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IoT Based Smart Agriculture and Animal Detection System

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Abstract: ***Agriculture, the science and art of cultivating plants, plays a pivotal role in the evolution of a primary agricultural economy. More than 50% of the population in India depends upon farming. Hurdles concerning agriculture have significantly retarded the growth in this sector. The most significant obstacle incurred by the farmers is inefficient crop management and crop raiding by external sources, especially the human-wildlife conflict. A cumulative approach including the application of "Internet of Things" and traditional farming techniques, along with methods to barricade crop destruction has been elaborately highlighted by way of integrated systems. Hence this proposed module targets at making agriculture smart by proposing a device detects the presence of any living being by using either PIR Sensor or Ultrasonic Sensor, especially animals around the land to be cultivated, along with smart irrigation control and real-time data analysis which is also inclusive of smart warehouse management parameters like- temperature, humidity and pressure measured by using (DHT22 Sensor and BMP180 Sensor). This data may either be visualized by using the Blynk Software or received in the form of messages through the GSM Module. To combat the ruckus caused by animals, detection of their presence along with a laser security system has been provided in the proposed system. Efforts have been made to help the farmer in rectifying multiple issues at once.***
Keywords: PIR Sensor, DHT22 Sensor, BMP180 Sensor, Blynk App, GSM Module

I. INTRODUCTION

Agriculture is the art of cultivating crops**.** This is the practice of rewiring nature's ecosystem to segment a part of their food energy for human and animal consumption, serves to be the spine of development for human civilization. It serves as the basis of life for the human civilization. An accelerator in the growth of a country's economy, it is the primary source of income for a majority of people. Mono-cropping, agroforestry, intercropping, poly-culture and crop rotation, are some of the traditional agricultural methodologies that have been widely adopted and practiced throughout the world. With an ever increasing population of not only India, but that of the entire world, agriculture has taken a veiled center stage, wherein all of us need the food to keep ourselves well fed but do not think about the grievances encountered by the farmers. In this proposed paper efforts have been made to integrate various small systems to deal with the countless problems faced by the cultivators. There are many factors which affect the crop yield in the farm. Some of these include improper cropping pattern, inadequate irrigation facilities, theft of crop or damage of crop when it is at the stage of harvesting. The new scenario of decreasing water tables, drying up of rivers and tanks, unforeseeable pattern of the environmental changes, stray animals (both domestic and wild) due to the vandalized fencing around the farms and forests along highways, and proper utilization of power from the renewable sources of energy available. [1] The existing method of manual calculations by farmers to calculate the parameters mandatory for the yield of crops is cumbersome and might not produce accurate results. [2] Research conducted a few years ago indicated that subjecting seeds and plants to frequent changes in atmospheric pressure, temperature and humidity may reduce the time for germination, improves the rate at which young plants grow, and result in expeditious root growth. Thus, by incorporating automation and IoT Technologies, multiple sensors and devices can be interconnected. [3] The essential application of sensors is seen in the measurement of various environmental parameters, like temperature, humidity and pressure, along with the moisture and nutrient content of the soil. [4] The cloud based remote data acquisition capabilities provide for an efficient system to be made. The effect of low prey density in the forest or the agricultural area due to natural or man created situation, deforestation and human intervention is causing animal migration towards the human habitats especially in the areas which come in forest territory. As per the survey report of FRI Dehradun, Uttarakhand, The State of Uttarkhand recorded forest area of 38,000 sq. km which is 71.05% of its total geographical area of 53,483 sq. km that is largely facing the real issue of human-animal conflict. To manage this variation in the various environmental factors, and to ensure a synchronized plant yield without any intervention, both man-made and natural, a system is being proposed to ensure the health of the soil (which will in turn monitor the plant health), to monitor the changing weather conditions and to keep the farmer safe from foul play by humans, and the unpredictable behavior of the animals.

