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Smart Irrigation System for Indian Agriculture

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***Abstract:** Technology plays a very crucial role in the field of agriculture. By the help of automation, a procedure or process can be executed without any or minimal human assistance. This project is an automation of farm irrigation and soil moisture control by Arduino using moisture sensor. This automatic irrigation system determines the moisture content (by measuring resistance) with the help of the sensor which senses the moisture content of the soil and switches the pump on automatically whenever the power is kept on. Agriculture has a long history in India, dating back to ten thousand years. It is a source of employment of many Indians and has great impact on the economy of the country.*

Rank	Commodity	Value (US$, 2016)	Unit price (US$ / kilogram, 2009)	Average yield (tonnes per hectare, 2017)	Most productive country (tonnes per hectare, 2017)	
1	Rice	$70.18 billion	0.27	3.85	9.82	Australia
2	Buffalo milk	$43.09 billion	0.4	2.00[72]	2.00[72]	India
3	Cow milk	$32.55 billion	0.31	1.2[72]	10.3[72]	Israel
4	Wheat	$26.06 billion	0.15	2.8	8.9	Netherlands
5	Cotton (Lint + Seeds)	$23.30 billion	1.43	1.6	4.6	Israel
6	Mangoes, guavas	$14.52 billion	0.6	6.3	40.6	Cape Verde
7	Fresh Vegetables	$11.87 billion	0.19	13.4	76.8	United States
8	Chicken meat	$9.32 billion	0.64	10.6	20.2	Cyprus
9	Potatoes	$8.23 billion	0.15	19.9	44.3	United States
10	Banana	$8.13 billion	0.28	37.8	59.3	Indonesia
11	Sugar cane	$7.44 billion	0.03	66	125	Peru
12	Maize	$5.81 billion	0.42	1.1	5.5	Nicaragua
13	Oranges	$5.62 billion				
14	Tomatoes	$5.50 billion	0.37	19.3	55.9	China
15	Chick peas	$5.40 billion	0.4	0.9	2.8	China
16	Okra	$5.25 billion	0.35	7.6	23.9	Israel
17	Soybeans	$5.13 billion	0.26	1.1	3.7	Turkey
18	Hen eggs	$4.64 billion	2.7	0.1[72]	0.42[72]	Japan
19	Cauliflower and Broccoli	$4.33 billion	2.69	0.138[72]	0.424[72]	Thailand
20	Onions	$4.05 billion	0.21	16.6	67.3	Ireland

Today, India ranks second worldwide in farm output. Agriculture is still the largest economic sector of India. Despite a steady decline of its contribution in the GDP, it plays a significant role in the overall socio-economic development of our country. The amount of rainfall has a striking effect on agriculture and irrigation. Plants or crops need water to survive, therefore rain (which is the most valuable means of watering) is important to agriculture. While a regular rain pattern is usually vital to healthy plants, too much or too little rainfall can be harmful and can even damage the crops. For this reason, we use this automatic plant watering and soil moisture monitoring system and this system proves to be useful in all climatic conditions. The main motive of this project is to automatically provide adequate amount of water to the plant or the crop according to its requirement. When soil goes dry pump will start watering the crop. Another major advantage of this project is that automatic irrigation is also very time efficient. The aim of the implementation this project was to demonstrate that the automatic plant irrigation can be used to reduce water use, prevent damaging of plant due to less or excess water supply as well as save your time.

