Detection of emitter clogging and pipe breaks in automatic drip irrigation

Nandan N[1], Umesha D K[2], Priya M K[3]

[1] Lecturer, Department of CS&E, Government Polytechnic, Arakere, Karnataka, India
[2] Lecturer, Department of CS&E, Government Polytechnic, Soraba, Karnataka, India
[3] Lecturer, Department of CS&E, Government Polytechnic, Ramanagara, Karnataka, India

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Abstract - *Automation of the drip irrigation system will solve the problem of the water wastage, man power and increase productivity but it will also raise many problems like emitter clogging the drip emitter causes the plant to dried out, pipe breakage causes the loss of water, wireless sensor network implemented in the farm has issues such as data loss in network, short range data transmission, and more power consumption at sensor nodes. The problem with the emitter clogging can be predicted by using the flow sensor and the pressure sensor, whenever there is clogging in the emitter which automatically increases the pressure at the end of pipe and measured using the pressure sensor in terms of bars and flow rate decrease will be detected using the flow meter sensor. The pipe breakage is predicted when the pressure decrease below the normal threshold pressure. Node MCU (ESP8266) is used to create the wireless sensor network which creates a high speed and secure network compared with Zigbee and Bluetooth. The Wi-Fi network avoids the data loss while sending data from the sensor nodes to coordinator node. Wireless sensor nodes are secure with high data transmission rate and long range data transmission.*

Key Words: Emitter Clogging; Pipe breakage; Node MCU; Wi-Fi;

1.INTRODUCTION

The agriculture was started thousands of years back. Agriculture provides the major contribution to the Indian Economy. Agriculture is the basic source of revenue for more than 60 per cent of India's population. Agriculture provides 50 per cent of employment to the countries labor force. The 18 per cent of Gross domestic product (GDP) of India is accounted from agricultural sector. Water source for agriculture in India is from rainfall, ground water, canal irrigation. Due to lack of rainfall or insufficient rainfall or uncertainty in rainfall is difficult to depend on the rainfall only. Ground water source is declining step by step because of the lack ground water recharging process. Canals are mainly base on the river water source which in turn connected with rainfall. Increase demand for the food products due to exponential growth of population in India. Creating work force for larger population is declining due to the irregular rainfall or unseasonal rainfall because of this reason predicting the rainfall is becoming difficult to the farmers those who are mainly depend on the rainfall. Farming profitability is declining step by step because of the absence of water resource and labor. To reduce wastage water resource and labor has lead expanded requests on automating applications in the field of agriculture to reduce the power, water and improves the yield. Various parameters are inculcated for the drip irrigation system automation. System node incorporates sensors to node like soil dampness sensor, Atmospheric humidity sensor, temperature sensor, soil pH sensor. Wireless sensor network for data collection at various specified points on the farm field. Using remote advancements in the field of cultivating have a ton of specialized challenges, for example, improving battery life, long distance data transmission, secure data transmission, transfer speed of system, data misfortune, data transmission rate and minimal cost.

Automation is done mainly to save the water resource for future and minimize the man power automation on drip irrigation comes into picture. Automation concentrated on the saving water by providing the necessary amount of water to each plant on the farm. The watering to plant is done timely based on the soil moisture, detecting the trespasser to the farm field, crop growth viewing using camera, soil quality and acidity information to apply fertilizers. Automation makes efficient water resource utilization for the farm field. This drip irrigation automation is also having problem like emitter blockage due to chemical used, hardness of the water source, biological factor and dust, pipe breakage due to the exposure to sunlight become brittle and breaks easily or due to trespasser or animals. Wireless sensor nodes consume more power even on the idle condition makes frequent changing of the battery for the nodes.

Basically internet of things works based on the sensors. There are different sensors available on the market for collecting the data. The major used sensors for agriculture are the soil moisture sensor for finding the soil wetness to make decision of motor to ON/OFF. Temperature and humidity sensor data is used to get the current weather condition on the farm field. Passive infrared sensor is used find the trespasser to the farm field. PH sensor is helped to collect the acidity data of the farm field. NPK is used get the quality of the soil based on which fertilizers are applied to the field.