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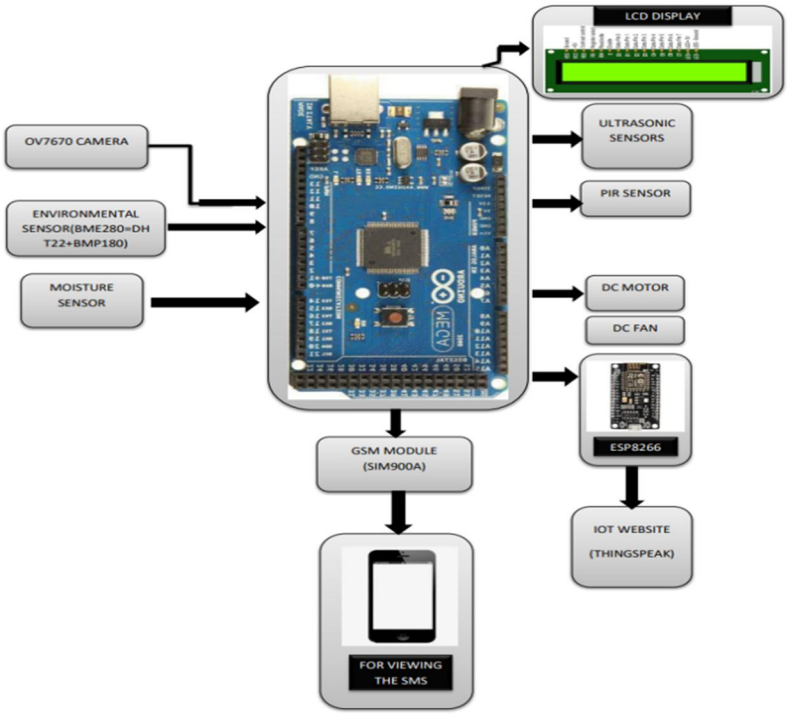
II. SYSTEM OVERVIEW

Today, the different sensors and devices are interconnected to one central server via wireless communication modules. The server sends and receives information from user-end using internet connectivity. There are two modes of operation of the system; auto mode and manual mode. In auto mode system takes its own decisions and controls the installed devices whereas in manual mode user can control the operations of system using android app or PC commands. A remote sensing and control irrigation system using distributed wireless sensor network aiming for variable rate irrigation, real time in field sensing, controlling of a site specific precision linear move irrigation system to maximize the productivity with minimal use of water was proposed by Y. Kim.et.al [1] The system depicts intrigues about the design and instrumentation of variable rate of irrigation and real-time field sensing. The module is used to protect the crops from the harm caused by the animals. It involves- the detection of the approach of animals towards the farms. This model indulges in the usage of Arduino Mega (or such like microcontroller), four ultrasonic sensors (HC SR-04), a PIR sensor, a GSM module and a LCD (16×2). The sensors detect the movement of animals in all possible directions thus, sending a signal to the controller, which is further, transmitted to the GSM module. [5,6] This sends an alert to the farmer in the form of a message or call. In case of use of NodeMCU, the GSM Module may be opted out, as the data can be sent to the cloud by using the Blynk App. This alert can be displayed both on the mobile phone owned by the farmer along with the LCD attached with the microcontroller.

The efficiency of the proposed module is to develop an effective system for practicing agriculture and growing food in a sustainable way. The system with the additions made, makes use of the wireless sensor networks which cumulates data from contrasting sensors deployed at various nodes and sends it through the wireless protocol. The add-ons consist of temperature and humidity sensor (DHT11), moisture sensor (YL-69), water level sensor and DC motor.[5,6] When the agriculture monitoring system based on Internet of Things starts, it checks the water level, humidity and moisture level, alongside detecting the presence of any living beings around the farm. It sends alert on the phone about the levels. Sensors sense the level of water if it goes down, it automatically starts the water pump. If the temperature goes above the level, fan starts. This all is displayed on the LCD(16×2) display module. The data may also be stored in the Blynk App, open platform cloud based service, which would aid the operator in data visualization. [5]

If given the provision, the proposed module may be incorporated with high-tech laser, which may scare away the animal, which if by any means tries to invade the farms and destroy the crops.

III. BLOCK DIAGRAM



IV. HARDWARE REQUIRED

A. Microcontroller Board (NODEMCU/ARDUINO)

A single board microcontroller may be understood as a single printed circuit board which has the provision mandatory for a useful control task. In this proposed module we may use either an Arduino board in combination with the ESP8266, or the NodeMCU board (which already has the provision of a built in Wifi module since it uses the ESP8266 microprocessor).

