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Project Plan

Version 2.0

Efficient Measurement of Soil Microtopography to Aid the Verification of European Space Agency and NASA Satellite Observations of Soil Moisture

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Problem Statement

The world's first satellites able to remotely observe near-surface soil moisture from space either have recently been launched (European Space Agency, 2010) or will soon be launched (NASA, 2015). Near-surface soil moisture is the water content of the top 3 to 5 cm of the soil surface. Near-surface soil moisture affects how water and energy move between Earth's surface and atmosphere, and observations of this phenomenon will be used to make better weather and climate forecasts. Before they can be used, the near-surface soil moisture observations must be validated using on-the-ground measurements. As we have begun to validate these observations, we have found that soil surface "roughness" or the mm-scale variations in the height of the soil surface (microtopography) can "confuse" satellites and therefore must be taken into account. The problem is that it is difficult and time-consuming to make good measurements of soil microtopography. We have heard rumors that the Xbox Kinect can be hacked to make scans of surfaces. Or perhaps commercial camera technology can be used to measure microtopography. Hence we are to come up with a method of measuring soil microtopography that is quick, accurate, and precise using commercially-available technologies that may have not been intended for this use.

Objective

Our objective is to design and develop the product that is able to take accurate scans of one square meter of soil and return a two-dimensional array where each cell represents one square centimeter in the original square meter. Our advisor/client has asked that the device be lightweight and portable. Our client is also challenging us to get to millimeter scale on the data results. The Xbox Kinect could possibly do this and so we need to make sure the data that we read from it is extremely accurate. The client is aware that the Kinect may not reach that scale. He is okay with this and just wants this project to be a test to see if the Kinect will be able to reach his goals.

Deliverables

Minimal Viable Product

After further review, our group decided to utilize existing hardware such as the Xbox Kinect and Raspberry Pi to assist us in working on the senior design. By incorporating the said hardware and our knowledge, ideally we should at least engineer a prototype that addresses the hardware aspect of the said issue. The hardware should be able to collect raw data and store it temporarily in its storage medium.

Future Iterations

Upon completion of the hardware, we should work on the software that interfaces with the hardware if necessary. The software should collaborate with the hardware seamlessly. The software should have the ability to read the collected data and build a topography map by using the said data.

Specifications

I/O specs

The system that we are designing will not need any inputs except for a type of trigger, either a button or toggle switch, which will turn the device on. The system will output the raw data from the Xbox Kinect directly to a flash drive that is stored on the Raspberry Pi. This data will then be able to be brought to another computer which has the second program for the second part of the system. The data from the Kinect will be used for input for the second half of the project. This second program will then take the raw Kinect data and display it for the user to read and analyze.

Interface Specifications

The Xbox Kinect will interface with the Raspberry Pi through the adapter that we will have for it which will allow it to connect to a computer through a USB port. The Kinect will be accessed through the use of the Xbox Kinect SDK that Microsoft has released for it. We will use the SDK to create a software program on the Pi that will store any data that it gathers into an SD flash drive that we will be able to remove from the Pi and insert into another computer. The computer that SD card gets put into will contain the other half of the program. This other half will contain the portion of the project that will take in the Kinect's data from the SD flash card and analyze it. So this portion of the project will need to find where the SD card is located and find the files contained in it. During the analysis of the data the program should be able to print it out in a user friendly way that allows the user to see areas that are rougher than others. We will then try to create a topographical map.

Hardware/Software specs

For this project we will be using an Xbox Kinect, Xbox Kinect to PC adapter, an external portable power supply, and a Raspberry Pi. The software that will be used for this project include two programs, one which will run on the Raspberry Pi and another that will run on another separate computer.

Testing procedures and specs

We will test the Kinect's data on the Lego structures against measurements that we will get by hand. From there the recorded data will be transferred to a storage medium which in this case would be the Raspberry Pi. This procedure is utilized such that the measurement data can be accessed by different computers without having to carry the Kinect around. The measurement recorded should have an accuracy in millimeter scale.

Operating Environment

There will be two different environments for this project.

The first is out in the field with the portable device that is the Pi-Kinect system. This will be taken out to fields and other similar locations so that it can be used for scanning the field's soil.

