Soil Microtopography

Team Members

Brant Walsh (Key concept holder and communicator)

Dillon McDowell (Webmaster)

Yan Yao Chan (Team leader)

Advisor/Client

Dr. Brian Hornbuckle

Co-Advisor

Josh Bertram

Project Problem Statement

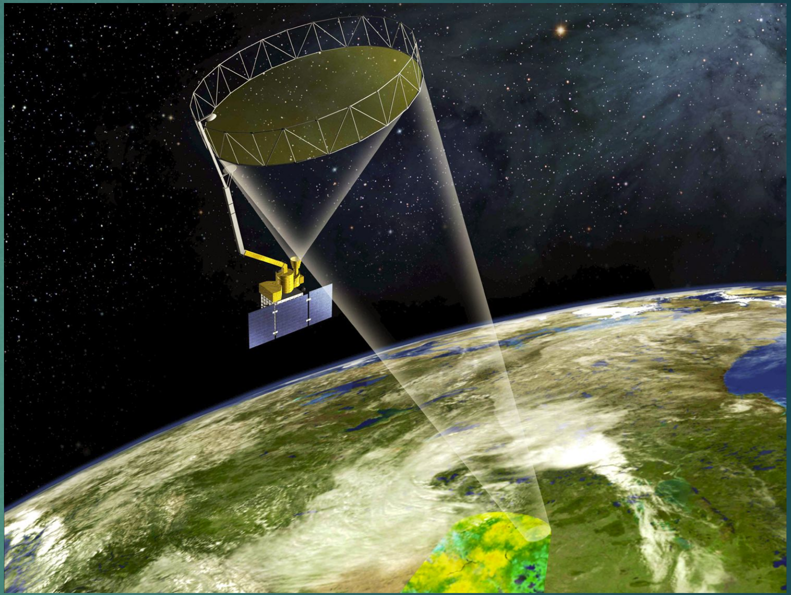
Recently the world sent two satellites into space that will be capable of taking soil moisture measurements on Earth.

One major problem with these satellites is that they do not take in account for the soil's microtopography.

Microtopography is the measurement of soil roughness or the millimeter variations in the height of the soil surface.

The objective of our project is to be able to quickly and easily take microtopography measurements.

These measurements will be used to check how much of an effect microtopography has on moisture measurements from space.



Functional Requirements

Hardware	Our system should use an Xbox One Kinect and the Odroid in order to take in the field measurements of soil roughness.
	The Odroid will need to store the measurements on a USB drive until the user is able to move it to another PC for processing.
	The system needs to be mobile, lightweight and easy to use.
Software	Odroid should start Kinect and process the data.
	Should output the data to a csv for the user to use later.

