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Original Article

Smart Subsurface Irrigation System Using AI and IoT

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Abstract: *This work presents a novel approach to optimize irrigation practices through the integration of an embedded based irrigation system with advanced sensors and artificial intelligence techniques. The system utilizes Arduino microcontroller for data acquisition and control, along with sensors, conductivity sensor, and DHT11 for monitoring soil nutrients, moisture levels, and environmental conditions. This closed-loop feedback mechanism ensures efficient water usage while maintaining optimal soil conditions for crop growth. The integration of the drip irrigation system with Arduino and advanced sensors, coupled with the use of a controller for predictive analysis, offers a smart and automated solution for precision agriculture. The proposed system demonstrates promising results in enhancing crop yield, conserving water resources, and reducing manual intervention in irrigation management.*

Keywords: *Irrigation System, AI, IoT.*

I. INTRODUCTION

Humans have always looked into agriculture as the main source of food production. Since the existence of human on earth, they have relied on crops cultivation for food security. With human civilization, they began to examine the aesthetic part of the green spaces by integrating manmade features with the natural resources. These green spaces evolved from agriculture to horticulture including public urban spaces, private gardens and parks, all the way to the street and interchanges. The innovation of green spaces has also offered an opportunity to move vertically by introducing the concepts of green walls, hanging planters, and vertical gardens. Urban green spaces not only used as a source of food production, but also a space where greenery exists for relaxation, meditation, social gathering and a purification buffer from the urban cities.

The increase of population and urbanization has put so much pressure into the need for more agricultural and landscape areas. Yet, as a result of climate change and global warming, water availability is becoming a critical factor impacting the efficiency of agriculture and landscape all over the world. Irrigation practices have gone through a massive development since the urbanization. However, the need for innovative and smart practices can be the ultimate solution.

Barriers of existing methods used in irrigation and the difficulties facing the agriculture and landscaping. There has been a paradigm shift in agriculture and landscape of the country due to the current irrigation methods and contributed positively to the development of the ongoing boosting of agricultural and landscape activities such as the parks and the gardens. Nevertheless, the population is on the increase mainly because of the higher birth rate among the local population and the continuous inflow of the foreign national in search of better pastures and stress free life not to mention the bad practices of the human beings with respect to the damage to the environment and the precious water sources. Irrational irrigation practices and the water usage is causing tremendous pressure on the water sources coupled with water wastage and increasing energy consumption. Many a streams have gone dry coupled with the Aflaj methods being subjected to drought, and it should be seen in conjunction with the pollution of the ground water and the unbridled use of the ground and surface water including the aquifers. The pace of the urbanization is sure to proceed in UAE with the possibility of many more being added to the urban population in the near future, the better management of the water sources and irrigation isparamount and imperative to sustain the present level of water consumption and to ensure enough water sources for our posterity.

The environmental concerns arising out of the large scale desalination plants as a result of the extraction of the salt from the sea water cannot be neglected. Heating seawater and condensing steam or the reverse osmosis in which the water is pushed through a membrane in order to filter out the salt, causes various environmental damages. The input concerns such as the large scale intake of the sea water can cause the destruction of the marine ecosystem in the region by destroying the local marine life and environment. The output concerns can arise from the oil spills and red tides as far as the Middle Eastern sea or marine water is concerned. The greenhouse gas emission arising out of the fossil use can further aggravate the situation in the gulf region by climate change bringing with it varied problems like drought, famine and flood on a random basis.

There is a water-energy –food nexus in the gulf region meaning water challenges are worsened as a result of this compounding of the multiple nexuses. Energy is an important part of the value chain of the water as the abstraction of the water is energy dependent not to mention the purification of the water using the high energy intensive means (Mahmoud, 2016). In addition to that the transportation to the urban areas is also another energy consuming process. This interlinks between the water and energy is on the rise in the Gulf region bring production and consumption of energy and water at a crucial juncture. The proper water management and governance is necessary to support water security and to facilitate the transition into the green economy. If there are energy efficient means and renewable energy sources for the extraction of the water and transportation, the environmental degradation can be prevented and sustainability can be achieved.

The water shortage and scarcity may lead to conflicts in the region endangering the fragile situation of already highly polarized society. The black farmers and the Arab nomads in the Darfur region of Sudan is a stark reminder of this inflammable situation in the MENA region as they engaged in numerous conflicts for the scarce water sources. Reaching a consensus for the fast depleting water sources use will be challenging for the modern nation states if there is no prior accord, policies and conventions to tackle it in the future. Water is the most important basic rights of the people and depriving it to the people even if other nationals is tantamount to denying the right to live.

