EDUCATIONAL PROJECT ON DECISION SUPPORT SYSTEM FOR PRECISION AGRICULTURE

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Abstract

The agricultural industry faces a challenging task of sustaining the world growing population. Through the use of well-timed information gathering and proper decision making, the tasks can be facilitated with modern technology. In the 21st century, precision agriculture equipped with Information Communication Technology (ICT) and Decision Support System (DSS) is adopted in rural areas. ICT enables farmers to collect critical crops information and DSS guides farmers to understand and utilize the information to make correct decision. In order to educate current undergraduate engineering and agriculture students necessary ICT and DSS knowledge, a group of faculty from multi-disciplinary programs at Prairie View A&M University acquired funding from United State Department of Agriculture (USDA) capacity grant to establish a smart irrigation system DSS through wireless sensor network (WSN). This project will involve four undergraduate students annually for three years.

Keywords

Precision Agriculture, Decision Support System, Information Communication Technology, Wireless Sensor Network

Background

Recent fast growing computer techniques changed the world dramatically. Some traditional industry also impacted by the computer era. For example, agricultural field used to be very manpower consuming. Now with the help of computerized devices, the agriculture fields can revolutionize the conventional farming methods by conserving natural resources, producing efficiently and cutting down labor hours. In 2011, 570 agricultural workers died from work-related injuries. The fatality rate for agricultural workers was 7 times higher than the fatality rate for all workers in private industry; agricultural workers had a fatality rate of 24.9 deaths per 100,000, while the fatality rate for all workers was 3.5. With the goal of reducing manpower in the fields and still increase the filed productivity, researchers investigate on precision agriculture. Precision agriculture is defined as "satellite farming" or "site specific crop management (SSCM)," is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops [1]. Essentially, Decision Support Systems (DSS) and Information and Communication Technology (ICT) are critical tools. Developed in this computer era, DSS are a class of computer-based information systems that support decision making activities [2]. Started in the 1950 and 1960s at Carnegie Institute of Technology and at MIT, DSS has grown substantially due to the development of information technology and evolution of the computer interface. DSS require relational databases and flexible query languages because models and information needs differ [3]. In 1985, group support systems and Executive Information Systems have made support systems available for corporate use. In the 1990s four influential tools developed for creating DSS. They are data warehouse, on-line analytical processing, data mining, and the World Wide Web. Data Warehouse is a database that collects business information from many sources in the enterprise, covering all aspects of the company's processes, products, and customers. Online analytical processing is the software that allows users to explore data from a number of perspectives. Data mining is an information-analysis tool that involves the automated discovery of patterns and relationships in a data warehouse. For our project the Data Warehousing Information Center has a list of tools and DSS products that will be useful in fulfilling our client's needs [4]. Since there are several factors related to farming, DSS in agriculture applications can be treated as interactive systems that help decision makers utilize data and models to solve unstructured problems [5]. The emergence of ICT has supplied the current society with ever-increasing demand to use computer controlled equipment in all kinds of areas.

The project goal is to design and develop a prototype automation system. The system receives data from field instruments such as humidity and temperature sensors to collect data in real time. A web based data viewing interface is designed not only display the real time data obtained for the field, but also incorporate other useful information, such as weather prediction. Applications for smart devices are also developed for farmers' convenience. Besides the real-time viewing, when the temperature or humidity value goes beyond the threshold, an alarm will be triggered, at the same time, a warning message will be sent out to the user's smart device for attention. It is possible to extend it to an automation irrigation system with automatically turn on the valve of sprinkler in the near future. This project is successfully implemented. By incorporating crop science, environmental protection, and economics condition, the system will provide the farmers with enough information for irrigation decision. This system can also keep continuous records of farm operations through a data cloud; thus, improve the accuracy of decision-making for enhancing quality of crops. During the design procedure, undergraduate students obtained necessary training on engineering techniques as well as the knowledge on agriculture industry.

System Design

The objectives of this design include that the cost of this system should be kept to a minimum. The instruments and equipment chosen must be available and integrated in this design. This system should have provisions for future expansions and future declared provisions. The design utilizes data storage and external data access. The system schematic diagram is shown in Fig. 1.

