Senior Design Dec17-13 Research Paper

The fundamental purpose of engineering and science in general is to better the lives of human beings. It is therefore not a surprise that agriculture has been significantly advanced through the application of engineering. In our senior design, we further investigated a way to make smart irrigation less expensive. Although our approach does not offer automated irrigation, it is able to give details about the soil and detect areas where irrigation is needed. The information provided by our smart irrigation system can readily be made available for a user in the convenience of their home, office, or even on an airplane regardless of their location in the world as long as they have access to the internet. This flexibility in providing 24 hour access to soil information is possible because we utilized internet of things (IoT). Apart from monitoring soil moisture content, our project has the ability to incorporate other sensors that would monitor different soil characteristics which might be of interest to the user.

The first research paper our group looked at was an article in the IEEE Xplore Digital Library titled "Big IoT Data Analytics: Architecture, Opportunities, and Open Research Challenges." This article discusses the importance of being able to process large amounts of data. The main point is that a lot of data with no way to perform analysis is considered worthless. It also talks about some problems such as privacy, big data mining, visualization, and integration.

The paper begins by describing the IoT movement (IoT movement is a platform for sensors and devices to communicate seamlessly and share information across platforms). Today there are over 50 billion devices connected to the internet and the next revolutionary technology by benefiting the full opportunity of this technology. The following section to this is, taking the large amount of data and performing analytics on it. This requires tools that can handle structured, unstructured and semi structured data. Some systems that are available are real-time, off-line, memory level and massive analytics. The last thing this article talks about is the relationship between IoT and the data analytics which describes the two as going hand and hand for the IoT devices.

This article is working with IoT just like our project. However, the article is on a much larger scale with a nonuniform specific application. Our project is on a much smaller scale and the data we are working with is a defined format for us to easily work with. Because of this, our analytics system does not need to be as robust as the one they call for in this article. One thing we can take away from this article is the strength of numbers. Statistically the more sensors and devices you have connected to the network the better your data and information perceived will be. This being said, if we wanted to expand our network of nodes to the level in this article, we could use the big data analytics to achieve our goal.

The second research paper, IEEE Research paper “Sensor Data Management System in Sensor Network for Low Power” by lead researcher YongBag Moon, reviews sensor data management in sensor networks focused on low power. This closely relates to our project as we are also creating sensor networks that rely on low power to operate.

Moon’s team notes how they extend the life of their sensor nodes by only sending data when necessary (that is when there is a change in data by a certain amount). A difference between our network and their network is that their sensor nodes can communicate to their sink node, while our home node will communicate with a few sensor nodes and the rest of the sensor nodes will propagate the information. What is incredibly similar is how the sink or home node collects all the sensor network data and then sends it up into the cloud. Something we can consider utilizing is only sending back data if the data changes by a certain threshold. If we operated in this way, we would not need to send data as often and would end up saving energy. Although considering our network setup and sensor nodes inter communication, this may not be the most efficient manner.

The overall idea of this research paper is to utilize a threshold of change and to only transfer data when the threshold of change is above a certain value. While this is a clever way of saving energy, our setup does not need to pole as often as this research paper does. We only need data ~3 times a day while this system would be ‘on’ hundreds of times more than ours. Seeing this, we would most likely not utilize the same energy saving methods as this team, we will focus on saving power by utilizing sleep modes.

The next article we researched, was a project created by Rachel Cardell-Oliver and Mark Kranz called “A Reactive Soil Moisture Sensor Network: Design and Field Evaluation”. As stated in the title, their project was a reactive soil moisture sensor network, keyword being reactive. Their product was able to detect when a rainfall was occurring, and adjust the frequency at which readings were being taken, to better analyze the moisture data. To achieve this, they used a protocol called SMAC which is a MAC protocol designed to address the problem of energy efficiency. Obviously, with a project like this, where you would have potentially hundreds of nodes, you wouldn’t want to go out to your field all the time to swap out the batteries. Basically, their nodes turned on briefly every 12 seconds to communicate with their neighbors. When rainfall is detected, that 12 seconds is shortened to capture more readings.

When it comes to communication protocol, ours will get the job done, but it does not have the ability to react to changes in the weather, like Cardell-Oliver and Kranz’ system can. In that respect, we are far outmatched. However, a large part of our project goal was to create a cost effective solution to capture soil moisture data. Kranz and Oliver had no such goal in mind when they designed their system. Their final product cost nearly $5000 for the whole setup, and that comes with only two nodes. Our design will cost less than $20 for each node, which means we can offer a much larger node network, and the nodes become far more expendable.

