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Deep learning and Swarm Intelligence based System for Smart Agriculture Using Wireless Sensor Networks

Kaniga.B , Dr.M.Sudha , Ravisankar Kandasamy
Dept. ECE,
Paavai Engineering College (Autonomous),
Tamil Nadu, India

ABSTRACT—*The WSN (Wireless Sensor Network) based agricultural drainage management system is a convergence technology to enhance agricultural production of crops from storm control, erosion control and water table control. In addition, implementing smart agriculture, through the convergence technology allows to determine the requirement of water resources, real-time monitoring of the field and support farmers in decision process. In addition, sensors help in collecting information on circumstances like level and flow of water in drainage area, soil moisture content and rainfall condition. We presented the survey about the WSN based smart agriculture and its techniques to future along future enhancement. The work further extends with the deep learning approach of analysing the data collected from the level and flow sensors and camera. The CNN based design can improve the performance of the system. The proposed ideation combines the swarm intelligence and CNN for better performance.*

Keywords—*WSN, Agricultural Drainage Management System, Automatic irrigation system, Wireless sensor node, Gateway node, Smart Agriculture, Water Resource Management.*

1. INTRODUCTION

Smart agriculture uses technologies like GPS services, sensors and huge data to enhance agricultural productivity. Rather than replacing farmer expertise, Information and Communication Technology (ICT) based decision support systems, collect real-time data can additionally provide information of all events at level of granularity. This enables optimization of resources, support decision process and more efficient in operations. The proficiency now required in agriculture include weather forecasting, science-based and technological solutions.[1]. Several machine learning methods were used for the analysis of data obtained from the sensors. These ML methods enhance the way the process is done. Machine learning is the current technology which is benefiting farmers to minimize the losses in the farming by providing rich recommendations and insights about the crops Application of machine learning in agriculture allows more efficient and precise farming with less human manpower with high quality production.

1.1. Architecture Of WSN In Agriculture

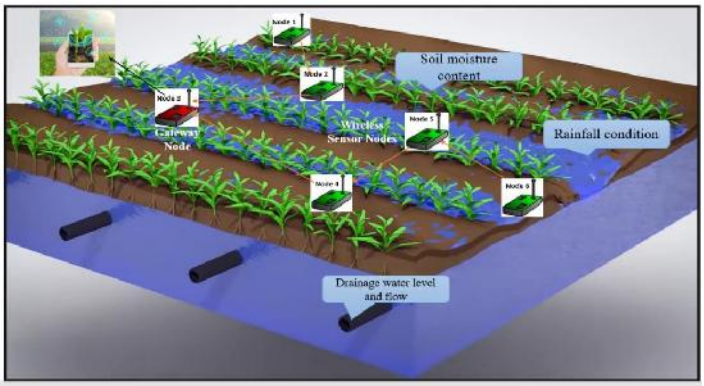

Figure 1: Basic architecture of Agricultural Drainage Management System using WSN

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1.2.A Survey on Smart Agriculture or Smart Farming :

The recent development of Wireless Sensor Network for the improvement of farming practices and the standards provided for wireless communications are overviewed through this work. Different sensors like Temperature Sensor, Humidity Sensor and Soil Moisture Sensor are used for collecting field data and central server for the processing the collected data. In human history, agriculture plays an important role; human developed different methods for checking the atmospheric conditions and for the development of crops. In the traditional methods, manual labour will provide the weather and land condition, according to the condition decision will be taken. System provides the different data from the different types of sensors like Temperature Sensor, Humidity Sensor and Soil Moisture Sensor. Agriculture system based on three module i.e. Agriculture environmental parameters measurement, which will be received from the different sensor, The Data are received by the central monitoring server, which will be transfer or received different module like ZigBee and third module the central server which provides the result.[2]

1.3.A Survey on Importance of Water Resource Management in Agriculture :

Water plays an important role in the agricultural practices for more food production and better raising of livestock. Currently, world population growth is increasing at a rapid rate, the demand for full supplies on agriculture highly depends on the complete usage of available water resources. With the rise in this critical issue, there is a need for water management. An effective water management system is essential for crops to attain their full potential and maximum yield. Agricultural Drainage Management System give farmers the tools to be able to actively control both excess and deficit water throughout the year which they never had before. So this system brings a new level of management and capability to their operation.

