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Lab 1: Measuring the Real World

Model description: the task is to represent an area of enclosed 2-D space through the measurements and visualisations

Description of the process: The enclosed 2-D area is measured by 4 different tools, taking 3 different readings per device and averaging them into one measurement for that device. The area calculation is done from the collected measurements with each of the devices. The 4 final results get represented in visualizations.

In the calculations I have to take some assumptions:

1. the measured enclosed 2-D area is of rectangular shape, assuming that the area is enclosed within the right angles and therefore calculating the area by the formula: AREA=HIGHT*WIDTH
2. consider the surface area to be flat, ignore any elevations
3. I considered the distances to be small enough not to take the roundness of the Earth into consideration and assumed that the paths are straight lines and not arcs

The no-technology-at-all device:

Each of the paths was measured in the length of my feet. I had to walk along the path on a straight line stepping that way that one foot will be tightly close to the other. Make sure that during each of the 3 measures per path, I will start and end at the same spot, by marking the ground.

I have measured the length of the shoes I walked with and I have got: 26.5cm for 8.5 USA shoe size

	NE-NW	**NW-SW**	**SW-SE**	**SE-NE**
Number of steps	226.5 = 60.0225m	170.5= 45.1825m	228.5 = 60.5525m	165 = 43.725m
	228 = 60.42m	170 = 45.05m	227 = 60.155m	166 = 43.725m
	228.5 = 60.5525m	170 = 45.05m	229 = 60.685m	166.5 = 44.1225m
Average	60.332m	45.094m	60.464m	43.8575m

From the measurements, the average WIDTH = 60.398m and the HIGHT= 44.47575m

Area = 60.398m *44.47575m = 2686.2463485m^2

Sources of error:

1. Not being able to walk in a perfectly straight line is one error source. Any deviations would increase the length
2. Not stepping tightly enough, making a gap space between the feet

GPS

I located myself on each of the 4 corners of the measuring area, recording the longitude and latitude information from GPS screen in decimal degrees. Make sure that during each of the 3 measures per path, I will start and end at the same spot, by marking the ground.

	NE		NW		SW		SE	
longitude (^{o}W)/ Latitude (^{o}N) respectively	084.91224	39.82381	084.91286	39.82386	084.91292	39.82344	084.91225	39.82342
	084.91221	39.82381	084.91285	39.82380	084.91288	39.82348	084.91222	39.82344
	084.91225	39.82384	084.91284	39.82383	084.91284	39.82341	084.91225	39.82347
Average	084.91223	39.82382	084.91285	39.82383	084.91288	39.82344	084.91224	39.82344

The next step is to average the shared coordinates as shown on the sketch to the left.

$X_1 = (084.91223 + 084.91224)/2 = 84.912235$

$X_2 = (084.91285 + 084.91288)/2 = 84.912856$

$Y_1 = (39.82382 + 39.82383)/2 = 39.823825$

$Y_2 = 39.82344$

Using the Coordinate Distance Calculator (http://www.movable-type.co.uk/scripts/latlong.html), I calculated the following:

WIDTH=53.03m HIGHT = 42.81m

Area = 53.03m * 42.81m = 2270.2143m^2

Sources of error:

1. It is also difficult to ensure precision in distance calculation source calculations
2. Taking a lot of averages leads to some rounding errors

Big Measuring Wheel

For each path, which I cleaned in advanced from stones and branches, I have used big measuring wheel, which I dragged along the path on a straight line. The scale on the wheel has to be reset to zeros each new measurement. Make sure that during each of the 3 measures per path, I will start and end at the same spot, by marking the ground.

	NE-NW	NW-SW	SW-SE	SE-NE
Feet	202.7f=61.783m	151.1f=46.055m	203.45f=62.012m	146.105f=44.533m
	202.85f=61.828m	151.11f=46.058m	202.15f=61.615m	147.3f=44.897m
	202.65f=61.768m	150.8f=45.964m	202.10f=61.6m	147.35f=44.912m
Average	61.793m	46.026m	61.742m	44.78m

