designed and implemented in few projects. Leaf wetness has been checked using motes with sensors [5].

A proposed model was presented in [6]for developing real time monitoring system used in smart agriculture for soil properties like temperature, moisture, pH, pest and disease forewarning. Image analysis and SMS based alerts can be used for crop disease identification. It would be possible to control various operations of the field remotely from anywhere, anytime by mobile as well as web application.

Nelson Sales et al., [7] this paper describes Wireless sensor Networks. Acquisition, collection and analysis of data such as temperature and soil moisture, these three nodes are performed in the network. Decreasing water consumption and environmental aspects are the best benefits of irrigation process of agriculture. An attractive solution for high storage and processing capabilities of large amount of data by the Wireless Sensor and Actuator Network is cloud computing. This activity is particular to agriculture, greenhouses, golf courses and landscapes. The three main components of architecture are - a WSAN component, a cloud platform component and a user application component. A simple protocol for WSAN implementation in a cluster tree topology is SimpliciTI. The soil moisture monitors if plant needs water for its development and sufficient usage of natural resources.

Mohamed Rawidean Mohd Kassimet al., this work describes a Precision Agriculture (PA). Using WSN we can solve agricultural problems like farming resources optimization, decision making support, and land monitoring. It helps in providing real-time information about the lands and crops that will eventually help farmers to take right decisions. Software process control, hardware architecture and network architecture of the precision irrigation system is explained by Precision agriculture systems based on the IOT technology. The maximized yield of crops and the water fertilizer through irrigation is due to implementation of WSN in Precision Agriculture [8].

The data uploaded to the cloud in terms of weather, soil information, moisture content etc. are collected using sensors and GPS. The agriculture related information is uploaded to the cloud using MAD [9] architecture. Applications were the medium through which information was provided to farmers.

One of the proposed solutions provided to the farmers is through SMS. It consists of client and server stub. In this there is a group of application like message process, query process, database and analytical process which helps in receiving queries from client stub and also providing the results back to the client stub. Information about crop, fertilizers, water management, crop protection, and weather and agriculture implementation is provided by server stub [10].

In wireless sensor networks a system is used for technological development known as Programmable System on Chip (PSOC), which conducts several experiments that helps in controlling and monitoring greenhouse parameter of precision agriculture. Irregular distribution of water to the crops can be avoided using this design [11].

V. System Model

The framework of intelligent farming system is shown in fig. 5 and fig. 6 represents architecture of it. Robo-bees are a combination of AI, IOT and drone system where they are miniature drones which use IOT to communicate, send and receive data and signals. The AI implementation in it is used to take appropriate decisions based on network system implementation and fuzzy systems.

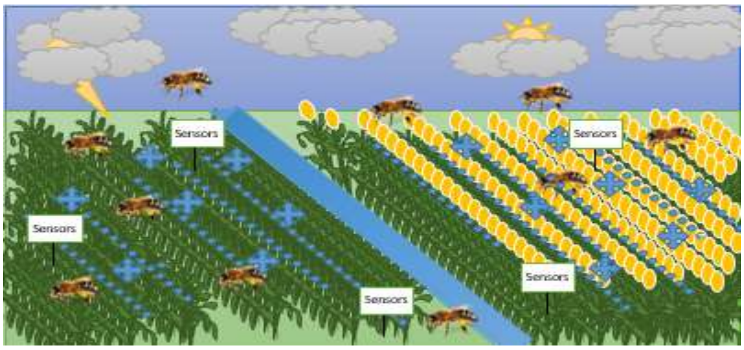

Fig. 5: Framework of Intelligent farming system

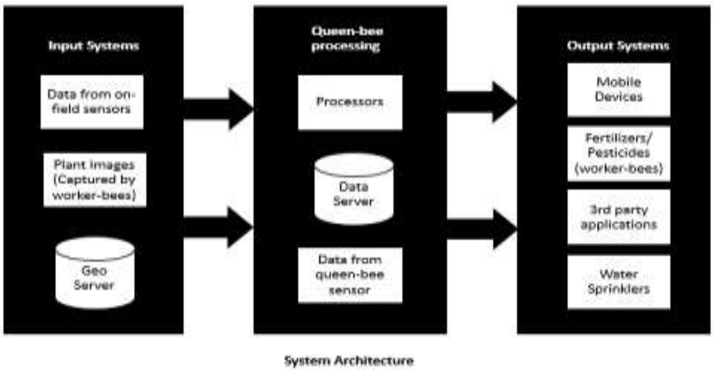

Fig. 6: System architecture of intelligent farming using Robo-bees.