1) *ARDUINO BOARD:* The ArduinoMega 2560 has been developed around the ATMega2560 board. With 54 digital input/output pins, 15 of these pins may be used as PWM outputs. It also has a provision for 16 analog inputs, 4 UART's (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP (In-Circuit Serial Programming) header, and a reset button. [6, 7]
2) *NODEMCU:* NodeMCU unites the merits of a microcontroller development board with a Wi-Fi breakout board and provides the entire package as a single development board. It is an open source platform based on ESP8266 which capably connects objects and allows transfer of data using the Wi-Fi protocol.

B. Ultrasonic Sensor

These sensors may be defined as the instrument which is used to estimate the stretch at which an entity is placed using ultrasonic sound waves. A transducer is used to transmit and receive ultrasonic pulses, thus measuring an object's approximate vicinity. The transmitter transmits the 40-KHz sound wave and the receiver receives the reflected 40-KHz wave and on its reception, it sends the electrical signal to the microcontroller. The range of operation of this economical sensor lies between 2cm to 400 cm. It provides a range accuracy of up to 3mm, and involves the mechanism of SONAR (Sound Navigation and Ranging) and RADAR (Radio Detection and Ranging).

C. PIR Sensor

This is an electronic sensor which is used to analyze the wavelength of the infrared rays being emitted from the object. It is used to detect the motion of an object. They are small in size, inexpensive and easy to use. It has a range of up to 10 meters (30 feet). The PIR sensor detects the changes in the wavelength of the infrared radiation being casted upon the object under observation. The PIR sensor comprises of two slots which are respectively made of a material particularly sensitive to infrared rays/radiation. Both the slots of the sensor detect equal amount of infrared radiation when the sensor is inert. As soon as there is any movement of a body (human/animal), one half of the sensor which first senses obstruction in the infrared radiation, causes a differential change (which is positive in nature) between the two halves, whereas, the reverse happens once the body has left the range of the sensing area, thereby causing negative differential change. This process results in the generation of pulses which is detected by the PIR sensor. To enhance the immunity towards noise, humidity and temperature, the main element of the sensor is sealed in a hermetically shaped metal. This sensor uses Fresnel lenses. [7]

D. GSM (Global System for Mobile) Module

This module originated in 1970 at the Bell Laboratories. Used predominantly in the world of communication system, an open and digital cellular technology, the GSM module finds its applications in the transmission of mobile voice and data services which operate in the following frequency bands-1850MHz, 900MHz, 1800MHz and 1900MHz respectively. It has diverse sizes of cell which include- macro, micro, pico and umbrella size. [6,7,8]

Features of a GSM Module include:-

1) Baud Rate= 9.6kb/s
2) High-quality speech
3) Support for improved services
4) Real time clock with alarm management
5) International Roaming
6) Improved spectrum efficiency
7) Fixed Dialing Number (FDN)
8) SIM phonebook management
9) Short Message Service (SMS)
10) Encrypted phone calls in order to ensure security

E. Buzzer

A portable and efficient electronic component, it is used to add the feature of sound to the respective modules. An audio-signaling device, a buzzer may be mechanical, electromechanical or piezoelectric. It is a two-pin structure, easy to use

F. LCD

LCD signifies Liquid Crystal Display. An electronic display module, LCD finds its application in various electronic gadgets namely screens of calculators, mobile phones, television sets, computers etc. In this proposed module we utilize the 16×2 LCD display. The representation- 16×2, is indicative of the pixel matrix, having 16 columns and 2 rows, and thereby a possibility of having 32 characters. In here, each character is respectively made of 5×8 pixel dots, thus making per character pixel count to be 40 pixels. The LCD display is easy to afford and extremely compatible.

