EXO-Smart

2018 Group #11-04

Group members:

Heng Ziyang (3A3) - Leader

Jovan Ng Chengen (3P213)

Joash Poon (3A2)

Brennan Chua (3A3)

Hwa Chong Institution (High School)

Abstract

Overirrigation is one of the main factors leading to water wastage. Irrigation is responsible for the consumption of 70% of the world's total water withdrawal, however, more than 60% of the water diverted or pumped for irrigation is wasted. Currently, the best method to tackle overirrigation is the use of wireless sensors to collect data, which will be used to control the amount of water irrigated by the sprinklers. However, this method is very cost inefficient as each wireless sensors require SIM card with data plans to function. Hence, many farmers prefer to stay away from this method of agriculture, as their profits would be greatly affected by the huge monthly instalments of the data plans for the sensors. In the view of this, we decided to develop a new system of data collection using drones to collect data from the sensors. This reduces the need of multiple SIM cards installed in each and every sensor. Instead, only a single SIM card is required to be on board the Raspberry pi attached to the drone. Hence, the costs of the sensor system to collect accurate data to control irrigation is significantly reduced, and people would be more willing to invest into this technology to tackle water wastage. Multiple experimental trial runs have found this solution to be feasible, and calculations have shown that the our drone-sensor system have reduced costs by 35%.

Introduction

Problem Identification

The main problem that we are tackling is **overirrigation**, which is one of the leading factors of water wastage. According to Worldwatch.org, irrigation is responsible for the consumption of 70 percent of the world's total water withdrawal. Currently, according to the UN Food and Agriculture Organization (FAO), an astonishing 60% of the water diverted or pumped for irrigation is wasted. Hence, to tackle water wastage, an efficient method of irrigation is important in the field of agriculture.

Current solutions to water wastage

There are many solutions to overirrigation. The conventional method of irrigation i.e. the **manual method** is cumbersome as there is a lack of labor and also there is a high possibility of over watering.

Currently, **precision agriculture** is main method being used to tackle the problem of water wastage in agriculture. This involves the use of wireless sensors to monitor and collect data to be transmitted back to the data centre, where it decides the necessary amount of water to be irrigated by sprinklers (if needed). However, this method is very **cost-inefficient,** hence many **farmers have chosen to stay away from it, as their profits would be greatly affected** by the huge monthly instalments of the data plans for the sensors. This method requires **multiple sensors (depending on the size of the farm) with a SIM card with data plan attached to every single sensor**. Data plans can be very costly, especially when you are required to buy in bulk. Moreover, it also gets more **expensive** as the size of the farm increases, as there would be a need for more sensors.

Hence, taking this into consideration, our project aims to reduce the cost of precision agriculture and make it more affordable for farmers to encourage its use to prevent overirrigation, and hence reduce water wastage.

Harmful effects of water wastage (Why we are tackling this issue)

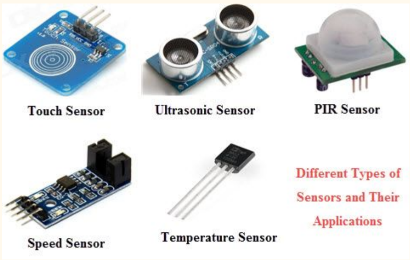
Water is an **important resource**. Wasting water will lead to several negative impacts. In places where clean water is scarce, wasting household water limits the availability of it for other communities to use. Excessive irrigation of plants can also affect crop yield. Plants growing in soil that is too wet suffer from a lack of oxygen which leads to the death of roots and a loss of vigor in the plant. Eventually, the plants will wilt and die. Water also takes a lot of energy, time, and money to filter and clean so that it's drinkable. Wasting water or overusing household water means you're wasting the energy-intensive process of filtration. The many steps of water filtration require non-renewable fossil fuels. As these resources become depleted, their dangerous by-products such as carbon dioxide build up in the Earth's atmosphere. This contributes to your carbon footprint and the Earth's rising temperatures.

Solution Design

Taking into consideration the problem that we are tackling, we aim to improve on the system of precision agriculture by making it more cost-efficient by introducing a new method of data collection using drones to collect data from the sensors. After the drones hover over the sensors and collect the data, the data will be immediately transmitted to a database, where it controls the amount of water being irrigated.

