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A REVIEW ON IOT ENABLED TECHNOLOIES FOR DESIGN AND DEVELOPMENT OF SMART AGRICULTURE SYSTEMS

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ABSTRACT

Indian economy majorly depends on the agriculture as its contribution is high in economy as well a grater population is depending on farming as they earn livelihood through the practice. An integrative way farming can be practiced to developed for smart agriculture, this practice increase the convenience of the farmers basing on climatic conditions and it also develops the flexibility of farmers to farming. The capability of smart farming can be extended by using IoT (Internet of Things) technology as it is a fundamental in industry 4.0. IoT implements an Automatic irrigation. In this paper, the discussion is done on the conventional practices and the new techniques through research works for development and growth of cultivation is performed in order to benefit the farmers. These works used different technologies and methods to build a smart farming based on IOT. Each work is described and their result analyses are analyzed. Then acomparative analysis is performed on all the works and the best method that can best in developing smart farming is chosen.

KEYWORDS: *IoT (Internet of Things), Automatic irrigation, Smart Agriculture.*

1. INTRODUCTION

GDP (gross domestic product) of Indian economy mostly depends on agriculture as it plays a key role in our country. Agricultural sector provides employment to 60 to 70% of Indian population. Many drawbacks in agricultural sector can be resolved with the help of IoT. India stands in second place as large populated country, so there is a high demand for increasing the rate of production. Harvesting of land is done with smart agricultural techniques for increasing the crop production and livestock. IoT means Internet of Things, shared

network or things is considered as IoT that promotes interaction with each other. The Automatic irrigation methods can be practiced to overcome the scarcity of water. Traditional agriculture is type of framing whichinvolves natural resources, organic fertilizers, traditional tools and some cultivation knowledge. Modern agriculture or smart agriculture which consists of advanced technologies involved in the practice of agriculture. With this new innovation in technologies and agriculture practice increases the quality and efficiency of production. Smart Agriculture or Smart Farming is a type of farming which uses innovative methods and modern technology. Such farming will help in improving the quality and quantity of agricultural products. IoT application is implemented in the field of agriculture to meet increasing global population. With the implementation of IoT in agriculture helps the farmer to effectively make use resources and land [6-8]

Cloud resources and virtual limitless capabilities can enhance the functioning of IoT. IoT service management can be effectively performed with the help of Cloud. Connected physical devices are accessed through internet in IoT ecosystem. It includes processing units, sensor devices, communication infrastructure and some other objects. Microcontrollers are utilized for connecting sensors in IoT environment. Values can be assembled by using thesensor. After completion of this process collected data is compared to actual data. Basing on this pre defined data there is automatic supply of irrigation. Based on the weather conditions of cultivation land the irrigation can be practiced either continuous or periodic way. Wastage of water can be excluded by using automatic irrigation. In this technique water is sprinkled or supplied by drip irrigation. There may be a great enhancement in the quality and quantity of the agricultural production with the help of IoT applications simultaneously improving the effectiveness of cost.

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In traditional farming, farmer has to keep track of his yield manually, as and when he needs to look after the field for threats and he needs to be updated with weather changes. With the implementation of IoT in farming will provide automated system, which functions without any human intervention and notifies the farmer even if he is not on the field. The farmer then makes the choice to solve the problems. Another factor which is affecting the yield of farmer is changing weather condition, so the IoT smart agriculture application will notify the farmer to take fast actions to prevent from harming the yield. IoT is used to monitor the health and state of farm animals, which collects the data and analyze that data for different reasons. The potential of IoT techniques and wireless sensors is discussed in this research paper. The drawbacks of conventional farming practices can be overcome with the help of discussed techniques. This study also explains in detail the application of IOT devices and wireless sensors which involves communication techniques that are encountered in agricultural sector.

2. ISSUES AND CHALLENGES OF SMRT AGRICULTURE

Smart agriculture is facing few problems currently which need to be addressed immediately. Some of the issues faced by faced by smart agriculture are signal interface, security network issues, hardware defect and some other challenges faced within the organization. Likewise there are some more issues faced by smart agriculture and applications deployment [9].
Following sections explains about the issues and development to the existing techniques.

