Sensor Technology In Agriculture

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Abstract

Agriculture is progressing with technological advances. There is a lot of technology that can be implemented in this industry. Already there have been major advances in data storage however we can take this a step further with a popular technology such as Wireless Sensor Networks (WSNs). WSN are sensors that can be placed anywhere in the environment and gather information from it's surroundings. This can easily be applied to agriculture to gather direct data from the field in which crops and livestock are be produced. As agriculture is heavily dependent environmental conditions these WSNs will allow for a closer understanding to the conditions. A closer understanding of these conditions will then allow for better decision making for farmers in maximizing crop production. This paper surveys the idea of WSNs and their potential impact on agriculture. This paper will conclude with an evaluation of determining what type of WSN(s) will be the most important in the coming years entailing what agriculture research we should be focusing on. I determine this to be soil and water associated WSNs as drought and higher temperature years are increasing.

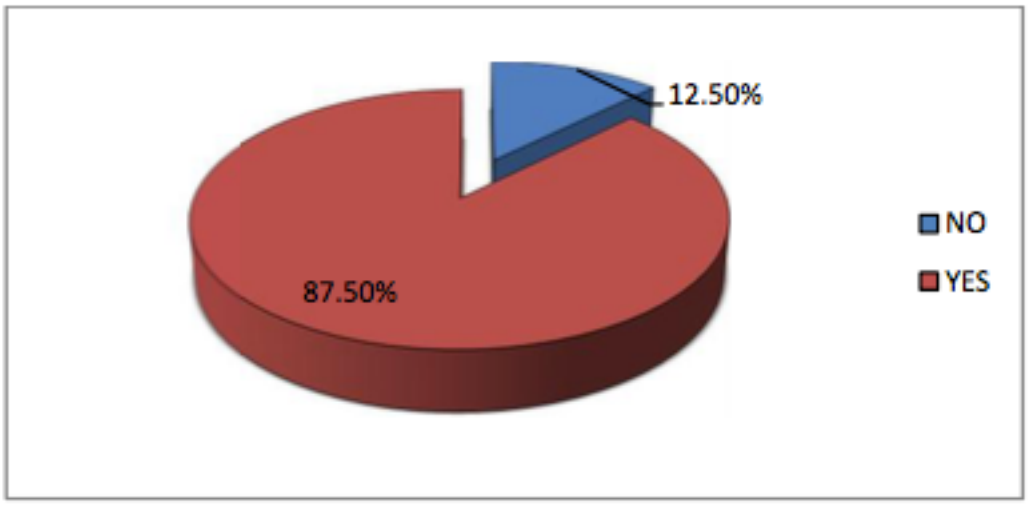
Introduction

Agriculture is an essential part of any community and vital to prospering other types of businesses and trade. We need agriculture to supply us with food and livestock. In recent years our population has grown to an unprecedented level. Because of this we have an extremely high demand in agriculture and cannot afford severe setbacks. For the most part we have stuck with traditional agricultural practices and in slowly moved to technological assisted agricultural style. This includes basic databases for storing and interpreting data. However this still leads to some of the risks we had before, decision-making. The next step to evolving our production is the use of Wireless Sensor Networks. This technology allows for the gathering of environmental information and then accumulating this data to a centralized location for further processing. The benefit of this will allow a deeper analysis of environmental conditions, as these sensors will be out in the actual field. Ideally we would want to have further computation action by allowing this data to initiate automated farming techniques like watering the field, spraying pesticides, etc. The uses of WSNs are limitless; however we must also decide what types

