Lecture 4
First homework, and an introduction to uncertainty

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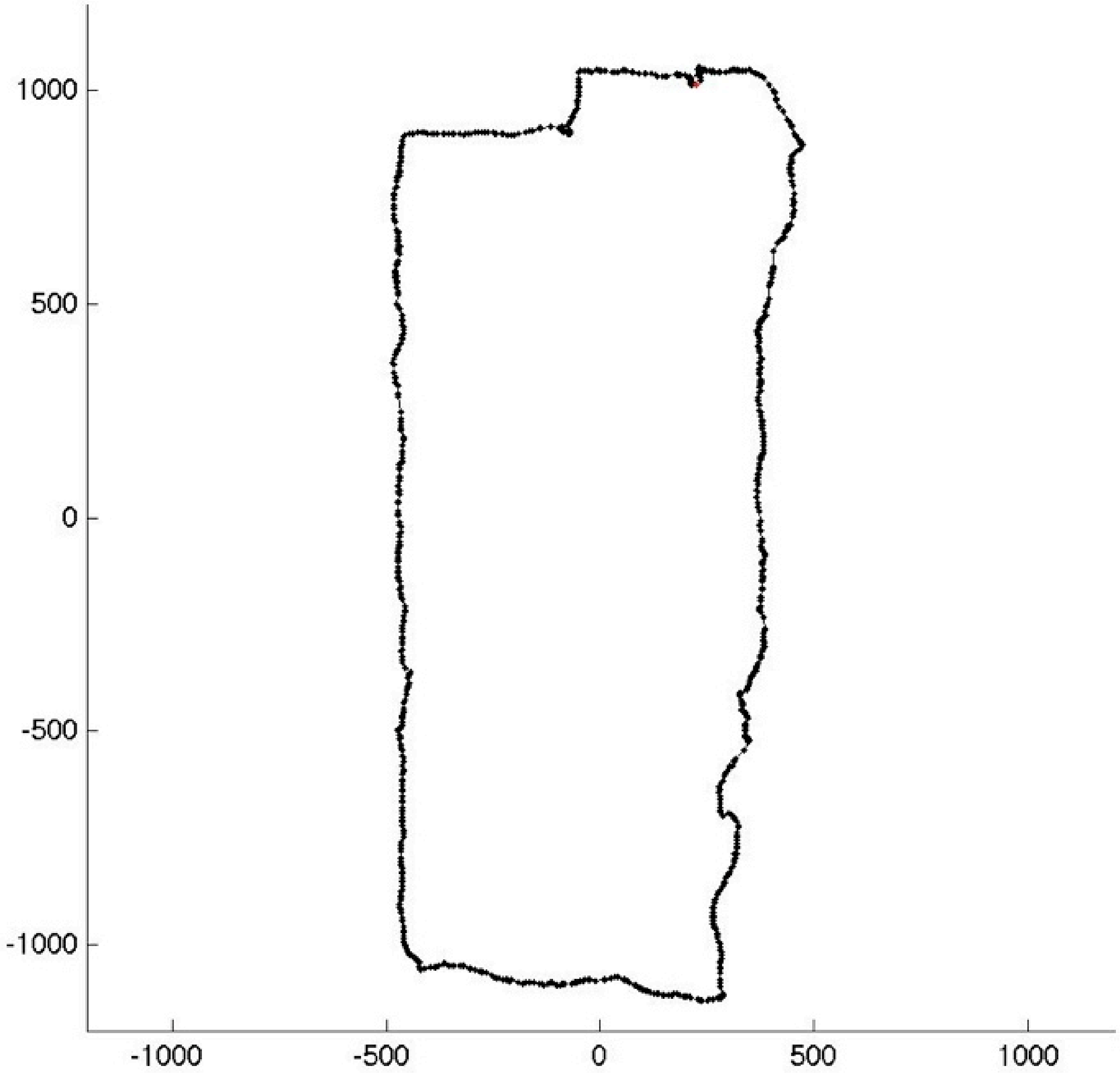
The first homework assignment has been posted

- Download it here.
- The idea is to use GPS data to display the user's position and path on a map of campus, as well as to show the total distance traveled (the length of the path).
- There will be a contest on Monday, October 1, at 5PM. The metric will be most accurately determining the total distance traveled. The winner gets a big prize.
- Submit your code, a brief summary of your solution approach, and logged data from the contest.
- There are a number of ways to make your implementation a lot cooler. Rotate the map as heading changes. Upload your location to a server. Test the accuracy of UIUC's campus map. Adaptively sample GPS position. Display names of nearby landmarks. Infer your mode of locomotion (walking, running, biking, in bus, in car) or your activity (in class, in transit, at lunch), and use this information to better filter the GPS data. Etc.

