Developing Your Model and Creating Graphics

This document provides example code of a model used for a fitness tracker. Typically, the first step before developing the model would be to collect sensor data. Once you have data, you can develop a model to take this data and output the information that you want. For the purpose of this exercise, a dataset has already been provided for you that will be used in the model. We will now take you through an example of making a model to convert GPS data to steps taken.

Counting Steps

1. Preparing Data

To work with the data, we must first load it into the workspace and store the variables that are going to be used in this example. While we can double click on the data to load it, we will use the `load` command to make this process easier to replicate.

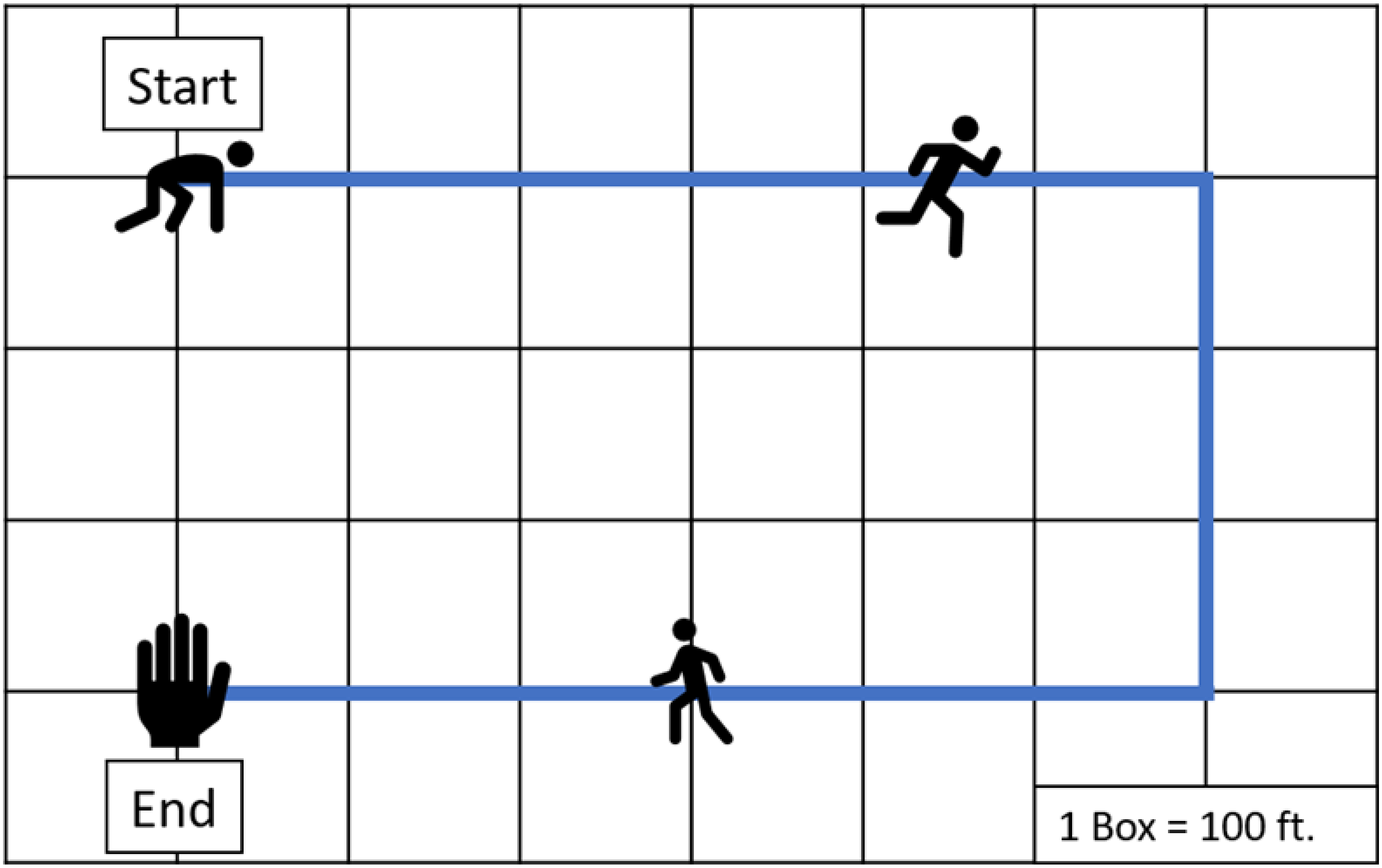
```
clear
load('ExampleData.mat');
lat=Position.latitude;
lon=Position.longitude;
positionDatetime=Position.Timestamp;

Xacc = Acceleration.X;
Yacc = Acceleration.Y;
Zacc = Acceleration.Z;
accelDatetime=Acceleration.Timestamp;

% We use the following to obtain linear time data in seconds from a datetime
array
positionTime=timeElapsed(positionDatetime);
accelTime=timeElapsed(accelDatetime);
```