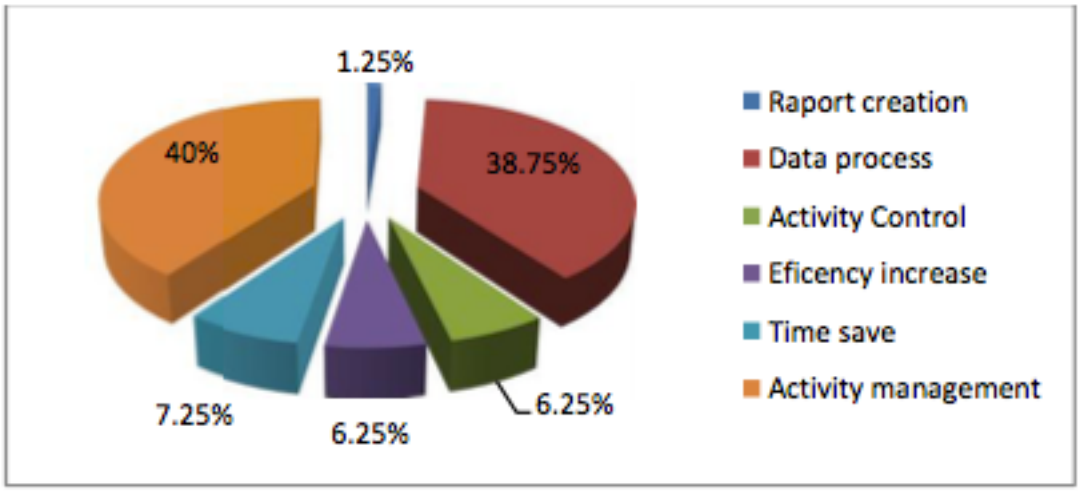
of WSNs we should focus on to improve our agriculture in the near future. In this paper I will deduce importance of agriculture in our society, the benefit technology – specifically WSNs – contribute to agriculture, and we should be focusing on soil/water WSNs for the future as droughts and higher temperature years are increasing.

Literature Review

Agriculture is and has been a critical part of our society. Without successful agriculture we would not be able thrive with proper food supply. This field allows for the proper allocation and efficient disbursement of a basic necessity to the masses. Our population on earth is at an all time high and thus agriculture is even more important than ever as the consequence of bad agricultural decisions are a lot more costly (Ojha T., Misra S. & Raghuwanshi N. S.). Unfortunately agriculture is very fragile creating even more stress on making the right decisions about agricultural methods. Many things can affect our farming from climate changes to insect infestation. These aspects are part of the agricultural process and must be accounted for in any research with this field. There is a climate forecast of changes in extremities like droughts and water flooding that will cause various negative impacts. These include soil corruption and insect outbreaks. Naturally these impacts will lead to overall agricultural damages that may cost millions of dollars or even lives (Kurukulasuriya P. & Rosenthal S.,). Additionally inscet breakouts can not only be severe but can be very difficult to terminate as parasites live about 90% of their lives in the soil below (Nickle W. R.). Technology has been propagating in the area of agricultural to try to improve the need for vast improvement and to keep up with the high demand of food supply regarding our current population. There have been steps to incorporating technology like the user of data storage and manipulation. There was survey conducted to employees of 80 different agricultural businesses regarding their usage of technology as well as what they use it for (Ahmeti A. & Gjermeni I.). The surveys resulted in more than 3/4th of these businesses adopted and use some form of software systems to conduct their day-to-day business. Moreover more than 3/4th uses of the businesses that use software systems use it for "Activity Management" and "Data Processing" (see figures 1 & 2 below – figures provided by Ahmeti A. & Gjermeni I.).



(Figure 1 – "Agricultural businesses that use Software" – *figure provided by Ahmeti A. & Gjermeni I.)*