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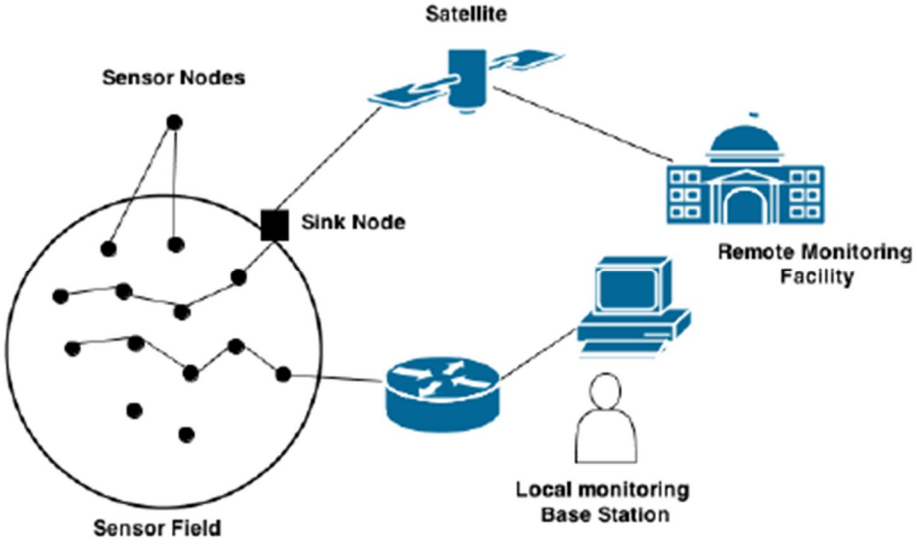
I. INTRODUCTION

In India, 60-70% economy depends on farming and agriculture so there is a great need to modernize the older and outdated agricultural practices for the better productivity. Due to wastage of water the ground water level is decreasing everyday, lack of rain and scarcity of land water also results in decrement in volume of water on earth. Nowadays, water shortage is becoming a global problem. We need water in each and every aspect of our life. Agriculture is one of fields where water is required in excessive quantity for proper growth and nourishment of the crops. Wastage of water is a major problem in agriculture industry. A lot of times the water supply is not controlled resulting in less or more water than required in the fields. There are many techniques to conserve or to control wastage of water in agriculture lands. The objective of the system is to

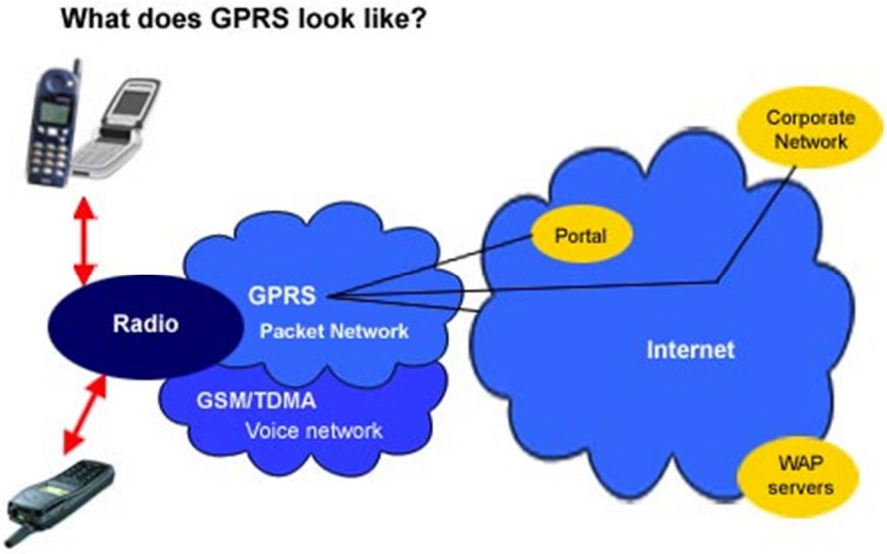
A. Conserve energy & water resources as well as reduce manual input required.
B. Handle the system manually and automatically with sophisticated sensors.
C. Detect the level of water in fields.

Due to the climatic changes and lack of precision by humans, agriculture have resulted in poor yield as compared to population growth. Irrigation is mostly done using canal systems in which water is pumped into fields after regular interval of time without any feedback of water level in field which is not suitable and constant for different seasons and temperatures. This type of irrigation affects crop health and produces a poor yield because some crops are sensitive to water content in soil. A smart irrigation system, contrary to a traditional irrigation method, regulates supplied water with feedback from different sensors which sense the surrounding. The feedback mechanism of a smart irrigation system is a moisture sensor and temperature and humidity sensor. Evaporation - transpiration (ET), thermal imaging, capacitive methods, and neutron scattering method and gypsum blocks are some of the technologies that enable moisture sensing. Capacitive sensors, however instantaneous, are costly and need to be calibrated often with varying temperature and soil type which may not be feasible for many. Neutron Probe based moisture sensors are very accurate but there are some radiation hazards, calibration difficulty and are costly. Also as the farming and agriculture lands are very vast and expanded often, a single sensor reading should not be relied upon so a large number of sensors are to be scattered around the field to get the view of the moisture in the land which is proposed in this paper.

