IFSG: Intelligence agriculture crop-pest detection system using IoT automation system

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ABSTRACT

The agricultural and technological combination is blessed for modern world life. Internet of things (IoT) is essential for comfort and development to our agriculture side. In our study, we detected the various pest using different types of sensors and this information has automatically sent to the farmer's mobile for the alert. All these sensors had a central database. Those sensors collect all the data and display the results compared to the central data. The High-image sensor will be able to detect all the rays emitted from the plant and another one is the gas sensor which is able to detect all the gases coming from the diseased plant. We mainly use sound sensor, MQ138, CMOSOV-7670, AMG-8833 for a better automation system. We test it with real-time environment conditions (40°C≤T_A≤14°C). Crop pest detection automatic process is more efficient than the other detection process according to testing output. As a result, far-reaching changes in the agricultural sector are possible. To reduce extra cost and increasing more farming ability we need to IoT and Agriculture combinations more.

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1. INTRODUCTION

Nowadays, the technological revolution is a great blessing for humanity. Similarly, Food is very essential for human life which depends on agriculture revulsion. For the great revolution we have proposed a collaboration between agriculture and internet of things (IoT) [1]. This combination is very helpful for farmers to cultivate. In our study, we have developed an automation crop pest detection [2], [3] system based on the image, sound, fluorescence, and gas base (ISFG) sensor method. To identification plant diseases or pest attacks, we develop an automation process. This process is active when any harmful causes are affected by pests. ISFG sensor method is a newly invented method which is we proposed. ISFG refers to imaging, sound, fluorescence, gas base sensor integration system. Crop pests are animals or plants that damage object crops in the farms. Trees are usually infested by insects, bacteria, and fungi. They are a serious threat and avail to over 30-50% retrenchment in farm yield. For the detection message transfer, we use global system for mobile communication (GSM) module and a wireless fidelity (Wi-Fi) monitoring module system. Our main focuses are given:

- Sensor-based pest detection system.
- Agricultural crop health monitoring based on image sensing.
- IoT based automatic message transfer system.
- GSM network system base integration circuit device integration.
- Cost reduction and high longevity device develop for the alert and detection method.

This automation system is twopenny and made with advanced technological materials. Wireless data access is a well-planned get-way to save time so that we attach this module [4]. The internet of things (IoT) is one of the best technology in this era so that we could be a benefit to use it for excellent life and technological expedition.

2. LITERATURE REVIEW

Insects pose a significant risk, also cause two types of harm to crops in the growth stage. The eating insects, which eat leaves or burrows in stems, fruit, or roots, cause direct damage to the plant. The second sort of damage is indirect damage, in which the insect causes little or no harm to the crop but spreads a bacterial, viral, or fungal illness. When it comes to rodents, seeds, leaves, roots, complete young plants, fruit, and grain are all on the menu. Sugar beet and potato viruses, for example, are spread by aphids from one plant to the next. Li *et al.* in their research, image segmentation algorithms were applied to segment the destination motive and preprocessing method deals with the images that have considerable extent differences between the color of the pest and the conditions. The main systems include thresholding, contour detection, and watershed algorithm [5]. Nagar and Sharma in their research, the main objective of this method pest's detection of plant parts such as roots and leaves using capturing of plant leaves as data collection and then feature extraction. Proper setup of the wireless camera network which is connected with Sticky traps for insect pests capturing. CISCO Linksys Wireless-G camera was used as latest technique. The filtering process clears the noise from the image appearance due to variable lighting conditions with image extraction method for the output image [6]. Durgabai *et al.* in their research, the yield production has condensed due to numerous influences like pest attack, diseases, and climatic surroundings. Crop protection is the science and repetition of supervision pests, plant diseases, and other pest creatures that damage agricultural crops. Machine learning is an imminent field of computer science that can be applied to the agricultural segment quite effectively. SetActionThresholds, Monitor and Identify Pests, Prevention, Control are the following steps. Bug detection using images of crop leaves has been employed using a pattern recognition branch of machine learning [7]. Wang *et al.* in their studies, whiteflies abdomens are yellow and their wings are the tranquil stage to detect, mature adult whitefly was selected as the target insect at full growth in this study. Veins are the vascular tissue of a leaf that has a lighter shade, so when segmenting a leaf image veins may be detected as whitefly by the algorithm. Three digital morphological features of an ellipse, major and minor axis lengths, and eccentricity, are commonly used to remove veins form images. The main miscalculation of their research was segmentation occurred when the whiteflies or the eggs overlapped with the veins because the proposed method was unable to deal effectively with this situation [8]. Brunelli *et al.* in their studies, an automatic process was occupied for monitoring parasite insects from images taken in pest traps as well as an intelligent sensor and communication system can be smeared in agricultural monitoring and control. Deep neural network (DNN) training contained approximately 1300 pictures and was incremented when more insects were trapped for the period of the initial testing. Codling moth and general insects were two classes of the dataset in addition detected object is to a general insect or the target Codling Moth provided by DNN [9]. Saranya *et al.* in their research, a controlling system for pest which collaborated the existence of pests in the farming land through Passive infrared sensor and image processing method which produces ultrasound that was insufferable to rodents and insects [10]. In the agricultural monarchy, detecting crop disease and pests is a serious difficulty. Traditional pest detection procedures are difficult, time-consuming, and prone to mistake. In recent years, there has been a greater focus on research studies on the use of various strategies in the field of agricultural pest management.