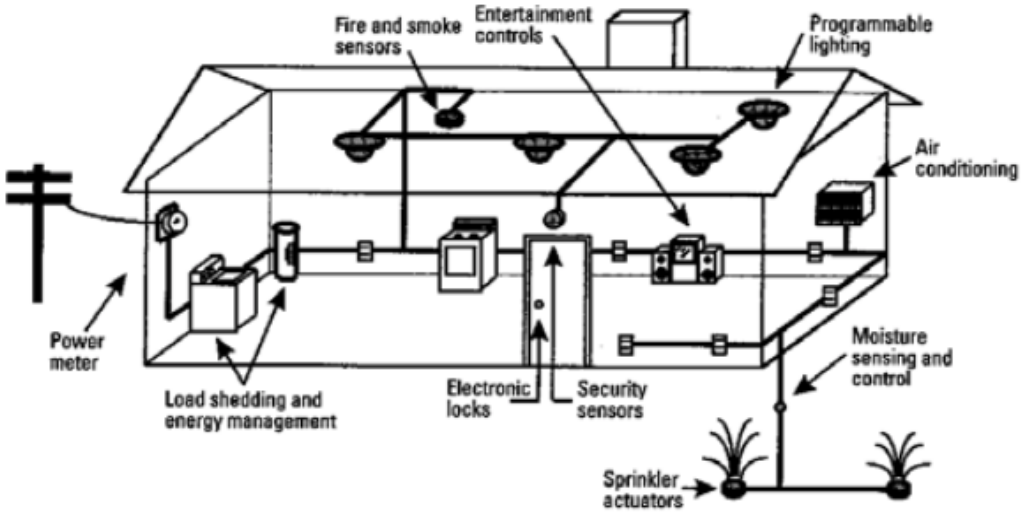
(Figure 2 - *figure provided by Ahmeti A. & Gjermeni I.)*

It is clear that data-storage driven technology is in abundance and in furthermore that technology is used mainly for storing and extracting data. The next step to increasing technological benefits in the agricultural industry is incorporating more intelligent systems. This takes into consideration not only obtaining data but also doing something with this data and acting upon this data in the most logical way possible that will increase positive aspects of agricultural. Intelligent systems can improve on this industry in

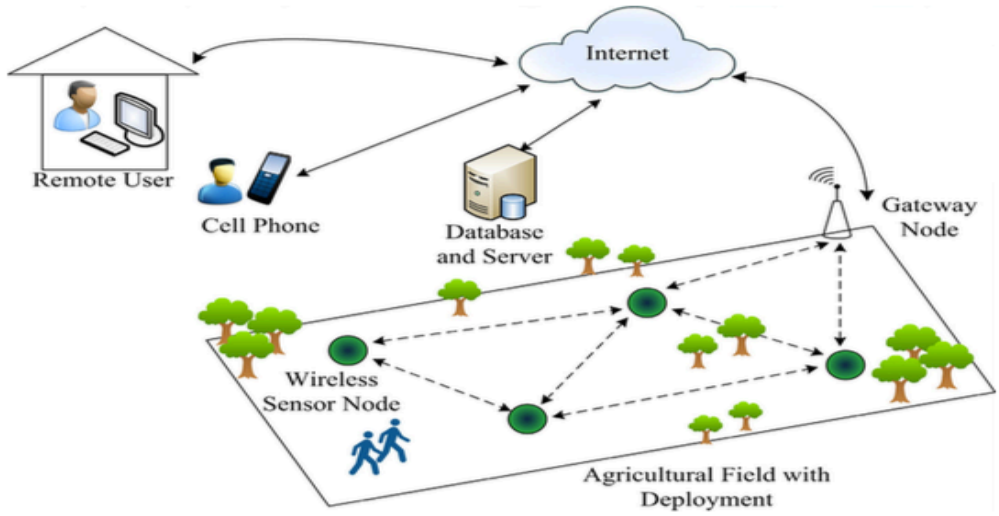
prediction, ability to learn, recognition of environment, and systematic innovation. These are the current areas with disability and have the most impact if guided incorrectly (Bhagawati K., Bhagawati R., & Jini D.).

Methodology

The study of this paper focuses on Wireless Sensor Networks (WSNs) used in the agricultural industry. These WSNs can be implemented in seemly limitless ways but all do the same thing, gather information from it's surrounding and then transmit this information to some other source. Once this information has been gathered and transferred to the origin/master Sensor it can then be sent to for manipulation, observation, or to initiate some designed events. A general comparison to WSNs in agriculture would be modern home that utilizes the basic utilities run by sensors. This includes fire detectors, air conditioner, sprinkler system, etc. Similarly, in a farming field you may sensor systems that sense the humidity in the air or the moisture in the soil to activate some other system or simply send important information to some local/origin point (see figures below).