The Wireless sensor network is implemented on the farm field to get the sensor figures from the different part of the farm field to make the decision correctly or accurately. There are many issues on the on creating the sensor network. The traffic on the network is mainly depends on the number of nodes installed in the field and topology of the network used for example star topology causes more data loss than mesh topology, the node placement on the field, line of sight, strength of signal is main factor for network stability. The sensor nodes and control node or base node network is created using different technology like Bluetooth, Zigbee, Wi-Fi, GSM, or LoRa. The best suited depend the farm environment condition.

2. LITERATURE REVIEW

In their study, Zhang et al. (2023) proposed an approach based on machine learning, which uses pressure and flow rate data to detect clogging in emitters. A random forest model developed by the researchers was found to achieve 95% accuracy in identifying clogged emitters [2]. A new acoustic sensor system has been developed by Li et al. (2022) in order to detect changes in water flow sounds as a result of clogging and identify the cause. As a result of these laboratory tests, this method has shown promising results, resulting in an 88% detection rate in laboratory tests [3]. In a study by Gonzalez-Perea et al. (2021), IoT sensors and fuzzy logic algorithms were combined to create a real-time clogging detection system that could be used in real-time. By comparing their approach with traditional threshold-based methods, they were able to reduce the number of false positives by 30% [4].Chen et al. Third, (2023) proposed to use a distributed fiber optic sensing approach combined with the dynamic odds ratio analysis method as a solution to detect and localize pipe breakages. For example, their method was able to locate leaks along a 1-km pipe length within 1 m of an actual break [5].

Kumar and Singh (2022) established an algorithm that enables the detection of very fine leaks and rupture by pressure wave analysis. Reading the Akademia videos, their system achieved a 92% leak detection rate for leaks as low as 1% of the total flow rate. [6]. Martínez et al. In their work, Esakki Balasubramanian et al., (2021) presented a multi-sensor fusion (pressure, flow and soil moisture data) approach. The system was able to detect pipe breakages with an accuracy of 97% in all the combinations of field conditions evaluated [7]. Wang et al. A hybrid of IoT sensors and edge computing was used to develop a fully-fledged monitoring system by (2023). These clogging and breakage were simultaneously monitored by a system of theirs, with an accuracy rate of 94% [8]. Alves et al. (2022) — A secure data collection and analytics blockchain mechanism for irrigation large-scale platforms. (Rightarrow) Resulted in better quality data and longer-term analysis of system degradations [9]. Rodriguez-Diaz et al. It then somewhat broadly examined drone thermal sensing technology in 2024 that could be used to detect clogging, but also to identify if a pipe was broken. Although still in preliminary stages, this approach carries potential for fast and cumulative investigation of systems at the finest scale [10]. Kim et al. A study Researched the Capabilities of Quantum Sensors for Extremely Accurate Flow Measurements. Other new products focus on early detection: one four-person startup has just completed a prototype that can detect changes in flow as small as 0.01%, which could drastically improve early warning time [11].

Automation of drip irrigation system is implemented using LPC2148 microcontroller, and nodes capable of sensing soil moisture, temperature and humidity data. The connection between the mobile user and the farm is established using HC05 Bluetooth module. The communication is established only when the user present within the reachable region from the sensor nodes [12]. Microcontroller used is the ATmega328p Arduino UNO and soil moisture sensor for colleting the wetness of the area. The communication between the mobile application and farm field is done using Bluetooth module. Here Bluetooth terminal is used for the interaction [13]. Wireless sensor network consisting of the node created using Arduino UNO with addition sensing capabilities like soil dampness, temperature and humidity. The network is established using the Bluetooth (HC05), the communication established between the nodes using the P2P communication, capable of single node communication with the coordinator node at a given particular time [14].

The sensor node and coordinator node in WSN is connected with the help of Bluetooth modules. Bluetooth nodes consume less power for data transmission and data receiving between the nodes. Network is with the higher data transmission rate and bandwidth for larger data. The point to point communication between the nodes makes other nodes to linger for data transmission and network consists of less number of sensor nodes. This incurs delay in the network, it is suitable for small distance data exchange and as it operating under RF so it not much secured.