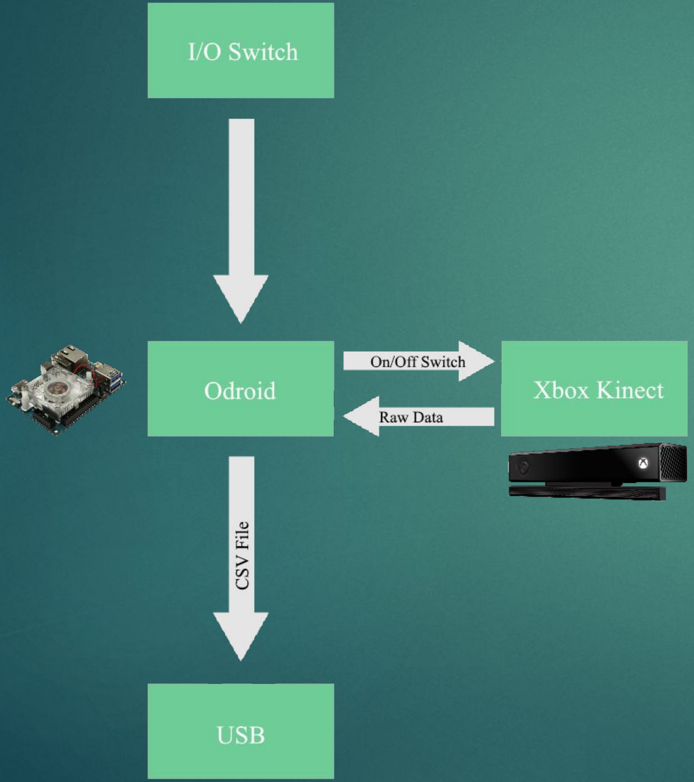
Non-functional Requirements

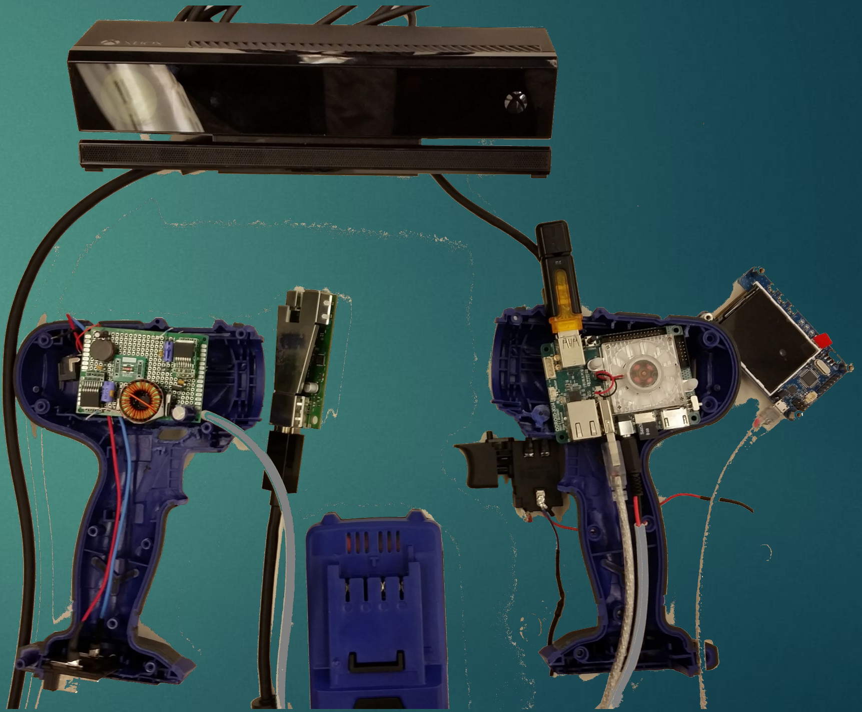
Lightweight	The total weight of our system is less than 5lbs (4.948lbs).
Easy to use	The software we are running waits for a button connected to the GPIO pins to be pressed. After the button is pressed the software will tell the kinect to send data and the Odroid will process that data.
Responsiveness	The software and hardware should allow us to capture data in real time. The hardware should operate upon input from the user.

Project Risks and Mitigations

Poor Accuracy	We were able to adjust the Kinect's code to reach millimeter scale for each pixel of a 512x424 image
Hardware Complications	We anticipated that the power converters may not work exactly how we want them to. Because of this we designed tests to make sure they work properly.
Lack of Experience	When we started this project none of us had experience with the different components of this project. We researched the different components of the system before we implemented anything

Block Diagram





Odroid development board

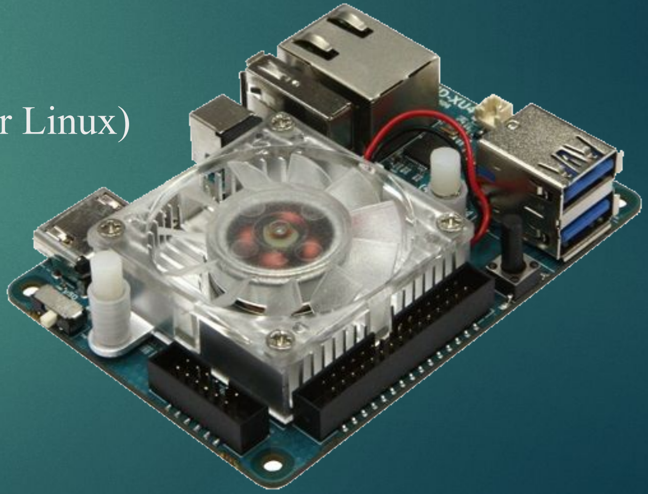
Small development board

Samsung Exynos5422 Cortex™-A15 2Ghz and Cortex™-A7 Octa core CPUs

Able to run Linux and Android

Works with Libfreenect (Open source Kinect drivers for Linux)