The other will be the client's lab or office where they bring the portable device to for the transfer of data from the portable device to the second computer for the creation of the two-dimensional array map. This environment could also be the same field as the first environment if the user brings the second computer to the field location along with the portable device.

User Interface Description

The user interface will be easy to use and will consist of a central view that will contain a two dimensional array that will show the value of the highest point in that section of the soil. The array will have cells that will be equivalent to a cm x cm patch of the soil. There will also be buttons to select which file the data will be pulled from and another to start the processing of the data.

System Requirements

Functional Requirements

Hardware	Our system should use a Xbox One Kinect and Raspberry Pi in order to take in the field measurements of soil roughness.
	The Raspberry Pi will need to store the measurements on a micro SD card until the user is able to move it to another PC for processing.
Software	The software on the Raspberry Pi should start the Kinect's depth sensor and take the measurements from the field. The second computer's software should import the data from the micro SD card and output an array where each cell contains the height of the soil in that cell.

Non-Functional Requirements

Easy to use	The hardware and software should be easy to pick up and use for the end user
Simple interface	The hardware should be simple and easy to use where the end user will be able to pick it up and figure out how to use it.
	The software should be easy to use and simple to import the field measurements.
Responsiveness	The software and hardware should allow us to capture data in real time.

Risks

Accuracy

There are concerns that the final product might not be as accurate as what our client wants. Additionally, the hardware that we are using is not capable of producing a high quality photographs in the first place, so that might be an issue even if there is method to improve the output quality.

Our client is aware that the Kinect may not reach that scale and is okay with this. The client just wants this project to be a test to see if the Kinect will be able to reach his goals. This will make the project into more of a research project for the client.

Competition

The product that we are making is essentially competing with existing similar products in the market. Since we do not have a lot of budget in the project as a whole, we only have access to limited amount of available hardware with decent functionality.

If this happens then we will do our best with the hardware that we have so that future senior design groups can possibly work on it and improve upon our work.

Hardware Complications

The hardware doesn’t interact with each other in the way that we expected. This could happen since we are using a newer Xbox Kinect. The Kinect could have some hardware and power specifications that the Raspberry Pi won’t be able to provide.

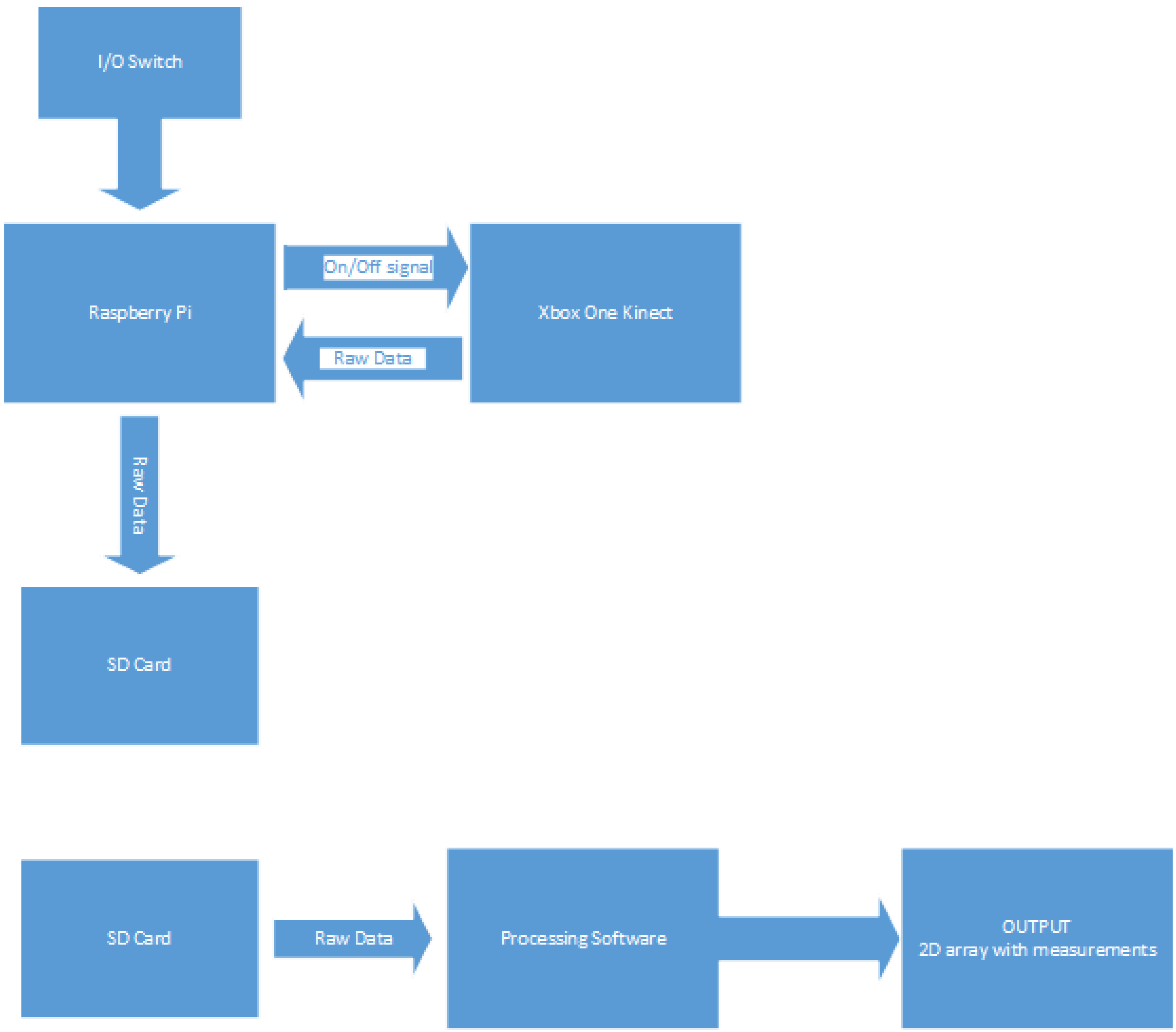
If we encounter hardware issues while connecting the Xbox Kinect to the Raspberry Pi, then we have the option of removing the Pi from the system and making the entire system run on what would originally be called the second computer.

