IOT Based Decision Support System for Agriculture Yield Enhancements

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Abstract-In agriculture Expert systems are used in a wide range of operation. Farmers mostly depend on agricultural specialists for decision making. These systems are used by farmers and others without the knowledge of computerusage.In this paper we present the part of expert system in agriculture and its approaches in crop production. It is a knowledge build system for information generation with existing knowledge. This supports farmers in identifying economically strong decision for crop management. On considering the success of expert system, various such systems were developed. IOT plays a key role in agriculture. The abstraction of IOT and its architecture is discussed in this paper. Expert system builds on Internet of Things (IOT) uses the input data gathered in real time is proposed in this paper. In this paper, an expert system in cloud based infrastructure is used. IOT components such as &Cube (IOT Gateway) and Mobius (IOT service platform) are integrated in proposed system. In the proposed system, Kalman filter (KF) is used in sensor node to minimize the noise in sensor fusion. This paper illustrates the need of expert system in agriculture and the advantages of IOT based farming.

I. INTRODUCTION

Agriculture is the strength of the Indian economy. Highyield is the main aim. In order to achieve this, expertknowledge is required. Based on that knowledge, growers canmake decision. The problems in agriculture are multidisciplinaryand very complex. These problems are due to lack ofavailability of enough experts for the farmer's to enhance theyield .There are different crop management techniques andcropping pattern. Farmers may not have knowledge about theproduction and management technologies, so they need toapproach all the possible information to make fast decisions to increase the yield and manage crops. In order to raise a successful crop, farmersmostly depend on crop experts to help them in taking rightdecision. Unfortunately, crop experts are not beingavail for consultation every time. In such situations, Expert systemapproach can help the growers. Over the recent times manypeople make decisions in agricultural activities withoutenough knowledge. ES in agriculture helps the farmers tomake more efficiently and timely decisions. A computer programmemodelled to replicate the issue solving behaviour in a specific discipline is an Expert system. It can also be defined as an informationgeneration tool. Information is either generated from data orknowledge. Statistical information is the information produced from data and advises produced is an example of information producedfrom understanding [1]. The two different levels of expert system are operation level and planning level.In operation level, the workers in the place can use the system.

Revised Version Manuscript Received on 25 November 2018.

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This supports them in making appropriate decisions. On theplanning level, the expert systemstell in advance or estimate the usage of water, fertilizers, and pesticides.Expert systems are cost efficient compared to human experts in the field of agriculture [9].

In recent times the application of IOT is developing abruptly.Internet of Things (IOT) connects different physical objectsthrough the internet. It associates human and devices through ahighly diffused network. Every IOT object has three capabilities. The primary one is awareness and second is representation and at lastinteraction. Awareness is the capacity of the objects to senseother entity and understand. Representation is the capacity ofthe entity to present, in accordance to the programmingbehaviour. Interaction is the capacity of the objects toexchange information with each other. The IOT is developing andbeing popular day by day. Ithas been estimated that there will be an interconnection between billions of objects in the world. Therefore, a smart farmingembedded with IOT system could deliver more agriculturalservice based on expert's skill or understanding.

In this paper, we have proposed an internet of things based expert system. The expert system helps the farmer byproviding an efficient crop management system. The rest ofthe paper has organised as follow, in section II, literaturesurvey is discussed, in section III, the architecture of theexpert system and expert system based on IOT is discussed, insection IV, an Expert system based on IOT is proposed and itsimplementation is described, in section V, and hence concludethe whole work.

II. LITERATURE SURVEY

S. J. Yelapure and Kulkarni[15] have discussed the need of expert system and reviewed different kind of expert system.Asaresult of the application of the expert system,many countries step forward to develop expert system.

AvneetPannu [2] has discussed on the work doneby the expert system on various fieldssuch as agriculture, station wagon,biomedical, teaching, etc. Diagnosis area of expert system include biomedical, station wagon and decision area includes teaching and guidance.

G.N.R. Prasad and A. Vinaya Babu[6]compared the availability of expert systems for the last 30 years. Expert systems were developed as a consequenceof evolution of Artificial Intelligence.The earliest expert system used in agriculture is Soybean diseases expert system. RaheelaShahzadi etal [7] proposed a cotton crop expert system that makes use of the Internet of Things technology. The first stage the system is deployment of sensors,the second stage is sending collected data to the server and last stage is processing the

data and sending recommendations to the farmers. 100 experts evaluatedthe system and results calculated shown that the system was very helpful to the farmers.

