Lab 7 - Motion Tracking

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FUNCTIONALITY

This program handles a recorded list of data obtained from a gyroscope and an accelerometer. It uses this data to classify different periods of motion across time given a desired threshold to determine whether or not the iphone is experiencing motion. 6 axes of motion are read in from a text file. To first determine whether or not the iphone is in motion, the variance of the data is taken at varying segments across each data column. I choose a window size of 5 to segment the data evenly, however the program can handle any change in window size quickly; this was intended to help with reducing the overall amount of error with testing at various other window sizes. The variance is calculated and stored for each window for every axis (6). These variances are then thresholded to determine whether or not a period of motion is indeed detected. Figures 1 and 2 graphs are created (of each calculated variance) to determine an appropriate threshold for the variances so that I can pick out distinct periods of motion. A threshold of 0.001 is chosen for the acceleration variance and a threshold value of 0.01 is chosen for the gyroscope variance, however I later found that the gyroscope threshold seemed to dominate motion detected regardless of the acceleration threshold.

The motion tracking begins once one of the variances (of a given sample period five samples large) crosses its respective threshold, then every consecutive variance and threshold is accounted for until none of the variances pass the threshold anymore. All of the consecutive periods of variance found to be above the threshold are grouped together and the overall distance and angular motion traveled is found.

The angular motion is found by singly integrating the provided gyroscope data. To mimic true integration, a Riemann sum is found for each window. Each sample (e.g. 5 samples) is multiplied by the time difference between each sample taken (0.05 seconds). The result is added to itself (maintaining a running sum) for each value in a given window. This provides an overall net radian movement in a given window, and every net radian movement is added to itself until no more motion is detected. These values are converted to degrees and printed in the last three columns shown in Table 1.

The displacement during a period of motion for each X, Y, and Z axis is found by doubly integrating the acceleration. First velocity is found by integrating the acceleration against the time between each sample. This is also multiplied by a factor of 9.8 m/s^2 to convert from units of gravities to m/s in velocity. I also subtracted the beginning of each windows’ acceleration from the currently selected acceleration to calculate. Once the velocities are found, the first and last velocity of a given window are averaged to find the average velocity of a given window. This average velocity is multiplied by the time period for each window to find the distance traveled for that given window (i.e. with a window of five, this would exhibit a time period of 0.25). The distances for X, Y, and Z are summed until no more motion is detected and printed out alongside the pitch, yaw, and roll in Table 1. The cumulatives sums of motion for each axis are then printed out at the end of a detected period of motion.

DISCUSSION OF RESULTS

The results of the gyroscope cumulative angular motions display good guesstimates as to what occurred at that time period. Looking at the graph of gyroscope data in Figure 2, the table in Table 1 displays a proportional relationship to angular motion for the last 6 detected periods of motion. Figure 2 shows (at T= 30 and 38 seconds) two peak yaw axis movements. Table 1 shows the cumulative motion for each period, linear and angular. At a time of T = 33s (recorded as the ending time of a detected period of motion) a yaw movement of 90 degrees is calculated. The next peak in the yaw axis (T = 38 seconds) is shown to be a movement of -90 degrees in Table 1 at a T = 39s. The succeeding double pitch and double roll bumps in Figure 2 (at a T > 40s) are also reflected in the overall angular motion measurements in Table 1. The last two periods of detected motion in Figure 2 follow the ~90 degree roll and -90 degrees roll back shown in Table 1 under a T = 55s and T = 60s. The preceding two periods before the roll observe the same pattern for the pitch axis, and that measurement is also shown in Table 1 for a time of T = 45s and 50s.

It can be seen that detection of angular motion produces significantly less error than does calculating linear motion given acceleration. Assuming that integrating once may cause a slight margin of drift, then double integrating will only amplify that drift (making it much worse). Table 1 shows the cumulative distance traveled for each period of motion on each axis in terms of millimeters. The acceleration samples are doubly integrated, and for the most part causes a large enough amount of drift to render the data almost entirely useless. Comparing Table 1's X, Y, and Z data columns with respective times to Figure 1, we can still pinpoint out moments in time that line up with the peak variances for the linear axes. For example, at a T = 55, we can note that X and Z both exhibit almost an equal amount of distance traveled at the time of our roll. Once the phone rolls back, X and Z then return to their previous position; having a cumulative distance that relatively negates the distance traveled in the previous period of motion recorded (when rolling forward 90 degrees). When the pitch movement occurs, we notice an inversely proportional relationship between the Y and Z distances traveled. This distance traveled is also backed by having two variance peaks for Y and Z at the pitching time, T = 45s and 50s in Figure 1.