Automated drip system is implemented with wireless sensor network on farm field includes number of wireless sensor node each node is provided with capability of sensing data with air moisture sensor, soil dampness sensor, temperature sensor. Sensor nodes are designed using ATmega32 microcontroller. Here the coordinator node is the PC and communication between the PC and sensor nodes is established using the Zigbee module. GSM module is used to send the data to cloud database and mobile application. System is controlled using mobile phone application remotely [15]. The Zigbee wireless sensor nodes are created to sense the farm field physical data like moisture, humidity, temperature. The nodes update the data to the network base station which takes the decision of turn ON/OFF the motor based on the physical data values sensed from the farm field [16]. The drip automation network is constructed using different nodes as coordinator or base node, sensor node or sender node and the server is design using raspberry pi. The communication is established between the receiving node and the sensing node is done by using the RF transceiver. It will send the data of the sensor gathered by sensor nodes to a coordinator node [17].

The Zigbee wireless network is suitable to create a personal area network (PAN) consumes minimum power and having low bandwidth. The Zigbee network nodes are having better battery life as it operates at low power and low data transfer rate. The Zigbee data transmission is less secure than with Wi-Fi network. The data loss is more in the network; Hence Zigbee is called as low power and lossy network which hinders subsequent networks.

The system collects the sensor data like soil moisture, temperature, humidity and pH values with the help of the Wi-Fi based microcontroller called ESP8266 module. The implemented system on the field also incorporates the IDS system that sends message to farmer when intruders on the field and also updates farmer about the crop field every time when changes happened on the field [18]. The system solves the problem of manual field work by introducing the watering of the plants automatically done and the complete information about the farm field can be obtained using android application. The sensors data like temperature, wetness, and humidity are received by the Arduino UNO microcontroller and sends the data to the server using ESP8266 Wi-Fi module [19]. The system implements the efficient water management in an automated irrigation system. The scattered wireless sensor network nodes are created using LPC2148 microcontroller, it has control node and web server. Every sensor mote placed in the farm field having soil-moisture sensor, temperature sensor and humidity sensors. The WSN nodes are powered with the help of battery. Control node gathers the sensor data with the help of the RF transceiver. Control node transfers the sensor data to a database using Wi-Fi module. With the help of web application user is able to control motor remotely by considering data such as soil moisture level, temperature and humidity [20].

Wireless sensor network constructed using Wi-Fi module is capable of send the images and video files within short distance of 100mt range. When compare to Bluetooth and Zigbee Wi-Fi Network provides high bandwidth and data rate. Set up of Wi-Fi network is easy and the sensing motes are connected to the Wi-Fi router and sends data securely when compared than Zigbee and Bluetooth. Wi-Fi sensor nodes consume more power for data transmission and receiving and also in idle state. When distance increase in turn increases the power consumption, leads to battery drain quickly.

The automation of drip controlling is done using the GPRS feature of the GSM module. The present farm condition is updated using GSM module. Based on the user requirement an SMS is sent to the user mobile to check the condition of the soil moisture on the farm land to save the man power manual checking. The soil moist is continuously checked to save the water wastage and provide necessary watering to the plants. The motor is turn ON/OFF by sending SMS to the control node which activated motor through relay module [21]. The system implementation is done using 16F877 microcontroller for computation. The farm field data is sends the user using GSM module. The microcontroller is programmed in such way that upper and lower threshold value of the soil moisture is fixed and if the soil moist values below that of lower threshold value the motor starts and if the soil moist values above the upper threshold value the motor gets stopped. The LCD display is used to check the values physically [22]. The smart drip is implemented using the ARM microcontroller for computation along with sensors such as soil moist, temperature and humidity. These sensors data are collected the controller and computation is done based on the prefixed soil moisture threshold value and irrigate the farm using the condition. The modules are attached with GSM module to send the data to user regular updating on the farm activities like start time of motor and end time of motor, power consumption [23].

User gets the information from the farm field easily and faster as it directly connected to the network tower. GSM module implementation cost increases on increasing nodes. Power consumption of nodes is more on signal search and on weak signal strength. It is not suitable for the area having no network or weak network signal.