Crop Monitoring System based on WSN



Wireless Sensor network crop monitoring application is very useful to farmer for productive agriculture. The application monitors the whole farm from a different location using Internet Of Things (IOT). Application works on sensor network and two types of nodes. Energy saving algorithm is used to save energy. Tree based protocol is used for data collection from node to main station. System having two nodes, one node that collects all environmental and soil parameter values and the other consist of camera to capture images and monitor crops. In this system, Environmental changes are not considered forthesensorreading. User is not able to program application by himself. There is no controlling system for this application.



Automated Irrigation system using WSN and GPRS Module optimize the use of water for agriculture crops and increase productivity. This system consists of distributed wireless sensor network with soil moisture and temperature sensor in WSN. Gateway units are used to transfer data from sensor unit to base station, send command for irrigation control and manage data of sensor unit. Algorithm used in system are for controlling water quantity as per requirement and condition of filed. It is programmed in microcontroller(foreg- Arduino) and it sends command through actuator to control water quantity through valve unit. Communication is duplex take place through cellular (GPRS) network although long range wifi can also be used. Web application manage the irrigation through continuous monitoring and irrigation scheduling programming which can be accessible via internet. It can also be done via smartphone apps so the programming can also be switched as per different modules for different crops.

II. COMPONENTS

A. ARDUINO

Arduino is an open-source electronic microcontroller. Arduino boards are able to read inputs like light on a sensor, a finger on a button and turn it into an output like activating a motor, turning on an LEDor activating an alarm. A microcontroller is a miniature computer on a single integrated circuit. In modern terminology, it is a system on a chip. It contains one or more CPUs along with memory and programmable input / output peripheral devices. Microcontrollers are designed for embedded application and are widely used in IOT modules. These are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines and other embedded systems in household as well as professional fields.

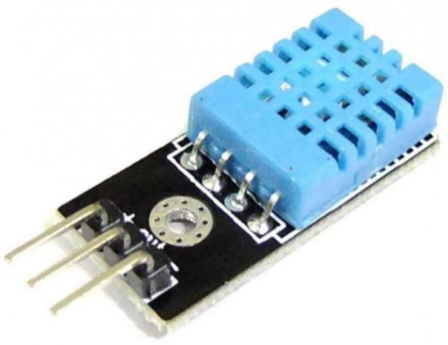
B. Soil Moisture Sensor

Soil moisture sensors measures the water content in the soil.Since the direct gravimetric measurement of free soil moisture requires removing, drying and weighing of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other properties of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a secondary analysis for the moisture content.

This sensor has two probes through which current passes in soil, then it reads the resistance of soil for reading moisture. We know that water makes the soil more prone to electric conductivity resulting less resistance in soil where on other hand dry soil has poor electrical conductivity thus there would be more resistance in soil. This works quite effectively in agricultural conditions.

C. Temperature And Humidity Sensor

The DHT11 is a basic, very low-cost digital temperature and humidity sensor shown. It uses a capacitive humidity sensor and a thermostat to measure the environmental air, and outputs a digital signal on the data pin. It measures relative humidity. Relative humidity is the amount of water vapor present in air vs. the saturation point of the water vapor in air.



At the saturation point, water vapor starts to condense and accumulate on surfaces forming dew drops. It detects water vapor by measuring the electrical resistance between the two electrodes and provides output.

D. Bluetooth Wireless Technology

Bluetooth is a high-speed, low-power microwave wireless link technology, designed to connect phones, laptops, speakers and other portable equipment together. Unlike infra-red (IR), Bluetooth does not require line-of-sight positioning of connected units. The technology uses modifications of existing wireless LAN techniques but is most notable for its small size and affordable cost. The fundamental strength of Bluetooth wireless technology is the ability to simultaneously handle data and voice transmissions, which provides users with a variety of innovative applications. Bluetooth 5 is the latest version which has many other advantages over its other versions. Bluetooth 5.0 is now starting a revolution using Beacon by creating new market opportunities such as Smart Building, Smart Industry, Smart Homes and Smart Cities using mesh connections which will use IOT. Mesh topology already available in Bluetooth 5 enables a variety of features like large scale device networks and many to many Bluetooth Beacon communications.

