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Original Paper : Applied Research – Experimental Research Paper

Energy-Efficient IoT based Precision Smart Agriculture Monitoring System for Enhanced Crop Fruitage

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Abstract: One of the In our technology, we successfully decode gene sequences and transplant seeds from various sources to produce greater productivity within crop yields in a shorter period of time. In a non-progressive way, its technology can have an impact on health issues and also go a long way towards preventing hunger. One of the world's more pressing issues is hunger. Considering important assessments of yields of crops, it is projected that worldwide populations could reach 10 billion and 11.5 billion by 2100, as reported by UNICEF, the Global Hunger Index (GHI), the Global Report on Food Crises (GRFC), and the UN Department of Economic and Social Affairs. It is expected that food production will improve accordingly. Technology advancements must be incorporated into the cultivation area to meet these needs. A major area of agricultural development innovation is the Internet of Things. By using this system, we can enhance the productivity of crops at a lower cost than smart farming. In order to analyze crop data, a variety of sensors are used, such as soil sensors, pest sensors, and environmental sensors. An increase in crop yield can be achieved through either automated or manual controls. Urban agriculture products can be organic and secure because less pesticides, chemicals, and manpower are used. In addition to reducing global warming, the system also produces automatic afforestation.

Keywords: IoT, Smart Agriculture, Global Warming, Synthetic Aperture Radar.

1. Introduction

Approximately 9.8 billion people will live in the world in 2050, and 11.2 billion by 2100, according to the United Nations division of economic and social affairs. In proportion to the growing population, food productivity and agriculture are in demand. Food production needs to be increased by around 70% in order to meet food requirements for the improved population, according to FAO (Food and Agriculture Organization). Due to the growing global population, it is imperative to enhance farming facilities exponentially to meet the growing demand for food. It is common in rural regions for farmers to be unable to supply and control crop needs.

Some of these problems include improper irrigation, seeding at the wrong time of year, a lack of knowledge of soil characteristics, unpredictable changes in the environment, and improper field protection. It is possible to conserve the needed resources and improve the quality of products in cultivation by using efficient irrigation, fertilization, and pest management methods [4].Food production is being challenged by a drop in labor in rural areas and an unexpected increase in production costs. According to the FAO, plant diseases and pests damage 20-40% of global crop yields [6]. There is a consistent devastation by pests and insects of as much as 30,000 crores worth of harvests in India, causing farmers to use pesticides [7].

It is imperative to have smart farming in order to meet production needs in an efficient manner as a result of the growing population [8]. As a result, modern technologies and connected devices are being implemented together in agricultural production. In addition to maximizing resources and data sources, the Internet of Things provides numerous benefits [9]. Providing solutions to farmers through smart farming reduces the maximum challenges farmers face. Through IoT, crop production can be improved while requiring less effort and manpower, which results in higher quality. Many people prefer organic food over conventional food these days, but most farmers use pesticides and chemicals inappropriately for early and huge productivity[10]. Global warming is attributed not only to damaging human health, but also to damaging the environment.

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1.1. Role of IoT in Agriculture Diagram

Several research studies have shown that the Internet of Things (IoT) can lead to precision farming, leading to significant increases in yield [11].

Using IoT, it is possible to monitor and control crops throughout their entire lifecycle. In addition to irrigation, soil preparation, seeding, pest control, fungicides, herbicides, animal control, crop monitoring, harvesting, and storage monitoring, there are several other areas that are controlled.

Precision farming can only be accomplished with the full use of the Internet of Things in agribusiness and it will lead, specifically, to addressing the food crisis of the world as its population increases [12]. By avoiding many of the current challenges, sensors that are easier to use and secure organizations can fuel further applications.

In addition to performing regular exercise and consuming nutritious and hygienic food, people nowadays are also becoming more conscious about leading a healthier lifestyle, which promotes the use of organic foods globally. As far as organic products are concerned, they are those that are grown without synthetic chemicals, such as pesticides and fertilizers made by humans, and do not contain genetically modified organisms. By ignoring or optimizing pesticide chemicals in agriculture, this emphasizes the organic products from cultivation.