Long range smart drip irrigation is implemented using LoRa Based Wireless sensor network or LoRaWAN. LoRaWAN is a MAC protocol used for WAN. The system with internet provides the capability of long distance data transfer with the low power consumption. LoRaWAN works on the second layer and third layer of the OSI model. LoRaWAN is implementing on top of ISM radio band. Network has End Device called Mote – it is battery operated low powered communicating device. The Gateway works as antenna for receive broadcasts from mote and vice versa. The Network Server maps the messages from motes to the correct Application, and back to motes. The Application is a part of software runs on a network server. The Uplink means a message to an application from device and the downlink means a message from a device to an application [25].

LoRaWAN nodes are works with low power with long with enhanced battery life for years based computation method. The data transmission between the nodes is possible up to 10kms considering correct line of sight other constraints. LoRa technology is best suited for the application sufficient with the low data rate. As LoRa operates on unlicensed ISM (open frequency) get intervention on that frequency makes to lower data rate and more latency.

3. PROPOSED SYSTEM

The automated system proposed is designed and developed to prevail over the limitations of the existing system. The emitter clogging is predicted by using the pressure sensor. As per law of pressure, pressure increase when there is blockage in pipe due to reduce the channel size or outflow size of pipe by using this concept when ever blockage is the emitter the pressure at the end increase indicates the emitter clogging. Similarly pressure decreases when there is breakage of pipe due to leakage in pipe or broken pipe by using this concept when ever breakage in the pipe the pressure at the end decreases indicates the pipe breakage in the row or column. The nodes are communicating in secure manner by using Node MCU (ESP8266) module. The motor is turn ON/OFF based on the set upper and lower threshold values. The power consumption at the nodes is reduced by taking nodes to deep sleep mode for certain period of time and wakes up at this time it will collect the sensor value of soil moisture, pressure, temperature and humidity to the firebase cloud database. The same will be reflected on the android application using by the user. The notification of the emitter clogging and pipe breakage will be indicated in the android application.

The automated irrigation system architecture consists of the control node, sensor nodes, Wi-Fi router and Firebase cloud. The sensor nodes collect the moisture value and pressure value and update the data to Firebase cloud through the Wi-Fi router as shown in the figure 1. The control node fetch the data like moisture value, motor state and pressure value using these data it will decide the irrigation of the crop land. The Firebase cloud gets the data and update to control node and user mobile application to make decision and notification of field status. User gets the emitter blockage or pipe broken notification on application can address the problem immediately to save plant or to save the water.

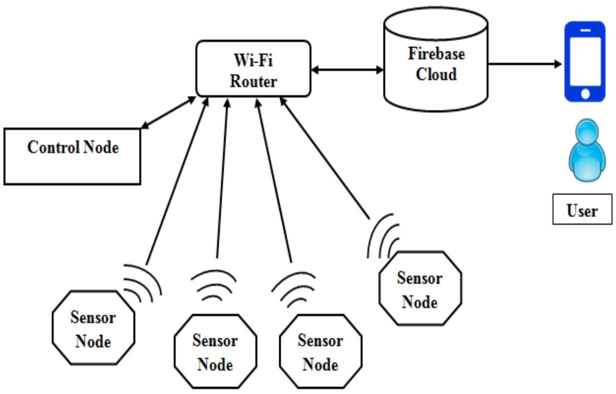

Figure 1: System Architecture

The control node updates the temperature and humidity data to the Firebase could and fetch the pressure value, motor status and moisture value from the Firebase cloud as shown in the figure 2. The data is updated to the server every 30mins once and fetch the data at the same time. This saves the energy of the node twice the in terms of extended battery life. Based on the soil moisture and motor state the motor gets ON/OFF controlling done with control node automatically. Control node works with 5V DC supply and the ESP8266 will go to sleep mode for 30mins and save half the battery life. It wakes up for less than a second and fetch the data from the cloud and take decision to turn ON/OFF the motor.