USB 3.0 ports (Required for Kinect)



Xbox Kinect V2

Kinect captures RGB, IR, and Depth data using a combination of three IR blasters a and its HD color camera

Depth sensor is able to produce a 512 x 424 pixel image at 30 fps

Depth data is returned by sending out an array of points from its IR blasters and then calculates the depth from the points as they come back to the sensors

Needs power adapter to connect to computers

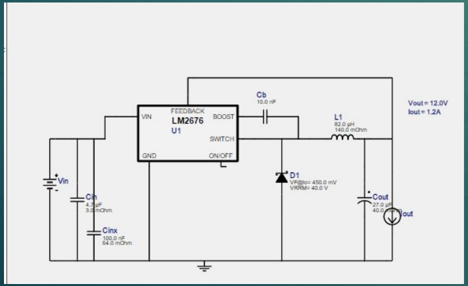
Power source

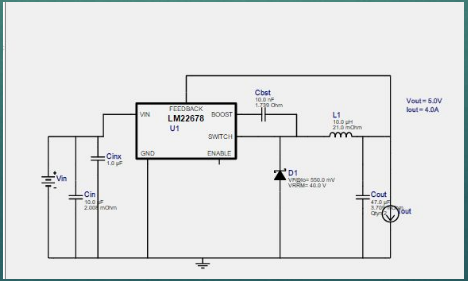
Main power source is provided by a power drill battery.

Buck converters are used to split the input voltage into two separate output voltage of different values.

Two simple switchers are used. LM2676 converts 18V to 12V whereas LM2678 converts 18V to 5V.

Voltage regulator is used for the Kinect instead. The voltage regulator steps down the voltage from 18V to 12V.





Software Details

C# Program

- Tells Kinect to collect depth data when button is pressed.
- Gets the data and makes it readable.
- Runs it through two polynomials to calibrate for error.
- Outputs three files, one for data, one for data reliability, and one for the image captured

C Program

- Was supposed to start when the Odroid powered up
- Loops continuously looking for a signal
- When signal will create a child process that would run the C# program with Mono
- Then it would display information from text file and finish loop iteration

Hardware Details

Drill battery

- Used as the main power for our system.
- Supplies 18V (21V max, 17V min)
- 1.3Ah power

Drill case

- Used to hold the whole system
- Easy to switch batteries
- Small and mobile

Buck converters

- Used to step down 18V supply to 12V and 5V

Voltage Regulator

- Regulates voltage from 18V down to 12V

Testing: Software

Models constructed of Legos due to their accuracy

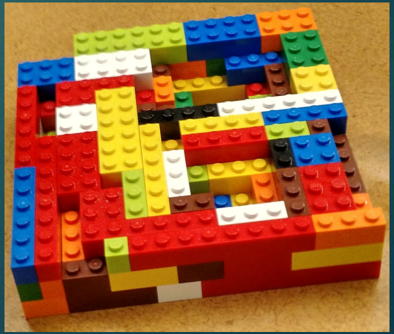
Created a test environment using these models

Manually measured the depth of the models and the center point

Positioned Kinect above center and took the data.

To fix the error we used MatLab's Curve Fitting Tool to find polynomials

Root Mean Square of 3.7620



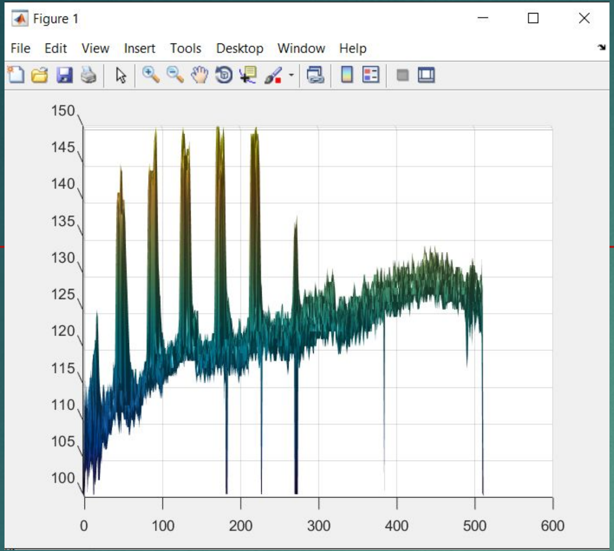


Figure 1
File Edit View Insert Tools Desktop Window Help
150
145
140
135
130
125
120
115
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105
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0 100 200 300 400 500 600

