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A Comparative Study on Internet of Things (IoT) and Its Applications in Smart Agriculture

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Abstract: *Agriculture plays a vital role in country's economy and it has an extensive contribution towards human civilization. Due to the growing expansions in sensor devices, RFID and Internet protocols the architecture of Internet of Things (IoT) has been made to support agriculture by making a Smart agriculture. This paper describes the implementation of various IoT techniques and intelligent decision support systems used in agriculture. It provides a wide review on methods and technologies like ANFIS and PLSR Model predictions, experiences in various challenges as well as further work are discussed through the review article.*

Keywords: Internet of Things, RFID-Radio Frequency Identification, ANFIS, PLSR, etc.

I. INTRODUCTION

Coping with agriculture and its demands are really a challenging one nowadays. Agriculture serves as the heart of Indian economy and half of the population in India survives because of agriculture. Farmer suicides up 40 per cent in a year, 1,2 Official sources said that the Agri-crisis was becoming worse due to poor rain and climatic conditions. From 2015 to till date farmers are suffering from severe scarcity and difficult to recover from drought.

The IoT is a technology which serves as a solution to the problem. It uses various sensors whichisconnectedthroughinternetandalsowiththeintegrationtothesatellitesitdowondersinallsectors.It also uses various protocols by enabling the IoT to grow faster.

II. SYSTEM ARCHITECTURE

Agriculture plays a vital role in country's economy and it has a extensive contribution towards human civilization. Due to the growing expansions in sensor devices, Intelligent Systems and Internet protocols the architecture of IoT has been made to support agriculture by making a Smart agriculture.

The Figure 1. shows the overall architecture of the system of how IoT is involved in various agricultural activities. Each smart system uses different techniques and IoT serves as the central part of all the smart works. It includes sensor devices, protocols, satellite imaging, drones and gateways which are all connected different techniques and IoT serves as the central part of all the smart works. It includes sensor devices, protocols, satellite imaging, drones and gateways which are all connected to cloud servers.

Each developed system captures its down data's such as soil moisture, temperature, humidity, pH level, oxygen requirements are collected and appropriate decisions are taken. Still the system is enhanced by totally automating the agriculture thereby increasing the economy of country.

III. IOT IN AGRICULTURE

Irrigation Nowadays water scarcity is becoming very high and it has to be used efficiently. It is an important source for Agricultural development and thereby increasing the country's economy. A new technique called an automatic smart Irrigation decision support System (SIDSS in short) is anticipated to effectively manage and irrigate the Agricultural fields. The Irrigation estimate is done as a weekly basis.

So every week the soil characteristics, climatic conditions and weather predictions are calculated. To achieve the SIDSS two machine learning techniques such as ANFIS and PLSR are proposed. The implementation was done and tested by the human experts and other research scientists. Various sensors are used to implement the SIDSS. One among this is a Soil sensor which detects the different crops and conditions and the device is modelled with GSM/GPRS modem to gather information from various locations. The environment variables such as Rainfall, humidity, depth of water level needed etc. are given as input to the system. Measuring the Irrigation needed for agriculture is a challenging one. The irrigation varies from place to place in a filed. So when and where how much of water is needed to irrigate has to be determined and it is done by ANFIS and PLSR techniques.

3.1 ANFIS and PLSR Model Predictions

The amount of water needed to irrigate the field is accurately predicted by ANFIS inference system which generates the fuzzy rules. The other technique which is used for predication is PLSR. It is a statistical method which is used to obtain the values of predictor variables ANFIS shows the better performance than PLSR to determine the water required for Irrigation. The experimental set up and the comparison of different sets of variables for the two machine learning techniques (ANFIS &PLSR) are shown. The soil moisture can be detected accurately by VWC sensors. Set of input variables which are necessary for the system is inputted and this process is done in a weekly basis.