II. LITERATURE REVIEW

Srilikhitha et al automates the irrigation process thereby reducing the manual intervention and the water losses. It is more helpful in the places where water scarcity is seen more. It consists of 2 sensors which takes the values of temperature of surroundings and moisture level of soil. Output of these sensors are given to ADC and then to microcontroller. Microcontroller compares the values with the threshold values and drives the relay which controls the motor.

K. Sreeram; et al provides a solution for these problems by helping farmer monitor and control various activities through his mobile via GSM and DTMF technology in which data is transmitted from various sensors placed in the agricultural field to the controller and the status of the agricultural parameters are notified to the farmer using which he can take decisions accordingly.

Deepali Kothari et al attempt to implement automation for control of electrical motor or pump used in agriculture domain. The agriculture work by its nature is a field job, hence devices used are sparsely distributed. This makes it difficult for farmers to control and operate these devices in real time. With the emerging technologies, we have seen the advent of many wireless communication techniques, having lower operating cost along with interactive protocols.

M. O. Sharma ; P. M. Sonwane propose android based agricultural support system, that is, automatic irrigation system which adjusts the quantity of water based on sensor data. Monitoring and control of water irrigation and level detector with liquid fertilizer is being proposed in dissertation work with different control schemes and monitoring methods implemented using the micro-controller 89S52 and PIC 18F4550.

A. Ruby Roselin et al proposed project is to making agriculture smart using IoT technologies. The important feature of this project includes the prevention of crops from spoilage during rain and efficiently recycling the rain water for irrigation. Secondly, it includes intruder alarm/buzzer which is used to detect any human/animal intruder into the farm

Ateeq Ur Rehman et al proposed design also has the feature of GSM which makes this system wireless. The electricity required by components is provided through solar panels hence this liberates us from interrupted power supply due to load shedding.

G Kavianand et al presents a fully automated drip irrigation system which is controlled and monitored by using ARM9 processor. PH content and the nitrogen content of the soil are frequently monitored. For the purpose of monitoring and controlling, GSM module is implemented.

K. S. Vijula Grace et al proposed work describes the automated system to make effective utilization of water resources for agriculture and crop growth monitoring using GSM. The effective utilization of drip irrigation process is improved by using the signals obtained from soil moisture sensor. The output signals of the sensors are coordinated by the microcontroller and transmitted to the user with the help of GSM Modem.

Ashok Jhunjhunwala et al presents a new approach to building an Agricultural Advisory System aimed at bridging the information gaps that exist between farmers and extension workers and agricultural scientists in a country like India. It

demonstrates the power of two-way mobile phones today, which when combined with innovative methods could provide services to farmers that could not even be envisaged till yesterday.

III. PROPOSED SYSTEM

The proposed system introduces a pioneering approach to modernize irrigation practices by amalgamating a drip irrigation framework with cutting-edge sensors and artificial intelligence algorithms. Employing an Arduino microcontroller as the central hub, the system integrates crucial sensors including conductivity sensors, alongside the DHT11 for monitoring soil nutrients, moisture levels, and environmental parameters. This sensor suite furnishes real-time data crucial for precision irrigation. By seamlessly combining the irrigation system with Arduino and advanced sensor technologies, alongside the predictive capabilities the proposed system promises to revolutionize irrigation management. Its implementation is poised to enhance agricultural productivity, optimize water usage, and streamline irrigation operations, marking a significant stride towards sustainable and efficient farming practices.

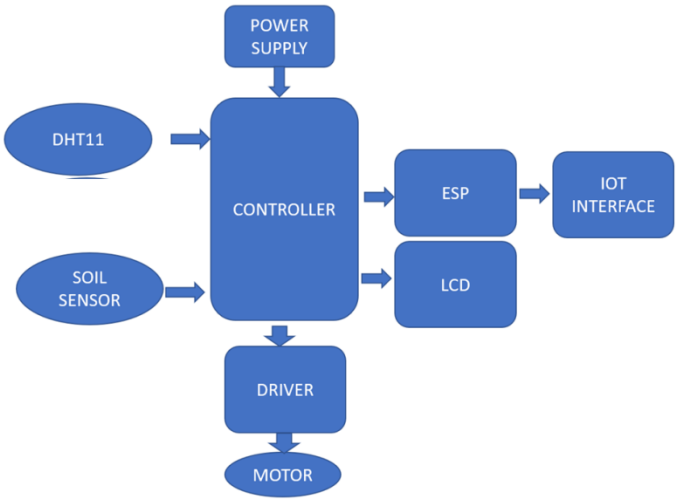

Figure 1: Proposed System

This project proposes an automated irrigation system which monitors and maintains the desired soil moisture content via automatic watering. Microcontroller ATMEGA328P on arduino uno platform is used to implement the control unit. The setup uses soil moisture sensors which measure the exact moisture level in soil. This value enables the system to use appropriate quantity of water which avoids over/under irrigation. IOT is used to keep the farmers updated about the status of sprinklers. Also, the sensor readings are transmitted to a Thing speak channel to generate graphs for analysis

The system is a combination of hardware and software components. The hardware part consists of embedded system and software is the webpage designed using PHP. The webpage is hosted online and consists of a database in which readings from sensors are inserted using the hardware.