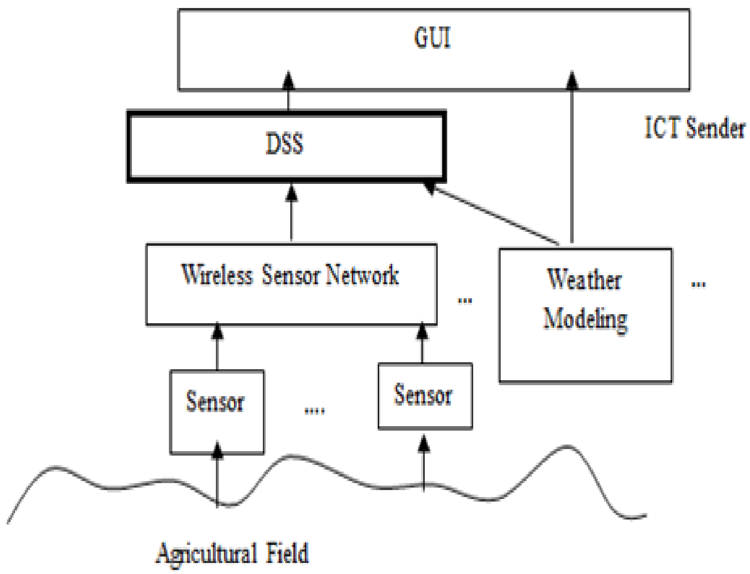

Fig. 1 Smart irrigation DSS schematic diagram

(1) Wireless Sensor Network and Data Cloud
Key challenges of choosing a feasible design include the difficulty in data acquisition from the field sensors and in return, sharing from remote data servers. To implement the system, National Instruments (NI) Wireless Sensor Network (WSN) is chosen to link field sensors to the DSS system. Real time data is inputted from WSN node to a gateway which transmits data to a local workstation. This workstation is connected to a Data Cloud via internet. A remote DSS server retrieves real time data analyzes it and makes a smart decision. This decision is relayed to the field devices. A notification is sent to user's smart phone. User can also make manual decisions using their smart phone to trigger the irrigation system. System diagram to explain the information flow of this smart irrigation DSS is illustrated in Fig. 2. The National Weather Service can be utilized

to provide perception information in the near future. The Data Cloud will give the opportunity to access real-time data with public access for data integration and importation. The system previously utilized NI Data Cloud to store data. Since recently NI stopped their Data Cloud service, a local Data Cloud is generated through author's NSF Major Research Instrumentation grant (Award No. 1229744) which established a High Performance Computing cluster for the college. A picture of the data center with the cluster is shown in Fig. 3. A proficient understanding of LabVIEW program will assist with the importance of the decision support system.