Soil sensors detect the moisture level and its relative temperature is found. Three various VWC's are used to find the volumetric water content depth level. Experiments have been conducted in various regions such Spain and Murcia countries with the network of 45 agro-meteorological stations and other stations located in the zones where Irrigation is required. In this scenario continuous soil measurements is required to exactly predict the need for irrigation required for crops. Human experts are needed to compare the analysis of results of prediction to obtain the correct understanding of variables and crops. The historical information of the crops are maintained for further enhancements. In the case of new plantation which has not previous history of information VWC sensors are removed. Further research focuses on different regions and with several conditions.

3.2 IoT in Detecting Nitrate Level in Surface and Ground Water

Nitrates are a well-known pollutant which is found possibly in fruits, vegetables and especially water. It is a harmful one and when its concentration is increased above the expected level it can cause methemoglobinemia which is said to be a variation in blood with the presence of ferric ion.

It can cause many diseases in humans as well as plant and the basic cause is increase in nitrate level. Similarly, if the same nitrate is increased in ground water it affects the growth of plants and crops which ultimately affects the growth of Agriculture.

To overcome this a smart nitrate sensor is introduced to monitor the amount of nitrate which is present in surface and ground water. The system is well equipped with relevant devices such as planar inter digital sensor, instrumentation, and along with electrochemical impedance spectroscopy which reports the amount of nitrate in soil moisture.

The system is proficient and can measure the level of nitrate deliberations in the range of 0.01–0.5 mg/Liter in both the ground and also surface water. There are many different methods to identify the nitrate-nitrogen in water other than spectrophotometric method.3, 4,5,6 The sample of water from river, lake and also from ground water are collected and tested on a monthly basis for nitrate detection. Moreover the system is aimed to be developed at low cost. According to the Protection Agency, the suitable level of nitrate-N in drinking water is 10 mg/Liter.

Previous research work has shown good accuracy under different conditions. But there is a variation in temperature across fields at certain conditions. Hence the compensation of temperature effect is needed and it is done using temperature compensated sensor to calculate the nitrate level at low cost. The sensing system is linked with Cloud server which is based on IoT through a Wi-Fi connectivity. The experimental setup its performance and evaluation are shown in paper.5 Planar-type inter digital sensors7 have been used to identify the concentration of Nitrate in water.

The Nitrate is detected based on the variations in electric field which is generated. The temperature has a great impact on the ions which is found in water hence it is essential to quantity the varying temperature of sensor at different temperatures levels. The complete experimental set up of all devices required are shown, such as Hikoi 3522-50 LCR meter, SCILO-GEX MS 7-H550 Digital Hotplate stirrer of Hikoi 4-terminal probe 9140, mercury thermometer, and computer for data gaining. Coming to the results and discussions of the paper various experiments have been conducted on (i)

The exact Measurement of Temperature –Same sensor can be used to measure the temperature of ground water and its resistance and reactance of the impedance are expressed in ohms(Ω). The result shows that there is an increase in temperature if impedance is decreased. (ii)Stream water Testing-Several tests has been done even with stream water samples. The concentration of nitrates in stream water has been analyzed using spectrophotometric method. (iii)The collected data has been sent to IoT cloud server. (iv) The Impedance measurement factor has been compared with the actual developed system and LCR. Moreover, various Improvements has been made on Temperature Compensation in the system. Finally, the developed system has shown good results in measuring and detecting the nitrate level in the sample water with the help of sensing devices and spectrophotometric method.

3.3 IoT Imprecision Agriculture and Ecological Monitoring

This paper reviews on building a precision agriculture and monitoring the ecological factors based on IoT. Various sensor nodes are utilized and deployed in addition to IoT Protocols and tools. The proposed system can be executed using different platforms and cloud technologies. In the past years monitoring the maritime environment has become a challenging factor. Nowadays the environment is highly polluted due small particles, use of plastics, human wastes, and Litter and greenhouse gases. The increase in pollution thereby increases the acidity in oceans, obstructing the marine life etc. The goal of the project is to control the pollution and improving the agriculture by monitoring the ecological factors.

