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Enhance Project-Based Learning Experience for Undergraduate Students with Wireless Sensor Network

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Abstract

The advancement of technology has changed the way how industries operate. With current advancement of computer and communication technology; the agriculture industry is transforming from labor-intensive to more and more technology-relying. To support the ever growing world population with limited farm land, researchers investigate the concept of precision agriculture, which helps to increase farm produces by using less resources. Precision agriculture successfully uses technology like Decision Support System (DSS) and Information and Communication Technology (ICT). The convenience and wide availability of smart devices make such technology accessible to small farms. Based on the observation, a project-based learning opportunity is offered to students at Prairie View A&M University. In the project, students investigate research focusing on a real-time DSS for smart irrigation. Temperature and humidity information is collected with field sensors, and then is transmitted through Wireless Sensor Network (WSN). WSN, which is operated based on the IEEE 802.15.4 standards, contains nodes that are used to help transmit data to a gateway. Mobile device programs, such as iPhone and iPad applications are developed for farmers to help them make decisions. The use of mobile devices in the farm will give the farmers the ability and convenience to observe data and make decisions in real time manner.

The WSN based DSS is successfully setup and tested by several senior design groups. Based on the success of the project, related topics will be included in a special topic course, which will be offered in the Department of Engineering Technology. Through these activities, students gain hands-on experiences on computing, communication, as well as smart sensor technologies. Students increase their confidence in pursuing future career opportunities in the abovementioned areas, especially in agriculture and engineering. By doing so, not only the students are equipped with cutting edge technology but also they will be more competitive in their future careers. The teaching project also provides a platform for collaboration among educators from diversified disciplines for enhancing agricultural and engineering education at Prairie View A&M University.

Introduction

Engineering education is more about problem solving and trouble shooting, especially in senior year. It is very important to find topics for students' capstone design projects. This paper presents an approach which successfully combines external funding resources, faculty expertise, and collaboration resources for a project-based learning environment. In 2010, authors collaborated in a USDA supported project to establish an agricultural robotics lab and In 2012, authors collaborated in another USDA supported project to establish an intelligent equipment lab both in Prairie View A&M University. The overall objectives of the projects are to establish an agricultural robotics lab and intelligent equipment lab for precision agriculture on Prairie View A&M University campus to provide students the opportunity to improve their hands-on experiences with the cutting-edge agricultural information decision support 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.

To develop our decision support system, wireless sensor network (WSN) technology was chosen for constructing the system architecture. WSN refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing to collected data at a central location [1]. WSNs are a significant technology for huge scale monitoring, allowing sensor dimension at high temporal and spatial resolution. The straightforward process is typical and direct where data are communicated to a base station; nonetheless, WSNs can also achieve in-network sort out operations such as aggregation, event detection, or actuation. The WSN papers a decade ago clearly articulated the promise of the technology for a diverse range of monitoring applications including forests, waterways, buildings, security, and the battlefield, and how it would transform the way we live [2]. Some of the earliest use of WSN technology started back with military use. In the 1950s the United States Military used a modern WSN technology known as the Sound Surveillance System (SOSUS), to help find Soviet's Submarines during the Cold War. The Sound Surveillance System provides deep water long range detection capability, that also helped destroy Soviet's Submarine [3]. WSN is a topic in the field of electrical engineering that is used in many job fields. WSN is also widely used in the agriculture field.

Background

The two grants supported senior design projects worked continuously for 3 years. In these three years, senior design student groups from both Electrical Engineering (EE) Department and Engineering Technology (ET) Department practiced on this project-based learning experience and gained significant skills both on technique and on life-long learning. Figure 1 shows the block diagram of the system students designed and constructed based on WSN technology.