2.1 Power Consumption

Smart farming focuses on improvement of indispensible wireless devices and the battery life of the devices is extended. Applications of the smart farming include high energy harvest and low power consumption technology. These solutions can include energy harvesting such as solar cells, sensors that consume low power basing on the demands in that situation protocols. The studies identified LoRa and ZigBee as the most appropriate wireless protocols for application in agricultural activities. The reason behind this is they consume less power and it provides high standards of communicating range [10].

2.2 Hardware

Hardware design of the IoT devices is very crucial which has IP67 standards of the hardware devices that are deployed in an open environment. Such hardware devices need to be protected from the jangling environmental conditions sush as heavy rainfall, high temperatures, and utmost humidity. These climatic conditions may destroy the hardware devices more particularly electronic parts.

2.3 Networking

Generally the conventional type of agricultural practices maintenance cost ishigh for wiring and communication at the transceivers become weak from the IoT devices due to obstacles in physical devices. To overcome this circumstance wireless communication is hugely deployed in smart agriculture. So, more robust and reliable network techniques have implemented in agricultural environment for data transformation [11].

2.4 Infrastructure

Agricultural environment has need of stringent support to environment and continuously real time monitoring IoT infrastructure. This infrastructure is more complex when compared with others. For a software platform a suitable service oriented approach (SOA) is considered to be best approach. Open sourcing tools have to be provided to the farmers in order to sustainable infrastructure.

2.5 Communication Signal

Network signals and communication plays a crucial role in the agricultural environment. Mostly rural areas are under developed and the developing areas, there may not be ample networking resources yet. Hence network performance and bandwidth of communication is highly required for implementation of smart agriculture. Unless, smart agriculture may not be developed completely. Dense trees and tall trees in the farmlands may be a drawback for communication and it leads to issues [12].

2.6 Reliability and Scalability

Usually IoT device deployment is done in open fields where there may be rigorous environmental conditions. These climatic conditions impacts on IoT devices that leads to failure of communication. When there is such failure, the collected data may not be sent to the server or cloud efficiently. To control this issue

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huge number of gateways are required for improving the performanceof IoT devices and its applicatons. Further, network and database of IoT agriculture should be reliable to coordinate with the complex applications [13].

2.7 Awareness and Knowledge

In general, farmers live in rural areas and they are mostly illiterate people due to this reason they are not aware of IoT applications. This might be a major issue for development of IoT in rural areas. So that, farmers have to be educated about IoT applications and how it helps them to improve the farming practices efficiently which leads to their growth in production and also the revenue.

2.8 Data Security

IoT applications usually deal with the smart devices. Primarily these devices are not designed basing on security and privacy terms. When there is no security some issues such as data authentication, integrity and access control measures [14] arises. Hence these IoT devices need to be verified for data security such that data has to be encrypted before transmitting the data. Data security mechanism has to be provided and assured through the network layers of IoT [15].

3. REVIEW ON IOT BASED SMART FARMING

3.1 "IoT based low cost and intelligent module for smart irrigation system", [1]

The objective of this work is to implement a irrigation system with low cost for smart irrigation.This system should maintain admin mode used to interact with the users. Remote data monitoring, irrigation schedule, neural decision making system can be processed with the help of one time set-up.

Results of this system can be presented with the help of a sample crop test which consists of data viewing techniques from remote places, neural net decision making andschedule of irrigational practices. Current sensor input and irrigation intelligence is provided by the neural network. Even when the user is away from the agricultural area the current situation of the crop information is provided with the help of techniques as Hyper text transfer protocol (HTTP) and Message Queue Telemetry Transport (MQTT).