Procedure

The data will be collected through the following procedures:



1. Sensors are placed on designated location
2. Drone, equipped a SIM card and data receiver, will take off from a Data collecting centre and begin its programmed flight path
3. Drones will fly overhead the sensors within the sensor's transmitting radius (sensors emit data over a small radius even without SIM cards) to receive data from the sensors
4. Drones will hover over the sensors for awhile when it is within the sensor's transmitting radius in order to ensure that it receives the data.
5. The data collected is then immediately transmitted to the database via the SIM card card in the drone, which connects to the internet and transmits the data
6. In the database, decisions can be made manually or automatically to activate the sprinklers
    a. If manually, a data analyst can check the data collected and determine the amount of water to be irrigated manually
    b. If automatically, a programme can run to analyse the data and calculate the amount of water that needs to be irrigated automatically
    c. Extreme values and Anomalies in data would be highlighted, and would not be taken into consideration during calculations for the necessary action required
7. Procedures 3-6 will repeat for each sensor in the flightpath
8. After collecting all the data from the sensors, the drone will land on a designated spot to charge and prepare for the next flight

   a. Drones can be charged wirelessly via a wireless drone charging pad, however this may be quite costly and this is a technology newly developed (eg. WiBotic Powerpad https://www.wibotic.com/aerial-applications/)
   b. Similarly, drones an be manually plugged using a cable by a person
9. The drone will wait for its next flight on command by the owner, similarly a programme can run to activate the drone every __ hour

Note: Alternatively, there isn't a need for a SIM card data can be stored in a memory space in the drone and be transmitted over the internet when it reaches a location with WiFi connection at the data collection centre.

Equipments

These are the following equipments that we have used for our project and their estimated value.

Equipments	**Estimated price**
Parrot Mambo Fly Drone 	$200
Solchip tensiometer sensors 	$150 each

SIM Card (With data plan)  	$10/month each
Data Receiver 	$250

The equipments that we have used for our project are budget equipments as we have a limit to our spendings. However, our system can be further improved by purchasing the following additional products.

Equipments	**Estimated price**
More advanced drone Drones come in different prices. More expensive drones are able to perform more functions, such as GPS capability, Giro sensors and proximity sensors functionality, which are absent in the drone we have used	$300-$1000 Price depends on flight time, and the functions that is required to perform the task
Wireless charging pad for Drones (WiBotic Powerpad) Optional add-on to improve automacy of the system	$1000 (Price may vary for this product)

Due to the lack of some features in our drone, such as GPS capability and proximity sensors, we had to look for alternative solutions to this problem. Hence, we decided to programme our flight path precisely and accurately to prevent collision mid-air, instead of setting the drone to flight to the designated GPS coordinates and moving away from obstacles when sensed.

Programming

<u>Programming Flightpath</u>

In our programming, we have 2 approaches to coding our drone flight path:

1. Tynker

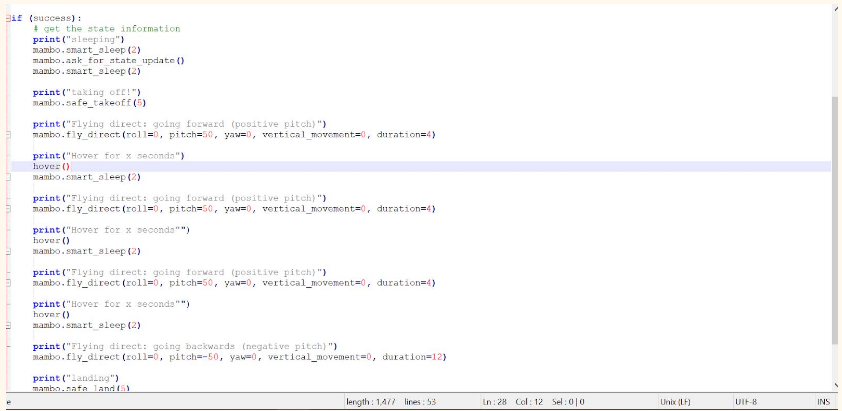
Our first method was to use a programming application for drones, Tynker. It is a coding tool similar to that of Scratch programming.

Pros	**Cons**
Easier to code	Limited to only a certain few blocks to control the drone
Easier to modify values to suit the situation	Requires human input in the starting of the programme and cannot be set to start automatically

2. Raspberry Pi

Our other method was to code our droneflight path using Python, coded into a Raspberry Pi. We applied a similar concept to that of the Scratch programming.