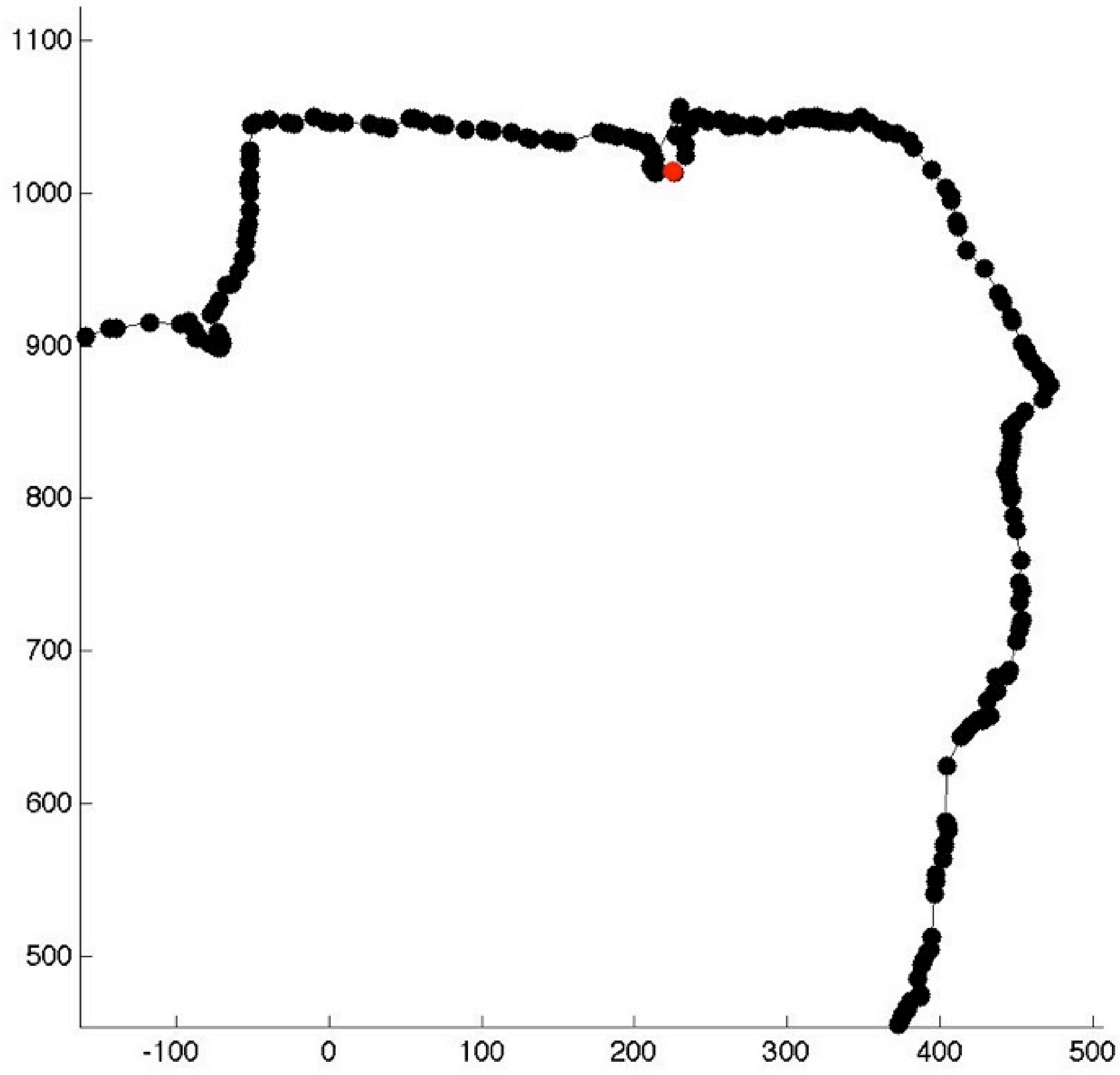
Alternative to the basic `positioning` module

- The positioning module in the PyS60 library is not very robust. In particular, it will often crash (and cause a kernel panic) if you exit Python while you are waiting for a position measurement.
- So as an alternative, we will use a third-party module, LocationRequestor. This module does not cause kernel panics. Moreover, it allows you to assign a callback to the GPS measurement, and gives you a bit more information about the satellites.
- Download a signed version of this module for your phone here. Refer to the documentation, which includes an example script, to see how this module is used (or come to office hours).