3.2 "An IoT based smart irrigation management system using Machine learning and open source technologies", [2]

based onsmart system, an open-source technology is presented in this work for predicting the irrigation field requirements with the help of ground parameters such as moisture content, climatic conditions and soil temperature with the help of internet in weather forecasting is performed. This helps to understand the requirement for irrigation in smart system working with open source technology. The sensors are fixed in the ground and environment sensors monitors the conditions such as moisture level in soil, air and soil temperature, humidity within the crop field, Ultraviolet (UV) light radiation etc. coming days weather conditions as humidity, air temperature, UV races and precipitation are sensed by using weather forecasting parameters the data is sensed with the intelligence of the smart algorithm. The main theme of implementation of this system is done on the basis of pilot scale. This system is developed with the help of wireless connection of sensor nodes with the cloud by using web services. Weather forecasting data in real time is obtained for acquiring information visualization and decision support system.

3.3 "IoT based Smart Farming: Feature subset selection for optimized high dimensional data using improved GA based approach for ELM", [3]

A decision support system of smart farming isdeveloped in this paper by using the Improved Genetic Algorithm (IGA) in an Internet of things (IoT) environment. Feature selection algorithm with enhanced multilevel parameter based IGA for ELM classifier called as (IGA-ELM). The quantity of chemical and fertilizers to be used for balancing the nutrients in the soil and the plant disease detection is performed in smart farming. All the requirements and advice are fulfilled in implementation of this smart farming by using enhanced IGA-ELM approach.

3.4 "Agri-IoT: A Semantic Framework for Internet of Things-enabled Smart Farming Applications", [4]

This section deals with the development of Agri-IoT framework. This framework is used for reason on real time stream of heterogeneous sensor data which is wide range. A pipeline of complete semantic processing is provided by the multiple cross domain data streams in Agri-IoT framework using the smart farming applications. Large scale

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data analysis, event detection is performed that ensures seamless operations among the sensors, operations, services, proecss are performed with Agri-IoT. The actions of relevant persons including linked open data sets and online information sources are are available on the internet.

3.5 "Fuzzy Logic based Smart Irrigation System using Internet of Things", [5]

In the proposed framework Global System for Mobile Communication (GSM) is utilized in smart farming system which waters the agricultural fields by reducing the burden on farmer. The environmental parameters like soil humidity level, surrounding temperature, power supply such as main power or solar power to the motor all these statuses are updated to the farmer in the form of acknowledgement messages. Such type of parameters are taken as input fromthe agricultural field like moisture in soil, humidity and temperature and generates motor status as an output. All these features in smart farming can be implemented with the help of "Fuzzy logic" for controlling all these features. In addition to these benefits the IoT based smart farming also turn off the motor usage for power saving when there is a unconditional rainfall.

4. RESULT ANALYSIS

4.1IoT based low cost and intelligent module for smart irrigation system

This Smart irrigational practice consists of three modules for automated irrigation method and farm monitoring:

(i) A module based on Intelligent IoT with low cost called as Unified Sensor Pole (USP),
(ii) Irrigational Unit (IU) and
(iii) Sensor Information Unit (SIU).

The IN needs of each plant differs from other plant basing on the respective family kingdom of that plant. The admin mode of the smart irrigation is designed in such away that details entering by the user such as: {soil type, δ and C} for the effective growth of the crop. The user connects to the access point which provides a unique id for each USP.

The one time setup module allows the computation of data by the users which is saved into the device. One time setup is entered by the USP when admin mode expires. The computed values are recorded from the sample crops that are given in Table.1 below. Best time and season for the irrigation of crops, it also determines the date and suitable soil for plantation. The user stores all the information in the device with the admin mode and it is utilized as model for future crops irrigation. The following table 1 depicts the suitable soil type, crop plantation date, computed IN need and the IN schedule for sample crops.