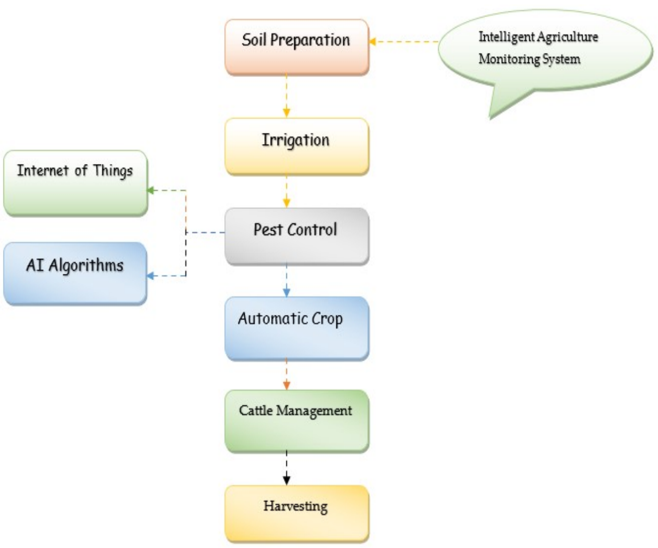

Fig. 1. Agriculture working process using IoT

People are becoming increasingly interested in how farmers combat pests as the organic market grows. Organic farms are being encouraged to pursue them today. In spite of producing good food, organic farming is more expensive, requires more jobs, and cannot supply enough food to feed the world's population.

1.2. Challenges in Agriculture

- Low manpower
- Lack of awareness of advanced technologies
- Lower financial support
- Impact of real-estate
- Unexpected climatic conditions
- Poor and Fewer irrigation facilities
- Unexpected interrupts in the power supply

2. Related Work

Agricultural research and development are constantly evolving based on technological advances. There are numerous IoT-based systems available for smart cultivation to improve crop quality. Different analysts have concluded their way forward and potential for further development based on their findings.

Paolo Visconti et al. To support decision-making by using IoT-based smart traceability and farm management, the system automatically adjusts irrigation and fertilization based on crop type and augmentation, soil and environment constraints, and weather conditions.

Kaushik Sekaran et al incorporated sensors, actuators, and other devices to build an IoT-centric cultivation framework to collect, analyze, and atomize cultivation processes [12].

Prem Prakash Jayaraman and others.SmartFarmNet The IoT system can automate the collection of data on soil, fertilization, and irrigation by using sensors, cameras, weather stations, etc. It can then compare and filter the data, storing it in the cloud for analysis and recommendations [13].

Uferah Shafi et al. detailed the installation of sensors in the field to collect accurate data and determined that a dynamic IoT-based smart system for monitoring produce health in precision agriculture is feasible [14].

Plant diseases and pests pose a significant hazard to agriculture and forestry globally, as stated by Jingcheng Zhanga et al. Enhancing protecting the plants may be simplified by creating non-contact, highly efficient, and cost-effective techniques for detecting and tracking plant diseases and pests over vast regions.

Nanidia G.S. Campos et al. [16] have created an advanced intelligent an irrigation system that utilizes soil moisture levels for monitoring, pre-processing, merging, synchronizing, and storing data.

Yingying Dong and colleagues developed an automated framework for collecting data from various sources, as well as models and algorithms for catastrophe prediction and monitoring, together with thematic

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maps. To create many feature modules with high cohesion and low coupling, various technologies such as Internet, remote sensing, and GIS are integrated comprehensively [17].

With the help of various sensors and IoT frameworks, Donzia et al. developed an intelligent system to improve crop productivity.

A motion-sensor-based IoT-based pest control system developed by Suzi Seroja Sarnin and et al. that detects pests and objects and sprinkles insect repellent accordingly [19] is described in a study by Suzi Seroja Sarnin and et al.

Using IoT and image processing technology, K.Saranya et al. developed a pest management system that would reduce pesticide use by controlling pests, as suggested earlier. Using the heat emitting by insects' bodies as a source of heat, an infrared sensor (PIR) can be used to detect their presence.

IoT-based irrigation management system developed by Fidaus Kamaruddin et al for reducing manpower needs and reducing water waste [21].

Using a system established by Doshi et al. , framers can carry out smart forming to maximize resources and increase yields by using field data available to them [22].