3.4 Prediction of Precise Agriculture

The overall system is made to support smart Irrigation, smart pests controls by monitoring the heath of plants thereby leads the way to smart spray of pesticides. In our scenario a grape vineyard is taken and infected parts of the field is identified by the help of drone. The information about the relative humidity, temperature, ultra violet radiation are collected every 15 min. The developed system requires remote sensing technologies and IoT, Cloud servers, intelligent systems and agricultural experts. The IoT nodes are located at various places across the field which collects the appropriate information and retransmit the information back to servers. The drones catches the images from field very precisely or by satellite imaging methodology. The Iot nodes have the capability to send data to cloud directly based upon the captured image, decision can be made to spray the pesticides only in affected parts of the vineyard. The Figure 2 represents infection caused by plasmopara viticola grape. Mainly this particular infection caused during summer period.

3.4 Mariculture and Ecological Monitoring

The environmental protection agency (EPA) of Montenegro was well known from the year 2008. The aim of EPA is to continuously monitor, control and reduce the pollution in the Environment. The important factors such as temperature from sea and air, humidity, Oxygen level at different locations are tested in a periodic basis. Precise digital images are captured using drones and the image is sent to cloud server and it can be retrieved from cloud at any time by the agricultural expert. The IoT platform is configured with IoT nodes and sensor data's are described in the complete description is shown in detail. The below diagram shows the prediction of ecology with the help of smart devices and cloud computing. The topmost part of the diagram shows the towers connected and it interacts with cloud which is connected to users. The IoT nodes are located in the farms at particular locations which has direct access to cloud servers.

- The IoT nodes can collect information's send to cloud directly. In Figure-3, the ecological Monitoring system finds the pollution in the fertile land. The IoT is literally helping for communicating with each

IoT Machine to collect the polluted data. The users can specify the area coverage to capture the images and it is intelligently done by drones and filed cameras. The expert can access the images from cloud using smart phone app or tablets. Each specific nodes and devices communicated through API's. The developed system is deployed in private cloud

- The IoT nodes are designed using Arduino, Raspberry Pi. It achieves good quality attributes such as reliability, scalability, availability and performance. The system is evaluated in three lemon trees of south east part of Spain and best results are noted.

3.5 IoT in Secure User Authentication

Coping with agriculture and its demands are really a challenging one nowadays. Agriculture serves as the heart of Indian economy and half of the population in India survives because of agriculture. Farmer suicides up 40 per cent in a year, Official sources said that the Agri-crisis was becoming worse due to poor rain and climatic conditions. From 2015 to till date farmers are suffering from severe scarcity and difficult to recover from drought. The IoT is a technology which serves as a solution to the problem. It uses various sensors which is connected through internet and also with the integration to the satellites it do wonders in all sectors. It also uses various protocols by enabling the IoT to grow faster

3.6 BAN and AVISPA Logic for Privacy and Security

In agriculture various parameters related to climate such as CO2, soil moisture, acidity humidity, temperature is collected and stored as a dataset. Any kind of changes such as inserting, deleting, updating of original data by unauthenticated persons may lead to great loss for the farmer as well as the crop which in turn affects the country's growth. So, an authentication method has to be developed for security as well as privacy. In this regard a Burrows-Abadi-Needham (BAN) logic is used to ensure that the exchanged information is trustworthy or not and then simulated using AVISPA (Automated Validation Information Security Protocol application) which is a push button tool to specify the security properties. The survey says that although there are various authentication mechanisms developed, they all lacks in any one aspect as in one aspect as in IoT.8,9,10,11,12 The WSNs are widely used as a sensor node with restricted storage capacity. In 2009,13 still the system is expanded and freed from security issues by the name Das's scheme and it lacks in finding insider attacks and then it is further improved. Later in 2010, Khan et al discover the security issues from Das's scheme such as lack of mutual