From the measurements, the average WIDTH = 61.7675m and the HIGHT= 45.403m

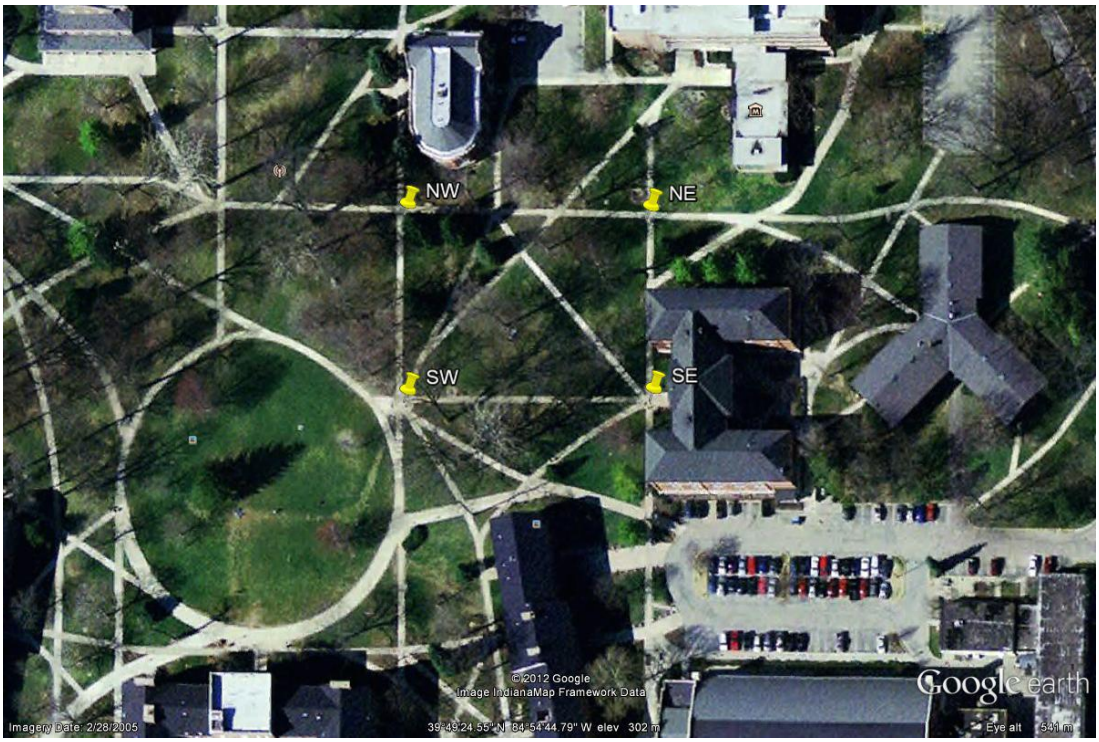
Area = 61.7675m * 45.403m =2804.43m^2

Sources of error:

1. Not being able to walk in a perfectly straight line is one error source. Any deviations would increase the length
2. If the scale is not set to zero perfectly
3. The path's surface isn't even; little rocks and branches were still on the way

Google Earth

I have located a placemarks on the map signifying the angles. Using the function of finding the distance between the placemarks within Google Earth (Right click -> Distance to/from here), I have collected the distance measurements of the paths. I have relocated placemarks 3 times for more accurate measures.



	NE-NW	NW-SW	SW-SE	SE-NE
Feet	200.43f=61.091m	148.31f=45.205m	207.44f=63.228m	154.36f=47.049m
	207.45f=63.231m	148.31f=45.205m	207.44f=63.228m	144.34f=43.995m
	200.43f=61.091m	148.31f=45.205m	207.44f=63.228m	154.36f=47.049m
Average	61.804m	45.205m	63.228m	46.031m

From the measurements, the average WIDTH = 62.516m and the HIGHT= 45.618m

Area = 62.516m*45.618m = 2851.854888m^2

Planimeter and a scaled map:

The Earlham College map scaled at 1''=40' determines the position of the vernier to be at 116.8 according to the provided with the planimeter instructions. The value of the vernier unit on the measuring roller is at 20'' for the given map scale. I have measured the area of the enclosed 2-D space by placing the pole outside of the measured area and calculating the area by the formula:

Area(sq feet) = Reading*20''

Reading1	1876
Reading2	1827
Reading3	1850

The average = 1851

Area = 1851*20''=37020 sq feet = 3439.27m^2

Sources of error:

1. If the scale is not set to zero perfectly
2. Not dragging the vernier in a straight line, any deviation enlarges the calculated results

General sources of error:

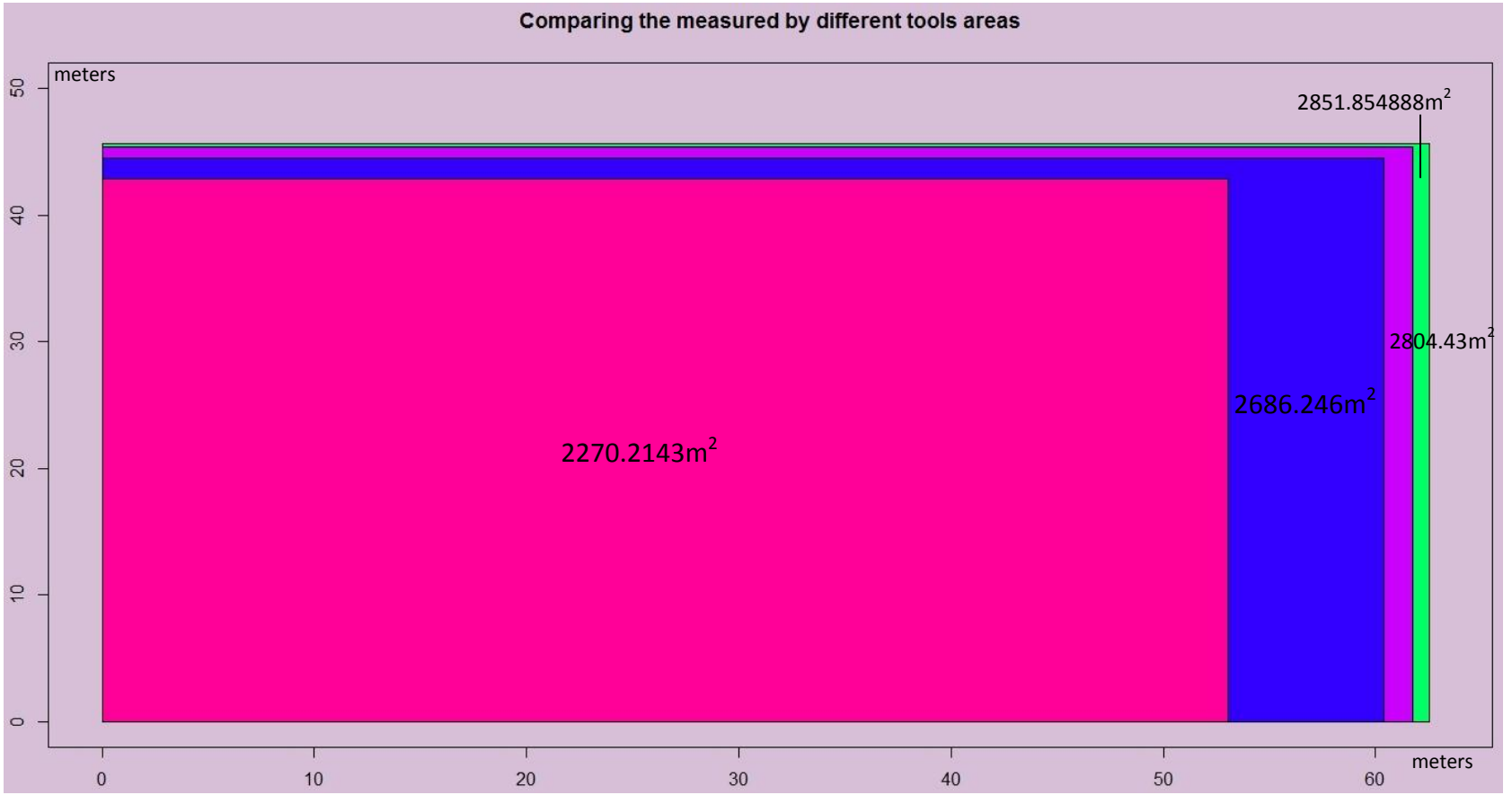
1. Converting one measuring units into the others leads to errors due to approximations
2. Rounding errors
3. The paths intersecting at SE and SW points don't physically link with each other, leaving it up to a human eye to determine the point of intersection.

Analyzing at the gathered data and the calculations, I can say that Google Earth method and the Big Wheel Method were the closest to each other. GPS had more differences. In my thinking such is so due to the fact that in GPS method a lot of averages were taken, plus I heavily relied on the third source to calculate the distances of the paths, which carried to the approximation in calculations errors. The area found with planimeter had a significant difference with all the other calculations. It was the hardest to collect the measurements: dragging planimeter on the scaled map made it hard to be precise, which most likely led to human errors.