Xian-YiChen and Zhi-GangJin,[14],have proposed digital agriculture approachbuild on IOT technology. The proposed system mainly focused on the IOT automations such as RFID technology,Electronic Product Code technology, andWireless sensor network technology. The IOTmechanics has been widely used in digital agriculture, acute home, disaster monitoring, biomedical, etc.

PinakiChakraborty etal[5],has discussed about the Expert System that help to manage the malformation disease of mango by foretelling or estimating the existence of the malformation and specifying appropriate treatment for disease.Theexpert system helps in increasing the productivity in agriculture.

Li Li, Hu Xiaoguang and Chen Ke He Ketai [3], have discussed on the approaches of WIFI based Wireless Sensor Network in internet of things which include smart house, precision agriculture, etc.The author suggested the concept of precision agriculture. On comparing both the technologies, WSN technology is effective or more desirable compared to ZigBee. Each and every IOT object hasthe ability of being addressed, recognised, read and locate through the internet by using RFID (Radio Frequency Identification), Wireless Sensor Network (WSN) or other key technologies.

Suhas M Patil etal [11], proposed a system using the concept of IOT and WSN .In the proposed system Kalman filter is used to acquire quality data and to transmit the data to WSN. The main components of the proposed system are IOT devices,data refinement, algorithm and machine learning algorithm for prediction.The main aim of the proposed system is to provide a growing environment for the crops with the IOT approach.

MinwooRyu, etal [4], proposed a connected farming system based on the Internet of Things (IOT) which aims to provide a suitable environment for crop environment. The connected farming not only allows the users or customers to remotely detect, track and control physical devices,but also share their understanding on agriculturethat enables to develop an Expert system.The investigation on WIFI based WSN and its approach has high importance in the success and growth of IOT.

Ahmed Rafea [1],discussed the aspects of the various expert system. Expert system inearly 80‘s, in agriculture are considered in this paper.He proposed a methodology based on the developing expert system in agriculture. The methodology is based on the principles knowledge level modelling and reusability task. Irrigation schedule for a specific crop is considered to be the main aim of the developed system.

Shailendra Kumar Yadav [10] , proposed a rice crop expert system.The proposed expert system is ontology & web based system. The expert system helpsagriculturist, extension workers, research people, etc. It provides a productive, systematic approach to resolve issues related to rice such asinsect-pest, rice crop diseases, fertilizers, irrigation, etc.

Saket Mishra etal[9], has discussed on the structure, role and the development of the expert system in various agricultural fields. The expert system is the first commercial product of Artificial Intelligence. The theory of Expert system can be used to resolve wide range of marketing or occupation issues.

TokihiroFukatsuand Teruaki[13], proposed a farm activity tracking system with wearable devices and RFID readers .The proposed methodology can keep track of farmer activities without disturbing their work. The system develops an application, which delivers useful information to farmers.

Raul Morais[8], has discussed on a application that implements a wireless sensor network for agriculture at a low cost.This network contains solar powered acquisition stations used on soil moisture measurement in a green house.The system is most suited for agricultural related activities such as smart irrigation and environment monitoring.

Table 1 compares various expert system used in agriculture with the technology used.

Table 1: Expert System in Agriculture

EXPERT SYSTEM	CROP	TECHNOLOGY	ADVANTAGE
NEPER WHEAT	Wheat	Multiple design approach	Microsoft Windows based application and provide an English, Arabic interface
COMAX	Cotton	Combination of expert derived rule of “if then” and result simulation model GOSSYM	The expert system is currently in use by 400 cotton growers.
CROPLOT	Suitable plot determination	Rule-based expert system	This expert system showed 90% agreement
VEGES	Pest, pepper, beans,cucumber	language translation module	Multilingual expert system
ESMMDM	Mango	Fuzzy logic based reasoning process	Interactive software tool and usage of graphic user interface
CALEX	Cotton	Module based	efficient data entry, management and integration of information
LIMEX	Lime	Expert system with multimedia. Developed by an adapted KADS methodology and CLIPS object oriented language.	Better understandable, more flexible, more interactive and easy to use .
POMME	Apple orchid management	PROLOG language was used. Based on decision making process.	More fundamental reasoning capability, than available from typical rule based.

