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Design Document

Version 1.0

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

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Table of Contents

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. I've 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 I challenge a senior design group 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.

System level design

System requirements

The system requirements include a set goal for the accuracy of our measurements, the amount of time that it takes to gather measurements, the area of one measurement and a final output style.

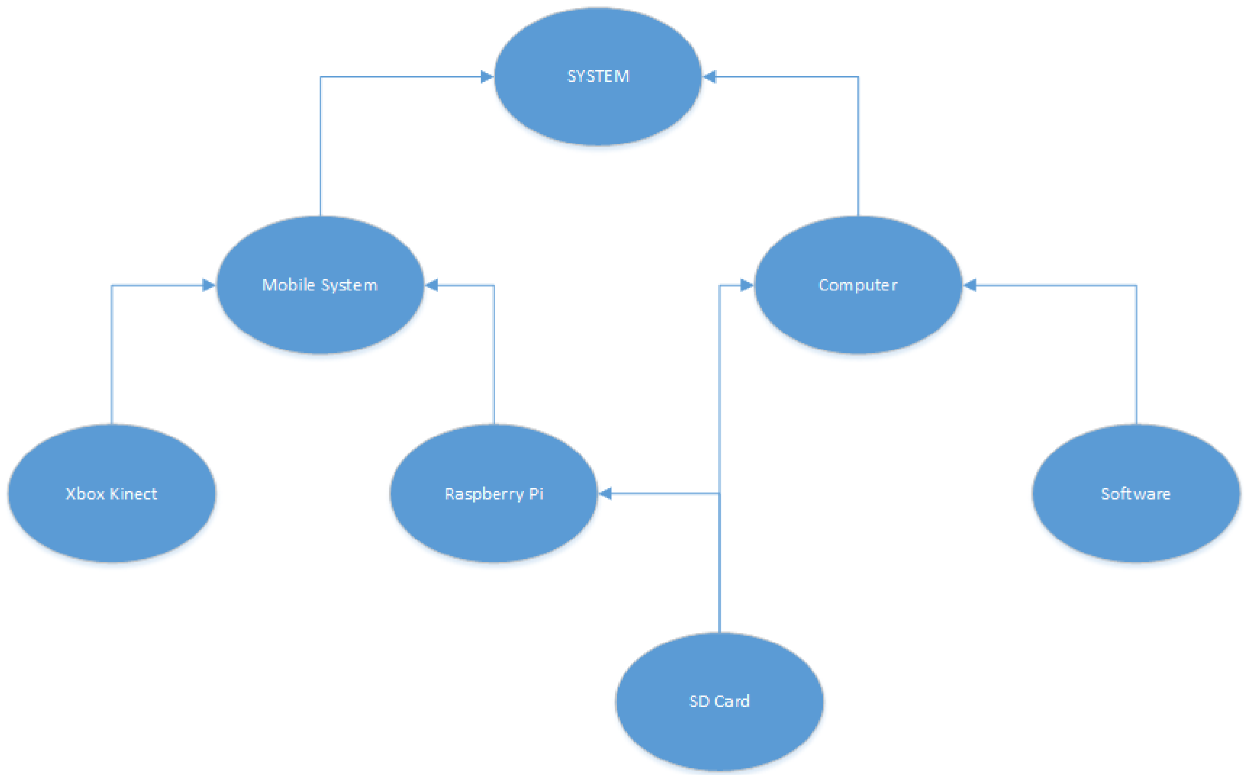
The project’s goal for the soil roughness measurement’s accuracy is millimeter vertical accuracy for every centimeter by centimeter horizontal area within a three square meter area. The client, Dr. Hornbuckle, would like us to use the Xbox Kinect to take the soil roughness measurements. To achieve this we will be using the IR depth sensor that is built into the Kinect to get raw data that we will analyze with a separate program on another computer.

Our client is requiring the system to display the information that we receive from the Kinect scanner into a format that is easy for the user to read and understand. To achieve this we will design our final output to be a two dimensional array where each grid cell contains the vertical height of one of the centimeter by centimeter areas corresponding to that section on the ground. This is to simulate creating a topographical map of the scanned area.

Our system is required to meet a time requirement of under an hour for taking the soil measurements. This is to see if the Kinect is able to have a faster scan time than our client’s current soil measurement device which can take around an hour to finish scans for one location.

These requirements are not set in stone and are more goals than requirements that we are going to try to reach with the final product. Our client is aware that the Xbox Kinect that we are getting may not be capable of reaching these accuracy goals. He has said that he wants this to be more of a research project that may or may not produce a product that can replace his current method of getting measurements.