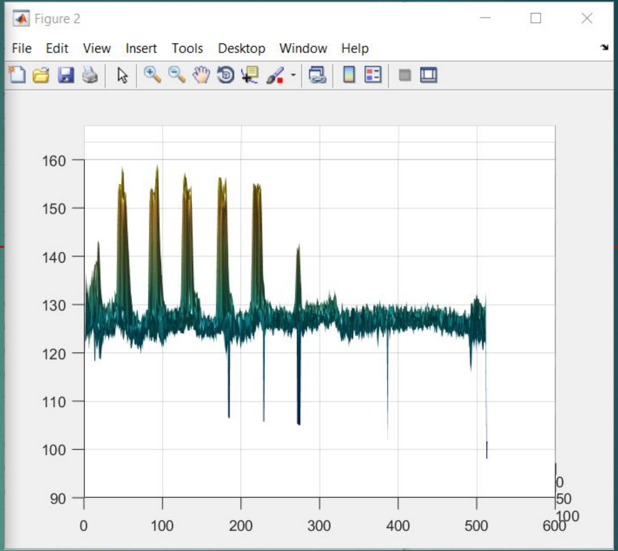
Figure 2
File Edit View Insert Tools Desktop Window Help
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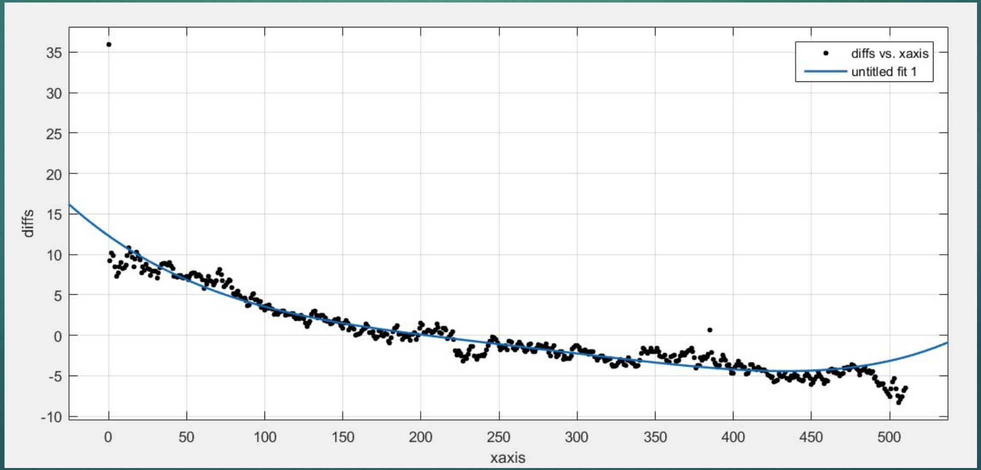

diffs vs. xaxis
untitled fit 1
35
30
25
20
15
10
5
0
-5
-10
diffs
0 50 100 150 200 250 300 350 400 450 500
xaxis

Testing: Hardware

After the circuits were built we needed to make sure the output did not have too much ripple for different loads.