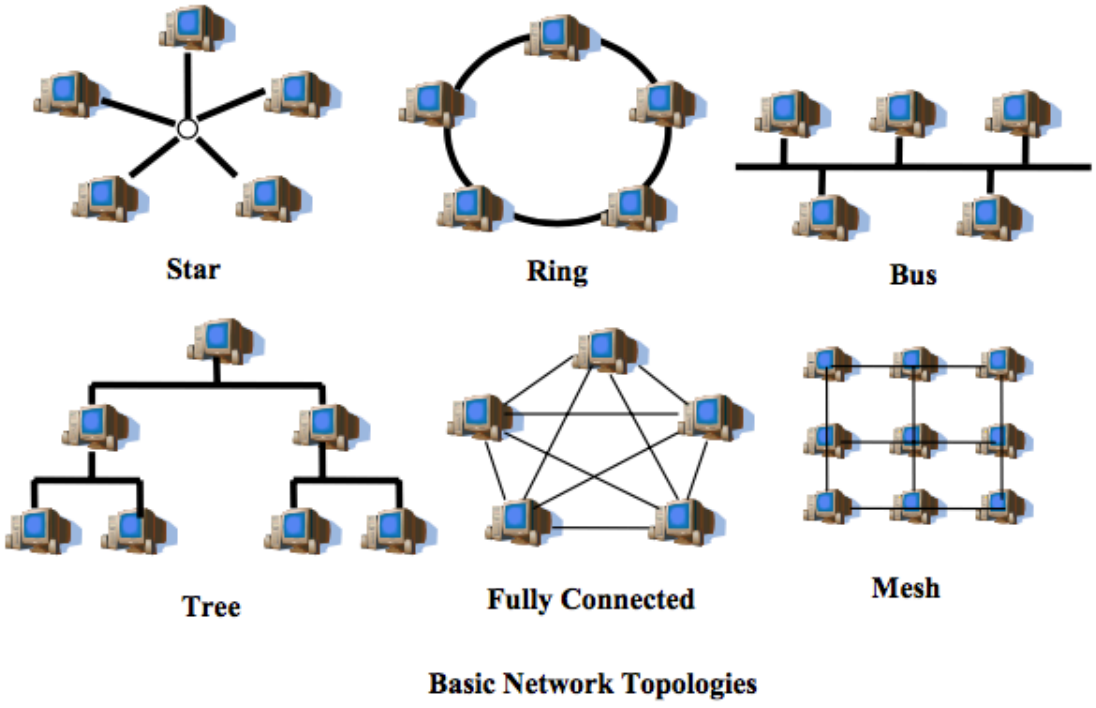


(Figure 3 – Home WSNs – figure provided by Lewis F. L.)



(Figure 4 – figure provided by Ojha T., Misra S. & Raghuwanshi N. S.)

Furthermore there are many different topologies of network systems that can be implemented (see Figure 5 below).



(Figure 5 – *figure provided by Lewis F. L.*)

The most common implementation of WSNs are those leading to an origin/master node similar to the "Tree" structure depicted in Figure 5 above. However the other structures like "Start", "Ring", "Fully Connected", "Bus", and "Mesh" can all be implemented using WSNs. Each different topology can have their respective benefits and actually the more connected each node (computers in the Figure 5) is to other nodes the more accessibility you have the more potential of an intelligent system you will have.

There are two generalized types of WSNs called Terrestrial Wireless Sensor Networks (TWSNs) and Wireless Underground Sensor Networks (WUSN). TWSNs are described as WSNs that are spread about *above* the ground as in figure 4. This will entail sensors collect data from the plants, air conditions, moisture, etc. WUSNs are sensors that are deployed under the ground which are less common however may be utilized to collect a more accurate depiction of soil information (Ojha T., Misra S. & Raghuwanshi N. S.). There are many different kinds of WSN's that can be used. Some specific examples (all of which are TWSNs) include the Pogo Portable Soil Sensor, All-In-One Weather Sensor (air moisture, rain, air pressure, etc.), and CI-340 Handheld Photosynthesis System. More WSN's will be are listed on Figure 5 below.

Table 5
Comparison of different sensors: soil related.