We have adapted our Python programming on the drone using this GitHub file that is published for everyone to use: https://github.com/amymcgovern/pyparrot

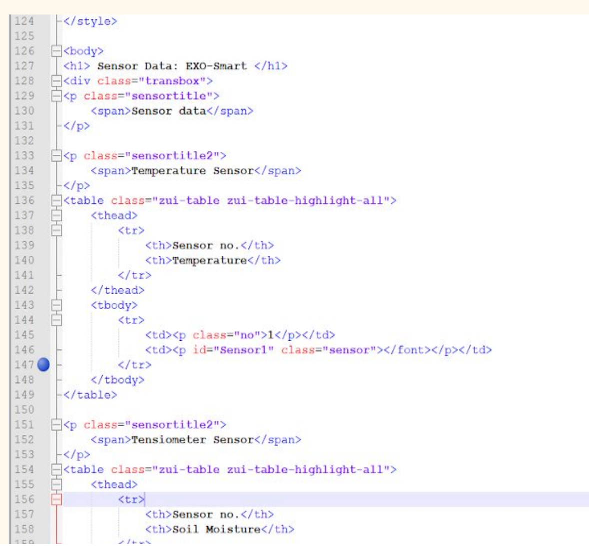


We downloaded the programme on our Raspberry Pi, and begin to programme the drone flight path, with the similar concept we used to programme Tynker.

Afterwards, we programmed the Raspberry Pi in such a way to activate our programme directly when we turn on the Raspberry Pi, since we cannot connect to a monitor when the Raspberry Pi is attached onto the drone, by using rc.local to run the programme on start-up. (https://www.dexterindustries.com/howto/run-a-program-on-your-raspberry-pi-at-startup/)

Pros	**Cons**
Access more functionality of the drone, rather than just sticking to the regular blocks in Tynker	Additional weight on the drone
Does not require human input as the programme can be coded to start at certain time intervals	Shortens drone flight time as it consumes battery as well

<u>Receiving data from sensors</u>



After programming our drone flight path, we had to code the drone to receive data from the sensors. To do so, we had to attach a receiver onto the drone and once the drone receives the data from the transmitter of the sensors, the data would be transmitted to the internet database (Using the SIM card attached to the Raspberry Pi/drone).

After the data is transmitted to a database over the internet, we have created a programme to collect the data into a folder, where a website that we create will collect the data from the folder and display it in the form of a graph/table. This will be coded using PHP/MySQL/HTML/CSS/JS, and the website is uploaded onto a local web server.

Our website:

http://www.engagenova.com/solchip.html

Testing/Implementation

Testing flight path

To test out our flight path programme, we first had to determine our location of fieldwork within the school campus. Hence, we came to a conclusion to perform our testings in a confined room (classroom) first as it is controlled environment.

https://drive.google.com/file/d/1DPKaxMpCxiHgW11HCbBRV-dJg3xJuZPh/view (Video)

https://youtu.be/34B4DdJLVb0

https://youtu.be/Oli90TIjBG0

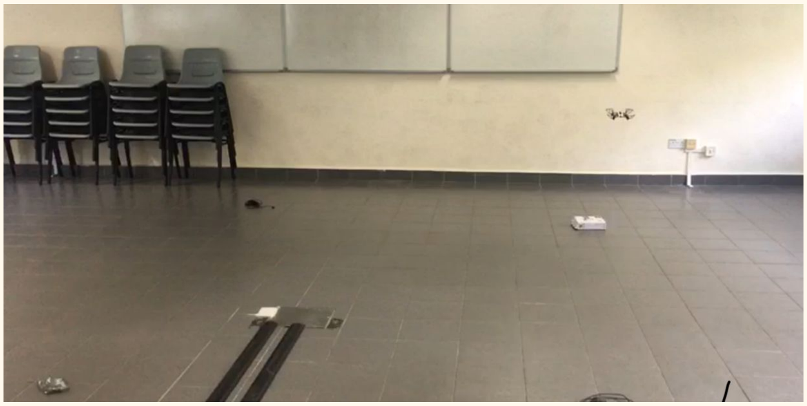
Only after we have established the basics, we decided to test out our programme outdoors and adjust our programme accordingly.

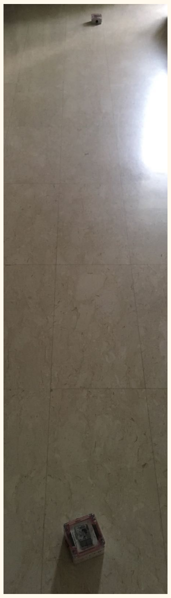
Code in action

https://www.youtube.com/watch?v=laNSgqA5RLU

Procedure

Firstly, we had to mark out the spots where the drones will hover over to simulate data collection. Then, we had to make calculations and adjustments to our programme to enable the drone to the assigned flightpath in the our fieldwork zone.