2. Determining Approach Method

Let’s say that you wanted to track the number of steps taken. One way that this can be done is by calculating the total distance traveled and then dividing it by your stride length. This works because stride is the distance taken for one step so if we look at the units they cancel out as seen below.

$$\frac{\mathrm{totalDistance(ft)}}{\mathrm{stride}\left(\frac{\mathrm{ft}}{\mathrm{step}}\right)} = \frac{\mathrm{ft}}{\frac{\mathrm{ft}}{\mathrm{step}}} = \mathrm{ft} * \frac{\mathrm{step}}{\mathrm{ft}} = \mathrm{steps}$$

Now that we have an equation, the next step is to solve it in MATLAB. First, we need to get the total distance traveled, which is done using data from your GPS location or the latitude and longitude sensor data. One way that we can calculate this is by looking at your start location and end location and calculating the distance between those points. If we did that with the figure below, the distance traveled would be 300ft because the start and end position is 3 squares apart.



We can see that the person traveled much further than this, so we must calculate the distance along the path using **each data point**. Now we can accurately calculate that the person traveled 1500ft, which is a large difference from the 300ft originally calculated.

Once we have an accurate measure of distance, we can divide this by average stride length to calculate number of steps taken!

3. Coding The Model

In this example, latitude and longitude have been stored into variable names *lat* and *lon* respectively. The first step in using these to calculate distance is to declare a couple of variables: one will represent the circumference of the earth in miles, the other will represent the total distance traveled, which will be set to zero for now.

```
earthCirc = 24901;
totaldis = 0;
```

To solve this problem, calculations will have to be repeated several times in a loop. Because of this, we use a function called a `for loop` which will repeat a block of code *for* a specified number of times. In this case, we want to have it run until the end of our vector of data. The `length` command can be used to determine the number of elements in a vector and therefore how many times we need to run the loop. When solving for the difference in position, one position and the next position are used at the same time, so we need to stop one before the end of the vector as seen below. If this isn't done, we will get an error because we will be trying to acces data from outside of the vector.

```
for i = 1:(length(lat)-1)
```

Now we save the first position and the second position into variables. We will do this using the variable *i* from above. This variable is a vector from 1 to the end of our latitude vector which can be used to index the latitude and longitude vectors.

```
    lat1 = lat(i);      % The first latitude
    lat2 = lat(i+1);    % The second latitude
    lon1 = lon(i);      % The first longitude
    lon2 = lon(i+1);    % The second longitude
```

Thankfully for us, MATLAB has a command `distance` that calculates distance when given latitude and longitude. This will give us the difference in degrees which we will then turn into length by creating equivalent fractions:

$$\frac{\text{traveledDistance}}{\text{earth'sCircumference}} = \frac{\text{degreesTraveled}}{\text{earth'sDegrees}}$$

From this we solve for 'traveledDistance'. We will use 360 for 'earth’sDegrees' because that is the total number of degrees in a circle. While the earth is not a perfect circle, this will still be a good estimation

```
    degDis = distance(lat1, lon1, lat2, lon2);
    dis = (degDis/360)*earthCirc;
```

Now we add up the distance and store it into the *totaldis* variable. What this code will do is take the previous total distance and add the distance just calculated onto it. With this, we have calculated everything that we needed to within the for loop and must close the loop by using the `end` command.

```
    totaldis = totaldis + dis;
end
```

Once the for loop has finished, we will have the total distance traveled! From here, we need to divide the total distance traveled by the stride to get the steps taken. For this example, we will use the average stride of 2.5ft. Since *totaldis* is the total distance traveled in miles, we will have to convert this into feet before we can divide it by the stride.

```
stride = 2.5;                   % Average stride (ft)
totaldis_ft = totaldis*5280;    % Converting distance from miles to feet
steps = totaldis_ft/stride;
```

An easy way to see the data that you are interested in is by priniting it to the screen once you find it. While you could also show it by removing the semicolon, the `disp` command allows you to add text as well to specify exactly what data you are looking at.

```
disp(['The total distance traveled is: ', num2str(totaldis),' miles'])
```

```
The total distance traveled is: 0.4093 miles
```