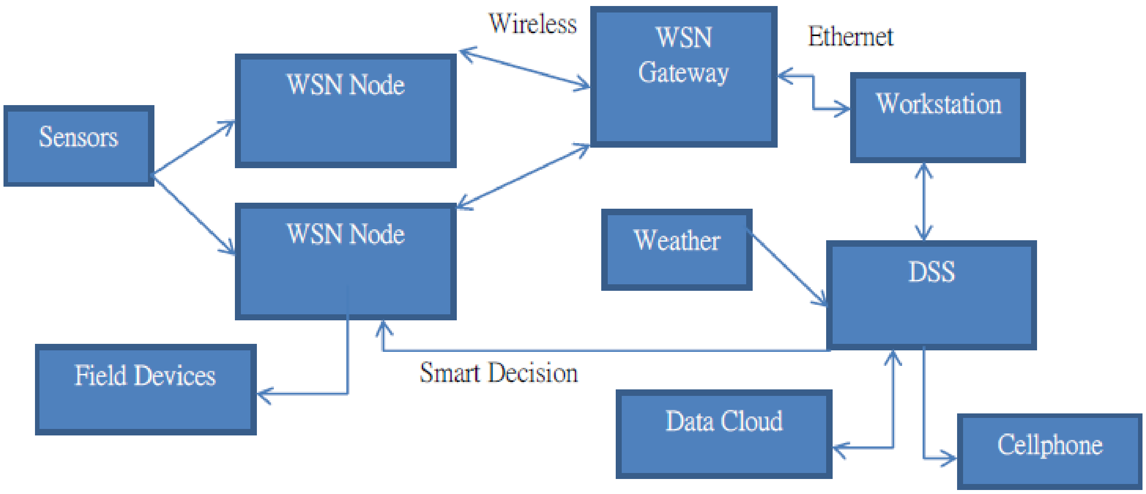

Fig. 2 ICT of the smart irrigation DSS

Fig. 3 Data Cloud for the College of Engineering

(2) System Platform

Since the NI WSN is adopted for sensor data acquisition, LabVIEW is the software platform to develop internet viewing interface. The block diagram and front panel design are shown in Fig. 4 and Fig. 5 respectively. As we can see besides the humidity and temperature values, this system can also display the signal quality and battery life. If the lights are off, no irrigation needed, the soil and temperature is at good condition for the crops. If one or more of the lights are on, they warn the farmer to take action on irrigating the crops.