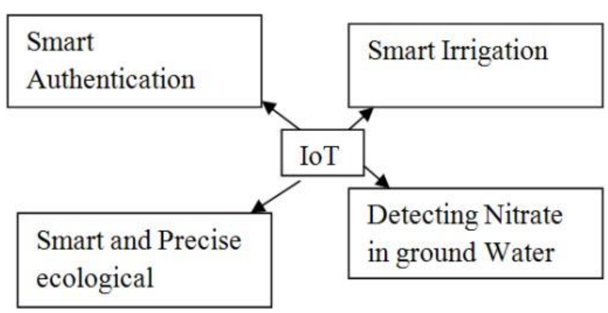

Figure 1: Architecture of IoT in agriculture

Authentication etc. A new mutual authentication method has been adopted to overcome the security threats. Still in 2012 it has been found that the system has various attacks such as stolen attack and impersonation attacks. Even after developing a authentication protocol the system is not able to resist with malicious insider attacks.14 Even in the years 2014 the authentication scheme doesn't provide good results due to spoofing attacks.15,16 In 2016, a remote authentication scheme with WSN's are developed which minimized the issues and attacks found in previous reviews. A fine protocol was developed with BAN and AVISPA tool which overcomes all types of attacks. The various qualities of security are achieved in this scenario. (i) Confidentiality (ii) Integrity (iii) Strong user and mutual authentication (iv) Security and privacy in contradiction to any type of attacks. The proposed scheme is implemented as different phases like (i) setup phase (ii) registration phase(A unique ID &

Password will be generated) (iii) login /authentication phase(A random number will be generated) (iv) Session key agreement phase.

3.7 Phases

AVISPA and BAN logic is implemented in various phases. Furthermore, perfect and even formal security analysis can be done using widely-recognized AVISPA (Automated Validation of Internet Security Protocols and Applications) tool, and ensures that the proposed scheme is secure against both passive and active attacks including the replay method and man-in-the- middle attacks. More security functionalities (confidentiality, Integrity etc) along with reduced computational costs for the mobile users make the system more suitable for the real-world applications as compared to Tsai–Lo's scheme and other connected schemes. Authentication and validation scheme should be designed using the efficient cryptosystems and other security standards to support secure mutual authentication and user secrecy without using SSL. The Figure 4 shows that the authentication scheme is implemented with the BAN & AVISPA logic. Various sensors such as ph sensor, oxygen sensor, and moisture sensor are used, through the access point which is connected to base station are communicated with cloud. The system is free from security threat and it achieves good quality parameters.

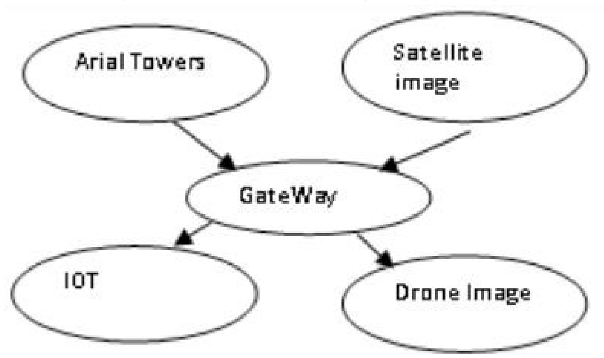

Figure 2: IoT in ecological Monitoring

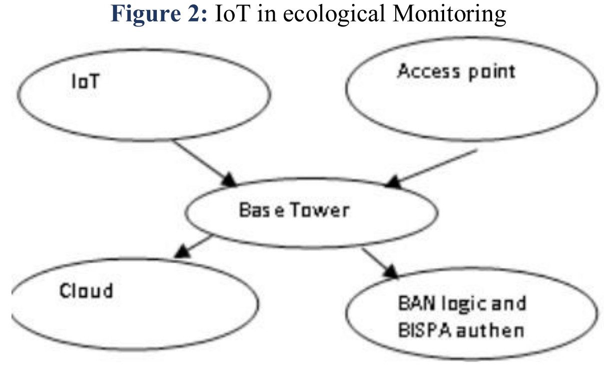

Figure 3: Smart authentication in Agriculture.