3. SYSTEM ARCHITECTURE AND MODEL

In our study, we separate our main model into two independent sub section one is the proposed model and another one System Architecture. For the IoT device structure measurement or design modeling of the device is very undoubtedly essential to go to the next procedure. Nowadays, development in IoT [11] and tracking system has solved our conventional and egregious problems more efficient way. For Accurate modeling and execution, we have designed two Architectural models so that any inconsiderable address of modeling point can evidently be identified.

3.1. Proposed model

In this section, we have designed an automated system that is set up in the Agri field. In This system, we are using four basic advanced sensors [12], [13] for pest detection and monitoring. For the automation process, we established a GSM module and also Wi-Fi connectivity. Our main target is SMS alerts to the end-user or Farmer about the field situation. In Figure 1 we set up all components into the Arduino device. This model is very advanced as well as low cost.

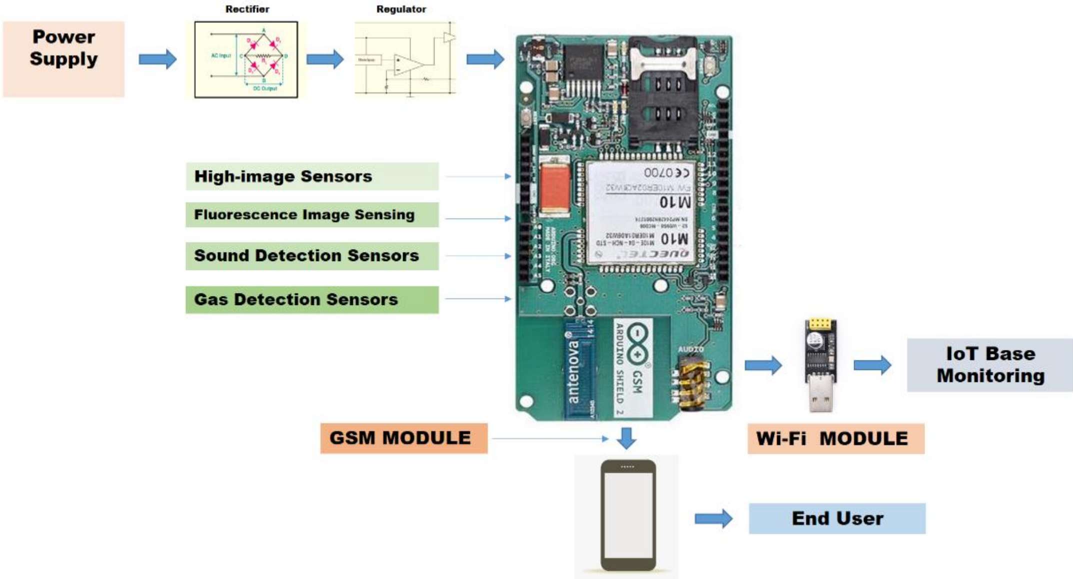

Figure 1. Device organized process model

3.2. System architecture

In this system as shown in Figure 2, we used four cheap and highly sensitive sensors to monitor, detect and prevent pest attacks in the agricultural field. By using these four, we made an automated device that can analyze data from previously stored and programmed by Arduino Uno R3 and have the ability to send data to users about real-time pest information of his field with having a long-distance using GSM SIM00A Module.