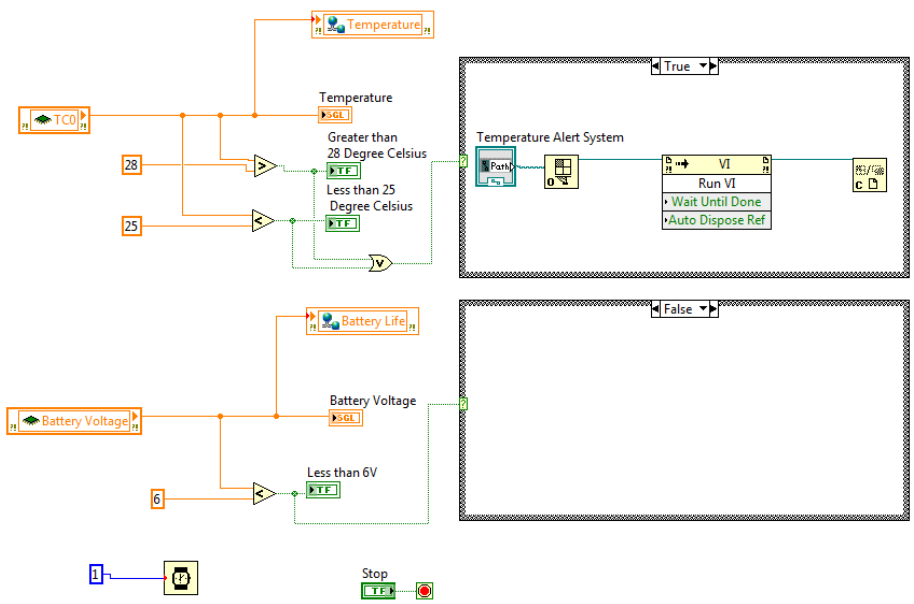

Fig. 4 LabVIEW Block Diagram

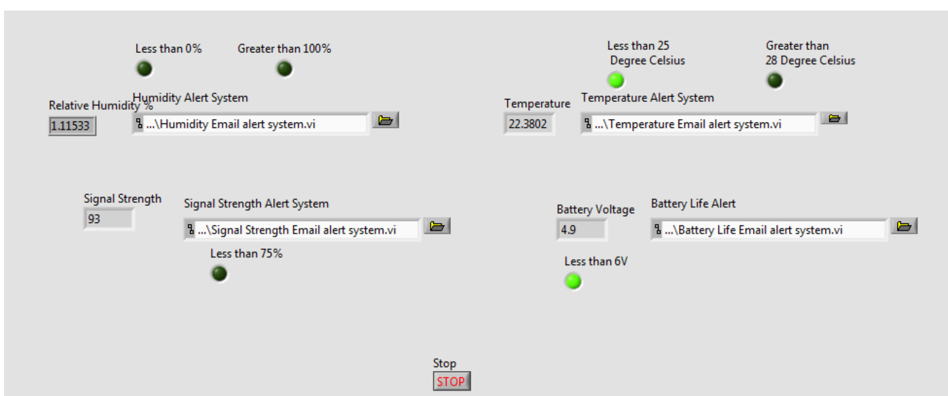

Fig. 5 LabVIEW Front Panel

(3) Sensors

To model the field irrigation need, temperature and humidity sensors are chosen to initialize the system. Both sensors can operate under harsh environment. Temperature sensor comes with NI programmable thermocouple input node as shown in Fig. 6 (a). It can operate between -40 and 70 □ C. User can program it to transmit only meaningful data to have extended battery life. Humidity sensor is manufactured by Veris Industries. It is accurate and durable. Also the sensor is easy to install and free of calibration as shown in Fig. 6 (b). They are connected to the NI WSN for data acquisition. Field temperature and humidity information comes through them to be obtained by WSN gateways.

(a) NI WSN-3212 24-bit programmable input node [6]

(b) Humidity sensor by Veris Industries [7]

Fig. 6 Temperature and humidity sensors

(4) Mobile Computing

After the procedures of acquiring and transmitting information, several cutting edge communication tools are utilized for this ICT. First of all, a website is developed to real time observe the field information though any computer connected to internet. Second, people can use iPad to retrieve data. Third, users can use smart phone to view same field information. Programming mobile devices belong to the idea of mobile computing. Mobile computing is now the primary way people use computers. Popular applications range from iPad to smart phone. The iPad application of this project is supported by NI Dashboard. The iPad interface is shown in Fig. 7.

Fig. 7 iPad application interface

Primarily, the NI Dashboard is able to run on Apple and Android tablets. This gives the user the ability monitor inputs and control outputs on Android, Apple and Windows smart phones [8]. In creating any application the following must be created: a set of view, content providers, a resource manager, notification manager and activity manager. For our project, it is important to provide the data in a database that can easily be accessible by the Data Cloud, providing a fast distribution of information.

Student Training and Educational Impacts

The overall objective of the project is to establish an intelligent equipment lab for precision agriculture at Prairie View A&M University campus to provide students the opportunity to improve their hands-on experiences with the cutting-edge agricultural ICT and decision making technique. On one hand, the lab facilities can be used as tools for training students to qualified agricultural industry workers and attracting new students to related programs. On the other hand, the system integration will promote the collaboration among the multidisciplinary team, and further benefit the team members' individual research endeavor.

Detailed objectives are listed below:

(a) Enhance multidisciplinary research/teaching collaboration and integration;
(b) Improve research/teaching capability in Agriculture Sciences, Technology, Engineering, and Mathematics (STEAM);

(c) Strengthen undergraduate students' working skills on up-to-date agricultural ICT;
(d) Establish a fully operated intelligent equipment lab for future research and teaching purpose.

With the smart irrigation system as a pilot project, Prairie View A&M University faculty and students were able to initialize the research and education foundation. Current automated irrigation system is designed by setting the starting and ending time of watering based on farmer's experience. There is no information collected from the field which may lead to the waste of water resources or risk of drought. The smart irrigation ICT system will install sensors in the field, collect data real timely, and transmit data to remote devices, such as computer, iPad, or smart phone for farmers to view the crop and field condition. This ITC system is also designed to have the capability to assist farmers to make irrigation decision by sending an alarm message if the collected data is out of the suggested range. Undergraduate students are involved in the project as their senior design project. And two undergraduate students (one from engineering and one from agriculture) are hired as undergraduate research assistants for the intelligent equipment lab. One master student is working on extend this project to his master thesis project. Preliminary results show the promising of this on-going project.

Conclusions

The prototype of a smart irrigation ICT system is successfully developed. Temperature and humidity sensors are connected to the system and provide real time field condition. A simple DSS is implemented by consider whether the data is out of the suggested range. Multiple communication platforms, such as computer, smart phone, and iPad are utilized to display the data. Farmers are able to access data remotely. This ICT system also trained a group of seven Electrical and Computer Engineering undergraduate students through senior design project. The project helps them understand the importance of precision agriculture. An intelligent equipment lab is established at the Prairie View A&M University and will provide research and education opportunities to both engineering and agriculture students.

Future Work

In the future, local weather modeling will be added to the system to provide more information in the ICT. Also network security will be explored for the data obtained and transmitted in the established WSN system.

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