G. Moisture Sensor

This sensor module is used to detect the moisture content of the soil. It is used to measure the volumetric content of water held inside the soil, thus, giving the output of the moisture level in the soil. The module has incorporated in it both digital and analog outputs along with a potentiometer to adjust the threshold level. The moisture sensor comprises of two probes which are used for the detection of moisture in the soil**.** A coating of immersion gold protects the Nickel probes from oxidation. They are used to provide a passage for current through the soil for the sensor to measure the resistance for recording the desired values. LM393 Comparator IC is used as the voltage comparator in this Moisture sensor module. Pin 2 of LM393 is connected to Preset (10KΩ Pot) while pin 3 is connected to Moisture sensor pin. The comparator IC will compare the threshold voltage set using the preset (pin2) and the sensor pin (pin3). [6,10]

H. ESP8266 (Used with Arduino Board)

The ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability. It provides capabilities for 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2), general-purpose input/output (16 GPIO), Inter-Integrated Circuit (I^2C), analog-to-digital conversion (10-bit ADC), Serial Peripheral Interface (SPI), I^2S interfaces with DMA (sharing pins with GPIO), UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and pulse-width modulation (PWM). NodeMCU may also be used as it has the provision for ESP8266.

I. BMP180

This precision sensor from Bosch, is one of the most efficient and economical sensor for the measurement of pressure and temperature. It may offer the user a measuring range of 300 to 1100 hPa with an accuracy of 0.02 hPa. High accuracy, ruggedness and long term stability may be achieved by using piezo-resistive technology.

J. DHT22

This sensor is a cost-efficient temperature and humidity with a single wire digital interface. Its temperature measuring range is from -40 to +125 degrees Celsius with +-0.5 degree's accuracy. The humidity measuring range, from 0 to 100% with a 2-5% accuracy.[6-8,11-12]

K. pH Sensor

Soil pH can be measured using this sensor. The output is in millivolts depending upon the pH value. It basically measures the hydrogen ion [H+] activity. For neutral solutions, i.e. at pH of 7 the output of pH electrodes is 0mV when ideally. [9]

V. SOFTWARES REQUIRED

A. Proteus 8 Simulator

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

It was developed in Yorkshire, England by Labcenter Electronics Ltd.

B. Arduino IDE

Arduino is an open-source hardware and software company, proposed module, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices. Arduino board designs use a variety of microprocessors and controllers. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs.

C. Blynk framework:

Blynk is an IoT platform for iOS or Android smartphones that is used to control Arduino, Raspberry Pi and NodeMCU via the Internet. This application is used to create a graphical interface or human machine interface (HMI) by compiling and providing the appropriate address on the available widgets. Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things.

VI. METHODOLOGY

Control of the water sprinkler may be achieved by the usage of soil moisture sensor (YL-69), which detects the moisture level of the soil. [6-8] It accordingly pumps water from the tank pump followed by the water pump. With the help of the pH sensor, the user may receive critical feedback about the soil nutrients (deficiencies or unwanted chemicals) may be achieved. [9] The pressure sensor (BMP180) and the temperature sensor (DHT22) enable the user to determine the essential environmental parameters, that is, temperature pressure and humidity. [11,12] The critical values of all the parameters are then transferred from the microcontroller board to the GSM (SIM900A) module (cellular network), which enable the users to receive various AT commands like SMS, and connect to the cell phones in the immediate vicinity.[8,10,11]. The usage of the Global Positioning System may be used either to detect the position and activities of animals or as part of precision agriculture.[12-14] Precision Agriculture is the art of doing the right thing, right place at the right time. [12] This begins by efficiently utilizing common tools such as planters, fertilizer applicators, harvesters and whatever else might be needed with utmost accuracy at the right time. [12] The application of ultrasonic sensors (HC-SR04) includes the detection of any living being in the near vicinity. When the transmitter transmits a signal, the signal will be reflected by the object that obstructs it, then the reflected signal will be detected by the detector.[13] The PIR (Passive Infrared) sensor (HC-SR501) may also be used instead of the ultrasonic sensor to analyze the wavelength of the infrared rays being emitted from the object. As soon as there is any motion in the body (human/animal) the first half of the sensor, senses obstruction in the infrared radiation, and causes a differential change (which is positive in nature) between the two halves, whereas, the contrary happens once the body has left the range of the sensing area.[13] All the important messages are displayed on the LCD (16×2) screen. Security System based on Laser is a type of security system that uses laser light. This is an economical, standalone, easy to install and efficient system capable of detecting any irregular activity. These are unmanned beams, so it does not pose any danger on the premises. Its ability to be hidden easily makes it free from the troublesome concern of being tampered. (In case it is used individually, the laser security system may work even in case of power outage, with the help of a battery).