Secondly, Bluetooth audio will takeover in 2021 by launching products supporting next-generation Bluetooth audio architecture called Bluetooth LE Audio. Bluetooth has always used the Bluetooth Classic (BR/EDR) audio signal which will be replaced by a new audio signal which will allow users high-quality audio and convert stream audio to multi-streaming audio, It will also allow people to transmit signals in a public place within large range.Bluetooth 5.0 was launched on 16 June 2016 and it is mainly focused on the internet of things IoT applications. The main highlight of Bluetooth 5.0 is the working range i.e. up to 250 m (800 ft.) approx. which is quite impressive. It also has a big improvement in the data transfer speed which nearly doubled when compared to Bluetooth 4.0 (earlier version).

III. PROPOSED SYSTEM

Irrigation can be automated by using sensors, microcontroller, Bluetooth, android or iOS applications. The low cost soil moisture sensor and temperature and humidity sensor are used to make it economically feasible. They continuously monitor the farm field. The sensors are connected to arduino board. The sensor data obtained are transmitted through wireless transmission and are reached to the user so that he can control irrigation process. The mobile smart applications can be designed in such a way so that they can analyse the data received and to check with the threshold values of moisture, humidity and temperature. The decision can be made either by the application automatically without user interruption or manually through application with user interruption(Manual failsafe is a must). If soil moisture is less than the threshold value the motor is switched ON and if the soil moisture exceeds the threshold value the motor is switched OFF. The sensors are connected to the Arduino microcontroller board. These hardware peripherals communicate through wireless Bluetooth transmission so that user can access the data through his mobile that has an android or iOS application which can get the sensor data from the arduino via Bluetooth. Bluetooth and WiFi technologies can be used for communication. With the introduction of Bluetooth 5 and 5g networks and Wifi with 5ghz band, data transfer becomes more simple, fast and reliable.

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The Arduino board is programmed using Embedded C language in order to control the transmission of sensor data and the working of motor according to the inputs made. The coordination of the motor and 3 sensors is maintained by the program fed into the Arduino microcontroller. Water is supplied to 3 different areas by using Servo Motors. It is a motor that can move its head at different angles. Using this, the head of the motor is made to move at 3 different angles so that water can be supplied at different areas where the sensors are placed. The sensors continuously send data regarding moisture content of the soil at a fixed interval (in ms). Whichever sensor indicates low moisture content to that place motor is switched on and then water is pumped until the moisture is restored, if it indicates high moisture content in soil then pumping of water is stopped by switching of the motor. All these are managed by the C language program that has been written into the Arduino Microcontroller. The Arduino and the user communicate via Bluetooth or wifi. The range of Bluetooth technology is application specific which can be extended using Bluetooth 5 and other devices too. The threshold values for both soil moisture and temperature and humidity, will be set and stored in the arduino and mobile application according to the crops, soil and its tendency to sustain in particular environment. The sensor value varies according the climatic and geographic conditions. The soil moisture will be different in summer and winter seasons and so the temperature and humidity values will differ too. The threshold value is set after considering all theses environmental and climatic conditions. The motor will be switched on automatically if the soil moisture value falls below the threshold value and vice versa. The farmer can even switch on the motor from mobile using mobile application with his specific phone. Through Bluetooth the decision is sent to the Arduino board and accordingly the motor switches are operated. The ultrasonic sensor is used to monitor water level in reservoir tank. The ultrasonic sensor works based on the piezoelectric method. It has a trigger pin and an echo pin. The trigger pin act as transmitter and the echo pin is a reflector. The trigger pin sends ultrasonic waves once it started functioning and the ultrasonic waves hit the water and are reflected towards the echo pin. The time duration to receive the echo is calculated and that indicates the water level in the tank. The duration is converted to the distance using mathematical equations.

Distance in cm = (duration/2) / 29.1 (1)

Distance in inches = (duration/2) / 74(2)

Before the motor is switched on, the water level is checked to ensure that require amount of water is available for irrigation and there is an alarm notification if water is not available. If required amount of water is not present, the motor will not be switched on or only less amount water can be supplied. The notification is sent to the farmer's mobile for further instructions. The farmer can also be able to switch on and off the motor from the mobile application (Android and iOS based).