IV. BENEFITS AND FUTURE ENHANCEMENTS

The agriculture is getting automated day by day by simplifying the work of farmers and optimizing the crop production. On the IoT in agriculture works by collecting information from soil, humid level, and temperature monitoring is easy and can be done in a regular basis which is helpful in predicting the ecological factors. The Mari culture can also be improved in this scenario. IoT together with cloud can improve the efficiency of country's production. Since water scarcity is becoming high, using this system the water is highly conserved

V. FUTURE ENHANCEMENTS

From the above information collected from various researches the work can be further extended in two broad ways. (i) Few parameters such as reliability, scalability can be improved and the open source programming languages such as R and python could be used as a program.17 The development of smart Irrigation system could be implemented in other plantations such as citrus crops and analyzing the performance. The data set can be still increased to improve the accuracy of the system In authentication scheme further complexities of the protocol are reduced without compromising security features. The entire work can be even merged with cloud computing environment.15 From the previous work some of the new decisions can be made in crops. There are sensors which can do amazing things in the agriculture. The country lacks in good agriculture and it could be made still smart. The data set is maintained for every smart work in agriculture and can be used for further reference.

Using drone with all the weather and temperature information the type of crop which has to be planted in agriculture can be found. Which crop suits to which environment, that historical information can be found and send to agricultural experts? With those data he can plant new crops. Also if the field has the capability to grow by spreading the seeds. It can also be automated. A new device may be invented and made to spread the seeds across fields based on soil type information. And if the climate is changed it can also be intimated through intelligent systems so that some different seeds can be speeded. Big data plays a great role in maintaining the dataset for weather information, soil type characteristics, based on the data collected the seeds can be thrown by agricultural experts or by drone like device to spray the seeds. Another important challenge is that the research has shown that the type of fertilizer can be identified for a particular soil. Similarly in future the type of pesticide to be sprayed across the field based on the crop can be identified in advance to save the plants. Those data's such as type of soil, crop type to be planted and the appropriate pesticide and fertilizer can be structured as a dataset.

Year	Research work on	Technologies /Devices Used	Outcome
2015	Wireless Sensor Networks(WSN) for agriculture: The state –of-the-art in practice and future challenges	Wireless Communication Technologies- Zig-bee, GPRS/3g/4g modules , Wi-Max, Wi-Fi, Bluetooth and Various Sensors (Soil moisture Sensor, Temperature Sensor, and other electronic devices are used.	Increase in Cost , Scalability has to be improved.
2016	A Decision Support system for managing irrigation in agriculture	PLSR (Partial Least Square Regression)and ANFIS (Adaptive neuro Fuzzy Inference Systems) machine learning techniques used	Good performance, Accurate Prediction of field related information.
2017	Architecting an IoT-enabled platform for precision agriculture and ecological monitoring	Sensors for data collection, Web portal implementation using PHP and laravel framework, Paas cloud deployment, drone for capturing images. Arduino and Raspberry Pi is used.	Accurate and regular monitoring of precision agriculture, aquaculture and monitoring various ecological factors. and very precise image taken by drone.
2017	A Temperature Compensated Smart Nitrate-Sensor for Agricultural Industry	Spectrophotometric method along with a planar type interdigital sensors are used to detect the nitrate level in soil, Arduino Yun has been used to produce sinusoidal volt and soil and temperature sensors has been used.	Portable, Linear across different nitrate levels, Performance improved with this method.
2017	A secure user authentication and key-agreement scheme using wireless sensor networks for agriculture monitoring	Wireless Sensor Networks based on IoT and BAN (Burrows-Abadi-Needham) and AVISPA tools are used for protocol validation.	Highly Secured, Cost is reduced
2017	Measuring Macro Nutrients Of The Soil For Smart Agriculture In Coconut Cultivation	Macro Nutrients such as Nitrogen(N),Potassium(P) ,along with that phosphorous(K) are collected deficiency level is identified using data forwarding algorithm	Improved Productivity Cost and time is also saved.

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