Sensor	Soil moisture	Rain/water flow	Water level	Soil temperature	Conductivity	Salinity
Pogo portable soil sensor (http://www.stevenswater.com)	✓	✓	✗	✓	✓	✓
Hydra probe II soil sensor (http://www.stevenswater.com)	✓	✓	✓	✓	✓	✓
ECH_2O EC-5 (http://www.decagon.com)	✓	✗	✗	✗	✗	✗
VH-400 (http://www.vegetronix.com)	✓	✗	✓	✗	✗	✗
EC-250 (http://www.stevenswater.com)	✓	✓	✓	✓	✓	✓
THERM200 (http://www.vegetronix.com)	✗	✗	✗	✓	✗	✗
Tipping bucket rain gage (http://www.stevenswater.com)	✗	✓	✗	✗	✗	✗
AquaTrak 5000 (http://www.stevenswater.com)	✗	✗	✓	✗	✗	✗
WET-2 (http://www.dynamax.com)	✗	✗	✗	✓	✓	✓

Table 6
Comparison of different sensors: environment related.

Sensor	Humidity	Ambient temperature	Atmospheric pressure	Wind speed	Wind direction	Rain fall	Solar radiation
WXT520 compact weather station (http://www.stevenswater.com)	✓	✓	✓	✓	✓	✓	✗
CM-100 compact weather station (http://www.stevenswater.com)	✓	✓	✓	✓	✓	✗	✗
Met Station One (MSO) weather station (http://www.stevenswater.com)	✓	✓	✓	✓	✓	✗	✗
All-In-One (AIO) Weather Sensor (http://www.climatronics.com)	✓	✓	✓	✓	✓	✗	✗
XFAM-115KPASR (http://www.pewatron.com)	✓	✓	✓	✗	✗	✗	✗
RM Young (model 5103) (http://www.stevenswater.com)	✗	✗	✗	✓	✓	✗	✗
Met One Series 380 rain gauge (http://www.stevenswater.com)	✗	✗	✗	✗	✗	✓	✗
RG13/RG13H (http://www.vaisala.com)	✗	✗	✗	✗	✗	✓	✗
LI-200 Pyranometer (http://www.stevenswater.com)	✗	✗	✗	✗	✗	✗	✓
CS300-L Pyranometer (http://www.campbellsci.com)	✗	✗	✗	✗	✗	✗	✓

(Figure 6 – "Listing of WSNs" – *figure provide by Ojha T., Misra S. & Raghuwanshi N. S.)*

These WSN's can be utilized to gather information and then send this information to he origin for processing. Ideally we would like to utilize this information in meaningful way, however this will still allow us to get more in depth data than traditional agricultural practices (Eaton J. & Watson A.).

Evaluation

With all these WSN's available we must decide on what type of WSNs we should spend our limited time to developing and improving. To do this we must decide what type of information would be the most pressing. Future weather conditions will allows us to pinpoint what may be the best option to spend our time wisely in developing the *right* WSN. There has been a trend of higher temperature years resulting in drier and higher frequency of droughts (Union of Concerned Scientists). This leads me to the conclusion that we should be concerning ourselves with saving as much agriculture affected from drought. This entails WSNs that will gather information about the soil moisture as well as the air humidity. As we continue to warm up, water will be a drastic resource for maintaining. If we under water we could lose all our agriculture and if we over water we will use up all our water and in turn loss our agriculture as well along with our water resource.

Conclusion

Agriculture is undoubtedly important to our society. In order to prosper as a community we must have proper food supply for all members. Agriculture is also very fragile in production as it can be easily disrupted by environmental changes like climate, insects, etc. In order to cope with higher demand of agriculture and provide better decision making for better production we must adopt specific technologies to improve our agricultural production. The main technology that will help agriculture is Wireless Sensor Networks that will allow the gathering of environmental information. We should focus research and development on soil and water associated WSNs as droughts continue to increase in order to save as much agriculture possible. Future work entails pinpointing

geographical locations of greater need for specific WSNs. This will allows for greater specify in developing meaningful WSNs.

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