Table 1: IN SCHEDULE FOR SAMPLE CROPS

Crop	Date of plantation	Soil type	Computed IN needs (mm)	IN schedule (dd/mm for 2018)
Spinach	5/5	Shallow	155.38	5/5, 10/5, 15/5, 20/5, 25/5, 30/5, 4/6
Beans	7/5	Sandy	159.07	7/5, 14/5, 21/5, 28/5, 4/6, 18/6, 2/7
Carrot	8/5	Loamy	149.89	8/5, 15/5, 22/5, 29/5, 5/6, 24/6
Walnut	8/5	Clayey	393.95	8/5, 28/5, 17/6, 20/7, 22/8, 24/9, 14/10
Corn	20/5	Loamy	112.63	20/5, 28/5, 12/6, 27/6, 7/8
Barley	24/5	Shallow	88.34	24/5, 8/6, 23/6, 3/8
Maize	28/5	Loamy	425.46	28/5, 9/6, 21/6, 11/7, 31/7, 20/8, 9/9, 29/9, 19/10

By using this smart irrigation system around ≈67% of water is saved when compared with conventional way of farming. This system is effective for the people away from the farming lands for monitoring thecultivation area and water scarcity places for effective farming. Usage of these automatic systems is required for preserving the

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natural resources. This automated farming system can be adopted in house vegetationandgreen house farming etc as it is a versatile system with low cost and easy access of application.

4.2 An IoT based smart irrigation management system using Machine learning and open source technologies

This system is so smart and intelligent that it can detect the moisture content in soil accurately. A sample test is conducted on the field for about three weeks for observing temperature and humidity in air and soil of the cultivation land. Hourly data is recorded for three weeks i.e., 21 days. Such recorded data is divided into two types, they are 30%of data as testing set and 70% of data as training data which is applied to the proposed algorithm. Below table.1 represents the accuracy of SVR + k-means and SVR approach. Higher accuracy is obtained with comparative calculation of SMD SVR + k-means method with mean squared error as low over SVR approach.

Table 2: Mse, R Squared And Correlation Comparison In Between Values Of Smd And Soil Moisture

Parameter	SMD		Soil Moisture	
	Predicted SMD using SVR	Predicted SMD using proposed algorithm (SVR + k-means)	Predicted Soil Moisture using SVR	Predicted Soil Moisture using proposed algorithm (SVR + k-means)
R (Correlation coefficient)	0.313454	0.559295	0.98	0.98
Accuracy (R squared)	-	-	0.96	0.96
MSE	0.160337	0.135599	0.15	0.10

This table 2 clearly depicts the SMR prediction of SVR + k-means approach results in more accuracy with low MSE when compared with SVR approach. In SVR + k-means combination 96% of accuracy with low MSE is observed for detection of combined soil moisture approach. It represents that SVR + k-means based proposed algorithm is more accurate and efficient when compared with SVR approach.

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4.3 Feature subset selection for optimized high dimensional data using improved GA based approach for ELM

A multi-level optimized parameter for IGA-ELM algorithm by GA is an efficient and a reliable feature**.** ELM and IG-ELM are usedto select the feature as it is represented in Fig. 7. The proposed IGA-ELM chooses features with low percentage i.e. Minimum of 34.50% to maximum limit of 45.27% for analysis is observed. Real time leaf images are utilized for testing the performance of IGA-ELM algorithm. Figure.8 clearly represents the aspects such as Plant disease (PD) and nutrient deficiency (ND) are tested for accuracy to evaluate performance of ELM and GA-ELM. By reducing 72.73% features and utilizing 27.27% features when compared with ELM exhibits the improvement of 5.71% with IGA-ELM algorithm is observed. The proposed IGA-ELM algorithm is observed to be more accurate when compared with the traditional practices of cultivation with is developedbased of IoT technology for fully automated system is explained in this paper.