Recently, technological solutions paved the way for water resources monitoring and management in agriculture. Internet of Things (IOT), Wireless Sensor Networks (WSN) and cloud computing have been used in various contexts in agriculture. The facilitation of water monitoring process, by applying correct degree of automation level and allowing farmers to access from anywhere and anytime to their farms.[3]

Water resources and agriculture work together to produce food and fiber for the world. An effective Agricultural Drainage Management system using WSN is essential for crops to attain their full potential and maximum yield. This paper survey about what is importance in monitoring the agricultural drainage system data as well as controlling the field operations which provides the reliability. The goal of this paper is to make agriculture smart using automation and WSN technologies. Firstly, This paper focuses on the importance of water management through agricultural drainage by continuously monitoring of level and flow in drainage. Secondly, Irrigation by reusing the excess drainage water from one area moved to less drainage water in other areas. Thirdly, Soil moisture and rainfall prediction for automatic based irrigation and water resources management. Collection of all these parameters from sensors through any remote device or PC connected to Internet and the operations will be performed by interfacing sensors, RF modules, Real time Clock, SD card and power supply with micro-controller and raspberry pi. Agricultural Drainage Management System also gives producers an opportunity to regain some control from unpredictable weather. Hence there is requirement of modern science and technology in the agriculture sector to maximize the yield. Most of the papers describes the use of wireless sensor network which collects the information from different types of sensors and then send it to server using wireless protocol. The collected information provides the different environmental parameters which in turn help to manage the system in a better when compared to earlier.

2. LITERATURE REVIEW

It reviewed the adaptations of WSNs and their efficiency for the evolution of various agricultural growth. It features the main farming and cultivation processes and checks the suitability of wireless sensor networks towards performance enhancement and profitability. It brings the system, node and communication architecture together for utilization in agricultural applications. The real-time wireless node sensors and different sensors such as soil sensor, PH sensor and plant-health conditions are listed. It describes a complete review of the state-of-the-art in wireless sensor network sending for improved agricultural uses. It presented the WSNs node architecture and system architecture, the related parameters according to specific applications. It outlines the different kinds of

accessible wireless sensor nodes, and several communication methodologies followed by node sensors.[4]

Precision agriculture PA used Wireless Multimedia Sensor Network (WMSN) to enable better and proper irrigation. It represents IOT and WMSN in agricultural practices especially in greenhouse management, It explained and demonstrated the capability of controlling greenhouse irrigation of crops using feedback control technique. The experiment was conducted to see these two distinct strategies. The techniques include irrigation by feedback or schedule control. Scheduled way of irrigation is to supply water to the crop at proper time period. Feedback control technique based irrigation is to supply water to crops when the moisture level came to predefined value. The experiment conducted shows that there is average profits of 1,500 ml for per tree in each day. In a greenhouse management using WSN or WMSN, the experiment clearly shows that the automatic irrigation is better contrasted to scheduled irrigation or open loop system. Optimization of water resources and fertilizers using automatic irrigation and retain the soil moisture levels as guided by agronomist.[5]

The WSN is widely used for decision support process implementation. In reality, these systems deal with lot of issues. Precision Agriculture is the main interesting area where decision support system is highly required. Through Wireless Sensor Network, agriculture can be associated to the IOT, where connections among agronomists, producers and plants made possible in terms of geographical differences. This methodology is helpful in real-time data collection about the crops and field which helps farmers in taking right decisions. The reduction in usage of fertilizers and maximizing the crop production is the significant role of WSN in Precision Agriculture and further enables to investigate field weather conditions. It deploys the control of entire framework in a single system. It will further make it easier and obtain better knowledge about the results by the simple users. It also keeps the users updated by continuously sending notifications of every changes happening in the field. The structure of sensor network is mainly concentrated, it enables in connection of agriculture to the IOT. The link is setup to connect both agronomist and farm, which leads to enhanced production. It is a broad system intended to achieve precision in agriculture.[6]

WSN is an proficient approach to optimize farming resources and support decision process. For the hardware, network framework and software process control are the need where precision agriculture depends on Internet of Things for the accurateness of irrigation system. The system uses feedback loop for collecting, analyzing and monitoring data from sensors which inturn activates the control gadgets based on pre-estimated threshold value.[7]

To perform tasks like weeding, animals caring, spraying, GPS based remote controlling robot is used. In addition, smart irrigation and intelligent based real time decision making of field data. Finally incorporates temperature, humidity maintenance and theft prediction through Smart warehouse management. Controlling the operations through computer connected to the Internet and interfacing sensors, Zig Bee modules, camera and actuators with microcontroller and Raspberry Pi.[8]