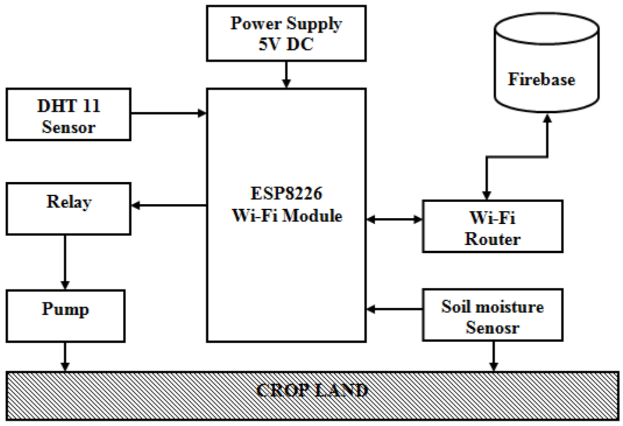

Figure 2: Control Node Architecture

The sensor nodes update the soil dampness and pressure value to the Firebase could as shown in the figure 3. The data is updated to the server every 30mins once. This saves the energy of the node double the in terms of extended battery life. Based on the soil moisture and motor state the motor gets ON/OFF controlling done with control node automatically. Sensor node works with 5V DC supply and the ESP8266 will go to sleep mode for 30mins and save half the battery life. It wakes up for less than a second and sends the data to the cloud. The pressure sensor attached to node works at 3.3V DC and values is in analog format. The pressure data is collected at the end of the each row pipeline. The soil moisture sensor attached to the node works at 3.3V DC and data is in analog format. All the sensor nodes are connecting to the Firebase cloud through the Wi-Fi router installed on the farm field.

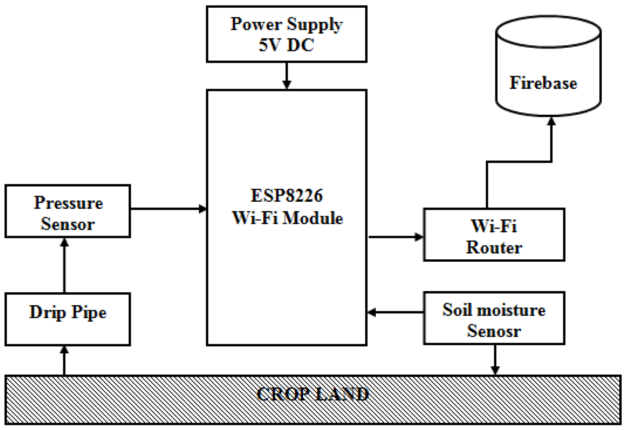

Figure 3: Sensor Node Architecture

3.1 ALGORITHMS

Algorithm -1: Motor_state( )

1. Initialize the setup with proper power supply
2. Read the soil moisture value (SMV)
3. If Soil_Moisture_Value > Upper_Threshold_Value
   Sufficient water so Turn OFF motor
4. Else If Soil_Moisture_Value < Lower_Threshold_Value
   Require water so Turn OFF motor
5. Else
   GoTo Step_2
6. End Else If

Procedure stops.

Algorithm -2: User_alert( )

1. Initialize the setup with proper power supply
2. Read the water pressure value (WPV)
3. If Water_Pressure_Value > Upper_Threshold_Value
   Send alert notification to user "Emitter is Blocked"
4. Else If Water_Pressure_Value < Lower_Threshold_Value
   Send alert notification to user "Pipe is Broken"
5. Else
   GoTo Step_2
6. End Else If
7. Procedure stops.

Algorithm -3: Update_database( )

1. Initialize the setup with proper power supply
2. Wait for set period of Time
3. If the values read from sensors
   Update the values on database
4. End If
   GoTo Deep Sleep mode for set period time
5. GoTo Step_2
6. Procedure stops.

4. CONCLUSIONS

Automated drip irrigation system now capable of predicting the emitter clogging and pipe breakage in an efficient way to save the farmer from loss crop and revenue. The emitter clogging prediction helps to famer from early drying of plants without sufficient water. The pipe breakage or leakage prediction saves the wastage unnecessary water and lack water to plants. The system is easy for installation as Wi-Fi module automatically connects to the router and send the data from the node to coordinator in turn to the could server. The user gets the information through the android application so it makes easy for him to watch the status of the farm remotely and if any problem in the farm like emitter clogging or pipe breakage he can immediately address to it that makes work simple. Wireless nodes are on deep sleep mode saves the 50% of the power that enhance the battery life to twice.

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