There are a lot of applications in which our we can advance this project further. As its main application is in farming and irrigation, it can be further converted into a completely automatedfarming system which will in the later stages undertake all the farming applications and completely automate the whole system all while providing easy access to the user.

One of the major application can be that creating a system which could examine content of the land and the soil parameters and also finding out it's fertility and then further on give an output in terms of suggesting which crop which crop can be easily grown foe the given land and soil type hence making it a crop prediction application.

Sinceit's the need of the hour to conserve and save water. this project provides the opportunity to explore that area too. Hence preserving the extra water by controlling its flow through various means also while providing an adequate estimate as to which farming application uses most water content. Thus it makes it quite suitable for sustainable water management.

This project can further be enhanced by adding an alert and control system to it. This system would become very beneficial for farming activities. This feature would ensure that the user is kept updated to the current scenario of the field which might affect the different kinds of operations being carried out. So, basically detect and report any kind of change above or below the threshold value which is set. Then the user is informed about the change instantly and thus providing the real time changes.

More advanced sensors such as pressure sensor, rain falling meter, etc can also be added to the project in order to generate a typical robust system. In addition,the realised sensor data can also be transferred wirelessly with the help of Wi-Fi chip or bluetooth module over APK smart phone application. Finally, data of the sensor can be sent to specific phone numbers via GSM module. To make cellular IoT connectivity further simpler Arduino introduced SIM plans for easy, global mobile IoT connectivity for Arduino IoT Cloud projects. Arduino SIM card helps in connecting arduino easily to IoT Cloud projects globally. the device can be monitored anytime and anywhere around the world just with the help of GSM / 3G network, which currently is the most advanced one. Arduino SIM is ideal for connected devices on the go, especially in areas without any other consistent IoT network or reliable WiFi. A range of microcontroller boards with integrated connectivity options including the Arduino MKR NB 1500are being offered by the Arduino MKR family - which features 5G ready LTE Cat-M and NB-IoT support. The Arduino SIM platform provides a solid foundation for users require to scale from a single to large numbers of devices in the coming future.

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It is quite difficult to get accurate weather for a particular location. With the advancement of technology, especially in the field of data acquisition and embedded systems, the problem of large set up area and cost has been reduced extensively**ArduSat** is an Arduino based nanosatellite, based on the CubeSat standard. It consists of a set of Arduino boards and various sensors. The poeple will be allowed to use these Arduinos and sensors for their projects, innovations as well as own innovative purposes while they are in space .with the help of ArduSat, it becomes easier to create own satellite based experiments thus providing the opportunity to create the same and collect real-world space data using the Arduino open-source prototyping platform. It is also possible to provide weather reports instantly and hence data of places with different altitudes as well as different time zones can be compared easily.

Addition of this Weather detection system to the smart irrigation will prove to be highly beneficial and will help in analysing the current weather, collecting data related to humidity, rainfall and hence further automating the smart irrigation system. The weather conditions will help in analysing the amount of water required and hence avoid wastage of water even further.

IV. ANDROID MOBILE APPLICATION

Android is used to develop mobile application for automatic irrigation and many other agricultural related systems. Android is a mobile operating system developed by Google, based on the Linux kernel and designed primarily for touch screen mobile devices such as smart phones and tablets and smartwatches. Android's user interface is mainly based on direct manipulation using touch gestures that loosely correspond to real-world actions, such as swiping, tapping to manipulate on-screen objects, along with a virtual keyboard for text input and now gestures and voice assistants are also becoming very common. The sensor data and threshold value are stored in local memory of the mobile or an external memory can also be used if the receiving data is large in quantity. The user can view the sensor data, and can set the system into an automatic mode so that the system automatically switches motor depending on the sensor data and previously set threshold value. Also the user can set the system to manual mode and he himself can decide the switching of the motor or can stop it if required due to some reason. He can also get the notifications regarding the water level in reservoir so that he can make alternatives when there is scarcity of water in reservoir tanks.