Sensors use CC 3200 chip for monitoring temperature and humidity in the farming field. Chip CC 3200 is used to interface Camera to capture pictures and send those pictures through Multimedia Messaging Service (MMS) with the help of Wi-Fi. CC 3200 acts as main block of this structure because it consists of microcontroller, network processor and Wi-Fi. It is highly secure low power consumption faster connection and portable. The change in environmental conditions affects the yield of crops. Sensors are used for detecting the change in condition of crop field. TMP 007-Temperature infrared thermopile sensor is used, which helps in real-time detecting of temperature values and HDC 1010-Humidity sensor is used in tracking the moisture level of air inside the field area. Camera interfaced with CC 3200 camera booster pack by means of busing MT 9D111 camera sensor chip to capture pictures and send those pictures through General Packet Radio Service (GPRS).[9]

E-Agriculture depend on Knowledge base and monitoring modules framework. It shows the importance of ICT in Indian agricultural sector, which replaces the conventional system followed by the rural farmers. Different kinds of sensors are used for observing modules and information sources are supplied from knowledge base. By using TICC3200 sensor modules and other electronic gadgets, mechanism of prototyping is done. Author presented a comparison between the current system and the developed system. The result overcomes the limitations of traditional way of farming by utilizing water resources effectively and reduction of labor cost.[10]

An automatic irrigation is done with reduced usage of water resources by integrating Internet of Things (IOT), Cloud computing and other optimization tools. The automated irrigation system utilizes low cost sensors to detect soil moisture, pH value, soil type and weather conditions. The data storage is done using Thing Speak Cloud

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Service. Wi-Fi modem and GSM is used for transmitting field data to the cloud, the ARM controller (WEMOS D1) used to figure out optimal irrigation rates based on solenoid value. The end results of the proposed methodology shows reduced water usage, enhancement in availability of data and visualization.[11].

Z. Hu *et al* (2019) designed an non-orthogonal multiple access (NOMA) application in wireless sensor Nnetworks for smart agriculture. The NOMA has capability to send multiple symbols con currently on same RE. The NOMA obtains the power levels of several symbols. S. N. Daskalakis et al (2018) innovated uW backscatter-morse-leaf Sensor. This Sensor was quite suitable for agriculture. It was a part of backscatter WSN. Morse code modulation with 868 MHz carrier signal. This Experiment has no battery but powered with solar panel of 20 μW. The Performance was up to 2 m distance. P. K. Reddy Maddikunta *et al* (2021) implemented an unmanned aerial vehicle (UAV) for agriculture. The UAVs was operated with Bluetooth to monitor agricultural fields. The UAVs plays vital in smart agriculture. M. E. Bayrakdar et al (2019) investigated smart insect pest detection with wireless sensor networks. An Effective underground wireless sensor was placed on the agriculture fields.

S. K. Sah Tyagi et al (2021) applied Internet of Things (IoT) in agriculture. Different sensor nodes or devices can be monitored in internet. The Back-Propagation Neural Network and Particle Swarm Optimization (BPNN-PSO) was utilized. J. J. Estrada-López et al (2018) measured the soil parameters with autonomous (WSN). It has used Internet of Things and cloud service communication. The Soil phenomena are monitored a whole days at needed time. D. Xue and W. Huang et al (2021) used node location algorithm with IOT for agriculture fields. DV-HOP was utilized. In DV-HOP, 30% of positioning error of reduced than original DV-HOP algorithm. A. D. Boursianis *et al* (2021) framed a smart irrigation system with AREThOU5A IoT Platform. The Radio frequency energy harvesting technique was utilized. This System was quite suitable for outdoor environment. N. Abdullah *et al* (2021) used improved fuzzy logic to control a pump's switching timings. The Sensors in agriculture fields are monitored and controlled with IoT. C. T. Kone et al (2015) used IEEE 802.15.4 for precision agriculture. The IEEE 802.15.4 performs its operation on sensors. The Sensor data sets are monitored and transmitted with IEEE 802.15.4.

3. BACKGROUND METHODOLOGIES

The excess water drained from agricultural drainage is monitored continuously using WSN based agricultural drainage management system. This system ensures the water flow and level are proper in the drainage to avoid flooding of crops with the help of sensors used. The sensor nodes placed in different position of field near drainage captures all real-time information from the sensors and send it to the server, which inturn help farmers to take appropriate decisions. The overall data obtained enables the farmers to analyze the water level and flow in the drainage. So, the excess water from particular field area can be efficiently moved to different field area with the help of a motor.