The smart farming framework is carried out into three major sections:
1) Input Systems
2) Queen-bee processing system
3) Output Systems

Input Systems

The smart farming framework constitutes of various components including the network sensors, Geo servers, robo-bees, etc. Multiple water sensors are placed all over the field to check the water content or soil moisture. These sensors send the collected moisture level data to the queen-bee for processing. The queen-bee also checks for the moisture of the soil in places where water level sensors aren't available. The queen-bee uses its own built-in sensors to check the fertility level of the soil by taking inputs from various corners of the field. The geo servers are used to gain information regarding surrounding environment temperatures. The queen-bee instructs and controls the monitoring process of the worker-bees. The trans-receiver in the queen-bee helps send and receive signals to and from other robo-bees i.e., the worker-bees as well as from sensors placed in the field area. As per the instructions of the queen-bee, the worker-bees capture images of plants covering the entire field as per the assigned co-ordinates. The electronic equipment inside the robo-bees that include of the processors, camera and other such hardware are light weighed same as that of an actual weight a real bee can carry. The camera placed inside the eyes of the robo-bees can capture images up to 120 degree wide angle. The processors are light weight and can process at a moderate speed. These images are sent to the queen-bee for further processing.

Queen-bee processing system

The data sent by the on-field sensors is received by the queen-bee which further processes it using a fuzzy system to determine whether the water level in the soil is good enough or not. This helps identify the need for water in the soil on the basis of which the queen-bee informs the water sprinklers about the amount of water supply. Whatever data sent and received by the queen-bee is stored over the data servers which are also used to carry out unsupervised learning for the system. Although certain fixed parameters are included based on the inputs of the farmers taken into consideration the information provided is accurate. The queen-bee consists of the neuromorphic computer chips which minimises the payload of the system. The images sent by the worker-bees that of various parts of the field are used to monitor the growth of the plants. The leaf texture is fed in the data server for variety of crops which the farmer can choose as per the crop being cultivated. The input images are processed by the queen-bee checking for any plant eating insects or the ones harming the growth of the plants. Based on the condition of the leaf, the queen-bee uses fuzzy logic to identify the need for an appropriate action regarding the same. The farmer can select the land type and soil colour can be identified by the images robo-bees capture as these two parameters drastically affect the crop growth. The data queen-bee collected using its own sensors monitoring the soil fertility also uses a fuzzy logic to check the level of the fertility in various parts of the field and takes necessary actions as per the fuzzy result. This doesn't guarantee the results to be perfectly accurate but they are the appropriate resultant values.

Output Systems

The decision taken based on the fuzzy system by the queen-bee to the amount of water that is needed in the fields is conveyed to the water sprinklers which in turn spray water around the field. Based on the leaf condition of the various crops the queen-bee takes the necessary decision depending on the results of the fuzzy logic the pesticides to be provided and in what amount. The type of pesticides also depends upon the type of crop and type of farming practice. The soil fertility inputs taken from the on-field sensors and queen-bee sensors, the fuzzy system comes to a conclusion to the type and amount of fertilizers to be sprayed in the farm. The job of spraying fertilizers and pesticides can be done by the robo-bees with a little improvisation in their mechanism. Time to time updates of smart farming being carried out is given to the farmers to keep them updated about their farm and other activities happening in the same. Based on various parameters taken as inputs and various other observations carried out by the robo-bees, the queen-bee helps calculate an approximate value of yield and production of crops. Also certain parameters like temperature, soil fertility, crop yield help identify the crop cycle and as well as which crop can be planted in the next season cycle. This will help take more appropriate decisions when it comes to farming making it more profitable and efficient. The following fig. 7 represents the data flow of intelligent farming system.