Tested open circuit voltage

Odroid buck converter - 6.3V RMS

Kinect voltage regulator - 11.9V RMS

Tested Load voltage:

Kinect

imax=1.2A Vin=12V so to pull the max power RL=12V/1.2A = 9.6Ω

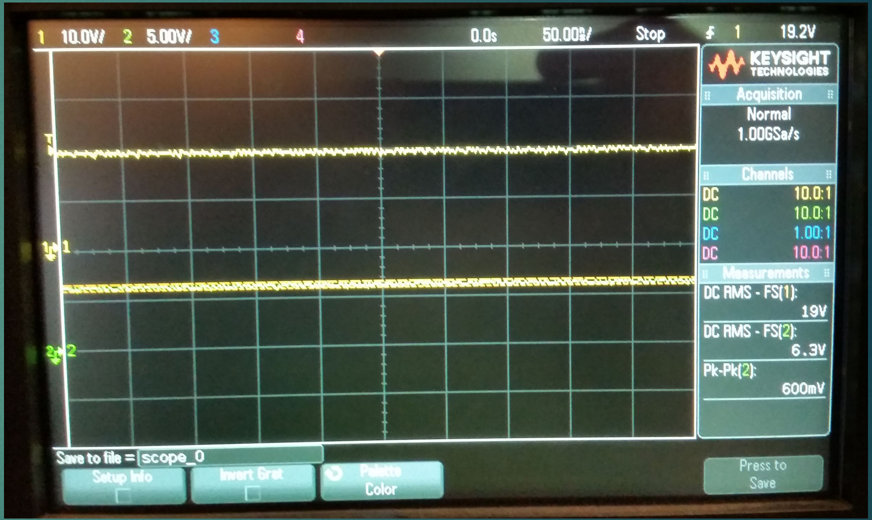
11.9V RMS

Odroid

imax=4A   Vin=5V so to pull the max power RL= 5V/4A = 1.25Ω

5.0V RMS

Voltage Regulator/Buck Converter



12V 1.2A Voltage regulator output (Kinect)
Unloaded: 11.9V RMS .6 Vpp
Loaded: 11.9V RMS .8 Vpp

5V 4A Buck converter output (Odroid)
Unloaded: 6.3V RMS .6 Vpp
Loaded: 5V RMS .1 Vpp

Current Project Status

Kinect software returns millimeter scale data for each pixel

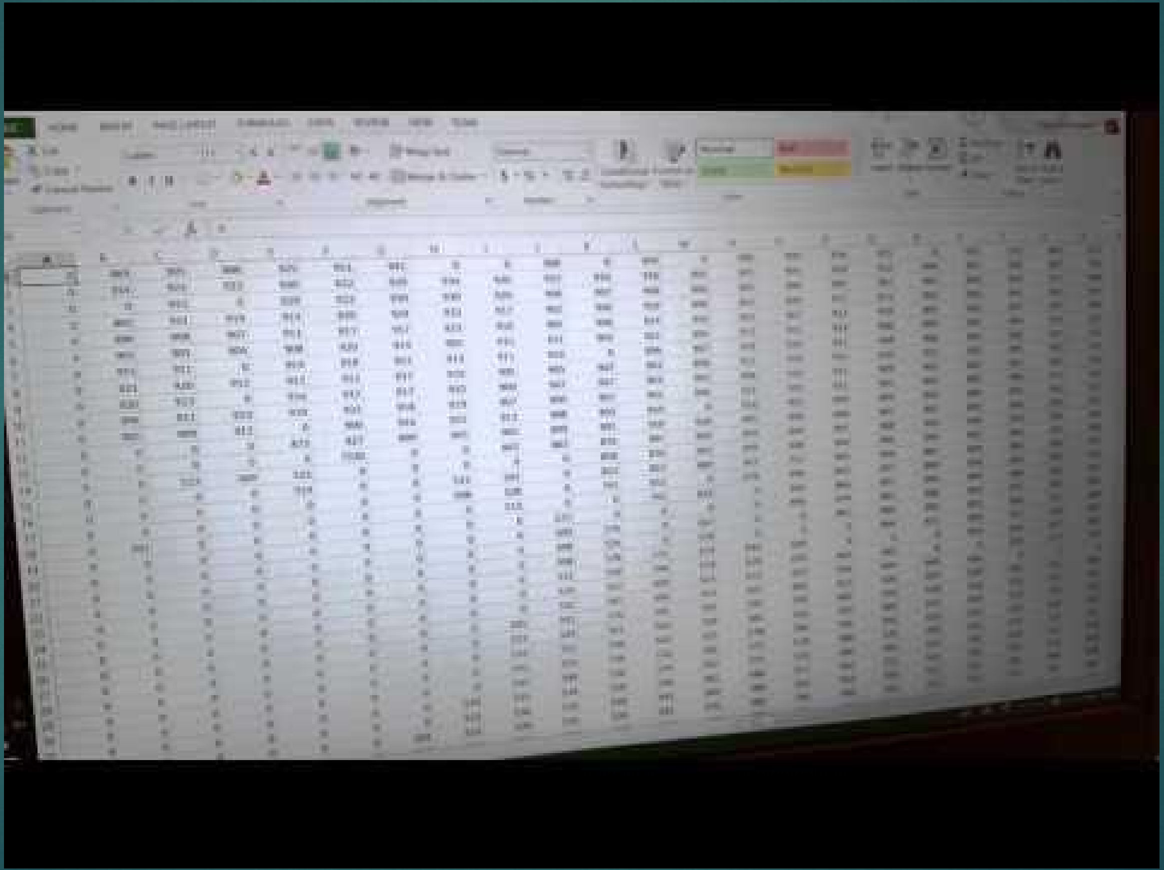
Have depth data reliability information that Odroid can read