VII. CIRCUIT DIAGRAM

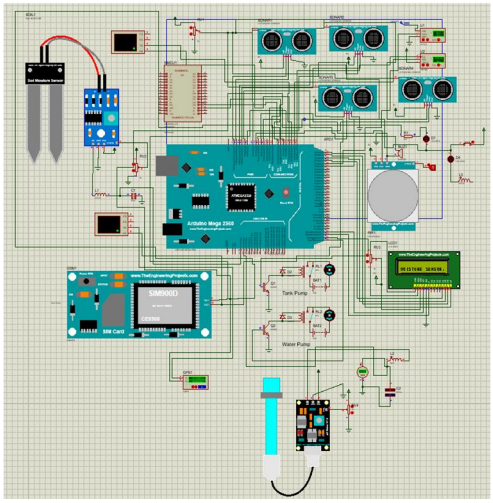


FIG. 7.1- Proteus Prototype for the proposed model

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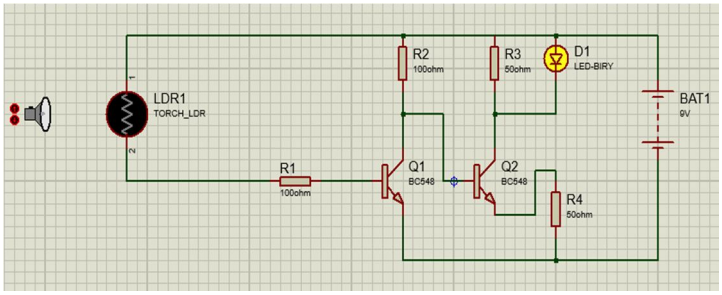

FIG. 7.2- Laser Security Model

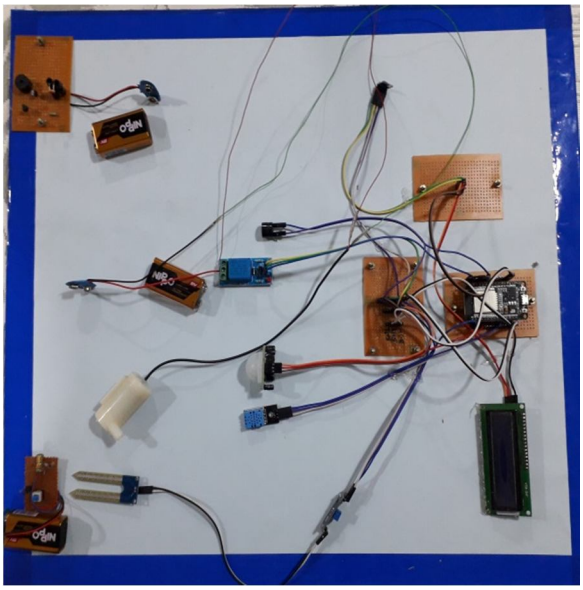

FIG. 7.3- Hardware Module of the proposed system

VIII. RESULT AND DISCUSSION

Estimating crop water requirements is a prerequisite for crop plant planning and management. The amount of water needed for evapotranspiration. To accomplish effective irrigation management, crop water requirements are met from the effective rainfall, irrigation water applied and the available soil moisture from the time of planting to harvesting for a given crop in a specific climate regime. [15]

Table 1 given below presents the data obtained by the proposed system.

TABLE 1- Climatic Parameters and Water requirement of Rice considering effective rainfall

Months	Max. Temp. (C)	Min Temp. (C)	Max. relative humidity %
April	35.96	20.42	47.09
May	39.85	26.65	64.86
June	46.08	27.73	72.80

On simulating the Proteus prototype model, the sensors communicate with the ArduinoMega 2560 to give the following output on the LCD display:

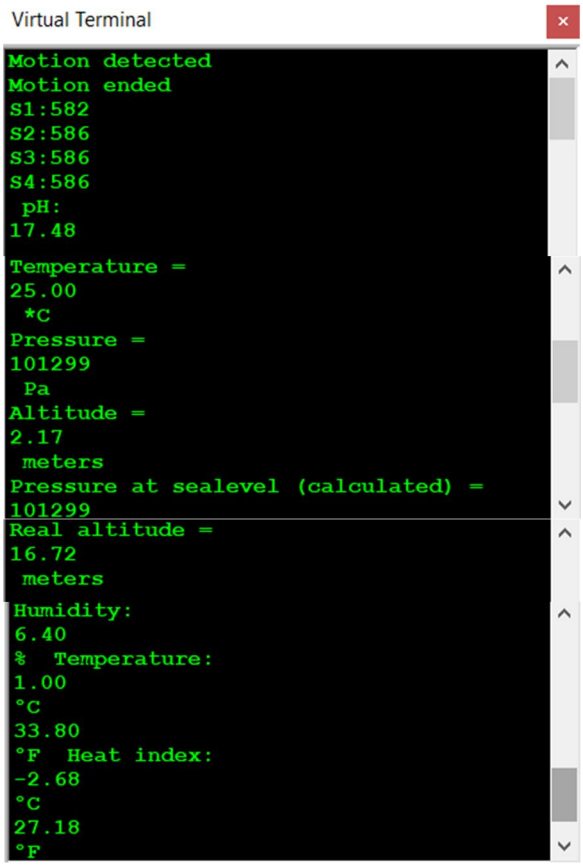

FIG. 8.1-8.4 - Outputs of the Sensor Parameters in Proteus

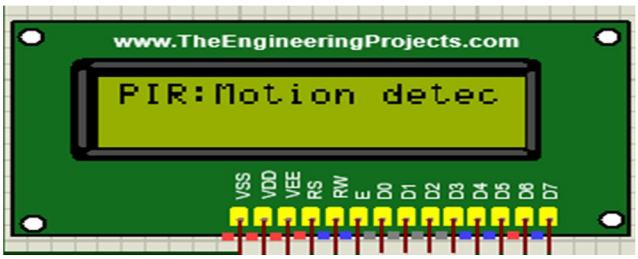

FIG. 8.2

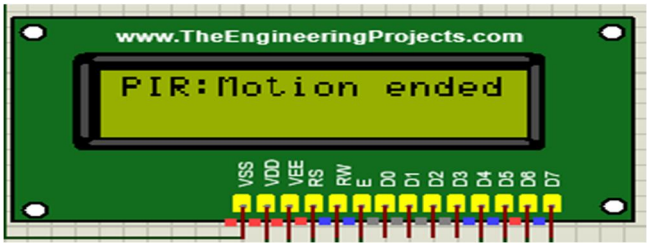

FIG. 8.3

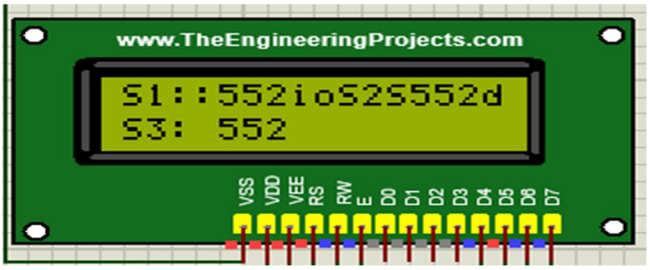

FIG. 8.4

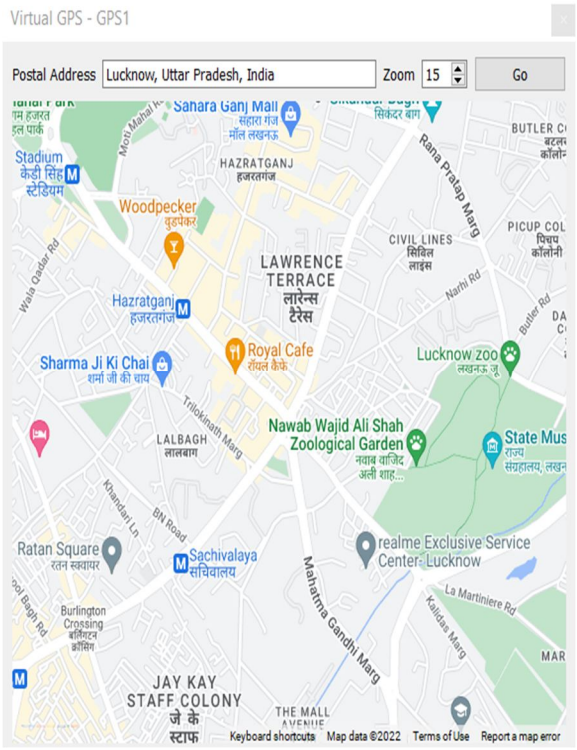

FIG. 8.5- GPS Display

From the Proteus Simulation of the circuit, the sensor values are obtained, which may aid the farmer to irrigate the land as per the climatic, crop and time requirement. The pH sensor may help the farmer understand the soil nutrient requirement, the DHT22 sensor helps determine the temperature and humidity of the soil, the BMP180 sensor the atmospheric pressure and the moisture sensor the soil moisture content of the soil, so that the farmer may provide apt water content to the soil taking into account the physiological parameters. The PIR sensor and ultrasonic sensors determine the presence of any living being around the field. The GPS sensor may have a dual nature of application, one being in locating the precise location of the living being near the farm and the second one being in precision farming, which helps in determining the location in which the seed is to be sown.

The hardware simulation can be used to obtain the weather parameters, that is, temperature, humidity and pressure using the DHT22/11 and BMP180 sensor. The values obtained from the DHT sensor, for temperature are 33°C for April, 41°C for May and 44°C for June, while that of humidity are 47% for April, 60% for that of May and 70% for that of June, with the effect of rainfall. The pressure recorded has been 1001hPa ± 5%. With regard to the obtained values, the soil moisture content of the soil can be obtained by using the moisture sensor and the water requirement of the soil can be fulfilled by the farmer from the readings obtained. The PIR sensor helps determine the presence of any living being around, and the buzzer alerts the farmer of the same.