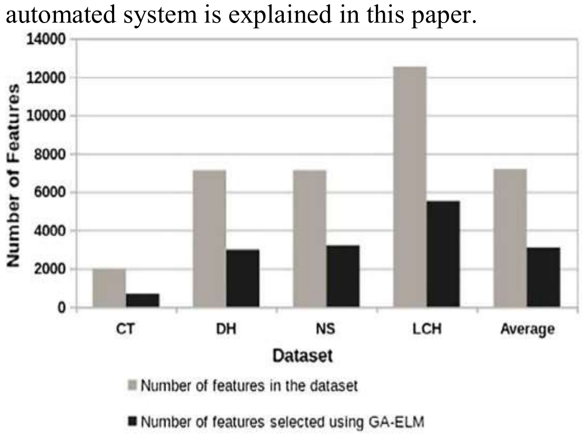

Fig. 7: Iga-Elm Feature Selection

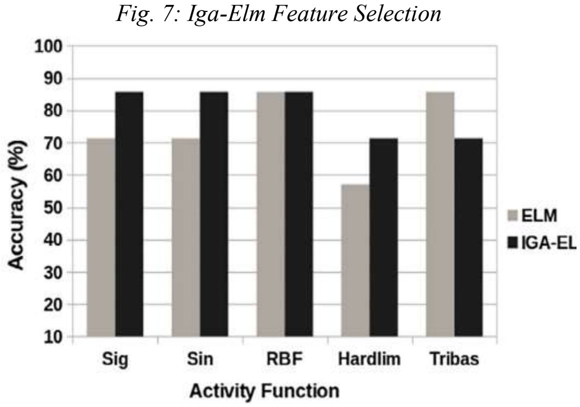

Fig. 8: Plant Disease Dataset Of Elm And Ga-Elm Performance With All Activity FUNCTION

4.4 Agri-IoT: A Semantic Framework for Internet of Things-enabled Smart Farming Applications

For evaluation of Agri-IoT in agricultural applications focuses on RDF Stream Processing (RSP) feasibility. The RDF based reasoning is a query language which manages continuous data streams that are supported by CSPARQL. Continuous Query Evaluation over Linked Stream (***CQELS***) is also a RDF query language. Real time analysis, processing and identification of event has a framework of high demand. The composition of soil such as index, salinity and moisture level are measured with the help sensors fixed in the soil. The soil fertility query is created by Agri-IoT that can instruct the farming regarding best timeto cultivate the crop by using this Agri-IoT technology.

Each time sensor produces three different observations that is why such query is complex and expensive when compared with previous ones. In such case more patterns of query are required resulting in usage of aggregate functions and more number of features. The suitable conditions for cultivation are predicted by the sensors with the help of these queries. When the threshold number is greater such as deployment of more than half of sensors in same land, query indicates the suitable condition and that is notified to the farmer. Different sensors are engaged to recognize the deployment of similar type of queries gives update about sensor frequency and it records query latency. All this memory and latency data is represented in below Fig. 1 and Fig. 2 respectively.

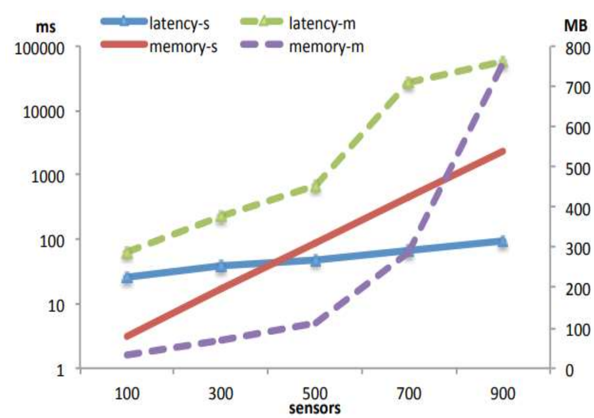

Fig. 1: Cqels Performance

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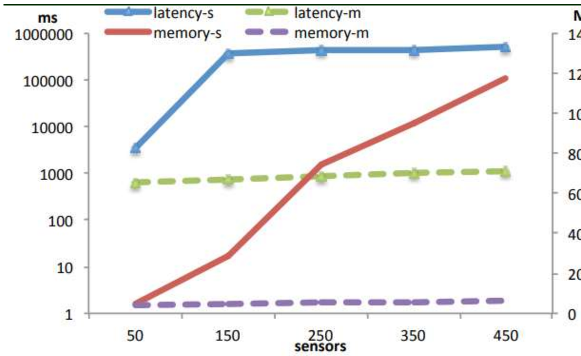

Fig. 2: Csparql Performance

From the Figures 1 and 2 it is observed that memory consumption has significant effect of CSPARQL engine by showing high sensor frequency with greater latency. CSPARQL is scalable whereas CQELS has better performance such as less memory consumption and better query latency.