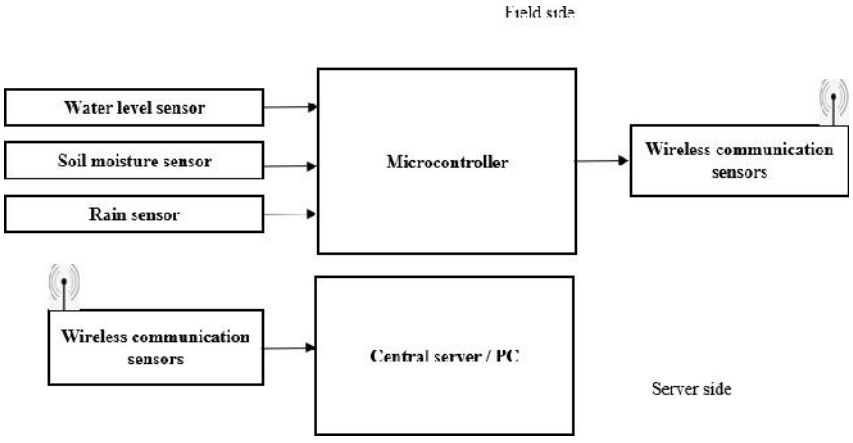

Figure 2: Basic methodology of the system

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Effect of Agricultural drainage water management in Nitrogen losses

The effectiveness of Drainage water management in reducing Nitrogen losses to surface waters is the results contributed by this paper. A study on effect of this management system on Nitrogen losses in drainage water is made and the summarised results are given in table 1.The net individual results shows that Nitrogen losses in drainage water are in nitrate form and the effect of Drainage Water Management on Nitrogen losses explained based on the effect on Nitrate-Nitrogen losses shown in (table 1). Our main focus is on the effect of Agricultural drainage water management, on water conservation and Nitrogen losses, the table does not include studies on automatic irrigation. These studies are more important to understand how Drainage water management work in different environmental conditions and if Nitrogen loads applied at state or regional scales[15]. However, table 1 includes the effect of Drainage water management on annual volumes of drainage and Nitrogen losses have been studied from field data measurements and observations.

Studies presented on the impact of Drainage water management on Nitrogen losses from 12 to 20 different sites. Depending on site and year, the annual drainage volumes reduced from 18% to over 85%. Drainage water management did not greatly affect Nitrate-Nitrogen concentrations and are consistent with observations from previous studies. Thus, the result shows that the effect of Nitrogen loads and drainage volumes are similar, with the reductions of Nitrate-Nitrogen loads among the sites from 18% to 79%. The ranges were similar for both drainage volumes and Nitrogen loads in response to Drainage water management compared to previous studies, some of which were conducted on sites containing different soils, crops and climate conditions. Additionally, all the conducted studies concluded that Drainage water management reduces drainage outflows by increasing evapotranspiration, seepage and Nitrogen loads in drainage water. The impact of Drainage water management on hydrological component depends on sites, management of crops, weather conditions and drainage system design.

Effect of Agricultural drainage water management on crop yield

The effect of Agricultural Drainage water management on yields depends on sites, soil and weather conditions, drainage system design and management strategy. Drainage water management can increase crop yield by removing excess water during rainfall periods and retaining water or reusing the same excess water being drained during subsequent dry periods. Therefore, this system provided best opportunity to conserve soil water essential for crops. The field test on crop yields are summarized in table 1. The result shows high percentage of Drainage water management on crop yields in most cases and in one case there were no significant changes [17]. Within short period of observations does not show positive effects on Drainage water management on yields for a range of soils, climate conditions and drainage system design and management strategies.

A review of previous studies shows that Drainage water management has a greatest impact on both reduction of Nitrogen losses and increase in crop yield in most of the cases. In addition, to reuse of drained water irrigation being incorporated shows more positive effects than compared to all cases.

3. PROPOSED IDEATION FOR A FUTURISTIC METHOD

In addition to the basic methodology given above the below block diagram shows the structure of a method where the WSN data can be analyzed for better agriculture. Since precision agriculture is been foolowed in several countries. In India, its still way behind in the involvement of technologies for better production. Here we proposed an idea where deep learning models for smart agriculture can be implemented using the Internet-of-Things (IoT). The Sensor information has to be processor used advance methods. The storage of data using Cloud-Computing or MobileComputing, with Big-Data analysis enhances the way farmers use. Apart from the sensors given in the block diagram addition units on flow measurement can be added. The Deep Convolutional Neural Network (CNN) can be suitable for the analysis of data. It reduces the parameters without losing the quality. The methods can be applicable for other problems facing due to water flow or optimum usage. Effective optimization approaches involving Swarm Intelligence can be adopted for the betterment of prediction In literature several

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methods like catswarm optimization (CSO) and particle swarm optimization (PSO) were used. We submit these ideation in this paper after a detail survey. Figure 3 and 4 shows the proposed ideation to be implemented. The Figure 4 shows the method by which CNN and swarm can be combined. Figure 3 Processing module will adopt the idea of Figure 4 using optimization techniques