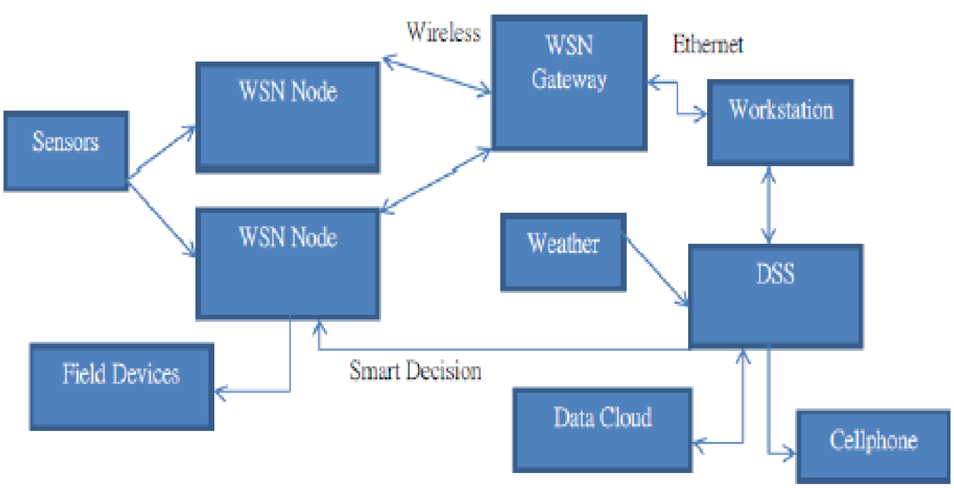

Figure 1: System Diagram

The system uses National Instrument (NI) WSN to connect with an DSS system. The NI WSN operates on IEEE 802.15.4 standards. The WSN nodes are equipped with real time sensors. The WSN Nodes takes the data from the sensors and transmit it to the WSN gateway; the WSN gateway is connected to the workstation (Computer) through Ethernet. The NI WSN node and gateway are shown in Figure 2 (a) and (b) respectively. Since the Smart Observation System is obtaining and updating data in an hourly bases, the growing data is stored on a local data cloud at Prairie View A&M University.

(a) WSN Node (b) WSN Gateway

Figure 2: National Instruments WSN nodes and gateway [4]

Project Activities

During the three years senior design practices, a lot of activities were conducted. In this section, we present some selected activities and some impacts on our undergraduate students.

System Simulation

A group of EE senior design students designed and developed a simulation system, which receives data from field instruments. The system makes smart decisions based upon this data with a DSS system. An operator interface was also developed for personal computers and smart devices. NI wireless control system was used. NI input and output modules have wireless capabilities, and can take real time data transmitted by radio transmitter to output modules, to gateway, and to local workstation. The workstation is connected to NI cloud via Ethernet. The NI cloud system is able to retrieve and analyze data, which makes smart decisions. The decisions are relayed to field devices as well as users via smart device or personal computer. Figures 3, 4, and 5 show the user interface and prototype of the simulation system built by the senior design students.