4.5 Fuzzy Logic based Smart Irrigation System using Internet of Things

This work utilizes the Arduinoprogramming and MATLAB simulation tool. Humidity and temperature information is collected byDHT11sensor as it has low cost and highly responsive at the time of monitoring data in agricultural field. The agricultural fields are monitored in real time scenario. The working model of rain, temperature and humidity module sensors is connected with GSM. Communication is possible through the connected mobile network. The water levels consumed in various irrigation methods are depicted in Fig.3. from the observations on sample data it can be observed that the proposed system consumes less water when compared with conventional practices such as drip irrigation and manual irrigation.

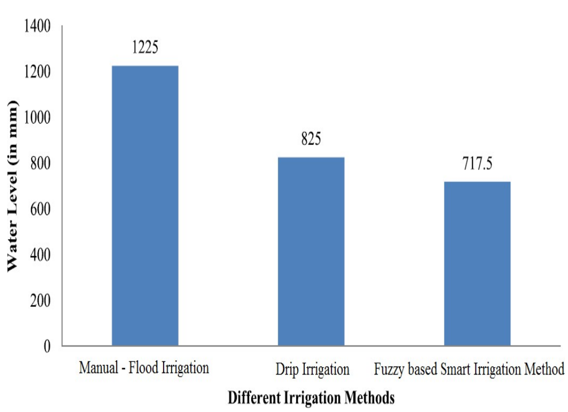

Fig.3: Several Irrigation Methodologies Water Level

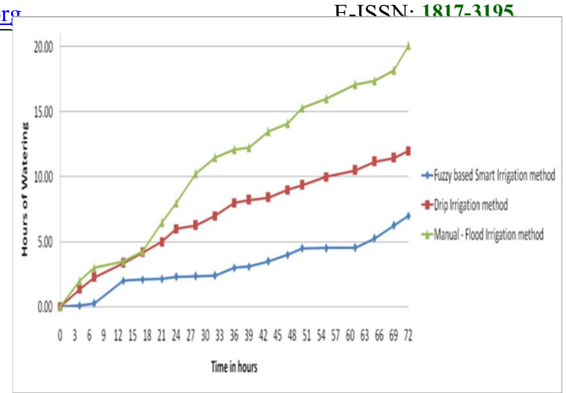

Fig. 4: Three Days Water Consumption

In the time span of three days, the water consumption level in three different ways is depicted in Fig. 4. From the graphical representation it can be observed that manual irrigation and drip irrigation method pumps water to the field in 20 hrs and 12 hrs. Whereas, water is pumped to the field by the smart irrigation system within 7 hours respectively.

5. CONCLUSION

The main aim of this study is to evaluate a smart farming technique which is based on IoT techniques. An intelligent and low cost smart irrigation system is developed with IoT is proved to be a best method that is suitable for farming lands and green house farms. A fully autonomous irrigation scheme is developed in the smart irrigation which uses the water resources with optimum efficiency basing on the requirement of the climatic conditions and it is proved to be an optimal technique for utilization of water during scarcity. With IGA-ELM method, many activities are handled by the IoT based Smart Farming and such as watering the farm, classification of plant disease, humidity and climatic conditions, soil type, and nutrient imbalance can be predicted. The external parameters of various domains such as weather condition, soil, moisture and regulations etc can be managed in a flexible and adaptive framework of IoT basedagricultural system. The smart irrigation system proved to be best effective measure for water and power conservation is developed using "Internet of Things" and "Fuzzy Logic". When compared with conventional system the proposed smart farming system is fully automated system which has simple operating system, less expensive and flexible. The main aim of this study is to develop an ideal smart cultivation sytem with effordable price, easy access to the farmers for fully automated system that monitors

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the crop continuously and helps in growth of crop production and also financial benefit of the user.

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