III. IOT BASED EXPERT SYSTEM

An expert system, a program or software, reproduces the knowledge of a

human expert on a specified problem and usesthis understanding to provide solutions to the issues close tothe expert's solutions. The three key modules that make up anexpert system are knowledge base, inference engine and userinterface.

A. Knowledge Base:

The knowledge base has the necessary knowledge on a specified topic for understanding, formulating and solving problems. The knowledge base contains rules and other information derived from the experts. The knowledge base stores the knowledge acquired from the experts. The knowledge in the knowledge base is represented as rules.

B. The Working Memory:

The working memory is a collection of facts about the problem. The expert system uses the information stored in this database to draw conclusion with additional information about the specified issues.

C. The Inference Engine:

The Inference engine takes an existing information storedinside the knowledge base and database of facts in the workingmemory to analyse the problem and obtain new informationregarding the problem and to reach conclusions and takeactions. The Inference engine is the rule interpreter of theexpert system. Forward chaining and backward chaining aretwo techniques used in the inference engine. If the fact storedin the inference engine matches the rule, then the inferenceengine compiles the rule to obtain conclusion. If theknowledge base has more than one rule, then the higherprecedence rule or the new rule added to the database will bechosen by the inference engine.

D. The User Interface:

The user interface which is considered to be the invisiblemodule of the expert system allows the user to interact withthe expert system. This interaction is done by using dialogboxes, forms, or other input processes. It is active during theconsultation of the expert system. The two basic componentsof user interface:

1. The Interviewer Component: It manages the communicationbetween the system and the user and allows them to retrieve anymeasured data from the system.
2. The Explanation Component: It gives conclusion orsolution to the problem and also a sequence of rules used toderive that conclusion.

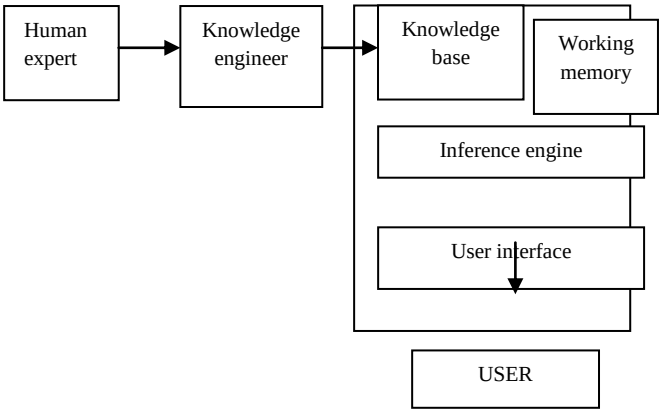

Figure1. Expert System Architecture

Internet of things (IOT) can be defined as aninterconnection of daily life objects through internetconnectivity. In IOT the data can be transferred withoutthe need of human to human or end user to machinecommunication.IOT has many applications in transport, healthcare, traffic monitoring,business, but the application of IOT inagriculture has a great impact as agriculture contributes moreto the development of our country's economy level. TheInternet of things is transforming the agriculture industry likenever before by helping the farmers in different ways. The IOT expert system and traditional expert system vary from each other with respect to input.

The IOT based expert system makes use of the input gathered inreal time. It allows the farmers to take prior measures toreduce the loss caused by insects/pests and climate change.This increases the productivity of crops. The sensors aredeployed inside the agricultural area to collect data regarding the environment.The data collected by different sensors are sent to server,where the expert system is deployed, which process the dataand analyse the data and give suggestion about the crop tothe farmers.

