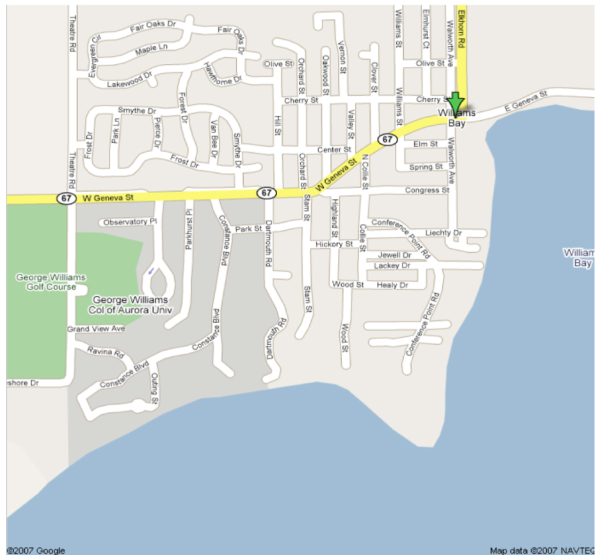
Mapping the Yerkes Grounds

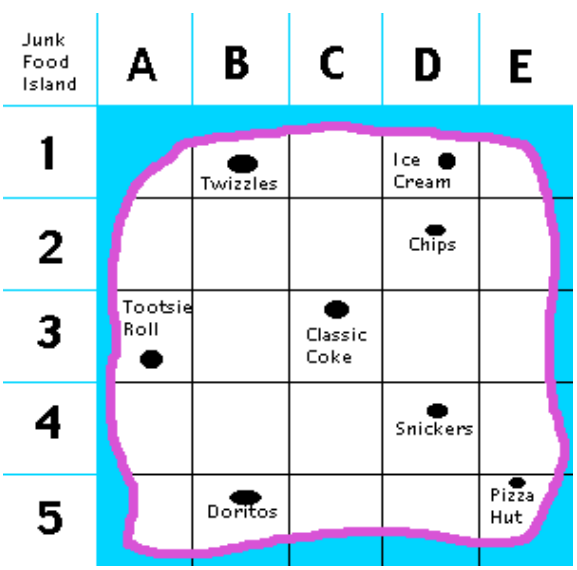
Christopher Thom, Zosia A. C. Krusberg & Robert B. Friedman

Introduction

You don't need to read this introduction to know the importance of maps. Maps are ubiquitous (*everywhere*), an essential part of our everyday lives, and many of us couldn't get from one place to another without them. An example of a modern map is shown in the figure to the right. What makes a good map? Certainly style, color, and clear labeling are all important concerns that might make a map more or less attractive and user-friendly. But what makes a map *useful*? The most obvious thing is an *accurate coordinate system*. Simply put, a coordinate system tells the reader of the map where he/she and other points of interest are located in the real world. If you want to determine the distance and direction between any locations on the map, a coordinate system is essential. Usually, a coordinate system appears as a simple grid overlaid on the map (see figure below). Some specialized maps, like a CTA route map, don't have a coordinate system. A CTA map can tell us the order of the stops and where transfers can be made, but one couldn't use it to find out how far it is from Wacker/Columbus to State/55th.



A Google map of the Williams Bay area surrounding Yerkes. (Image credit Google)



An example map of an imaginary Junk Food Island. The grid is a basic coordinate system, which helps you locate the relative locations of various junk food choices. For instance, chips are located in D2 and tootsie rolls in A3. On this map, there is no indication of which way is North or West. How would you get from one place to another? The map is missing an orientation! (Image credit: http://www.mcwdn.org/MAPS&GLOBES).

In this lab you will be creating from scratch a map with an accurate coordinate system. Specifically, you will use an existing coordinate system - the latitude/longitude system - to construct an accurate map of the Yerkes Grounds. You will then use your map to locate a number of hidden markers on the grounds.

Coordinate Systems

You might be wondering where coordinate systems come from. That's the hard part. Since a coordinate system on a map provides locations and directions, someone has to go out and measure those locations and directions first. One way to do that would be to break out a sturdy ruler and a compass and start measuring. As long as you were really careful, that would probably yield a great coordinate system, especially if you were also really patient and measured the distances in very fine units like millimeters. While that's probably the simplest way to make a map, it would be completely hopeless in practice. Who wants to measure the distance from Chicago to Los Angeles with a ruler?! That's where good science and math come in; finding a smart, quick, and easy way to measure coordinates and distances accurately.