Data is being calibrated and returns correctly

The Odroid is able to run small test programs on the small screen that we have.

The battery is able to power both the Kinect and the Odroid
    not at the same time though

Current Kinect Status



Issues/Challenges Encountered

Hardware

Over the summer, our hardware and parts were stolen. This resulted in spending more time as the hardware had to be ordered and delivered again.

Due to the fact that the Odroid uses Linux and the Xbox Kinect being a Microsoft product there were issues getting proper drivers for the Odroid.

Because our system needed to be mobile, we needed to find a lightweight power source. We decided to use a drill battery for this purpose.

The drill battery only supplies a fixed output voltage, hence voltage regulator and buck converter are utilized to obtain the required output voltages for each device.

Issues/Challenges Encountered

Software side

Kinect was reading data in inches

- Found that original code was dividing data by an unknown number

Kinect was getting errors in the data

- Originally tried to fix using geometry
- Fixed by using MatLab to find polynomials to calibrate data

Data shows areas where no data can be returned.

- No idea on how or why they are there.

Questions

Future Iterations

Get the buck converters working with Odroid and Kinect running.
Should allow team to get the rest of the project working

Complete the C program to run the Kinect

Possibly improve on the accuracy of the output

What we learned

Start early and expect delays

Things never go as planned

Don’t be afraid to ask questions

Lock up your stuff

Project Milestones

The Kinect is successfully set up with a computer interface such that images captured by the Kinect can be processed by C# software directly into raw data.

Lego structures for testing successfully built.

C# software and code reconfigured/edited to process the raw data into readable output for further processing and measurement.

Kinect output was modified to give depth in millimeter scale.

Able to power the Kinect and the Odroid using portable power drill battery.

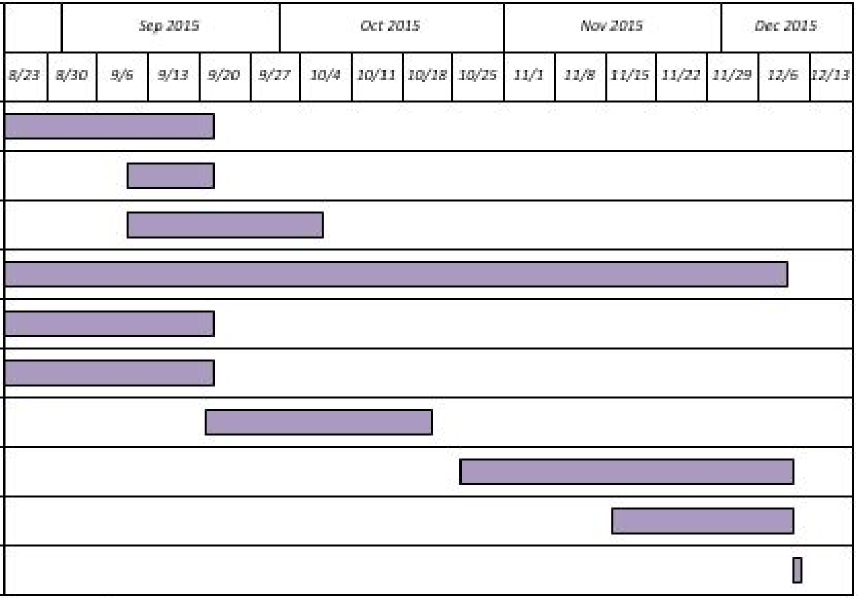
What didn’t work

- Initial development board was a Raspberry Pi
  - Scrapped because of lack of USB 3.0 slot