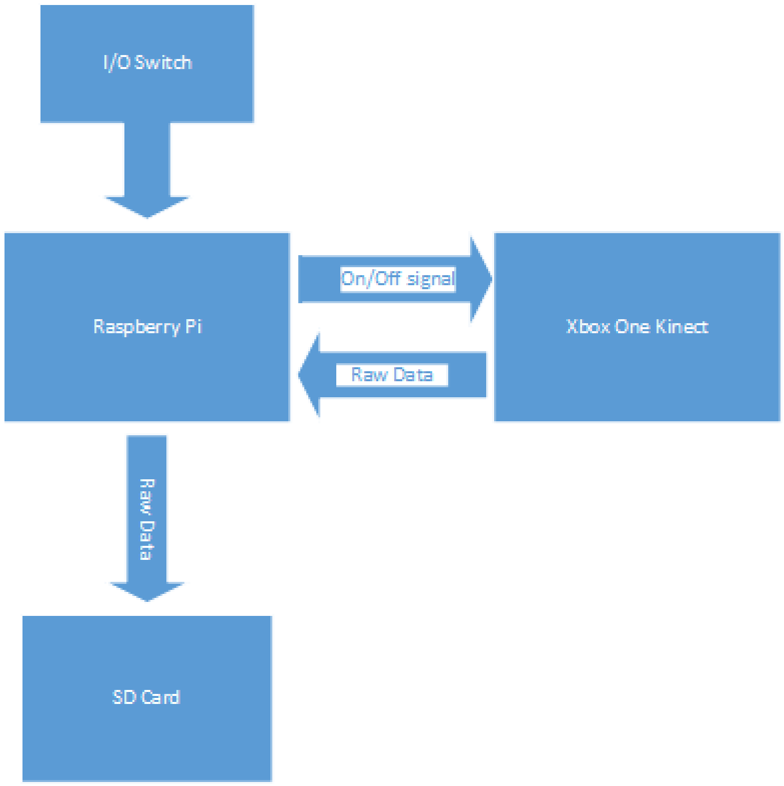
Functional decomposition

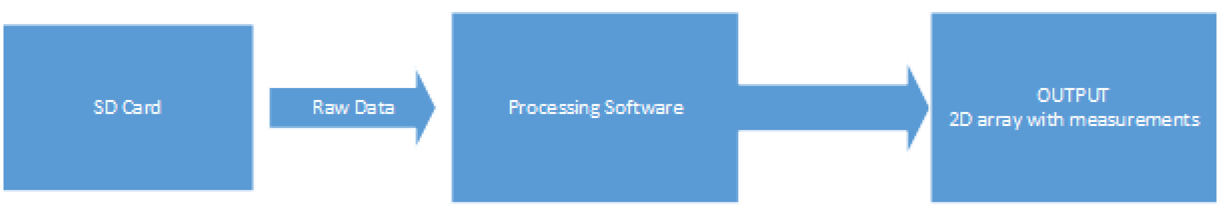


System analysis

Our system is comprised of two main parts, the mobile and computer. The mobile side of the system will contain software that will run on a Raspberry Pi and an Xbox Kinect. These two pieces will work together and store the data on the SD card that is used to bridge the gap between the two major parts of the system. The SD card will be used on the computer side of the system as a way to get input for the analysis software. This software is how we will be using the Kinect data to create a “topographical” map of the ground with a two dimensional array. So by using the mobile side of the project with the computer side of the project the entire system gets created. This whole system will allow us to take data from a field’s soil and transfer the data back to a computer via an SD card and from there analyze it into an array which can be used to display soil roughness measurements.

Block diagrams of the concept





Detail description

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.

Simulations and modeling

We will be constructing small test models. These models will allow us to test the device in a controlled environment. They will be made out of boards and Lego structures that we create.

Implementation issues/challenges

Our client, Dr. Hornbuckle, wants our device to be highly portable so getting a weight that isn't heavy could be a challenge. The majority of the weight will probably be in the battery since it will need to be big enough to power the Raspberry Pi and the Xbox Kinect at the same time over a period of time in the fields.

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.

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.

Other documents

Bill of materials

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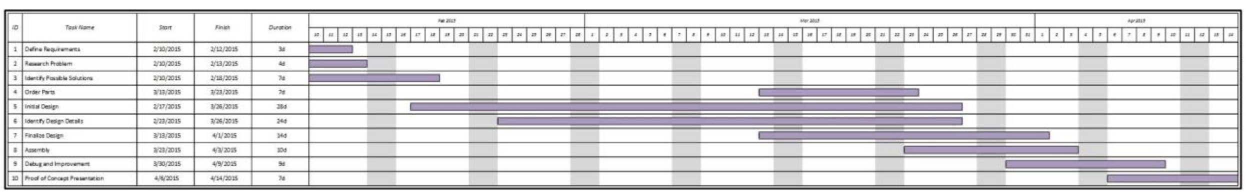
Bill Of Materials Feb 24 2015 15:20:22

Item	Qty.	Ref.	Cost ($)	Part Desc.	Supplier	Supplier#
1	1	XBK	149.99	Kinect for Xbox One	Microsoft Store	Kinect for Xbox One
2	1	KAW	49.99	Kinect Adapter for Windows	Microsoft Store	Kinect Adapter for Windows
3	1	Rpi	28.9	Raspberry Pi Model B+	Amazon	Raspberry Pi Model B+ (B PLUS) 512MB Computer Board
4	1	MSD	32.99	micro SD card	Amazon	SanDisk Ultra 64GB UHI-I/Class 10 Micro SDXC Memory Card Up to 48MB/s With Adapter- SDSDQUAN-064G-G4A

Gantt chart (timeline of project design)



Conclusion

By compiling what the design document proposes, we should be able to create a system that can accurately take scans of a location's soil and store that data so that the other half of the system can analyze the data and display it in an easy to understand format.