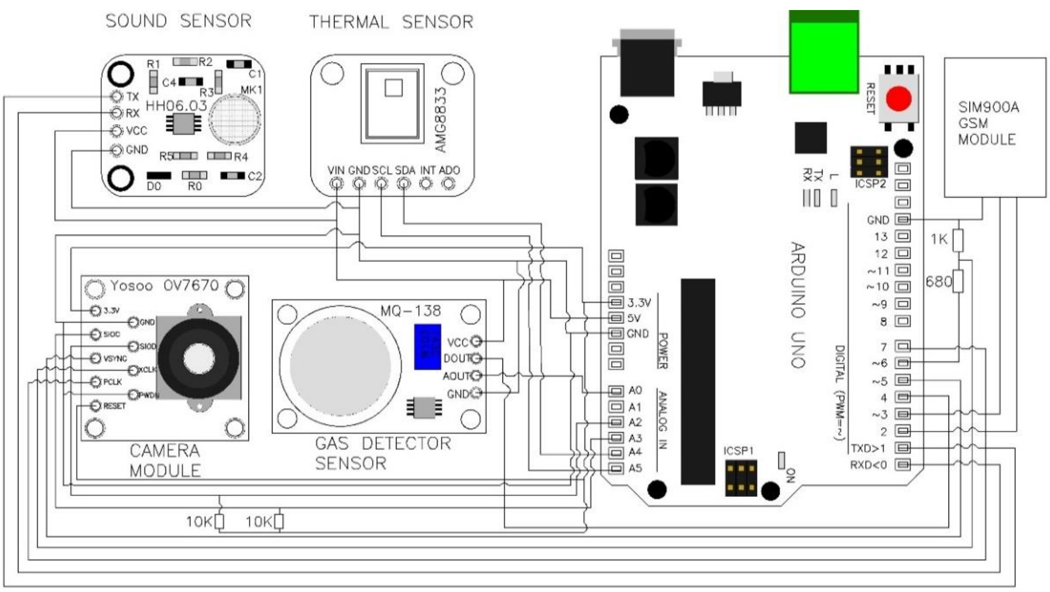

Figure 2. Circuit design for IFSG automation system

We have six hardware in our system those are decibel detection sensor HH06.03, thermal sensor using AMG8833, camera module 0v7670, gas detection sensor MQ-138, Arduino Uno R3 and GSM SIM900A module. In this System, we used four cheap and highly sensitive sensors to monitor, detect and prevent pest attacks in the agricultural field. By using these four, we made an automated device that can analyze data from previously stored and programmed by Arduino Uno R3 and have the ability to send data to users about real-time pest information of his field with having a long-distance using GSM SIM00A Module. We have six hardware in our system those are decibel detection sensor HH06.03, thermal sensor using AMG8833, camera module 0v7670, gas detection sensor MQ-138, Arduino Uno R3 and GSM SIM900A Module.