Workstation Control Panel

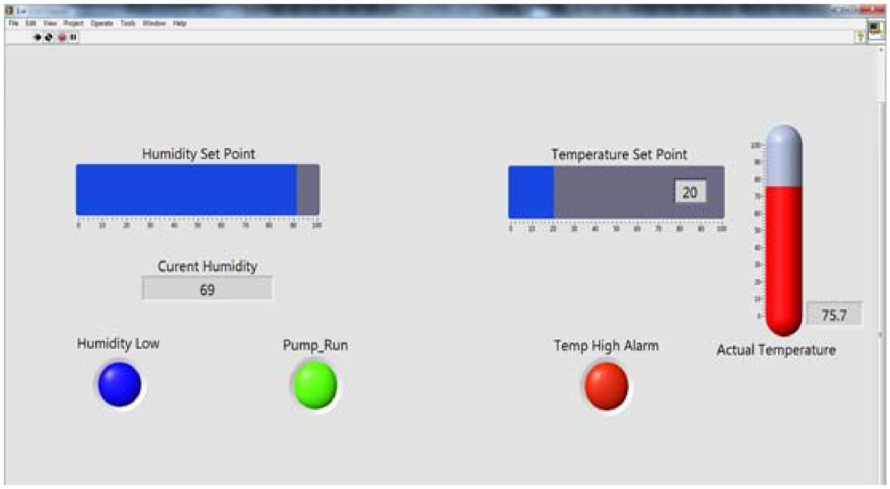

Figure 3: Workstation view in LabVIEW

Ipad Application Interface

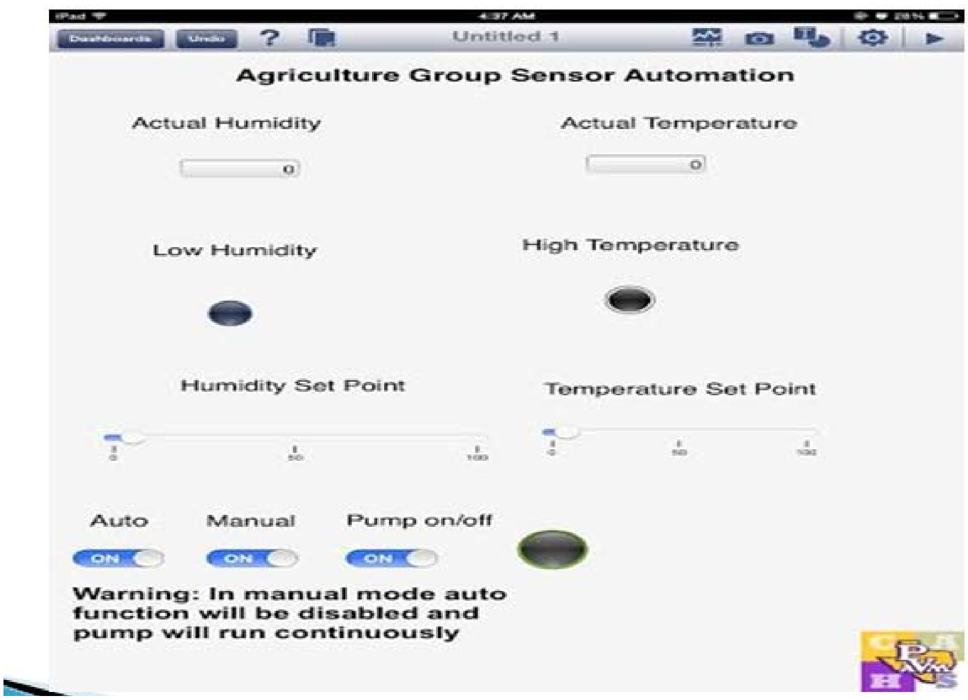

Figure 4: Application view on iPad

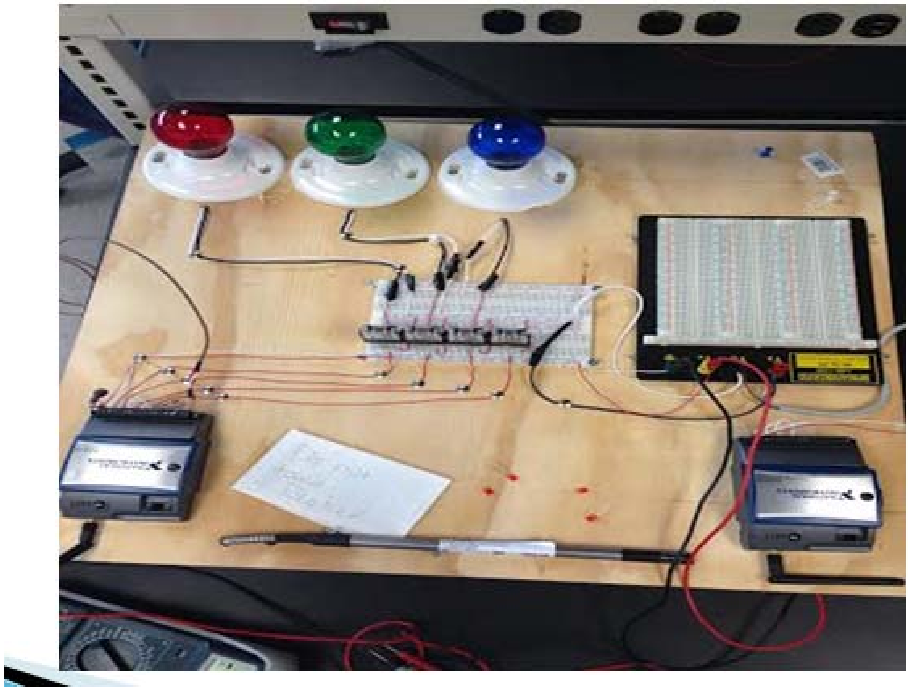

Figure 5: NI WSN simulation system

Agriculture Department Demonstration

The authors demonstrated our system to an Agriculture Department class in spring 2014 semester. In the demonstration presentations, the authors demonstrated the agricultural robotics system as well as the DSS system to the students. Students expressed their interests on the system. One student wrote: "promote it more to students and create more jobs." More survey results are presented in the next section. Figures 6 and 7 show how the demonstrations were presented to the students.