When it comes to viewing the data, The Reactive Soil Moisture Sensor Network had a similar solution to ours, in that their nodes send the data to an online server where it is stored in a database. However, in order to view the data, you must subscribe to their SOAP web service, and develop your own user interface to pull and view the data. With our project, that is included. You are able to create an account, claim homenodes, and view the data that they are sending, all without much work. In the end, their project seems to be a much more robust solution to the node network problem than ours, but the problem is that systems like theirs already exist, and are just as expensive. Our project drastically reduces the cost involved in the node network, while also providing a user interface for the data.

For our third research topic, I chose research on web applications that already exist instead of an academic paper. As a web developer for our team, it makes sense to investigate other competing products to glean what features we should have, and how to present them. I chose to research two sites that exist. These sites are Aquaspy's "AgSpy" and John Deere's "Field Connect" service. I chose these services because they have fully functioning demo sites that are representative of the products, and let us compare what our plans were to real world applications.

First up, AgSpy has a feature that we had planned on from the beginning, so that was nice to see. You are greeted by a Google Map overlay of all the fields that AgSpy's service manages. This is a feature we had planned on including. By clicking on a map pin, or selecting your field from a list, you are brought to a page that shows details about the field. From here' I was really not a huge fan of AgSpy's design. You are greeted with a graph that is not labled easily, with some vague lines that aren't intuitive. This may sound like something that that a field expert might understand, but after showing it to our advisor he agreed that it was difficult to understand. It also has some graphics that look like they were 1990s clip art. The design did not look modern, and was difficult to understand. I feel like we already have a cleaner design, that was much closer to the next application I reviewed.

John Deere's Field Connect is a very clean application that presents data clearly. While it didn't have the google map, it does a good job of displaying all the user's fields in a clean interface, with an immediately visible moisture level. This is exactly what a user want's to see, immediate and understandable information about their field. The moisture level is represented as a colored bar that is full and green if a sensor is reading proper hydration, and red and depleted if a sensor's area requires irrigation. This is something we hope to emulate by providing clear information to the user that is available to them by the first page, or only one click away. By clicking on these sensors, detailed information such as the owner and the option to move the sensor are provided. It is a simple and clean interface that does not require knowledge of the field and is instantly understandable.

In conclusion, looking into products that exist on the market is extremely useful, and arguably more useful than an academic paper in the context of creating our web application. We were able to affirm that some of our ideas were good, and some of them could be cleaner. Field Connect was a little difficult to find, but is an excellent example of how information about field moisture should be displayed.

Finally, we are not trying to reinvent the wheel. We are just trying to make the wheel better. Other similar options are available. However, these options are expensive. Some of the option are not user friendly and require technical skills and a lot of money to keep the service or maintain the parts. Our project is aimed at reducing the cost of agricultural production and at the same time improving the quality of crops produced by identifying when there is an urgent need for crop irrigation and making this information readily available for the user so that appropriate action can be taken.

Appendix

I. (n.d.). Big IoT Data Analytics: Architecture, Opportunities, and Open Research Challenges. Retrieved October 29, 2017, from http://ieeexplore.ieee.org/document/7888916/

Relevent Sources:

- AgSpy: https://demo.agspy.aquaspy.com/
- Field Connect: https://login.fieldconnect.deere.com/login (Select the Demo Login button)

As explained during the meetings, you are expected to conduct a literature overview/survey and identify 4-5 *research* papers that are closely related to the main topic(s) of your project. In this homework, you are supposed to provide a 1-2 pages summary of those related work (i.e., identify how each reference is related; what is it that separates your project from the intended topic(s) addressed in that reference, etc.) casting your project in the respective contexts. The main intent is that you can easily (compress, if need be) and copy+paste in your final reports.

http://vellidis.org/

http://ieeexplore.ieee.org/document/4493812/ -Steve

http://journals.sagepub.com/doi/abs/10.1080/15501320590966422 - Charlie

Sign Up for Parts to complete

Intro / Conclusion: Terver: done

Research 1: Tim I took the IEEE one: done

Research 2: Took another IEEE one.

Research 3: Ian- Aquaspy and John Dee

Research 4: Reactive Soil Moisture Sensor Network

Research 5: Khoi Cao