– Sound sensor: We know that pests are using 30dB to 52dB for their internal communication. Pests use to attract their opposite sexual making noise between 200Hz to 600Hz [14]. Here we used a sensor to catch and analyze their sound. A decibel detection module sound sensor with serial transistor-transistor logic (TTL) output having 30dB to 130dB and 40Hz-8 kHz Sensitivity is used, its model name is HH_06.03. It's so cheap. As it can be operated in 5V it's so easy to connect it with the Arduino Uno R3 board. Its VCC and GND are connected to Arduino's 5V and GND. HH_06.03's 'TX' and 'RX' Pin will be connected to TX and RX of Arduino Uno R3 as this sensor have transistor-transistor logic (TTL) output. It will analyze the ambient noise and will identify the sound as programmed in a specific range as It is pests sound or not. It will identify the noise of pest wingbeats or sound by their mouth of anything else for their basic instinct [15].
– Thermal sensor: This sensor is used to sensing fluorescence [16]. Chlorophyll fluorescence will be identified by this sensor as a healthy leaf's fluorescence data will be stored previously. By analyzing the stored and real-time pictorial view the Arduino will say as programed whether it is attacked by pests or not. Here we used the AMG8833 Thermal sensor module. Its SCL and SDA Pin are connected to A5 and A4 in Arduino Uno consecutively. VCC and GND are connected to 5V and GND in the Arduino Uno board.
– Camera module: Here we used a CMOS OV7670 Camera Module 1/6-Inch 0.3-Megapixel Module to identify pests. This camera module will sense the major change in its image [17]. This camera module has an image array capable of operating at up to 30 frames per second (FPS) in VGA with complete user control over image quality, formatting and output data transfer. All required image processing functions, including exposure control, gamma, white balance, color saturation, hue control and more, are also programmable through the SCCB interface. It's so easy to connect with Arduino Uno R3. The camera module is properly connected with Arduino Uno R3 as a given circuit diagram.
– Gas detection sensor: An MQ-138 Gas detection sensor is used in this automated system. It has a widespread tracking scope, rapid response and strong sensitivity, fixed and long life and having a simple drive circuit. It is used in Breath alcohol detectors, solvent detectors, Air quality control types of equipment for buildings/offices. It's VCC, DOUT, AOUT, GND Pin connected to 5V, A1, A0, GND in Arduino Uno R3 Board. Ethylene, nitric oxide, jasmonic, methyl jasmonate, ocimene, limonene, plastoquinone, geraniol, linalool, citronellol, and lycopene are different VOCs that come from plants. This sensor will identify some of those compounds and identify the health of the crop.
– Arduino Uno R3 and GSM SIM900A Module: In this project, Arduino Uno R3 is used to analyze collected data from those four sensors. Sometimes it's analysis data that is previously stored by the program. On the other hand, GSM SIM900A Module is used to send data at the user end. GSM Module can send data with a long-distance and at any situation like dense fog or heavy rain.

4. METHODOLOGY

For the research study, we associate all materials composed of a microcontroller and different kinds of advanced sensors like IFSG sensor, GSM module, crop and sensor collaboration. All data from the GSM Module would be received on a pest detection device and the Arduino would also send the regulating action to the chip by efficient C++ programming.

4.1. GSMSIM900A module structural setup

The SIM900A is an essential and unique GSM/GPRS module used in different kinds of IoT fields. The module can also be utilized to develop IoT and Embedded Applications. It works in the 900-1800 MHz frequency range. An RS232 interface is included with the modem, allowing you to connect a PC as well as a microcontroller with an RS232 chip (MAX232). The inbuilt TCP/IP stack in the GSM/GPRS modem allows you to connect to the internet through GPRS.SIM900A GSM/GPRS Modem Features: (1) Input Voltage: 12V DC (2) Supports MIC, Audio Input & Speakers (3) Dual-Band GSM/GPRS 900/ 1800 MHz (4) RS232 interface selection (5) Lithium battery Interface (6) Configurable baud rate (7) Antenna (SMA antenna interfaces) (8) SIM Card slot (9) Network Status LED (Built-in) (10) Built-in powerful TCP/IP protocol stack for GPRS internet data transfer (11) DATA GPRS: download transfer max is 85.6KBps, Upload transfer max 42.8KBps. In Figure 3 shows the full stracture of this module structural setup.

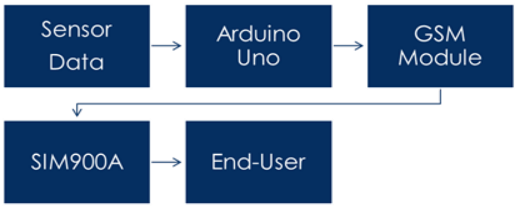

Figure 3. GSM SIM900A protocol

Connection setup: nowadays, we interface a GSM module with an Arduino module to send data. The advantage of the GSM module signal is available in a wide range of areas. GSM module works with AT commands. Using IoT connections, we have recorded data from a farmer's field. In this article, we are going to set up a circuit diagram of Arduino to interfacing the GSM module. To send sensor data to Arduino Uno R3 and receive SMS alerts, we have used the SIMCOM, SIM900A-GSM module. It’s pretty simple to interfacing with Arduino and GSM modules in Figure 4.