Figure 6: Agricultural robotics system demonstration

Figure 7: DSS system demonstration

Graduate Pathway

One of the student involved in this project-based learning experience was so interested in such technology, he then decided to go to graduate school to pursue his master's degree. He extended the system into a more practical system with a more complex topology, as shown in Figures 8 and 9. The student successfully received his master's degree.

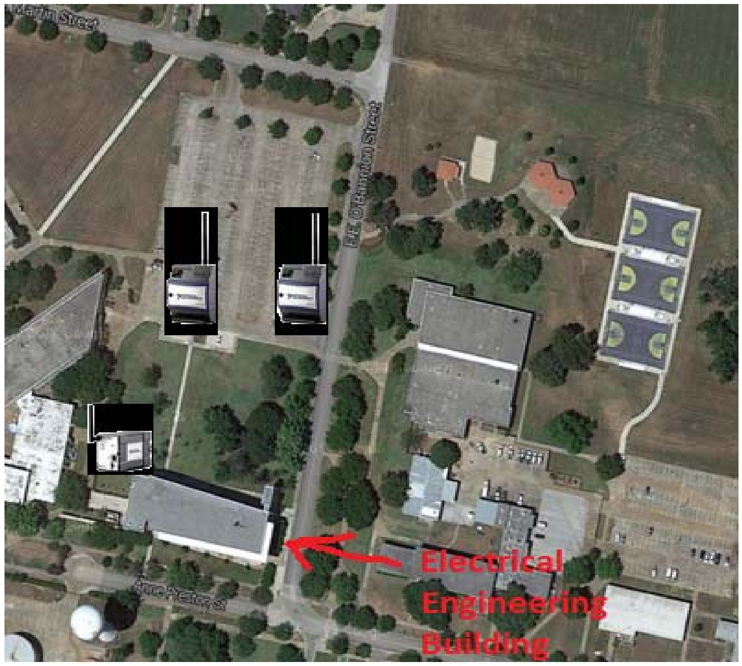

Figure 8: Map of experiment location [5]

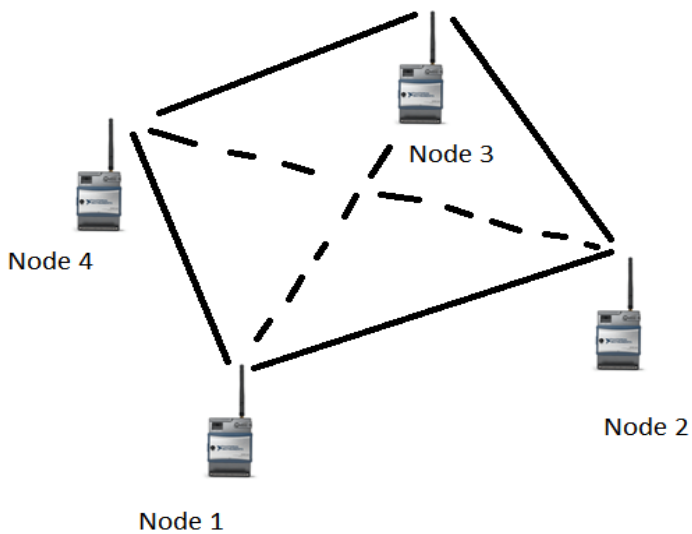

Figure 9: Mesh Topology

Survey Results

Survey Results for the Agriculture Department Demonstration

To understand the effects of the system demonstrations, student survey was conducted after the presentation. The survey questions are listed in Table 1.