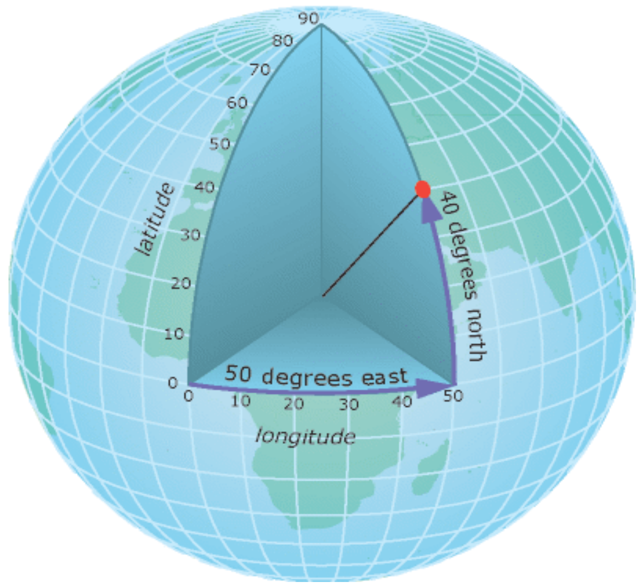
Instead of generating our own coordinate system from scratch, we will employ an existing and widely used one, the longitude and latitude coordinate system. Latitude and longitude are the *angles* used to describe locations on the curved surface of a sphere, like the Earth. Like other angles they are measured in units of degrees, minutes and seconds:

1 degree (°) = 60 minutes (') = 3,600 seconds(")
1 ° = 60 ' = 3,600 "
1 minute(') = 60 seconds(")

Knowing the latitude and longitude of two points does not tell you the physical distance between those points. To obtain this distance, you need to know the radius of the sphere they are sitting on (i.e., the radius of the Earth), but we won't bother with that. All we need to know is where we are and where we need to go in terms of latitudes and longitudes; the actual distances will not be important.

Global Positioning System

In order to determine your coordinates in the latitude/longitude coordinate system you will employ the Global Positioning System (GPS) using a GPS satellite receiver. Briefly, GPS is a system of satellites orbiting the Earth that uses triangulation to find the location of your receiver. When this calculation is accomplished, the receiver displays its longitude and latitude coordinates in degrees on its screen. Triangulation is a method of identifying the relative position of an object through the cooperation of several observers. In this case, the satellites (the observers) know their positions very well and triangulate to find yours (the object's) relative to theirs.



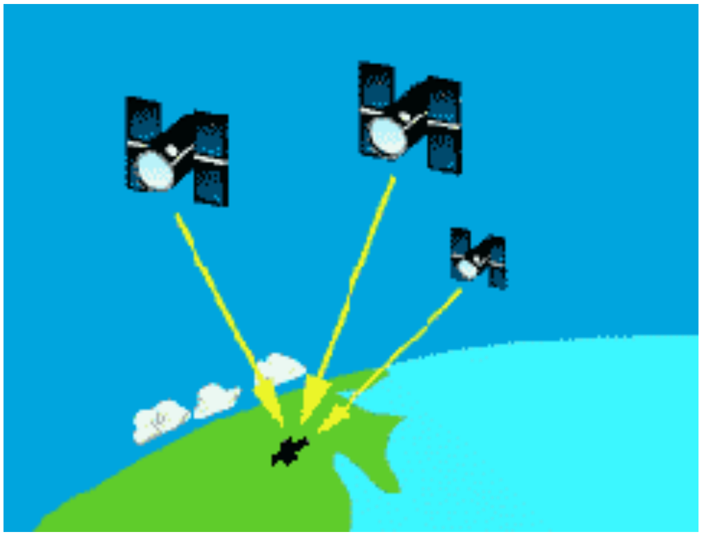
A diagram of Earth demonstrating the longitude/latitude coordinate system (image credit: http://webhelp.esri.com/arcgisdesktop/9.2/)