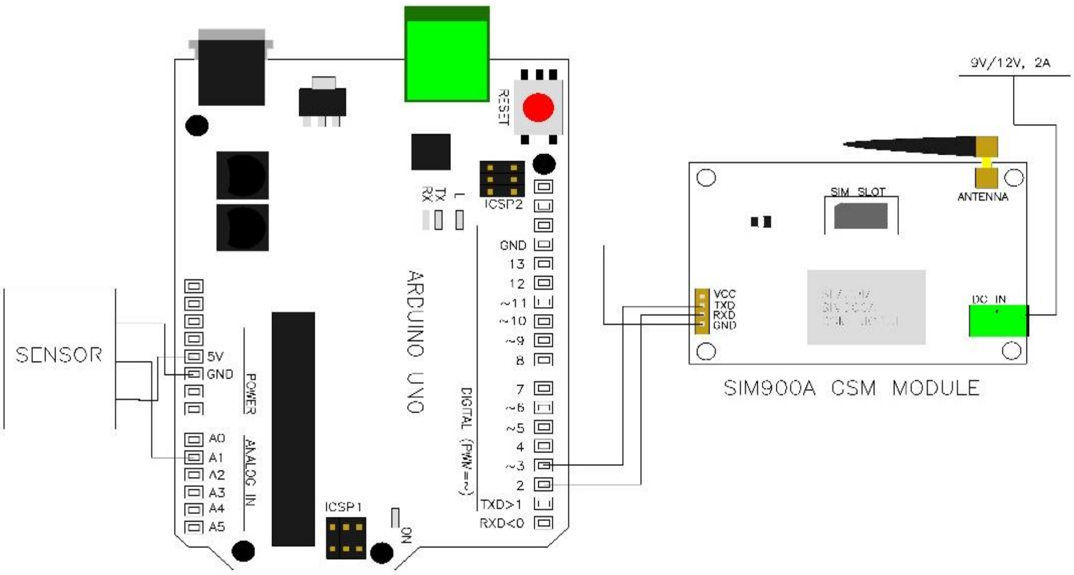

Figure 4. GSM SIM900A structural function

4.2. Crop pest functional analysis

Insects, viruses, and fungi attack sometimes cause a huge of damage in the agricultural sector. To avoid this problem, we worked on 4 sensors: sound detection sensor, fluorescence sensor, high-image sensor, and gas sensor. As a result of these 4 sensors, any disease can be detected before the field is damaged and there is an opportunity to take necessary action accordingly. With the improvement of science, these sensors will now open a comprehensive door for improvement in agriculture.

– The use of sound to identify insects is a groundbreaking invention. These sensors have antennas that are able to receive various sounds from insects. Most insects usually make a sound of 4000 Hz to 20000 Hz range. Our sensor received all sounds in the range between 4000-20000 Hz. Every insect creates its own type of sound. And the frequency differs from each other. Usually, the Ensifera sub-order of Orthoptera order and the Cicadoidea sub-family of Homoptera order used sound for mating, Copulation induces and territories are declared and defended, and other purposes [18]. Genus gryllus crickets create sounds by scraping a scraper on a forewing along its opposing forewing for rough teeth and the rate is increased by the rising of temperature [19]. Because of the clean and low frequency, they create a euphonic sound. Through the low-frequency sound and the sound kind, sensors detect them. Cicada (Cicadetta montana) is an alarming pest for the woody plant which makes whole in the stems. And eggs lay inside the stems [20]. They produce a higher frequency sound which is less pure than Genus gryllus.