The values obtained from figure 8.6 and 8.7 may provide validity of the proposed system module to the farmer, which supports the values given and parameters studied by the previous researchers.

FIG. 8.6- Blynk App Output for Temperature, Pressure, Humidity and Pump State

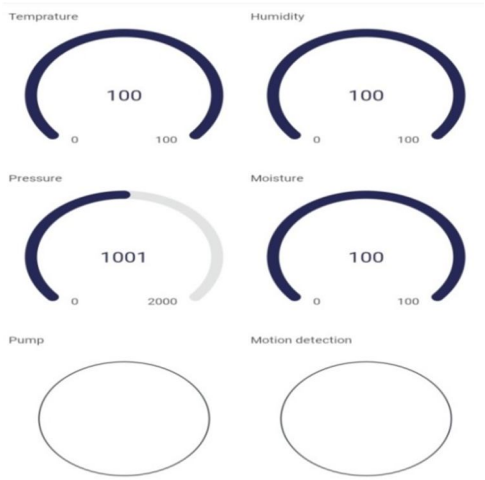

FIG. 8.7- Blynk App Output when pump is on and moisture sensor is active

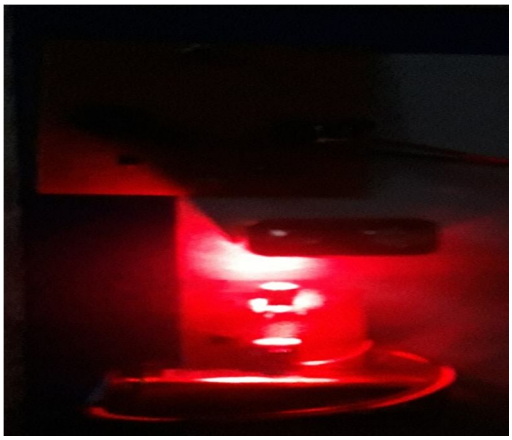

FIG. 8.8- Laser Security System

The laser security system primarily comes into action at night when the farmer is not around. A buzzer is provided with this circuit, which acts as an alarm in case the laser light reaching the LDR (Light Dependent Resistor) sensor is interrupted.

IX. CONCLUSION

In this proposed module an effort has been made to aid the "Internet of Things" into detecting the presence of animals or human beings such that the farmers could be saved from bearing the expense of the damaged crops. This initiative if executed systematically might prove to be helpful in improving the feeble financial conditions of the farmers. Though the challenges in incorporating the gps module and the pH module may be overcome in the future studies. The embedded systems industry has been analyzed to have an exponential growth in the time to come. Driven by the tireless advancement in Artificial-Intelligence (AI), Virtual-Reality (VR), Augmented-Reality (AR), machine-learning, deep-learning, and the Internet of Things (IoT), the cognitive embedded-system will be the epicenter of trends like: reduced consumption of energy, enhanced security for embedded-devices, cloud-connectivity, mesh-networking, deep-learning applications, and visualization tools with real time data.

