The effect of the time of day on the accuracy of the Global Positioning System (GPS) to predict a location

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Abstract
The Global Positioning System, or GPS, is a widely used navigational system since it was first introduced in the 1970s, although it was primarily by the government. It can now be found in most cars, planes and institutions. The main objective of this study was to determine if the time of day affected the readings taken from hand held GPS units. Readings were taken twice per day for 10 days of a specified location. Through data analysis it was found that the readings were not affected.

Introduction
The Global Positioning System (GPS) is a navigational system first introduced by the military as a method of pinpointing locations of soldiers and targets all over the world. In the 1980’s it was introduced for civilian use. The system is based on a network of 24 satellites that orbit the planet twice per day constantly transmitting signals. These readings are then recorded by hand held units which interpret this data. A minimum of four satellites are needed to triangulate a position.

The main objective of this experiment was to test if the time of day affected the accuracy of GPS readings to predict the position of a particular location on the Blacksburg campus. Past GPS studies have shown variability in location, ranging in accuracy from 5 to 20m from the actual location, with weather and time not being a concern. In this experiment several factors were taken into account. This included assuming that the speed of light was $3 \times 10^8$ m/s and that the first readings taken would be the true readings, the same GPS unit was used, the location was fully uncovered and did not change, and the readings were taken approximately the same time each day.
Materials and Method
A specific location on the Blacksburg campus (see fig 1) was chosen and GPS readings were taken using a Magellan GPS 315 unit # 478. 5 readings of the northern and eastern were taken every two min for a total of 10 min twice per day.

Fig 1 showing area of study, represented by the black square pointed out by the arrow.
Results:

Table 1 showing GPS readings collected for 10 days

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Graph 1 showing deviations in GPS readings taken in the morning and evening

Graph 2 showing average deviations in GPS readings taken in the morning and evening
Graph 3 shows a scatterbox plot of the GPS readings taken in the morning and the evening.

Analysis of Data
A 2-sample paired t-test was used in evaluating the data with a level of significance of 0.05. The following results were achieved:

Hypothesis Test

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95% Confidence Interval for the Difference between Two Paired Means

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where the null hypothesis being tested is that there is no difference in readings taken by the GPS unit at different times of the day. This data is also shown graph 4.
Discussion
There was a high level of deviation in the readings taken each day, as observed by graphs 1 and 2. This was attributed to the amount of satellites that were available each day, which bordered between 3 and 5 at each sitting. A 2-sample paired t-test was used to analyze the data due to two factors. The first was the use of the same GPS unit and the second was to compare the two sets of data and determine a correlation. Graph 3 showed a scatterbox plot of the readings taken over the ten days. As observed, most of these readings fell towards the evening side. This was due to use of the first set of morning readings as the true readings of the location. Observations are reversed when the first set of evening readings were used as the true readings, resulting in most of the points falling on the morning side. It has been assumed that the points would fall almost equally on either side if the true reading for the location was used.

Using the level of significance, $\alpha$, to be 0.05, and the null hypothesis to be 0 (i.e. no difference in readings between time of day) a p-value (probability of $\alpha$) of 0.0818 was found. Since the p-value is greater than $\alpha$, we fail to reject the null hypothesis, which means that the time of day does not affect the readings from a GPS unit. This was also demonstrated in graph 4 where the t value does not fall in the rejection region (shaded region).
Bibliography

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