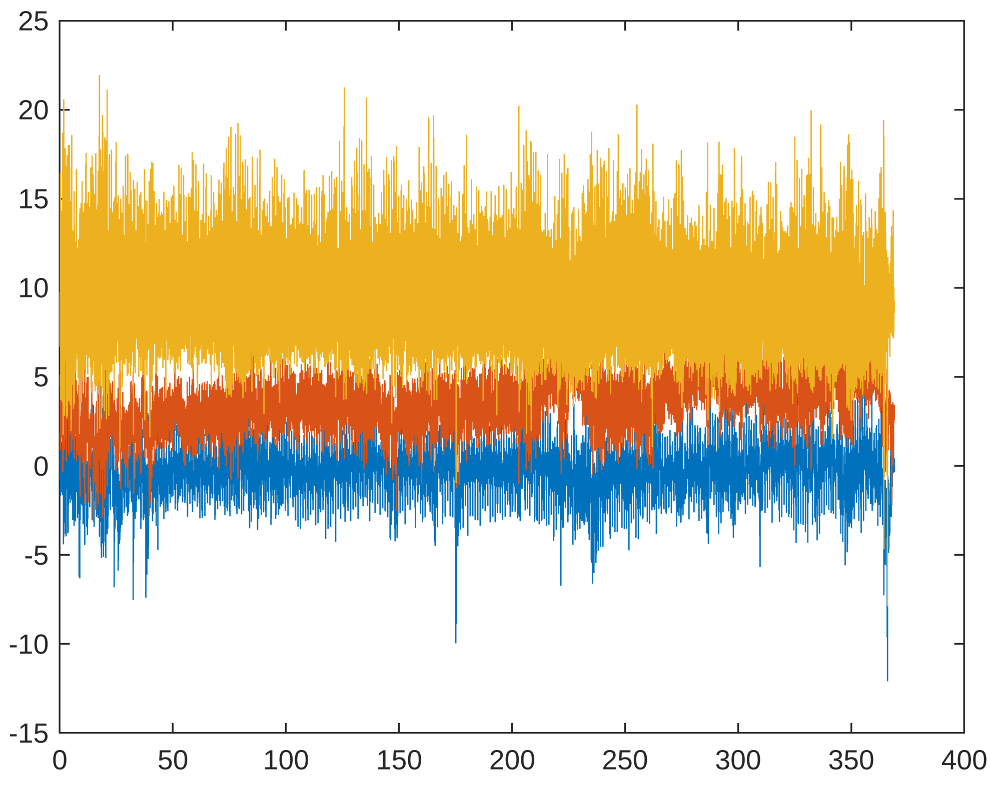
```
disp(['You took ', num2str(steps) ' steps'])
```

```
You took 864.4514 steps
```

Creating Graphics

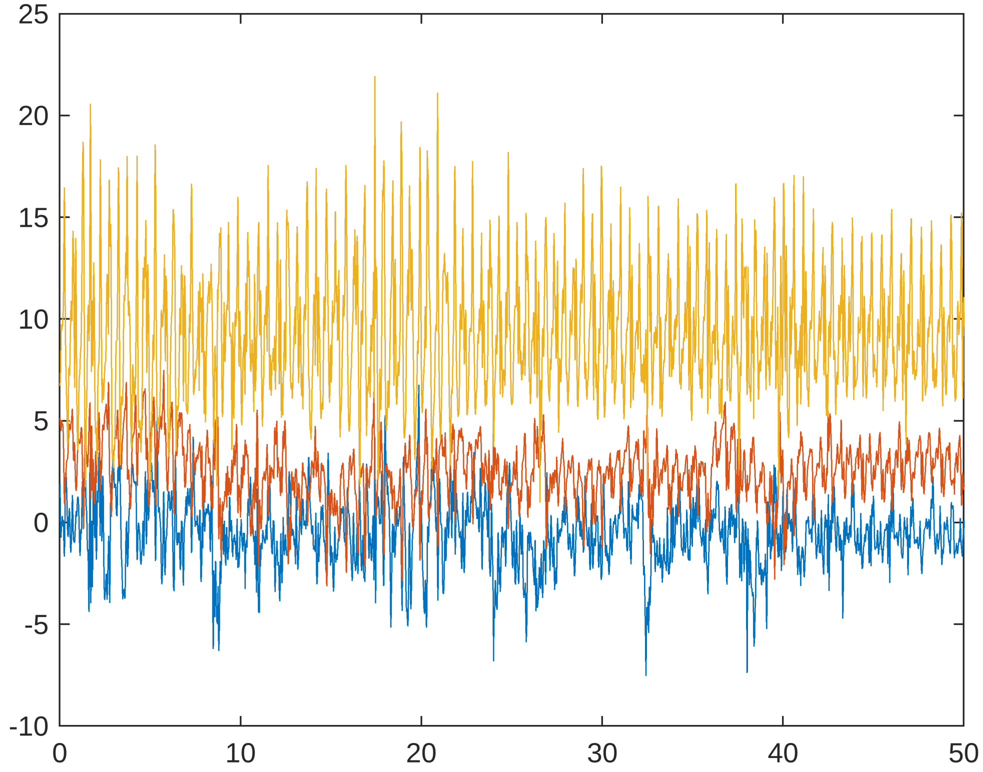
There are many ways in which you can visualize data in MATLAB. Say we wanted to graph the acceleration data that we took earlier to compare how the X, Y and Z data compare against one another. We can do this using the `plot` command. The only problem with this command is plotting multiple data on the same graph the code can be messy in one line. Because of this, we use the `hold on` command to plot multiple lines on the same graph. Don't forgot to also use `hold off` when you are done or else everything you plot will go on the same graph.

```
plot(accelTime,Xacc);
hold on;
plot(accelTime,Yacc);
plot(accelTime,Zacc);
hold off
```



