Emily Pavlovic
September 9, 2012

Lab 1: Measuring the Real World

Introduction

There are many errors and difficulties associated with measuring things in the real world. This lab investigates some of the issues surrounding taking these measurements. Different tools have their own strengths and weakness which are explored here. Five different techniques were used to measure a 2 dimensional area of land on Earlham campus which is show below.

Materials and Methods

Five measurements were taken for each of the five devices. Measurements were then averaged. An assumption was made that the area of the plot was a rectangle, therefore making the area equal to the width times the length. To obtain a number for the length and width the readings of the shorter sides (B and D) and longer sides (A and C) were averaged.

Human Estimate

The length of each side of the enclosed area was measured using my stride (the distance from the back of my right foot to the back of my right foot after stepping). Each stride was equal to 1.07 meters.

Limitations: Not all of the strides were equal in length because it is difficult to walk with exactly perfect stride. Also, when a stride did not match up perfectly with the end point an estimate of what fraction of a stride had to be made. This estimate may not have been very accurate.

Measuring Wheel (Large and Small)

Each side of the polygonal area was measured using each of these devices. The wheel was kept close to the edge of the sidewalk and was moved in as straight of a line as possible.

Limitations: Especially with the small wheel, it was difficult to keep the wheel moving in a straight path. Any straying from a straight line would cause the measured distance to be greater. It was also a bit challenging to start and stop in the same places since the device is a wheel with no clear beginning and end. Any bump on the path could also add more distance to the measurement.

Global Positioning System (GPS) Device

Readings of latitude and longitude were taken at each corner of the polygon. Degrees of latitude and longitude were converted to distance in meters (http://www.csgnetwork.com/gpsdistcalc.html). Five readings were taken at each corner.

Limitations: The accuracy of the GPS device fluctuated between 8 and 20 meters while the readings were taking place. For such a small distance, this fluctuation of numbers can have a really big impact of the accuracy of the measurement. The device may not have been in the exact same place for each measurement.

Google Earth

The ruler under tools was used to draw a line on each of the sides of the polygon. This then displayed the distance in meters. Five measurements were taken for each side. Area was calculated from the averages of the measurements.

Limitations: Putting the path in the correct place every time was difficult. The map did not have the best resolution, so it was challenging to see exactly where the corners were. Also, the paths did not appear to all be exactly straight.

Results

The measurements show that the sides differed in length suggesting that the area is not a rectangle. From the Google Earth image it can be determined that the angles are not 90°. However, for the calculations the assumption was made that the area is a rectangle allowing for simplicity.

The area is assumed to look like the image below with A and C slightly longer than D and B. The GPS measurements were taken at 1, 2, 3 and 4.

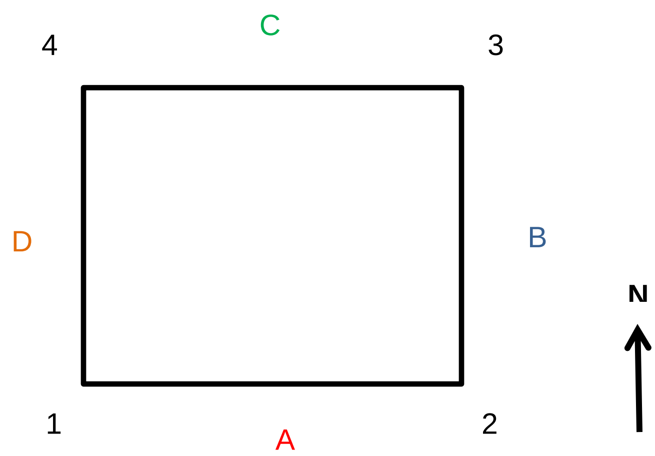


Table 1: Shows lengths of sides using different measuring devices. Using each device five measurements were taken. The average and standard deviation of these measurements is shown below.

	STRIDES		MEASURING WHEEL (LARGE)		MEASURING WHEEL (SMALL)		GPS		GOOGLE EARTH	
Side		Average		Average		Average		Average		Average
A	51.2 m	51.5 ±0.5 m	61.90 m	61.82 ±0.04 m	62.6 m	62.5 ±0.1 m	91 m	93±2 m	62.31 m	61.6 ±0.6 m
	51.2 m		61.80 m		62.4 m		93 m		62.18 m	
	51.7 m		61.80 m		62.4 m		94 m		61.09 m	
	51.2 m		61.80 m		62.5 m		96 m		61.2 m	
	52.3 m		61.82 m		62.7 m		92 m		61.25 m	
B	38.4 m	37.9 ±0.5 m	44.96 m	44.96 ±0.03 m	45.3 m	45.7 ±0.6 m	79 m	77±4 m	45.06 m	45.3 ±0.3 m
	38.4 m		44.91 m		45.4 m		80 m		45.03 m	
	37.3 m		44.98 m		45.4 m		80 m		45.33 m	
	37.9 m		44.98 m		46.7 m		72 m		45.45 m	
	37.3 m		44.98 m		45.6 m		72 m		45.84 m	
C	50.7 m	50.7 ±0.4 m	62.1 m	61.8 ±0.2 m	62.3 m	62.4 ±0.2 m	97 m	92±4 m	60.78 m	61.2 ±0.4 m
	50.7 m		61.7 m		62.3 m		93 m		61.73 m	
	50.7 m		61.7 m		62.3 m		90 m		61.19 m	
	50.1 m		61.7 m		62.7 m		90 m		61.32 m	
	51.2 m		61.7 m		62.6 m		88 m		60.73 m	
D	38.4 m	38.2 ±0.3 m	46.1 m	45.9 ±0.2 m	46.5 m	46.3 ±0.4 m	67 m	70±5 m	46.52 m	45.8 ±0.5 m
	38.4 m		45.9 m		46.5 m		71 m		45.6 m	
	38.4 m		46.1 m		46.5 m		63 m		45.15 m	
	37.9 m		45.6 m		45.6 m		70 m		46.02 m	
	37.9 m		46.1 m		46.5 m		78 m		45.57 m	

Table 2: The area was assumed to be a rectangle so the long and short sides were averaged. Length A & C and B & D were averaged. Calculated areas for each measuring device are also shown. Absolute error is shown as the ± value and relative error is shown in the last column.