IV. PROPOSED SYSTEM

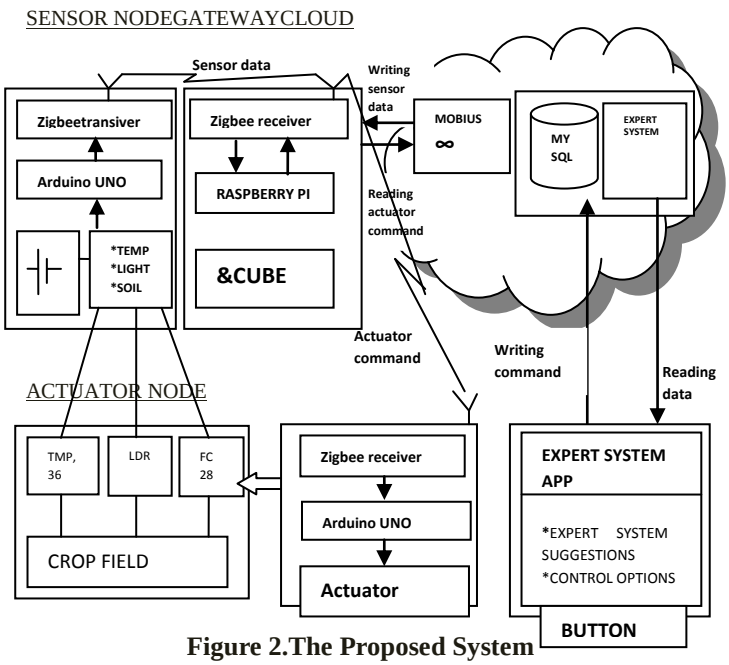

Figure 2.The Proposed System

The figure 2 above shows the structure of the proposed system, which consists of mainly three components; the IOT devices which also includes sensors and controllers, gateway and MOBIUS(service platform).

In the sensor module, all the sensors are connected to the Arduino UNO, a microcontroller that senses the surrounding by collecting input from different kind of sensors and control it's surrounding by actuators. The Arduino UNO is used because, the programming environment and the language is very easy to understand even for people who have not programmed before and is probably the best choice for beginners .The microcontroller along with the sensors is called a sensor node.

The process of fusing data from various sensors and aiming tocalculate a result that could be more than the result detected by a senor alone is known as sensor fusion.

A Kalman filter is deployed in sensor node to minimize the noise in sensor fusion. A Kalman filter is an algorithm which takes the measurement observed over time, containing uncertainty, error or noise and sort out useful parts of interest, to reduce the uncertainty or noise.

In the gateway module,every sensors and controllers are linked with the gateway Raspberry Pi which inturn is associated to the service platform.Gateways help to connect the sensor network (things) to the internet through infrastructure.

Since Arduino does not have built in features for networking, and working with REST servers and databases are complicated in arduino, Raspberry Pi is used. The main drawback of sensor node is that it doesn't have enough processing power and storage to locally handle the information. It uses a low-energy radio communication network to send the data to the gateway (Raspberry pi). The interaction bridge between the sensor nodes and the gateway depends on ZigBee. Zigbees are tiny modules that are mostly used for serial communication that can communicate wirelessly between Arduino and Raspberry Pi.Zigbee is used because it support wide range of node, has a very long lasting or lengthy battery lifeand easy to implement.Now, the sensor module makes an outbound association with the internet and cloud platform by means of gateway.

In the cloud module, the data from Raspberry pi is uploaded to Mobius, an Internet of things(IOT) server platform that collects and stores the sensor data in the cloud .It also forwards data to applications (e.g. web, mobile) and used to develop IOT applications. An end-user application is developed that has the ability to add, change, or delete data present in the system, such as viewing the present value of the temperature and humidity sensor and controlling the led, etc.

For this, first each device placed in the system has to be recorded into the service platform using &Cube.&Cubework together with the service platform. It supplies the common functions of IOT. It helps in transmission of data, managementof the process and acceptanceof the control commands.Every device has its virtual representation after getting registered in Mobius. After the completion of registration of the sensor and actuator with the Mobius through &Cube,data collected can be retrieved from the sensor module by REST application interface. MQTT proxy, database, REST Server, and MQTT broker are considered to be the main parts of the server system.

A requirement based expert system is used in the proposed system because it can provide flexible and intelligent auto decision model. The rule based system uses knowledge in the form of rules to provide advice or suggestion on the basics of the input data. The algorithm used here is decision tree algorithm (if-then rules). According to the rules present in knowledge base and the input data that get stored in MY SQL database, the inference engine in the expert system make suggestion.

In the proposed system, the hardware and software of the expert system are implemented in the cloud to improve security control and to integrate resources. The expert system architecture in the cloud has the following components: back-end, front-end, and the transaction subsystem. Using these technologies, the expert system is not dependent on existent operating systems on the server that is to be installed, thus ensuring a high degree of portability. There are multiple benefits in moving the expert system infrastructure to the cloud. It reduces operational costs and the demand on hardware resources, just as virtualization has already done. The most significant benefit of moving to the cloud is reduced management costs. The cloud computing security infrastructure of the expert system is the highest priority.