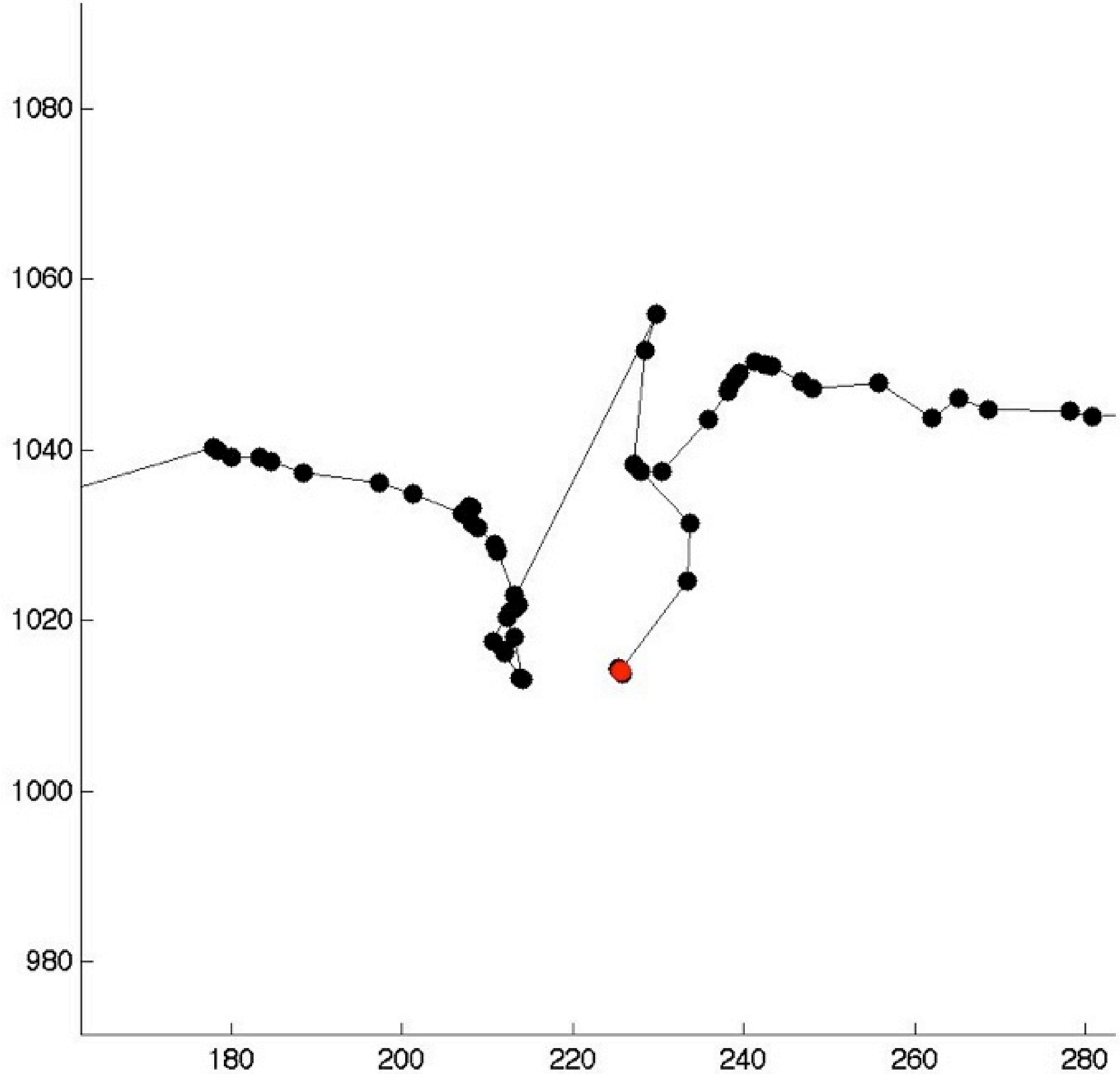
Example data (1)



Example data (2)



Example data (3)



What does the example data tell us?

- GPS data is noisy, not very accurate, and suffers from signal drop-out. We can fix this problem by using more information.
- One source of information is a dynamic model, that tells us how position (more generally, the state) should vary over time. For example, if we assume the position changes slowly over time, we might use a low-pass filter (a moving average). If we assume heading changes slowly, we might fit a spline to recorded position data. If we assume the receiver is a point mass, we might enforce a relationship between position, velocity, and acceleration.
- Another source of information is another sensor. Ask the user for their current mode of locomotion. Use GPS speed/heading (from a doppler shift measurement) as well as position. Use an accelerometer (a pedometer is a low-cost example), or more generally an inertial measurement unit (IMU).

Difference between GPS and an IMU (for example, an accelerometer)

- GPS provides absolute position measurements, whereas an IMU only provides relative measurements. So when you turn on a GPS receiver, it computes your latitude and longitude, but when you turn on an IMU, it always starts at the origin.
- GPS is drift-free, whereas an IMU accumulates error over time.
- However, an IMU is very accurate over short distances and provides measurements at a very high rate.
- So it is often a good idea to combine a GPS receiver with an IMU.

Incorporating this extra information

- So we know where to get more information (for example, from dynamic models and other sensors), but we still don't know how to incorporate this information.

- How would you combine the following two 1-D "GPS" measurements? The measurement uncertainty is clearly important.

    x=10m, accuracy=5m

    x=20m, accuracy=50m

- Often, it is also important to know if two sources of information are independent. Why is this the case?

Key idea

- Optimally incorporate new or different sources of information (and make optimal choices based on this information) using an explicit representation of uncertainty.