According to Victor M. Larios et al., they propose using IoT to eliminate water foot printing in agricultural crop fields, which in turn reduces carbon dioxide emissions by optimizing energy consumption. When the levels are tiny, the system alerts the farmer [24]. Kodali et al. propose a structure for the minimal effort screening of agricultural farms.

Using a network of sensors such as an air temperature sensor, a soil pH sensor, a soil moisture sensor, a humidity sensor, an air flow sensor, and a water volume sensor, Rahul Dagar developed an IoT-based device for monitoring the supply of water to the fields in a smooth manner in order to minimize water and energy loss.As a result of the challenges in the agricultural sector, Akash Sinha et al. developed a user-centric IoT architecture to meet the needs of growing populations [26] to enhance the competitiveness of agriculture. To allow users to access plantation data whenever and wherever they need it, Yixiong Wang et al. developed a plantation monitoring system for data collection, data transfer, and data analysis. According to Bauer et al., an agriculture system for smart farming has been designed, which utilizes a server-based system to store and analyze data, as well as monitor crop growth with precision. IoT-based monitoring system developed by Prathibha S R et al. senses temperature, humidity, and photos of crops to capture data, and wifi is used to communicate with the user.

UN sustainable development states that "end hunger, achieve food security, improve nutrition and promote sustainable agriculture" [27]. Also, the UN department of economic and social welfare said that the global population could reach 9.8 billion by 2050.FAO estimates that by 2050, food requirements in proportion to the growing population will need to be doubled in the agricultural field. In addition, they aim to ensure that all people have access to sufficient, secure, and high-quality food to run a healthy lifestyle.Our objective was to promote sustainable agriculture in a way that is economically feasible with quality products while also encouraging sustainable agriculture.

3. Proposed Work

With the growth in population statistics, the proposed system would take care of agriculture fields using the Internet of Things in order to meet the population's food needs. Sensors used in the system include temperature sensors, humidity sensors, smoke sensors, touch sensors, soil moisture sensors, and sound detectors. As a result of these sensors, data can be gathered. Based on the collected data, control actions can be applied. It is necessary to compare soil moisture values with those in the table in order to optimize water resources so that either the manual supply or automatic supply of required water quantity minimizes water wastage [27-29].

3.1. Methodology

System Architecture

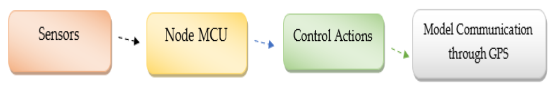

Fig. 2 General Architecture

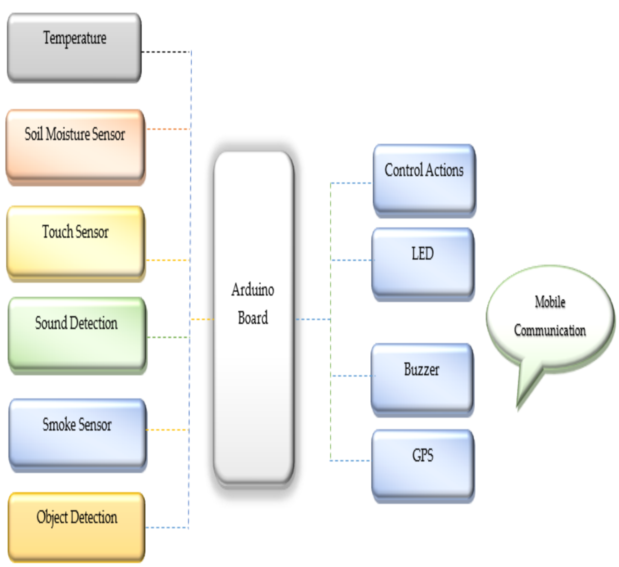

Fig. 3 System Architecture

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Common sensors used in identifying plant diseases and pests include visible and near-infrared spectral sensors (VIS-NIR), fluorescent and thermal sensors, synthetic aperture radars (SAR), and light detection and ranging systems (LIDAR). In our research, we utilized an inexpensive sound detection sensor capable of identifying prevalent pests based on the frequency values. A fire accident can be controlled by spraying water based on the severity of the smoke sensor reading. Detecting and controlling pests at an earlier stage can reduce or optimize pesticide usage. The system also detects objects that damage the fields, such as animals or other objects [30], and these objects can be controlled either manually or automatically. In addition, the system also communicates the field's data and status to the user's mobile devices.