The Expert system on the server side, processes the data and gives suggestions.The user can interact with the server through the mobile app developed with the help of REST APIs. Based on suggestion each and every device in the system can be controlledremotely by the service platform and gateway of IOT through mobile applications developed .The mobile app sends actuator command to the cloud server platform and the data is retrieved from the cloud platform by the raspberry pi.Then arduino will send the control command to the actuators depending on the commands received from the gateway through Zigbee. In the concept of the IOT, the server should send the control commands to the actuators of the fields, so they can take suitable or proper decisions. For this purpose, an expert system is deployed as it can perform automatic decision making.

In the developing countries, there is an increase in usage of mobile phones and apps. Mobile phones are electronic, wireless, portable device which is everywhere. Mobile phones have really changed the way of communication as it provides us an easy and fastcommunication overlongdistances. It has become a necessity for many people throughout the world. A few years back, mobile phones were not so common but now mobile is every one's first choice gadget, either an educated person or an uneducated person. Hence mobile apps were used instead of web servers in the proposed system. The developed IOT mobile app runs on Android Operating System (OS). The two main parts of the application are user interface and suggestion .The user interface contains buttons to control actuators, and the expert system suggestion which provides advice to farmers. The suggestions provided by the expert system are used by farmers to control the actuators to provide increase productivity.

V. CONCLUSION

In this paper,an IOT based expert systemfor smart agriculture using decision tree algorithm is proposed. The IOT devicesused in the system provides an automated solution for data acquisition from sensors deployed in the field. Raspberry pi is used as a gateway to connect to the cloud server. The system incorporates IOT gateway &Cube in Raspberry Pi and IOT server platform Mobiuswhich provides API to develop mobile app. The role of Mobius is to communicate with Expert system and control actuators. Since themobiles areused everywhere, mobile apps are

Suggestedinstead of web browsers. In today's growing world, the farmers are not aware of technology and agricultural practices, the proposed system can help the farmers to take preventive measures to reduce the losses in agriculture and increase productivity in crops.

REFERENCES

1. "Expert System Applications: Agriculture",AhmedRafea Central Laboratory for Agricultural Expert Systems P.O.Box 100 Dokki Giza Egypt rafea@esic.claes.sci.eg.
2. AvneetPannu, (2015) "Survey on Expert System and its Research Areas", International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 10, April 2015.
3. "The Applications Of WiFi-based Wireless Sensor Network In Internet Of Things And Smart Grid", Li Li , Hu Xiaoguang, Chen Ke.
4. Design and Implementation of a Connected Farm for Smart Farming System,MinwooRyu, Jaeseok Yun, Ting Miao, Il-YeupAhn, Sung-Chan Choi, Jaeho Kim.
5. 2008 "An Example of Agricultural Expert SystemsBeing Used in India" 1 Pinaki CHAKRABORTY, 2 Dr.Dilip Kumar CHAKRABARTI.
6. G.N.R. Prasad, Dr. A. Vinaya Babu,(2006) " A Study on Various Expert Systems in Agriculture"
7. RaheelaShahzadi ,JavedFerzund ,Muhammad Tausif , Muhammad AsifSuryani,(2016) " Internet of Things based Expert System for Smart Agriculture",(IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 7, No. 9, 2016.
8. Wireless Sensor Network for Smart Irrigation and Environmental Monitoring: A Position Article Raul Moraisa , A. Valente b , and C. Serôdio c IJSTE–International Journal of Science Technology &Engineering|Vol.1,Issue 5, November 2014| ISSN(online):2349-784X,"
9. Expert Systems In Agriculture: OVERVIEW" SaketMishra , B.Tech. Student Department of Information Technology, ASET, Amity University, Noida.
10. RICEsmart: An Expert System to Enhance RiceYield", Shailendra Kumar Yadav1 , Niraj Singhal2 andVivek Yadav3
11. Suhas M patil, Sakkaravarthi R, (2017) "INTERNET OF THINGS BASED SMART AGRICULTURE SYSTEM USING PREDICTIVE ANALYTICS".
12. Expert System for Agriculture Extension " ,Sujai Das *, LaxmikantaNayak
13. Farm Operation Monitoring System with Wearable Sensor Devices Including RFID", 1 Tokihiro Fukatsuand 2 Teruaki Nanseki.
14. Xian-Yi Chen, Zhi-Gang Jin ,(2012) "Research on Key Technology and Applications for Internet of Things",2012 International Conference on Medical Physics and Biomedical Engineering.
15. S. J. Yelapure , Dr. R. V. Kulkarni,(2012)"Literature Review on Expert System in Agriculture", International Journal of Computer Science and Information Technologies, Vol. 3 (5).