Testing receiving data from sensors

In this test, we will test out the functionality of our data receivers on the drone and the data transmitters on the sensors. Using our programme from the flight path testing, we applied the same concept but added the sensors and receivers to the set-up.

Since our drone is weak, it would be unable to carry the receiver as it would add extra weight, hence we decided not to mount the receiver onto the drone. Instead, it will be placed near the testing area and collect the data. Since the testing area is small, the receiver is able to receive data even without needing it to be carried around.

The test will be considered a success when data is being transmitted to a database as the drone hovers over a sensor.

Use of data collected

Since, we were unable to get hold of a programmable sensor which can trigger a reaction, and we were also unable to obtain a sprinkler that can be programmed to sprinkler based on data collected, we will leave this to the user to determine how they will use the data collected.

How can the data be used:

- ★ Using the data collected (temperature, soil moisture, etc.), the farmer can determine the best course of action
    - If the farm doesn't have a sprinkler system, the farmer can decide to invest more in building the sprinklers or simply just water the plant manually
    - Using the data recorded for temperatures, the farmer can perform a personal investigation for the best temperature for the growth of a specific type of plant
    - If the farm has a sprinkler system, the farmer can set the programme to trigger the sprinklers and even control the amount of water irrigated to ensure that the plants are sufficiently watered (not overwatered). This would be these best choice. (Also known as precision agriculture, which

we are hoping to promote by lowering its costs using the drone-sensor system)

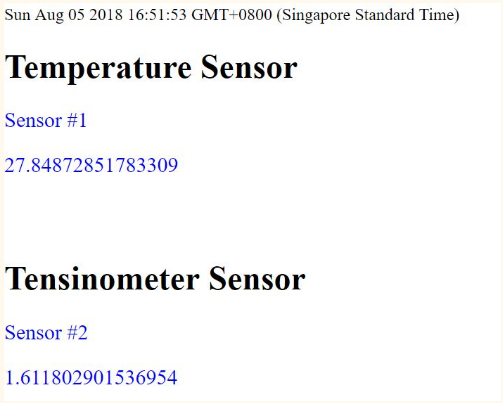
Results and Discussion

Results of our Tests

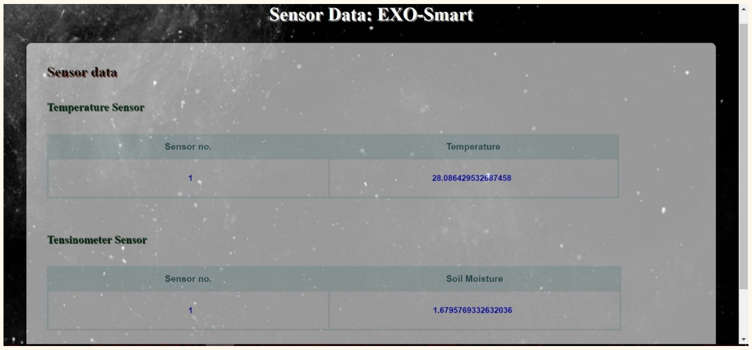
Data collected

The data collected from the sensors are recorded on a website that refreshes automatically every few seconds whenever a new value is recorded.

Website Version 1



Website Version 2



The first version was dull and the organisation of data was poor. With the new and improved second version, data is presented in a tabular format, meaning that it can accommodate to more than 1 sensor per category, and the data will be arranged neatly. The website is also more aesthetically appealing and easier to the eyes.

Total costs saved

Comparison (Our system)

For 100 sensors over a year

Equipments needed	Price estimate
Drone	$300-$1000
Receiver	$250
Solchip sensors	$150x100 = $15000
Data plan (1.2 GB monthly)	$10 x 12 =$120

Comparison (Conventional system)

For 100 sensors over a year

Equipments needed	Price estimate
Solchip sensors	$150x100 = $15000
Data plan (1.2GB monthly)	$10 x 100 x 12 = $12000

Total price: $27000

Our System vs **Conventional system**

$17287+$120/year vs $15000+$12000/year

In one year, our system is estimated to cost about $17407, while the conventional system is estimated to cost about $27000. Hence, our solution is able to solve an approximate of 35% in the first year of instalment!

Furthermore, since our system is very self-sustaining (sensors are solar equipped and equipments are durable), yearly instalments are much cheaper without the need for SIM cards in each sensor, hence future yearly instalments will have a significant drop of an estimate of -$11880 per year.