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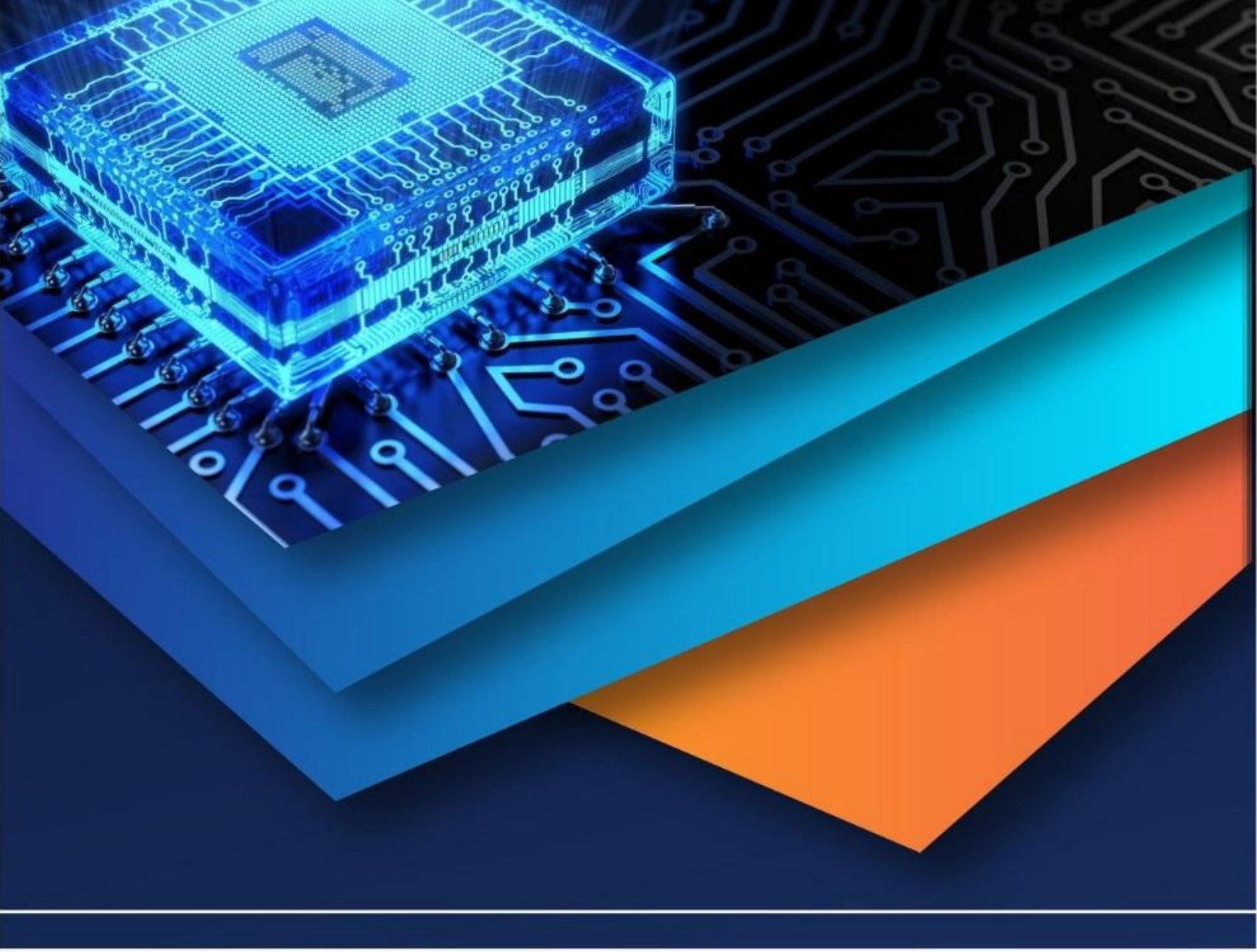

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