Name(s)	Project Number
Sophie Q. Carter	**S0803**

Project Title

GPS-Denied Navigation Using Altimetry

Abstract

Objectives/Goals
The goal of my project is to be able to navigate outdoors using sensors available on a cell phone, but without GPS. The inertial sensors on a cell phone measure angular and velocity rates of change that must be integrated to calculate position. Small errors in these rates accumulate so that tracking accuracy rapidly degrades. One way to overcome this problem is to use barometer data as a measure of elevation, which can be compared to a reference topographic map and used to reduce position error to a useful level.

Methods/Materials
I created a local elevation map using data available online. I used a cell phone equipped with a magnetometer, gyroscope, accelerometer, and barometer. I walked around a neighborhood block while recording data from these sensors at a rate of 10 Hz.

Starting with an initial GPS position fix, I used a particle filter to process the sensor data. I used the magnetic and inertial sensors to propagate the position estimate from one time step to the next and then updated it using the barometer-estimated elevation. I calculated the accuracy of the position estimate using GPS measurements for ground truth only.

Results
In multiple trials, I was able to track my position to within a few tens of meters over a period of about eight minutes without the aid of GPS. This accuracy is a useful level for navigation and far better than what could have been achieved without the aid of the barometer measurement.

Conclusions/Discussion
GPS signals can be lost due to poor reception in dense forests, urban areas, and mountainous regions or to signal jamming. My navigation technique is very general and would have many important applications. Examples include aiding hikers lost in the wilderness and underwater navigation. It would also have uses in the military such as guiding soldiers through GPS-denied regions.

Summary Statement

My project demonstrated a navigation method that works in the absence of GPS signals by comparing barometer-estimated altitude to a topographic map.

Help Received

I performed the experiment and analysis myself. I used IDL to code my algorithm and generate plots. My father, Dr. Paul Carter, helped me find out more about particle filters.