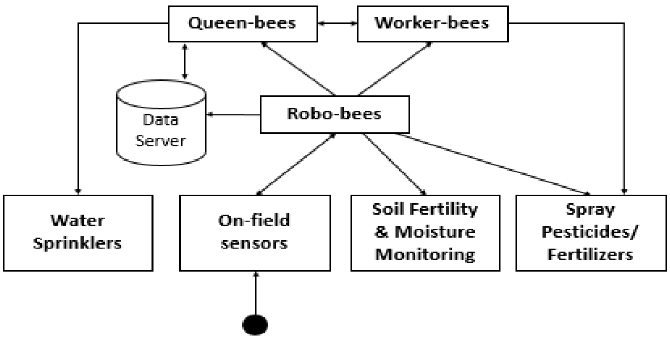

Fig. 7: Data flow of intelligent farming system.

Predictions

The robo-bees will be able to artificially pollinate crops in the coming 10years. This will be a breakthrough as the farmers need not wait in hope for the bees to pollinate the crops instead the robo-bees will do the needful. Precision farming is being implemented in certain areas under tech giants agreeing to work on these fields. In the coming few years large scale precision farming will be implemented as even the government is taking steps in implementing the same. The robo-bees can move places only by flapping its wings. Although if a malfunction occurs there are chances it might just crash. In order to avoid this various sensors and algorithms are being developed so that robo-bees can avoid the crash and even if its crashing it can sustain the same and still manage to fly. These robo-bees can go under water without affecting any of its components. The camera installed inside the robo-bees can be made more advanced with higher resolutions. This can be useful in search and rescue operations as well going into places which are manually out of reach. They can also be used to enter enemy zone without actually depicting its presence due to its tiny size.

Advantages

- The system helps take appropriate decision with respect to crop season cycle, supply and production.
- Connection oriented system
- If a queen-bee fails due to any conditions, one of the worker-bee is made the new queen-bee.
- It predicts total yield of crops based on parameters it identifies and also given as input by the farmers.

- The system is simple to use and has high usability.
- A lot of research is being carried out on robo-bees which assure further enhancements in the same.
- Precision agriculture helps attain viability in farming and take appropriate decisions for farmers.

Disadvantages

- The manufacturing cost of the robo-bees is high if not manufactured in bulk.
- The system is not cost-effective for farmers.
- Not applicable for very small farms.
- High chances of robo-bees crashing due to its flappable wings.
- Monitoring of robo-bees is necessary until certain advancements.

VI. Research Hypothesis

The proposed framework implementation suggests improvement in profit, yield and environment friendly option. Let the null and positive hypothesis are as follows

H0: Farmers will stick to traditional farming method.

H1: Farmers will accept the Intelligent Farming System.

VII. Conclusion

The major goal of this research paper was to bring the advancements of robo-bees in the field of agriculture. Robo-bees which are a combined technical invention of technologies including AI, IOT and drone system can be brought to use as per the necessity of human intervention. Various research papers, inventions and enhancements are being carried out using robo-bees in various sectors although agricultural sector remains untouched leaving the crop pollination part of it. Precision agriculture has high impact on the production and yield compared to the traditional farming practices being carried out all over. Combining robo-bees and precision agriculture a huge amount of improvisation can be carried out in the agricultural sector whether it is supplies, production, total yield, etc. Although it isn't that cost effective but if carried out on a larger scale and with a little help from the government can help make it possible.

Going through various research papers one thing is sure, i.e., the speed in which new advancements are happening and various other enhancements are being proposed in the agricultural sector. With the use of the system proposed in this research paper there are high chances of increasing the food production in the country. Although it's difficult to convince the farmers doing traditional farming, with the changing technologies the farmers will get involved in it too with the help of a little bit of marketing of the system. The Proposed system which is a combination of robotics and precision farming will help achieve profitable and efficient farming.

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