Now, there's just one more thing we should mention. We claimed that a useful map has an *accurate* coordinate system. This is an important detail since an inaccurate coordinate system would not be terribly useful. Imagine if Google Maps told you to drive 3 miles to a place that, in reality, was 4 miles away. While that would be off by just 25% (1 mile error out of 4 true miles => 1/4 = 0.25 = 25%), you'd have a hard time finding it. Well, GPS is a very accurate coordinate system: a basic GPS receiver can determine your position to within about 10 meters or 30 feet. That's 10 meters out of the entire circumference of the Earth (40,000,000 meters), which is an accuracy of 10/40,000,000 = 0.000025%!!! Of course, the GPS uses the longitude/latitude coordinate system, so the readout isn't in meters but in degrees (we'll leave it up to you to try and figure out the accuracy in degrees). Still, even if your accuracy is good on an Earth scale, it might be useless on a smaller scale. Suppose you were trying to find a buried treasure but didn't know where it was to within 10 meters: you'd be digging a long time. Part of the challenge of this lab is to keep your coordinate accuracy as good as possible when constructing your map.

Part 1 - Triangulation & The GPS Receiver

In the first part of this lab, we'll do a simple exercise to learn how triangulation works.

Goal:
To understand how the GPS uses triangulation to determine locations.



A simple picture of multiple GPS satellites that work together to determine a position. (image credit: http://www.fc.up.pt/lic_eg/imagens/)

Materials:

- GPS unit
- Stake and string

Procedure:

1. Take a GPS unit outside, and figure out how it works! Just play with it. Find the part that tells you latitude, longitude, and the accuracy.
   (a) You need to be able to determine your longitude and latitude coordinates.
   (b) The unit needs to make contact with several satellites before it will display coordinates (there's actually a definite number, but you'll have to figure out what and why that is in part 2).

2. Get a coordinate sheet, a stake, and string from the instructors.
   (a) On the sheet there is a latitude/longitude coordinate. Use the GPS to navigate to this coordinate.
   (b) Locate the colored marker at your specified coordinate. Drive the stake into the ground at that point and attach the string.
   (c) The second item on your coordinate sheet is a distance to a SPECIFIC point. Use the string fixed to the ground at your coordinate to locate that point! (*Hint: how do you know which direction this point is in? You can use anything, or anyone, to find this point.)*

In your lab notebook, answer the following:

- What is your GPS unit's accuracy in meters?
- How does that accuracy change as the GPS receiver acquires more

satellites and runs longer?
- Why does the accuracy change?
- How does your GPS unit's accuracy make this task a little hard to do?
- How were you able to determine the location of the point?
- What do we call this method?
- Compare what you've done to what GPS satellites do.

Part 2 - Constructing a Useful Map

While it may not be obvious, most of us live inside a coordinate system (the Chicago streets, of course!). But not every big city is laid out in such a convenient grid, nor are forests and rural areas. In fact the regular nature of the streets are a consequence of rebuilding the city after the Great Chicago Fire of 1871. In this lab we will construct a map of an area without a built in coordinate system like the north/south east/west streets of Chicago.

Goal:
To construct a useful map of the Yerkes grounds using the GPS receiver and the longitude/latitude coordinates of ~20 landmarks on the grounds. *You will need this map for a scavenger hunt later – so make it accurate!*

Materials:
- GPS unit
- giant graphing paper
- writing and drawing materials
- ruler

Procedure:
1. Building a list of coordinates: You must determine the coordinates of ~20 - 50 reference points/landmarks on the Yerkes grounds. Record a description of each point and its coordinates in your lab notebook. Sketch the landmark/point if appropriate or useful.
   (a) Get a list of mandatory locations from the instructors. Go to these locations on the grounds and record the latitude/longitude of the locations. These are the first points on your map.
   (b) Select your own additional landmarks/locations and record their latitude/longitude coordinates. Make sure to use easily identifiable points on the grounds. Record BOTH the landmark's coordinates and a small description. You will be using this list to create your map.
2. Making a Map: Now that you have a set of coordinates for different locations around the grounds, it's time to set them down on a map. We will all be making maps with the same size and scale on over-sized graph paper.
   (a) Draw a latitude and longitude grid on your paper using the map

boundaries defined by the instructors. This grid is your latitude/longitude coordinate system, and by overlaying different locations/latitudes at the correct locations on the grid you can produce a map.