Visualisation:

Image 1 was built with the use of R:

```
>
>  plot(c(0,63), c(0, 50), type = "n", xlab="", ylab="",
+ main = "Comparing the measured by different tools areas")
> rect(0, 0, 62.516, 45.618, col=rainbow(15, start=.4,end=.3))
> rect(0, 0, 61.7675, 45.403, col=rainbow(17, start=.8,end=.2))
> rect(0, 0, 60.398, 44.47575, col=rainbow(11, start=.7,end=.1))
> rect(0, 0, 53.03, 42.81, col=rainbow(17, start=.9,end=.2))
>
```



	GPS (decimal degrees)							
	1		2		3		Avr	
NE	084.91224	39.82381	084.91221	39.82381	084.91225	39.82384	084.91223	39.82382
NW	084.91286	39.82386	084.91285	39.82380	084.91284	39.82383	084.91285	39.82383
SW	084.91292	39.82344	084.91288	39.82348	084.91284	39.82341	084.91288	39.82344
SE	084.91225	39.82342	084.91222	39.82344	084.91225	39.82347	084.91224	39.82344

Avr dimensions	Width=53.03m Hight=42.81m

Image 1

	Steps(m)				Big Wheel(m)				Google Earth(m)			
	1	2	3	Avr	1	2	3	Avr	1	2	3	Avr
NE-NW	60.0225	60.42	60.5525	60.332	61.783	61.828	61.768	61.793	61.091	63.231	61.091	61.804
NW-SW	45.1825	45.05	45.05	45.094	46.055	46.058	45.964	46.026	45.205	45.205	45.205	45.205
SW-SE	60.5525	60.155	60.685	60.464	62.012	61.615	61.6	61.742	63.228	63.228	63.228	63.228
SE-NE	43.725	43.725	44.1225	43.8575	44.533	44.897	44.912	44.78	47.049	43.995	47.049	46.031

Avr dimensions	Width=60.398m Hight=44.47575m	Width=61.7675m Hight=45.403m	Width=62.516m Hight=45.618m

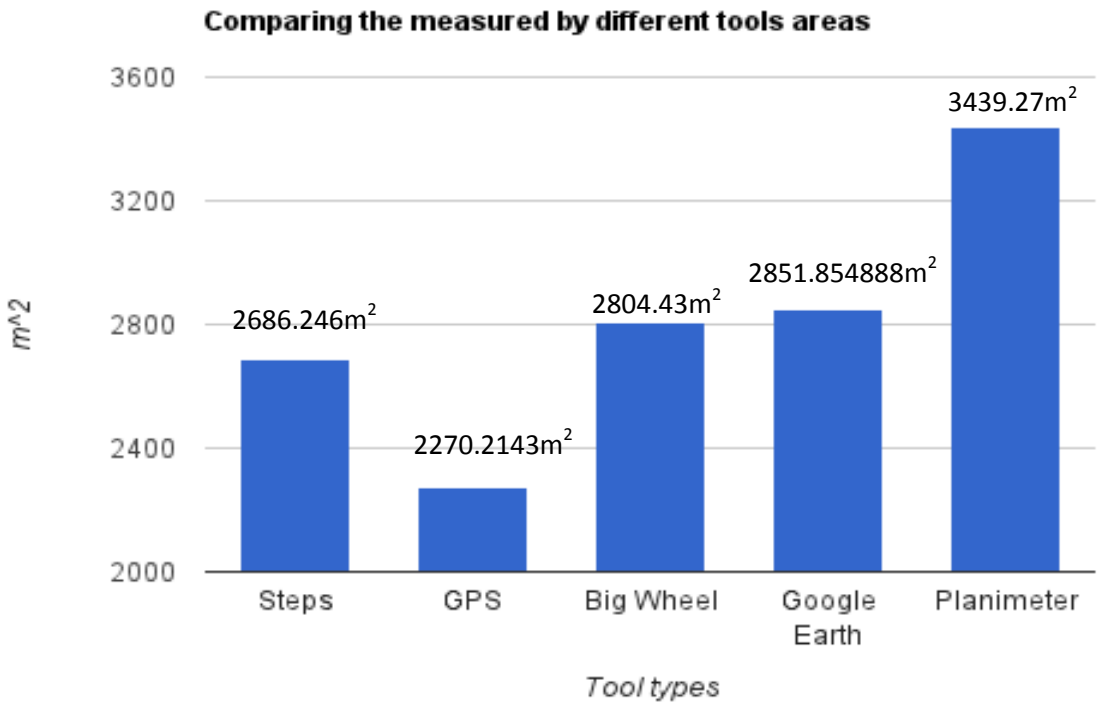


Image 2

	Steps	GPS	Big Wheel	Google Earth
Avr Hight	44.47575m	42.81m	45.403m	45.618m
Avr Width	60.398m	53.03m	61.7675m	62.516m

Planimeter			
Units	1	2	3
	1876	1827	1850

Image 2 was built with the use of Spreadsheet:

	Calculated area
Steps	2686.2463485
GPS	2270.2143
Big Wheel	2804.43
Google Earth	2851.854888
Planimeter	3439.27