In the graph we just made it is very difficult to differentiate between the lines because there is so much data being graphed in such a small window. We will want to zoom in on the graph in order to see any trends between the different data lines. To do this, we set a limit on the x axis usng `xlim` so that we can look at the first 50 seconds of data.

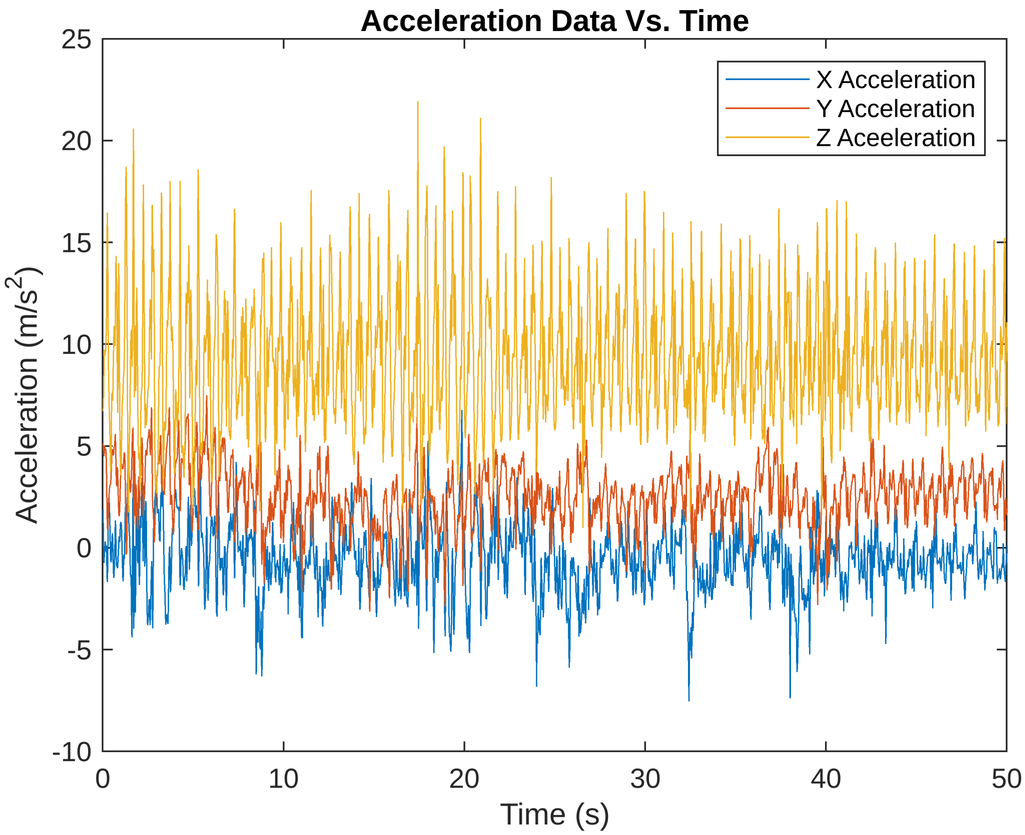
```
plot(accelTime,Xacc);
hold on;
plot(accelTime,Yacc);
plot(accelTime,Zacc);
xlim([0 50])
hold off
```



While this isn't the prettiest graph, it still gives a better idea as to what each data line looks like. Now we need to add labels onto the graph so that we may know which line corresponds to which set of data. We will also want to add a title and labels onto this graph so that someone who doesn't know what this data is can read the graph without looking at the code.

```
plot(accelTime,Xacc);
hold on;
plot(accelTime,Yacc);
plot(accelTime,Zacc);
xlim([0 50])
legend('X Acceleration','Y Acceleration','Z Aceeleration');
xlabel('Time (s)')
ylabel('Acceleration (m/s^2)');
title('Acceleration Data Vs. Time');
```

```
hold off
```



With this, we now have a meaningful graph! There are many other properties that we can add and edit on this graph depending on the kind of information we want to display. One important tool when it comes to graphing is called the `LineSpec` or line specification, which allows us to edit the properties of the graph. To learn about the many customization options available when plotting, check out the `plot` documentation page!

Check out this documentation page to learn more about other plotting options available!