V. IOS APPLICATION

iOS (formerly iPhone OS) is a mobile operating system created and developed by Apple Inc. exclusively for its hardware (iPhones and iPads). It is the operating system that powers many of the company's mobile devices, including the iPhone and iPod Touch and the term also included the versions running on iPads until the name iPadOS was introduced with version 13 in 2019. It is the world's second-most widely installed mobile operating system, after Android by Google. It is the basis for three other operating systems made by Apple: iPadOS, tvOS, and watchOS which are present in iPads and Apple Smartwatches respectively. It can be used to run apps similarly like android and can be used to control irrigation systems.

VI. WORKING AND CIRCUIT DIAGRAM

The Smart Irrigation System is based on the soil moisture sensor. This soil moisture sensor module is used to detect the moisture of the soil. It measures the volumetric content of water inside the soil and gives us the moisture level as output. The module has both digital and analog outputs and a potentiometer to adjust the threshold level.A small charge is placed on the electrodes and electrical resistance through the sensor is measured. As water is used by plants or as the soil moisture decreases, water is drawn from the sensor and resistance increases. Conversely, as soil moisture increases, resistance decreases. The input from the sensor is converted to a scale of 1 – 100. This conversion takes place using the Arduino. The analog input from the soil sensor to the Arduino is scaled and compared with a predefined threshold value. The threshold value is prestored in a variable in Arduino according to the crop and the geographical conditions. If soil moisture is less than the threshold value the motor is switched ON and if the soil moisture exceeds the threshold value the motor is switched OFF. This On / OFF is done by providing an output from the Arduino to the motor. This is a digital output so it has only 2 values, HIGH and LOW thus acts simply as a switch. Any motor of any power rating can be used with this system as the system acts just as a mere switch. Also the variable threshold can be updated any time by either changing the code or implementing any other method like remotes, wifi module, Bluetooth etc.

Now it was necessary that the smart irrigation system was able to check the availability of water before turning on a motor otherwise this could result in electricity wastage. To overcome this problem, an ultrasonic sensor is placed to check the water level of the reservoir tank. The ultrasonic sensor works based on the piezoelectric method. It has a trigger pin and an echo pin. The trigger pin act as transmitter and the echo pin is a reflector. The trigger pin sends ultrasonic waves once it started functioning and the ultrasonic waves hit the water and are reflected towards the echo pin. The time duration to receive the echo is calculated and that indicates the water level in the tank. The duration is converted to the distance using mathematical equations.

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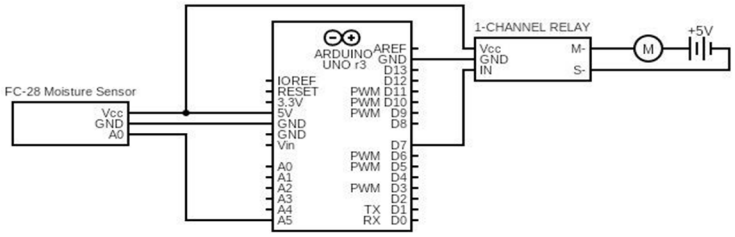
Before the motor is switched on, the water level is checked to ensure that require amount of water is available for irrigation and there is an alarm notification if water is not available. If required amount of water is not present, the motor will not be switched on or only less amount water can be supplied. The notification is sent to the farmer's mobile for further instructions.

The whole program runs on loop and thus the process of check soil moisture keeps going on continuously. When the moisture level reaches the threshold value, the Arduino receives the signal and sends the output LOW to the motor and thus it turns off. Once started, this processs does not need any kind of manual interference and takes very low power to operate.

Circuit Diagram



VII. CONCLUSION AND FUTURE WORK

The automated irrigation system implemented was found to be feasible and cost effective for optimizing water resources for agriculture production and also reduces manual labour which is required. This irrigation system allows cultivation in places with water scarcity thereby improving sustainability and quality. The irrigation system helps the farmer by making his work smarter rather than harder. As the demand for water increases, along with the need to protect aquatic habitats, water conservation practices for irrigation need to be effective and affordable specially in countries like India. As multiple sensors are used water can be provided only to the required area of land thus reducing water wastages and manual inspection everytime. This system reduces the water consumption to greater extent. It needs minimal maintenance and is very cost effective too. The power consumption has been reduced very much as the motors don't need to keep running and hardware like Arduino and Bluetooth modules consume very less power. The crop productivity increases and the wastage of crops are very much reduced thus helping a farmer economically too. The extension work is to make user interface much simpler by just using intertnet or native android notifications within the apps and to operate the switches.