Table 1: Pre and Post survey questions

#	Survey Questions	Conduction
1	Consider your level of awareness about agricultural robots (AgRobot) and intelligent equipment for precision agriculture (IEPA) both BEFORE and AFTER this class.	*Pre & Post*
2	Consider your level of interest in AgRobot and IEPA both BEFORE and AFTER this class.	*Pre & Post*
3	Use the scale to indicate the extent of your gains in understanding of Agricultural Robotics	*Post*
4	Use the scale to indicate the extent of your gains in understanding of Ground-Based Remote Sensing	*Post*
5	Use the scale to indicate the extent of your gains in understanding of Data Acquisition through Sensors	*Post*
6	Use the scale to indicate the extent of your gains in understanding of Decision Support System (DSS)	*Post*
7	Use the scale to indicate the extent of your gains in understanding of Information and Communication Technology (ICT)	*Post*
8	This class helped me understand the value of a multidisciplinary approach to solving problems?	*Post*
9	Knowing more about using intelligent equipment for precision agriculture will make me more marketable when I graduate?	*Post*
8	I would like AgRobot and IEPA projects to be used in more classes?	*Post*

Table 2: Pre and post survey statistics of Agriculture Department demonstration

Question #	*Know some basic AgRobot and IEPA concepts and applications*	*Know some basic AgRobot and IEPA concpets*	*Know only a few things about AgRobot and IEPA*	*Only head the term AgRobot and IEPA*	*Never heard*
1 pre	*1*		*1*		*13*
1 post	*7*	*7*	*1*		
Question #	*Very Interested in AgRobot and IEPA*	*Interested in AgRobot and IEPA*	*A little interested in AgRobot and IEPA*	*Not at all interested in AgRobot and IEPA*	*Never heard anything for AgRobot and IEPA*
2 pre			*4*	*1*	*10*
2 post	*5*	*6*	*4*		
Question #	*A Great Deal*	*A Lot*	*Somewhat*	*A Little*	*Not At All*
3	*5*	*4*	*5*	*1*	
4	*6*	*2*	*4*	*2*	*1*
5	*4*	*4*	*3*	*2*	*2*
6	*4*	*3*	*5*	*1*	*2*
7	*6*	*3*	*4*	*1*	*1*
Question #	*Strongly Agree*	*Agree*	*Neutral*	*Disagree*	*Strongly Disagree*
8	*7*	*7*	*1*		
9	*7*	*6*	*2*		
10	*7*	*6*	*2*		

Feedback: From the students' survey obtained (shown in Table 2), it is obviously that before this class, the students were lacking of the knowledge in AgRobot and IEPA. This had been greatly improved at the end of the demonstration. One student wrote "continue to create innovative equipment for farmers."

External evaluator Conducted Survey

External evaluator was hired to conduct student survey to evaluate the effectiveness of the student learning experience. Students valued their experiences with the project and believed they had benefited from their participation. They were excited about the project and believed they were gaining knowledge and skills that would help them in securing jobs in their future careers.

Specific details about the interviews are provided below.

Impact on Students' Knowledge and Skills

All students indicated that they learned to use LabView as a result of their participation in the project. Other examples of the project's impact on their knowledge and skills are:

- I learned more about how connectivity works.
- I learned how to work in groups.
- My people skills increased.
- I think I can network better now.
- I learned that I can really go above and beyond on a project.
- I believe I have gained trust and rapport with teachers and that will help me get good recommendations when I start to look for a job. So I am hoping this experience will help me in the future.

Impact on Students' Educational and/or Career Paths

One student shared that he already wanted to go to graduate school and get a PhD, and his work on the project had increased his desire to go to graduate school. The other student indicated that he had "done his research about graduate school at Prairie View A&M University but was really still up in the air about going on." Both students indicated that their work on the project had impacted their career goals. Other comments from the students when they were asked about the project's impact on their educational and/or career goals were:

- Through the project, I am getting more exposed to various companies and what they are developing so that gives me an idea of the skills that I will need in the future.
- I have learned where I want to focus my career.
- With each internship that I have done, there has been a database involved. Since I will be working on the project next year, I want to learn more about databases, both how to create a database and how to secure one. I am actually taking an extra class to understand more because I think it will help me on the project. I think this knowledge about databases will be very valuable for my future employment.

Conclusions

After the three years of implementation, the concept of intelligent equipment based precision agriculture is successfully integrated into senior design projects. Students' feedback is positive. Project impacts on student learning experience are significant. In the future, more courses are to be revamped and developed by infusing intelligent equipment contents. The results will be disseminated through conferences and school demonstrations. Another aspect of the future plan is to continue enhancing undergraduate students' research capability on related projects. Aiming at producing qualified graduates, educators must create an environment to involve students in the loop.

Acknowledgment

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[4] http://www.ni.com/

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