3.2. Algorithm to Pump Water

The logical view of the System

Step-1: Initiate the system
Step-2: Interpret the field data
Step-3: Collecting data from sensors
Step-4: Examining the collected data to initiate the required control measures
Step-5: Notify the user of the issue via mobile communication. Repeat the previous steps.
Step-6: Retrieve data from the moisture sensor
Step-7: Analyze the correlation between the reading and soil condition.

a) Soil moisture readings ranging from 0 to 100 do not require water pumping.
b) When the moisture level is between 101 and 400, adjust the water delivery according to the type of crop.
c) When the reading is between 401 to 700, it means the moisture level is at 50%. Water the crops according on their specific water requirements.
d) The moisture level is 20% in the range of 701-1000, determined by the crop's water supply management.
e) A soil moisture level of 1001-1023 indicates dry soil. Commence pumping water based on the needs of the crops.

Step-8: Reiterate the procedure.

Pest-Classification

Pest Classification Control Logic
Default threshold value = 29HZ
(based on environmental conditions)
((threshold value<100HZ)&&(threshold value>70HZ))=Rodents
((threshold value<70HZ)&& (threshold value>40HZ)= Insects
(threshold value>200)=others

Sensors & their Use

Table 1. Sensors and their usage

Sensor	Purpose	Threshold Value
Insects	Green	5-15 KHz
Insects	Bird Cherry oat aphid	20 KHz
Insects	Corn leaf aphid	30 KHz
Rodents	Mouse ERG	-2.20 KHz
Rodents	Mouse VEP	-5.23 KHz
Others	Climate	50 KHz

Pest Detection-Using -Sound Frequency

Table 2. Sound Frequency Range.

Sensor	Purpose
Soil Sensor	Water Content in Soil
Fire Detection Sensor	Smoke Content in the air
Touch Sensor	Detects and records physical touch
Sound detecting Sensor	Detects noise level
Animal Detection Sensor	Detects the presence of wild animal objects

4. Experimental Results

The research utilized an actual-time setting, and the results are depicted above through graphics showcasing different choices.

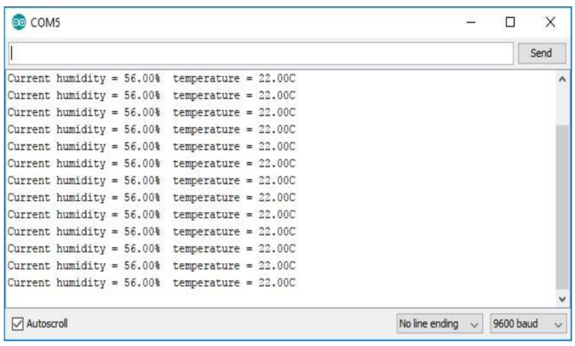

Fig. 4. Working of Humidity and temperature Sensor

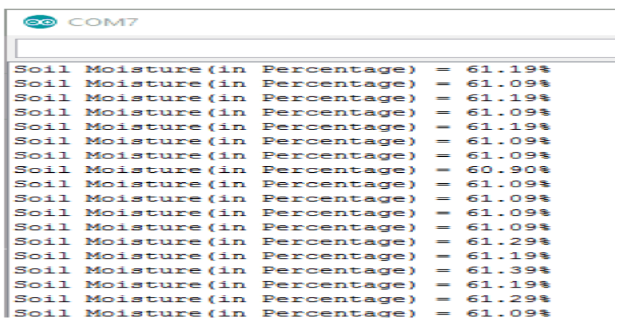

Fig.5. Working on Soil sensor

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Fig. 6. Detecting Pets and Bugs