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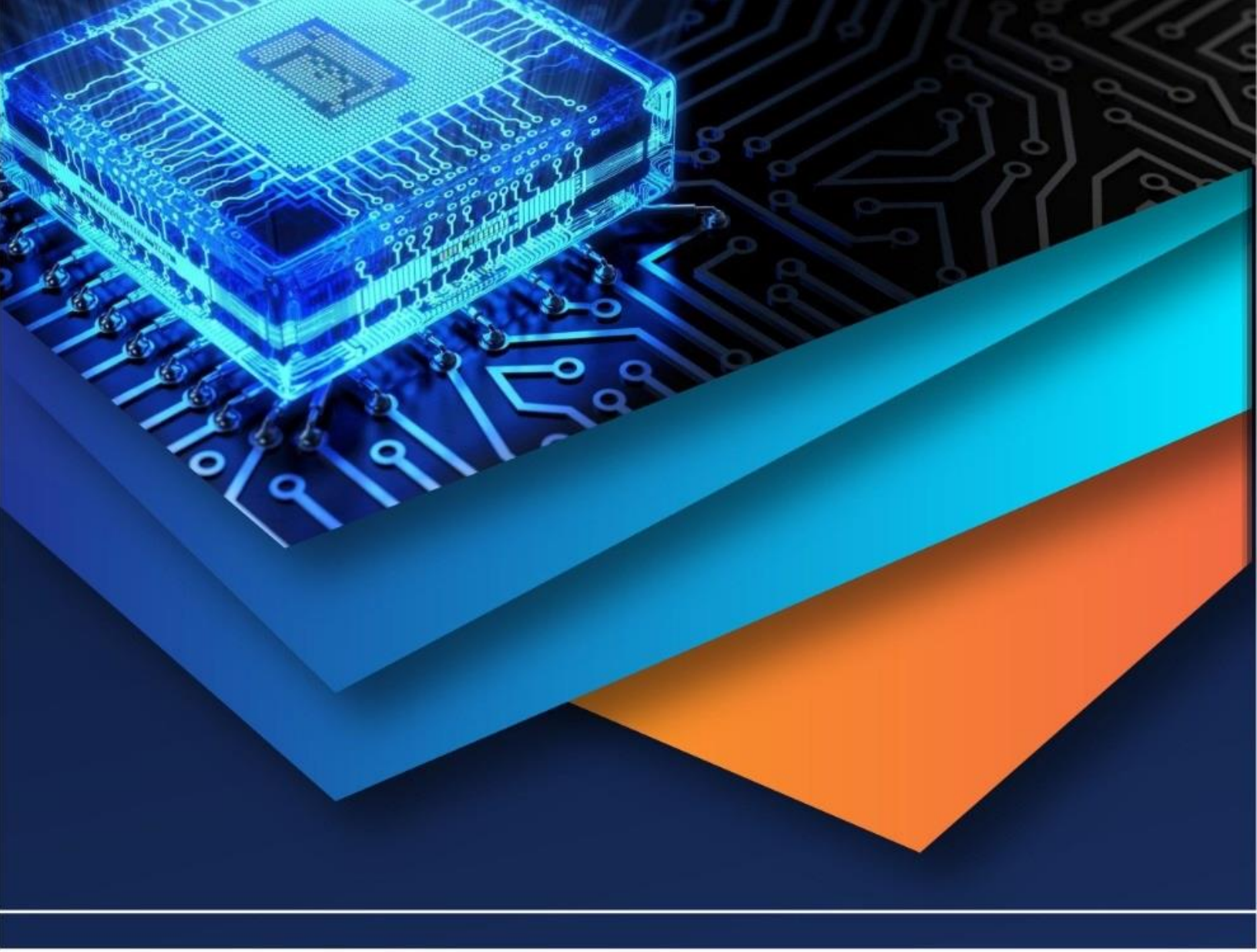

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