Feedback/Comments from Farmers

Expert Farming Company Interview

We have collected some feedback from a farming agency through our mentor via Google forms. (Farming agency: Good Harvest Sdn Bhd (Malaysian Farming Agency))

Precision Agriculture is a farming technology which uses sensors to collect data to ensure precision in farming. With our system, we will be able to reduce costs of implementing this system. Would you be more encouraged to install such systems in your farm? *

- (●) Yes
- ( ) No

Would you consider implementing our system of data collection to monitor plant growth in your farm? *

- (●) Yes
- ( ) No

Do you have any suggestions for how we can improve our project or any feedback/considerations?

Learn to be a farmer to understand the needs of a farmer.

Are there any reasons for your decision?

To save on labour.

Are there any potential problems that could occur in in your farm assuming our system is in place?

Yes, farming is relational, just like humans. You can have the best technology like our Smart Phones but it can never replace a walk through your farm, touching the plants, feeling the air around them, watching the area feeling the soil with your fingers with your eyes and other sensory. My plants and fishes speak to me as I walk amongst them. Think I'm crazy? That's what separate the serious farmers from the farm administrators. It's like raising children, you can put Spy Cams all around them and talk to them over the phone but they will never grow up right.

If you have a system of data collection to monitor plant growth, would you like to share the cost of implementing your system in your farm?

Not applicable. I don't have a system. Mine is manual.

Does you farm have any form of data collection to monitor plant growth? If so, what method of data collection does your farm utilize ? *

No

Does your system have any areas for improvement or problems you wish to be addressed? *

Labour is a constant problem. So few Singaporean are prepared to be farmers.

https://docs.google.com/forms/d/e/1FAIpQLScEzHI5Vw_iXw9mWObjbs1DG08unQATf1WbHrTxX92tV0mW2Q/viewform

Notable responses

Based on the responses, we can see that the company is currently using the conventional method of farming. They were keen to adopt our system of precision agriculture due to its lowered costs compared to the current method of precision agriculture However, they noted that there must still be interactions between the plants and Farmers.

Evaluation

Effectiveness

Based on our test results, we were able to see that our solution was **feasible** and is able to **function**.

We were also able to see that the process of data collection was **quick and efficient** as the response time for the triggering of reaction is almost instant once the drone hovers over the sensor.

Most importantly, we were able to meet our main goal, which was to keep the system as **cheap** as possible to so that **farmers would be more accepting** of this new technology due to the lower costs, helping to **reduce water wastage** in real life contexts.

Limitations

Our test model **does not involve a sprinkler**. Hence, it may not be able to accurately simulate a real life situation.

We have observed that drones have a **very short battery life** and are only able to **travel limited distances** after we added more weight to the drone by adding the receiver and batteries for the receiver.

Our test model is only a **small scale testing** for the proof of concept, hence it **may not be as accurate** compared to testing in a real setting.

Since we had a low budget, our drone may not be the best for such situations as it does not come with many features and is very light and weak. A few important features that we were not able to use were GPS functionality, which allows us to direct the drone to the destination more accurately rather than just coding how long it has to fly. Furthermore, the drone did not have the function to stabilise itself and avoid obstruction from wind due to lack of a Gyro Sensor. Hence, our drone is easily affected by wind and we have to keep retesting. Hence, our testing may not be as accurate due to our lack of equipments for actual testing.

Lastly, we **did not attach the receivers onto the drone**, hence it cannot do a proper simulation.

Future improvements

We have came up with some solutions to our problems, which can be easily achieved with more funding. Our system can be tested using an actual sprinkler to better simulate the experience and make it more realistic. To solve the problem of inadequate battery, we can use a larger drone with a larger battery installed, more functionalities and more powerful motors in order to cover long distances. The receivers will also be mounted onto a more powerful drone that is able to carry its weight.

Hence, to sum up, our limitations can mostly be solved with a more powerful drone used in testings.

Conclusion

In essence, in our project, we have found out that it is feasible to use drones to collect data from sensors instead of using SIM cards (with data plans) in sensors to transmit data over the web. We have also found that by reducing the cost of precision agriculture through our system, farmers would be more willing to adopt this new technology to reduce water wastage. This system can prove to be very useful, even in other sectors (apart from the agricultural sector that we were working on), for example it can be used to monitor traffic by flying drones over expressways or even monitor mosquito breeding on the rooftops using heat sensors and using drones to fly over the sensors to collect the data. However, our system is not perfect yet, and we do have limitations due to the lack of budget and equipments, hence we hope that there could be further development from the company we are working with, Solariz, using more powerful and capable drones to better simulate the experience and functionality.

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