This project utilizes all these fears accordingly with the distance of the elephant from the human settlements. The block diagram is shown below. As shown in the figure , our solution involves vibration sensors. The vibration sensors have different operating range (say 20m, 15m). When the heavy vibration caused by elephant movement is sensed within 20m, first vibration sensor sends the electrical pulses . It is then compared with the threshold value. If the value matches, the powerful flashing lights are activated. This should drive it back to the forest. Due to this, vibration sensors will turn off the flashing light. If it doesn't and if the elephant continues in its path without fearing for the light, vibration sensor 2 gets activated once it is within 15m range and sends the electrical pulses, if it matches with the same threshold value and after some distance, it activate relay which in turn activates the sound system which produces bee's sound and with the help of repelled.

A. Flow Chart

Flowchart is a graphic representation of a logic sequence, work or manufacturing process, organization chart, or similar formalized structure. The flowchart is a means to visually present the flow of data through an information processing systems.

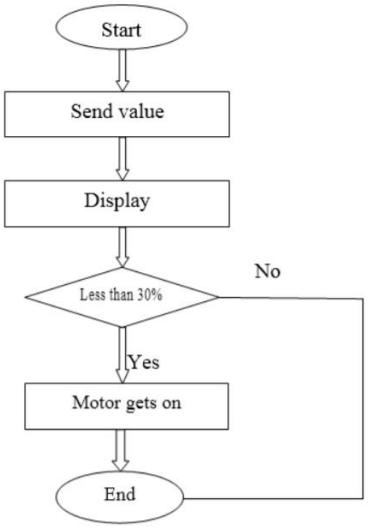

Figure 2: Flow Chart

B. Soil Moisture Sensor

This below Figure shows the procedure of displaying soil moisture value. Flow chart of Soil moisture sensor Soil moisture sensors measure the water content in soil. Moisture in the soil is an important component in the atmospheric water cycle.Sensor module outputs a high level of resistance when the soil moisture is low. It has both digital and analog outputs. Digital output is simple to use, but it is not as accurate as analog output based on moisture level motor gets turn on/off automatically.

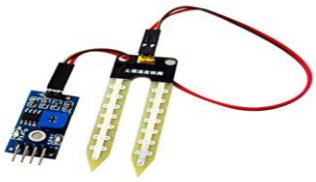

Figure 3: Soil Moisture Sensor

C. Humidity Sensor

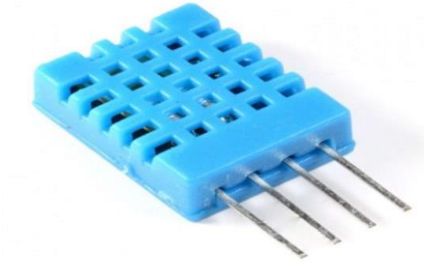

Figure 4: DH11 Temperature Sensor

This DHT11 Temperature and Humidity Sensor include an aligned advanced flag output with the temperature and mugginess sensor ability. It is incorporated with an elite 8-bit microcontroller. Its innovation guarantees the high dependability and magnificent long haul steadiness. This sensor incorporates a resistive component and a sensor for wet NTC temperature estimating gadgets. It has great quality, quick reaction, hostile to impedance capacity and high performance.

D. Arduino Micro Controller

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world.

The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on the Processing project, which includes support for theC and C++ programming languages.

The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The hardware design specifications are openly available, allowing the Arduino boards to be manufactured by anyone. AdafruitIndustriesestimated in mid-2011 that over 300,000 official Arduinos had been commercially produced, and in 2013 that 700,000 official boards were in users' hands.

Figure 5: ESP32 Development Board

Figure 6: Bluetooth Module

The ESP-01 ESP8266 Serial WIFI Wireless Transceiver Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

This module has a powerful enough onboard processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existing interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions and requires no external RF parts.

There is an almost limitless fountain of information available for the ESP8266, all of which has been provided by amazing community support. In the Documents section below you will find many resources to aid you in using the ESP8266, even instructions on how to transforming this module into an IoT (Internet of Things) solution!

Note: The ESP8266 Module is not capable of 5-3V logic shifting and will require an external Logic Level Converter. Please do not power it directly from your 5V dev board.

E. DC Motor:

A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current in part of the motor.

Figure 7: DC Motor

DC motors were the first form of motor widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

A coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. The direction and magnitude of the magnetic field produced by the coil can be changed with the direction and magnitude of the current flowing through it.

A simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes. (Brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes.) The total amount of current sent to the coil, the coil's size and what it's wrapped around dictate the strength of the electromagnetic field created.