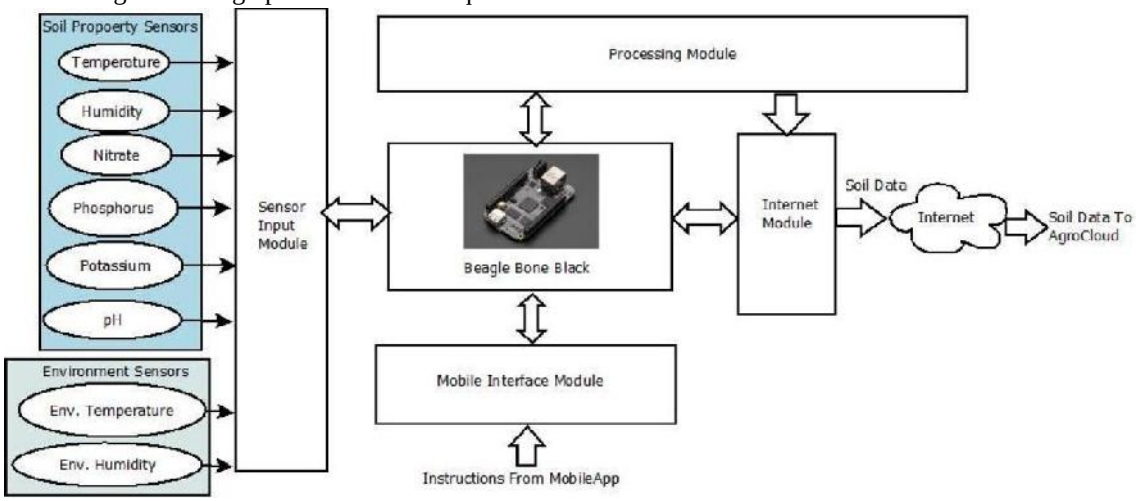

Figure 3: Proposed Ideation and Proof of concept system

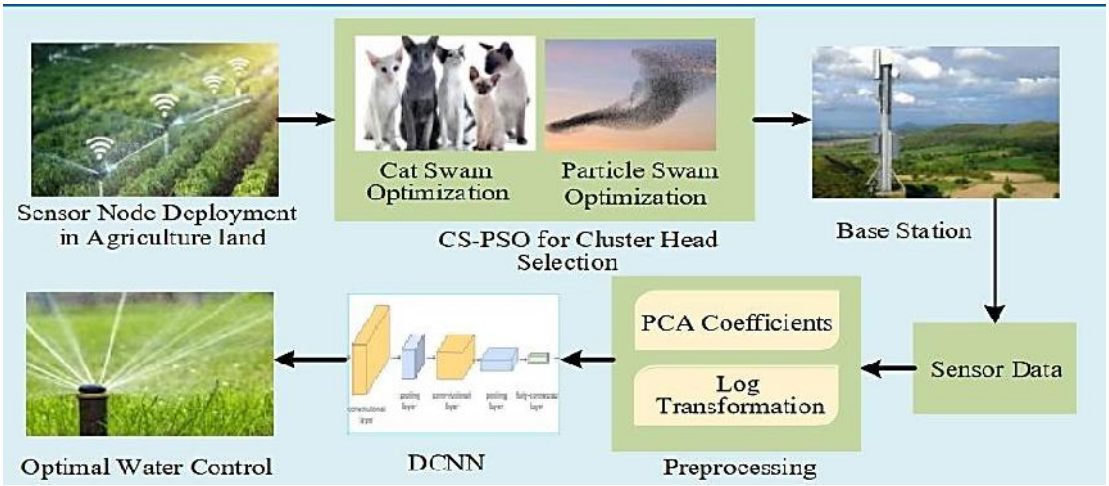

Figure 4: Proposed Ideation of steps

CONCLUSIONS

The WSN-based agricultural drainage management system has built on the long-lasting desire of farmers to ensure their land remains productive for the future. It also addresses the farmer's expectations and concerns for safe production without causing any disturbance to the environment. An agricultural drainage, irrigation and soil monitoring for the enhanced agricultural production using WSN technology and implemented it as GIS visualization software was designed. The WSN based agricultural management system through correlation analysis of agricultural environment information has enhanced the ability of farmers and researchers to analyze

current conditions and predict future harvest. Additionally, agricultural products quality can be improved because farmers observe whole cycle using this WSN based agricultural management system. By taking advantage of WSN technology, the efficiency of agricultural production can get a significant improvement. With constantly improving, agriculture WSN must be able to lead agriculture production to a new era. A new ideation is presented for the process of data analysis.

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