Lack of Experience

This group does not have any prior experience working with the Xbox Kinect SDK or Raspberry Pi. So we have been dedicated to learning the hardware and software that we will be using.

We started by researching different ways that a Kinect and Pi can be connected. Our client is aware that we do not have prior experience and is challenging us to learn as much as we can.

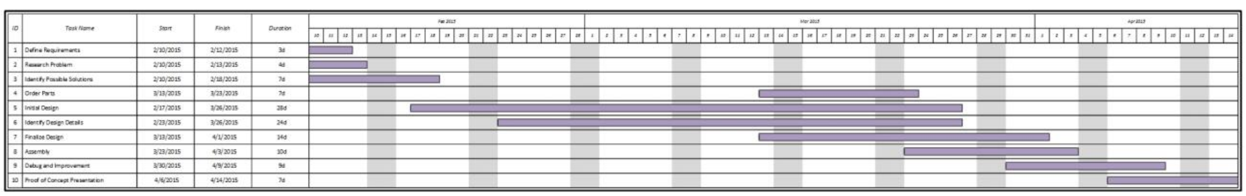
System Block Diagram



Resource Requirements

Resource	Purpose	Means of acquiring	Estimated/Actual cost
Xbox Kinect	Used to photograph the soil	Purchase	$149.99
Xbox Kinect Windows Adapter	Used to connect the Kinect to a computer.	Purchase	$49.99
Raspberry PI	Used to store the data	Purchase	$28.9
Battery Pack	Used to power the devices	Purchase	$100 - $150
64GB Micro SD card	Used to store information from the Kinect.	Purchase	$32.99

Project Schedule/Work Breakdown



ID	Task Name	Start	Finish	Duration
1	Define Requirements	2/10/2015	2/12/2015	3d
2	Research Problem	2/10/2015	2/13/2015	4d
3	Identify Possible Solutions	2/10/2015	2/18/2015	7d
4	Order Parts	3/13/2015	3/23/2015	7d
5	Initial Design	2/17/2015	3/26/2015	28d
6	Identify Design Details	2/23/2015	3/26/2015	24d
7	Finalize Design	3/13/2015	4/1/2015	14d
8	Assembly	3/23/2015	4/3/2015	10d
9	Debug and Improvement	3/30/2015	4/9/2015	9d
10	Proof of Concept Presentation	4/6/2015	4/14/2015	7d