- Chlorophyll fluorescence sensor used a laser or LED light that evaluates it by transferring the photosynthetic electron [21]. Which is visualized the efficiency of photosynthesis. Pictures of healthy grain leaves are already inputted in the database of the sensor. If the leaf is infested with fungus or insects, this time the pattern of chlorophyll is compared with the previous one. The change in chlorophyll can be seen on that leaf. And according to the change in the chlorophyll of the leaves, it is easy to find out what kind of fungus or insect has attacked. Many insects (Anoplocnemis curvipes, Halyomorpha halys, and Schizaphis graminum) eat the leaves of the crop and many insects change the leaves (by laying eggs) in a different way. Similarly, the sensor detects the various types of fungus (Puccinia recondite, Phytophthora infestans, Cochliobolus heterostrophus, Bipolaris maydis, Erwinia amylovora, and Xanthomonas oryzae) by various spots under or above the leaves. Leaf spot, Leaf Blights, Rusts, Powdery Mildew, and Downy Mildew are the major fungal diseases.
- Each plant reflects a certain amount of light energy in nature. Using this reflection concept, an overall idea about the grain can be obtained through this high-image sensor. Plants diffused different types of rays such as x-rays, UV, infrared, and radio waves. The reflected spectral signature data from each crop is pre-recorded in the database by a high-image sensor. When the crop is attacked by an insect or disease, the amount of reflected light is changes. Then the data is compared with previous data with the help of data mining, which became a vital technology in plant science [22]. This gives an idea of whether the crop is diseased or infected by insects. For example, a healthy barley leaf reflects about 0.6% of the light of 1000 nm wavelength, but when the leaf is affected by rust disease, the same wavelength decreases by 0.5%. In the case of powdery mildew diseases, the reflection is further reduced to about 0.45%. Grains for different diseases give different reflections at the same web length. From this, it is facile to get an idea about the attack of various diseases through this sensor.
- A plant can produce more than one lakh chemical compounds. About 1700 chemicals are volatile among them [23]. Plants used volatile organic compounds to defend themselves against insects, for pollination, for communication between plants themselves [24]. In addition, if a plant is infected by a pathogen, it produced a volatile compound. In the sensor, samples of any volatile substance emitted from a plant under any circumstances are inputted into the data from before. Whenever the sensor detects such type of substance, it presented the condition of the plants/crops by receiving the volatile substance. Cucumber, cabbage, corn, tomato, and lima beans plant releases a chemical that attracts the predators of herbivores. The growth and germination of Monilina laxa are considerably reduced by carvacrol, trans-2-hexenal, and citral which come from plants [25]. Ethylene, nitric oxide, jasmonic, methyl jasmonate, ocimene, limonene, plastoquinone, geraniol, linalool, citronellol, and lycopene are different VOCs that come from plants. The gas sensor detected this type of VOCs and easily detected all stress of plants.

4.3. Sensor integration with GSM

In the preceding sections, the system prototype is described properly. Sensors are used to receive the data from the environment and the processing methodology is done by Arduino Uno R3. After process data from sensors, Arduino Uno prepared the final result as Arduino is programmed in before. With the help of the GSM SIM900A module, this final result is delivered through this system user’s mobile phone as a text SMS. Using this system user/farmers can remotely sense their filed real-time condition. This system introduced GSM to transfer data so it could be used from mile to mile. In this research four sensors are used. It is possible to transmit four sensors’ analyzed data to the user's cell phone both individually and together. Sensor's status could be checked by sending a text SMS to GSM No. of SIM900A Module. In an audio detection sensor, the sound made by pests (e.g., wing beats, and attract another sexually) is detected. A specific range of decibels is used for specific pests. By using this sensor with proper Arduino program pests are identified. And to send this data remotely to the field owner GSM module is needed. The rest of the sensors have the same characteristics of receiving or collecting data from the ambient environment and are analyzed via Uno R3. In this system, we made a strong and automated Arduino program with which if the four sensors provide an unusual reading, one text SMS will send the user's cell phone automatically. But in a regular situation users have to send a text SMS in the SIM900A module to monitor the sensor reading as well as the agricultural field from pest.

5. EXPERIMENTAL ANALYSIS

In this section implies that the mail automation system visualization and demonstration in real life. We use this device for real-time data collection and analysis about its working mechanism. At the first, it is set up with all sensors into a hardwood then the full system installs into the field. In Figure 5, shows visualize the proper functional arrangement of this automation system.