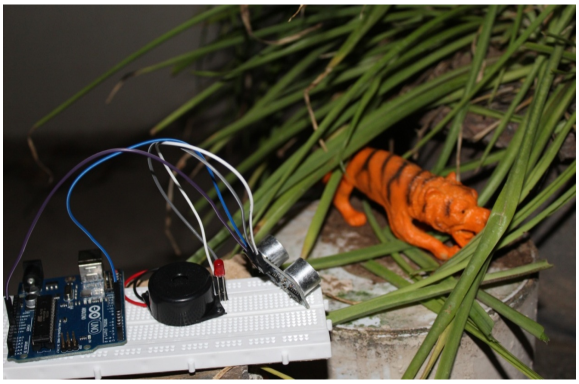

Fig.7. Object Detection

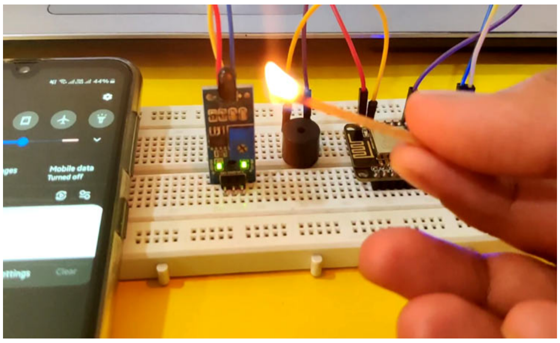

Fig.8. Fire Detection

Comparative study of Existing methods and proposed system for pest control

By developing a model that is affordable to most people, especially those who are farmers, the proposed work aims to accomplish this. Based on the results, it is clear that overall communication among devices is feasible and data is adequately collected. In the process, the main concern is detecting pests based on their thresholds. Manual checking requires a greater amount of personal involvement than the previously described models, because it takes longer to identify problems and other issues. It is important that a person has an understanding of the crop and its seasonal changes, as well as the weather conditions, when trying to detect seasonal changes. Genetic seed manipulation is expensive for practical applications.

Table 3. Comparing Proposed work.

Model	Cost	Accuracy	Scalability
Manual Checking	Expensive	Low	No
Seasonal Detection	Expensive	Low	No
Genetic Seed Manipulation	Expensive for Practical Application	Low	Less Significant
Image Processing	Expensive	Low	Less Significant
Smart IoT proposed Methodology	Low	High	High

Automated detection and warning systems have been developed to reduce the manual intervention and increase efficiency. These systems use sensors to detect the presence of pests and send out an alert when a threshold is reached. Automation also allows for better data collection and analysis of the data.

There are high risks associated with it, including disruptions of the ecosystem and gene flow. With the use of IoT and image processing techniques, farmers have been able to capture images of pests and process the information so that they can further determine what they can do to eliminate pests and other factors that affect them. As a result of this data, farmers can determine the best course of action to take to prevent pests from spreading and damaging their crops. Finally, it can also be used to monitor the success of pest control treatments by tracing pest spread and letting farmers know they need to take preventive measures. This data can also help farmers identify which pests are most prevalent in their area, allowing them to take targeted action. Additionally, it can help farmers to determine the best pesticides to use, and the best times to apply them to their crops.

The proposed methodology offers the end user a dependable model of the tools and technology utilized [35-36]. Since it is less time consuming, accuracy is high, and scalability is important since the system can adapt to updates whenever necessary. Additionally, the methodology can be used by non-technical personnel, making it more accessible and user-friendly. Furthermore, the model is extensible, allowing it to be easily modified to fit new requirements.

5. Conclusion

In order to perceive pests, bugs, rodents, and insects, a low-cost Internet of Things (IoT) centric intelligent farming system was designed and constructed with sensors that sense soil moisture, humidity, temperature, smoke, and ultrasonic and sound signals. A control action is initiated

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by the system based on real field data to optimize resource wastage and crop quality. This system can be used to identify and target areas of infestation, allowing for more efficient pest control and management. It can also be used to detect early signs of diseases and pests, helping farmers to take preventive measures. The use of a low quantity of pesticides can prevent timely detection of pests. It is also responsible for controlling cattle, other types of living, and non-living organisms that are damaging the fields, among other things. There should be subheadings in this section. These should summarize the experimental results, interpret them, and draw conclusions from them. The conclusions should include recommendations for further research and implementation. They should also suggest potential applications for the research findings. Finally, the section should identify any limitations or risks associated with the research results.

Thus, the proposed system provides quality agricultural production at low costs to meet the food demand as a function of population growth with a limited amount of manpower at the same time. Additionally, the system can be used to monitor roadside plantations, thereby controlling global warming by improving greenery. This, in turn, helps to reduce air pollution and improve public health. Furthermore, the system can also be used to conserve natural resources, such as water, soil, and biodiversity.

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