- Initial power supply was going to be a uninterruptible power supply
  - Scrapped because the power supply was too heavy and couldn’t work like we expected

Project timeline

ID	Task Name	Start	Finish	Duration
1	Define Requirements	8/24/2015	9/21/2015	21d
2	Research Problem	9/10/2015	9/21/2015	8d
3	Identify Possible Solutions	9/10/2015	10/6/2015	19d
4	Order Parts	8/24/2015	12/9/2015	78d
5	Initial Design	8/24/2015	9/21/2015	21d
6	Identify Design Details	8/24/2015	9/21/2015	21d
7	Finalize Design	9/21/2015	10/21/2015	23d
8	Debug and Improvement	10/26/2015	12/10/2015	34d
9	Assembly	11/16/2015	12/10/2015	19d
10	Proof of Concept Presentation	12/11/2015	12/11/2015	1d



Resource/Cost Estimate

Our Bill of Materials

Bill Of Materials		Sept. 9 2015					
Item	Qty.	ref.	Cost($)	part Desc.	Supplier	Supplier#	sub total($)
1	1	xbk	149.99	Kinect for Xbox One	Microsoftstore.com	307499400	149.99
2	1	win adap	49.99	Kinect Adapter for Windows	Microsoftstore.com	308803600	49.99
3	1	xu4	74	One+ 18-volt drill kit	http://www.homede	1001168292	74
4	2	Cb	0.1	10nF, ESR=0Ohm	Digikey.com	490-1664-1-ND	0.2
5	4	Cin	0.36	CAP CER 4.7UF 50V X7R 1206	Digikey.com	490-6521-1-ND	1.44
6	2	Cinx	0.1	CAP CER 0.1UF 25V X7R 0805	Digikey.com	478-3755-1-ND	0.2
7	1	Cout	1.32	CAP POLYMER 33UF 20% 16V SI	Digikey.com	565-3206-1-ND	1.32
8	1	D1	0.49	DIODE SCHOTTKY 30V 1A SOD1	Digikey.com	B130LAW-FDITR-ND	0.49
9	1	L1	0.83	FIXED IND 56UH 2.5A 95 MOHM	Digikey.com	SDR1307-560KLCT-ND	0.83
10	1	Cout2	2.36	CAP POLYMER 180UF 20% 16V	Digikey.com	P16460CT-ND	2.36
11	1	D2	1.39	DIODE SCHOTTKY 40V 5.5A DPA	Digikey.com	VS-50WQ04FNPBF-ND	1.39
12	1	L2	2.37	FIXED IND 27UH 8.2A 14 MOHM	Digikey.com	M8761-ND	2.37
13	1	xu4	74	ODROID-XU4 with 5V/4A PSU	hardkernel.com	ODROID-XU4 (Option : 5V/4A PSU US plug)	74
total							358.58

What makes the project unique

Other systems for taking microtopography measurements are large and heavy and/or take a long time to take the measurements. Our system will be light weight and be able to take measurements in the amount of time it takes to take a picture.

Only known system to measure microtopography using the Xbox Kinect.

Individual Contributions

Brant Walsh

Designated as the key concept holder and the communicator
Designed the testing structure and assisted in programming issues.
Responsible for hardware testing and circuitry construction helper.
Installed driver software on the Odroid.

Dillon McDowell

Designated as the webmaster.
Maintained and updated the group website on a weekly basis.
Designed the data processing software for the Kinect and Odroid C program.

Yan Yao Chan

Designated as the group leader
Responsible for group documents such as weekly reports and design documents.
Assisted in hardware testing.
Responsible for circuitry construction.