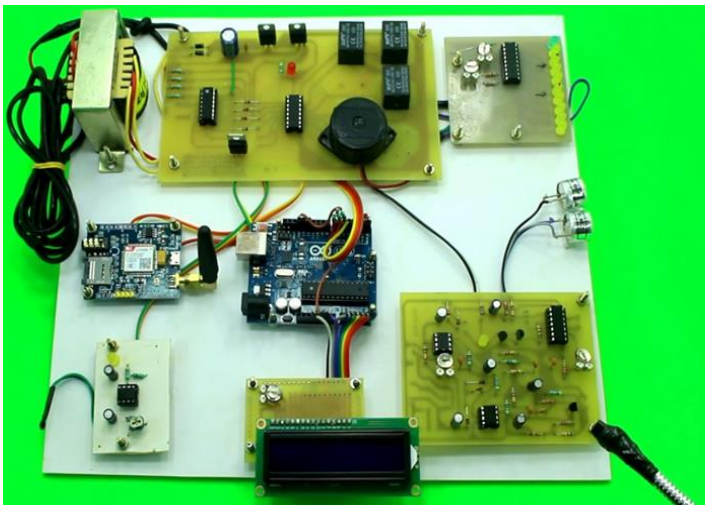

Figure 5. Full setup system for real-life demonstration

In this circuit board, we use all premium and long-lasting sensors with some register and LED display. All the functions connect with the GSM module for the data card and pest detection protocol. From the examination, we create a model chat and data table which is used for result analysis. Arduino Uno R3 and GSM SIM900A Module and all sensor combinations have been used for the teen pest and moderate pest detection Otherside all thermal sensorss used for all critical pest detection system.

6. RESULTS AND DISCUSSIONS

To the outputs generate and decision making we have set up a system data sheet. In this Table 1, implies that some different conditions and which types of result output from the automation system. After analyzing all data, we compare it to the benchmark stander data evaluation. We use ISO and IEEE standards value. After the set-up devices, it works 92% accurate data storing and provides the perfect SMS to the user.

Table 1. Testing data chart

Parameter	Test Conditions	Sound Sensor		MQ138		CMOSOV7670		AMG8833	
		S_1	S_2	M_1	M_2	C_1	C_2	A_1	A_2
Accuracy	T_A=25°C	86.9	89.7	77.2	89	88.2	90.1	87.3	89.2
	T_A = 35°C	90.56	90.78	80.8	90	89.2	90.8	88.9	90.85
	T_A = 15°C	82.6	85.8	75.6	85	86.8	77.9	72.6	98.6
Sensor gain	$T_{MIN} \leq T_A \leq T_{MAX}$	9.9 mV/°C		10 mV/°C		8.7 mV/°C		9.2 mV/°C	
Temperature coefficient of quiescent current	40°C ≤ T_A ≤ 14°C	0.39		0.56 V_c:5.0V±0.1V; V_H:5.0V±0.1V		0.59		0.62	
Average Response rate	Normal	85%		88%		89%		82%	
Test Performance	Normal	Good		Good		Good		Good	
Unite	°C	dB		△Vs		fps VGA		°C	

In this data chart, we have input four different types of sensor values according to real-time. Condition type is the main environmental temperature (T_A/°C) when we test the sensor reading and pest detection. For testing sensor data, we use different samples like M_1, M_2/A_1, and A_2.

7. CONCLUSION

The intention is to maintain up with the latest scientific and technological advancements in agriculture. Currently, there is no alternative to smart farming to produce more crops. This necessitates the use of sophisticated pest control technology. Crop output is hampered the most by these insects. With this purpose in mind, we worked using four sensors to achieve this goal. Our pest-removal automated systems will be an incredible scientific success. The first sensor is the sound detection sensor. Through which the noise of various sorts of insects made in the field is identified and data is sent to the main database, while the type of insects aching is also detected. The fluorescence sensor is the second. The image of the leaf will be collected by this sensor, which will then display the amount of chlorophyll in that leaf. The third is the high-image sensor, which will be capable of detecting all of the plant's rays. The fourth device is a gas sensor, which can detect all gases emitted by the diseased plant. There was a central database for all of these sensors. These sensors collect all of the information and compare it to the central data. Farmers can enhance grain yield by 2 to 3 times by adopting an automated pest removal system. The employment of four different types of sensors makes detecting all types of dangerous insects quite simple. Insects will no longer be a scourge for the grain. As a result, the agriculture industry may undergo significant changes. It will usher in a new era in agriculture.

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