(b) Place your locations at the appropriate points on the coordinate system grid. Be as artistically accurate as you wish, but don't waste too much time!

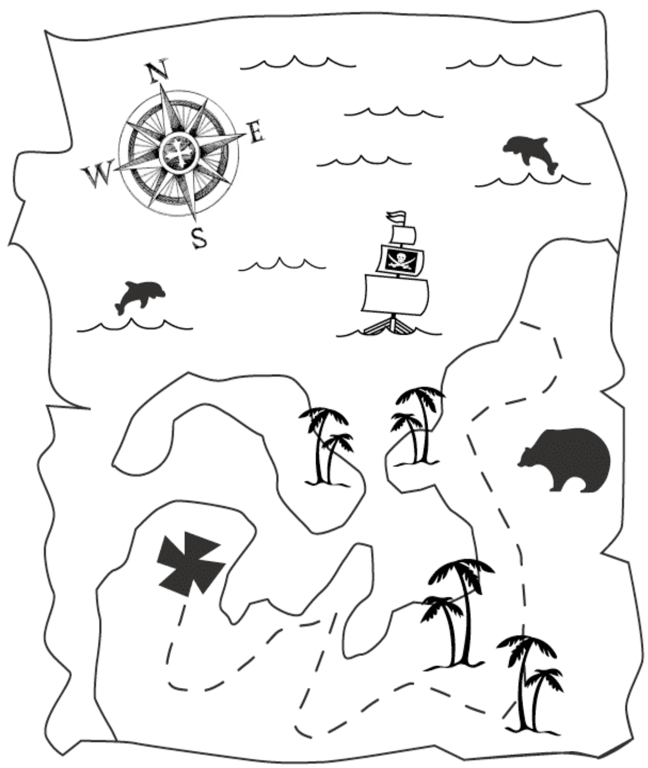
Part 3 - Using Your Map (and Winning)

Goal:
To use your map to locate a number of objects given their longitude/latitude coordinates.

Materials:

- Your map
- A list of coordinates from instructors

Procedure:
Now that you've spent a significant amount of time constructing your own map of the Yerkes grounds (using an accurate coordinate system and a large number of landmarks) let's put your hard work to use! Your instructors will hand you a list of longitude and latitude coordinates corresponding to the locations of small objects hidden in the grounds. No other information will be provided to you. Use your map to locate the objects, bearing in mind the inherent uncertainties in your previous measurements. Consult your fellow group members about efficient ways of locating the objects. Keep in mind: the team that locates the most objects wins a prize!



Remember: you will **NOT** *have the GPS for the scavenger hunt. You will need to rely solely on your map!*

BIG QUESTIONS:

1. Do you think you could get home from Yerkes alone? Describe how you would do it, providing both proper coordinates and directions of course! (Try to start at the Yerkes front door or the dorm down the hill, and then use your imagination to plot your course. You can use any form of transportation that comes to mind). Write down every step of the way. If you get on a bus, which one? Where do you get off? Now what?

2. GPS is a sophisticated system that has recently emerged to provide us with extremely precise navigation abilities, yet humans have navigated for thousands of years without GPS. Imagine you were lost in the woods. How might you track your position and move in the right direction without GPS? What if you were lost at sea? (Consider clues that are already presented to you by nature).

3. In early 1964 NASA initiated a Lunar Orbiter program. Over five years, five "Lunar Orbiters" were sent to photograph the surface of the moon and make a high-resolution map. This was done in preparation for the first human moon landing in 1969. Why do you think NASA needed to map the moon? How could you use photographs taken from a spacecraft to produce high-resolution maps of lunar topography (think about how you might determine elevations, etc.)? What if you were an explorer on a new planet and your job was to create usable maps for others to navigate by. How might you create such maps most efficiently?

4. You have decided that you want to leave behind a record of what life was like in 2007 for people alive one hundred years later in 2107. You fill a time capsule with ten emblematic, present-day objects and bury it in a safe, remote location in the woods. To make things fun for your great-great grandchildren, rather than simply providing a GPS coordinate, you decide to make a map of the time capsule's location. What information will you put on your map to be certain it can be found all those years later? Make sure to consider what sorts of things change and/or stay the same over that much time. Remember that buildings can be demolished, and trees uprooted, so they might not be good enough.