The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a torque on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor.

At high power levels, DC motors are almost always cooled using forced air. Different number of stator and armature fields as well as how they are connected provides different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems which adjust the voltage by "chopping" the DC current into on and off cycles which have an effective lower voltage.

Since the series-wound DC motor develops its highest torque at low speed, it is often used in traction applications such as electric locomotives, and trams. The DC motor was the mainstay of electric traction drives on both electric and diesel-electric locomotives, street-cars/trams and diesel electric drilling rigs for many years. The introduction of DC motors and an electrical grid system to run machinery starting in the 1870s started a new second Industrial Revolution. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles and today's hybrid cars and electric cars as

well as driving a host of cordless tools. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Large DC motors with separately excited fields were generally used with winder drives for mine hoists, for high torque as well as smooth speed control using thyristor drives. These are now replaced with large AC motors with variable frequency drives.

If external mechanical power is applied to a DC motor it acts as a DC generator, a dynamo. This feature is used to slow down and recharge batteries on hybrid and electric cars or to return electricity back to the electric grid used on a street car or electric powered train line when they slow down. This process is called regenerative braking on hybrid and electric cars. In diesel electric locomotives they also use their DC motors as generators to slow down but dissipate the energy in resistor stacks. Newer designs are adding large battery packs to recapture some of this energy.

IV. RESULT & DISCUSSION

The implementation of the proposed system yielded promising outcomes in enhancing irrigation efficiency and crop productivity. The dynamic adjustment of the water pump's pulse width modulation (PWM) based on the predictions generated by the controller ensured that crops received the appropriate amount of water tailored to their specific needs. This closed-loop feedback mechanism not only maximized water utilization but also minimized water wastage, contributing to water conservation efforts in agriculture.

V. CONCLUSION

The integration of a drip irrigation system with Arduino, advanced sensors, for predictive analysis presents a promising solution for modernizing irrigation practices in agriculture. Through real-time monitoring of soil moisture, nutrient levels, and environmental parameters, coupled with dynamic adjustment of water delivery based on predictive modeling, the proposed system demonstrates significant potential in enhancing irrigation efficiency and crop productivity.The results of this study highlight the effectiveness of the closed-loop feedback mechanism in optimizing water usage while minimizing wastage. By tailoring irrigation schedules to the specific needs of crops, the system contributes to water conservation efforts and promotes sustainable farming practices.

VI. REFERENCES

[1] Siuli Roy, Somprakash Bandyopadhyay, “A Test-bed on Real-time Monitoring of Agricultural Parameters using Wireless Sensor Networks for Precision Agriculture”

[2] C. Arun, K. Lakshmi Sudha “Agricultural Management using Wireless Sensor Networks – A Survey” 2012 2nd International Conference on Environment Science and Biotechnology IPCBEE vol.48 (2012) © (2012)IACSIT Press, Singapore

[3] Anurag D, Siuli Roy and Somprakash Bandyopadhyay, “Agro-Sense: Precision Agriculture using Sensor-based Wireless Mesh Networks”, ITU-T “Innovation in NGN”, Kaleidoscope Conference, Geneva 12-13 May 2008.

[4] "DIFFERENTIAL PRIVACY TECHNIQUES IN MACHINE LEARNING FOR ENHANCED PRIVACY PRESERVATION", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.11, Issue 2, page no.b148-b153, February-2024, Available: http://www.jetir.org/papers/JETIR2402116.pdf

[5] Yiming Zhou, Xianglong Yang, Liren Wang, Yibin Ying, A wireless design of low-cost irrigation system using ZigBee technology, 2009 International Conference on Networks Security, Wireless Communications and Trusted Computing, 978-0-7695-3610-1/09 , IEEE.

[6] Ning Wang, Naiqian Zhang, Maohua Wang, “Wireless sensors in agriculture and food industry—Recent development and future perspective”, published in Computers and Electronics in Agriculture 50 (2006) 1–14.

[7] Izzatdin Abdul Aziz, Mohd Hilmi Hasan, Mohd Jimmy Ismail, Mazlina Mehat, Nazleeni Samiha Haron, “Remote Monitoring in Agricultural Greenhouse Using Wireless Sensor and Short Message Service (SMS)”, 2008.

[8] Jeonghwan Hwang, Changsun Shin, and Hyun Yoe “Study on an Agricultural Environment Monitoring Server System using Wireless Sensor Networks”, 2010.

[9] Zhang xihai, Zhang changli Fang junlong. Smart Sensor Nodes for Wireless Soil Temperature Monitoring Systems in Precision Agriculture 2009. 237-241

[10] Bogena H R, Huisman J A, OberdÊrster C, et al. Evaluation of a low cost soil water content sensor for wireless network applications Journal of Hydrology, 2007, 32-42