	LENGTH	WIDTH	AREA	RELATIVE ERROR
Strides	51.10 m	38.0 m	1943±40 m^2	2%
Measuring Wheel (Large)	61.8 m	45.5 m	2809±10 m^2	0.5%
Measuring Wheel (Small)	62.5 m	46.0 m	2873±50 m^2	1.6%
GPS	92.5 m	73.2 m	6775±700 m^2	10%
Google Earth	61.4 m	45.6 m	2796±50 m^2	1.8%

Figure 1: Comparison of all measurement devices. Vertical axis is area (m^2). The areas calculated from the measuring wheels and Google Earth are pretty similar, whereas the GPS calculated a much greater area and the no technology method a smaller area.

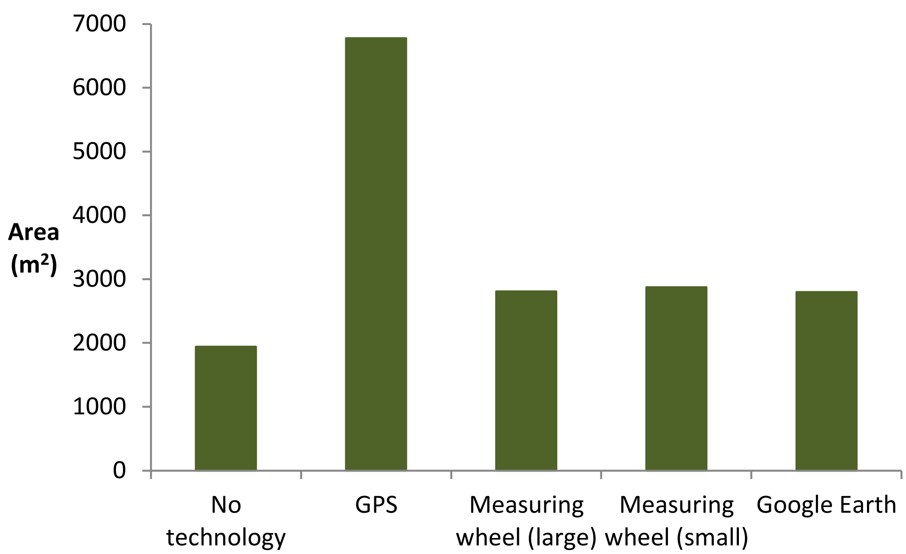
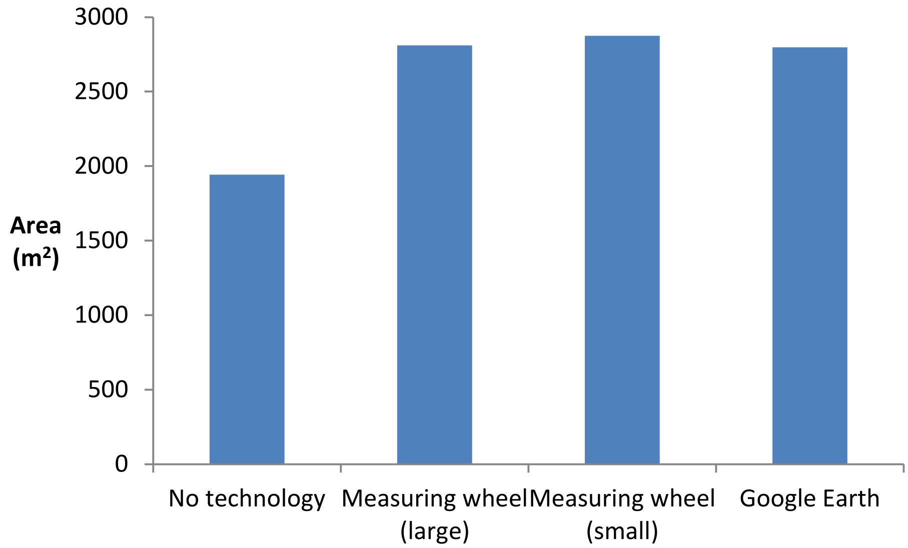


Figure 2: Comparison of measurements excluding GPS device. This graph shows a better comparison between the techniques that yielded similar areas.



Discussion and Conclusions

Sources of Error

There is always room for human error in measuring. Also, anytime something is converted from one unit to another, rounding errors occur. Calculations of area also involve the addition of error. All of the devices had their own unique sources of error which are described above in the materials and methods section. A large source of error may come from the gigantic assumption that the area was a perfect rectangle.

Findings

The measurements with the GPS appear to be pretty inaccurate. The measurements taken with all the other devices were within 1000 m^2, but the GPS gave a measurement that was ~3000 m^2 different. This suggests that high technology may not always be the best tool for certain tasks.

The large measuring wheel gave the most precise measurements, followed by the small measuring wheel, Google Earth, and finally the no technology technique. The no technology technique contained the most areas for human error, so it makes sense that it would not be as precise or accurate.

The interesting thing about measurements is that it is difficult to compare it to a known. Some kind of device must be used to make the measurements, meaning that error will be inevitable. There is no perfect answer, only an answer close to the truth. However, it may be safe to assume that the area of the plot is pretty close to those obtained by the measuring wheels and Google Earth.