However, since linear motion must be calculated via a double integral instead of a single integral, we notice a lot more noise amongst the column of distances traveled as opposed to the angular motion traveled. I also noticed that, when altering window sizes, the cumulative distance shown for the typical periods of motion I found seemed to proportionally increase or decrease depending on the size of window (this was not the case for the gyroscope data). For instance, I chose a window size of 5 to represent and graph the data shown below. However, when a window size of 10 is chosen, then the distances traveled in Table 1 for each linear axis roughly doubled (proportional to the increase in the window size). In general, it can be said that accelerometers are not very accurate in terms of measuring distances traveled, and instead something along the lines of a linear actuator will be more accurate.

DATA TABLES AND FIGURES

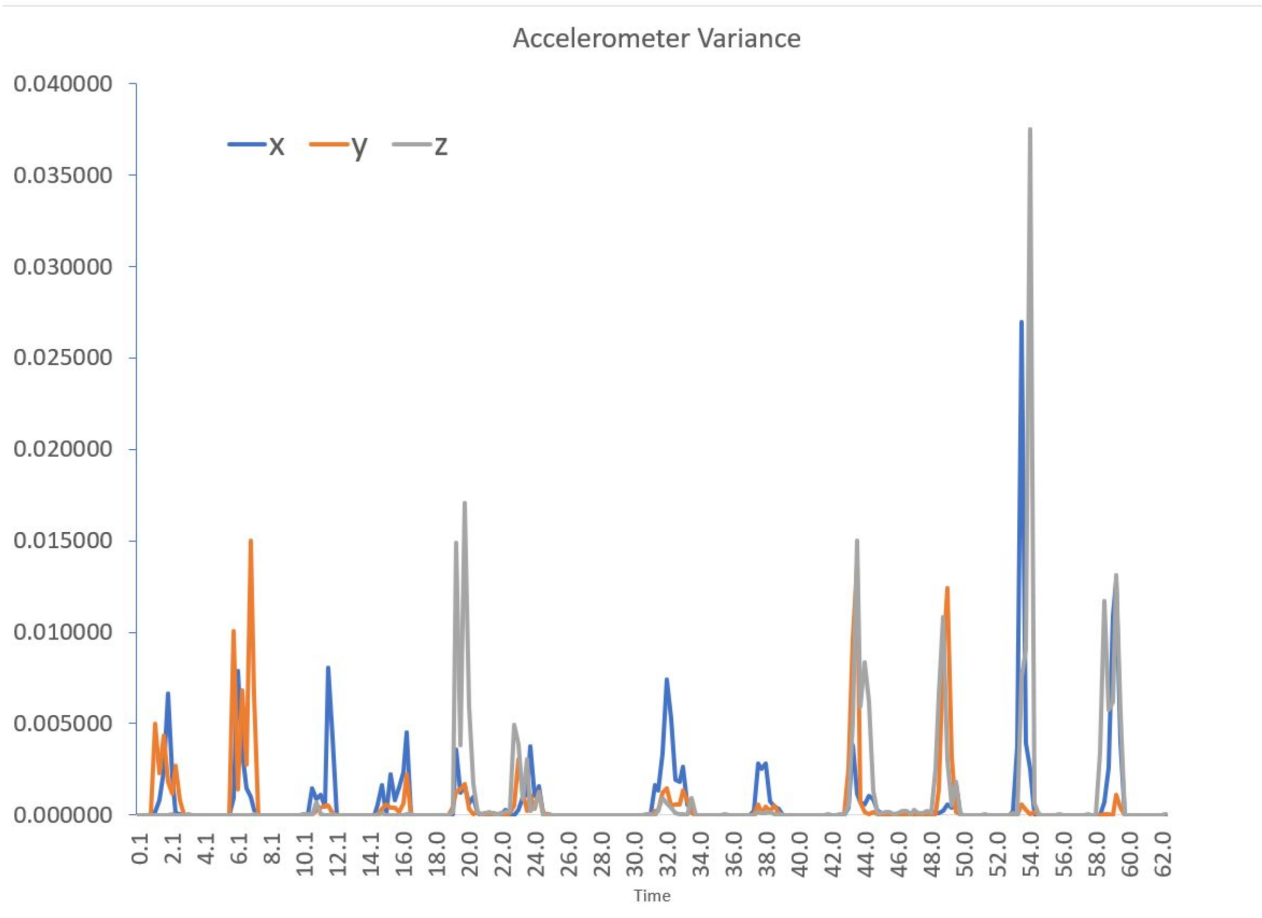

Figure 1: Graph of Accelerometer Variances (window of 5)

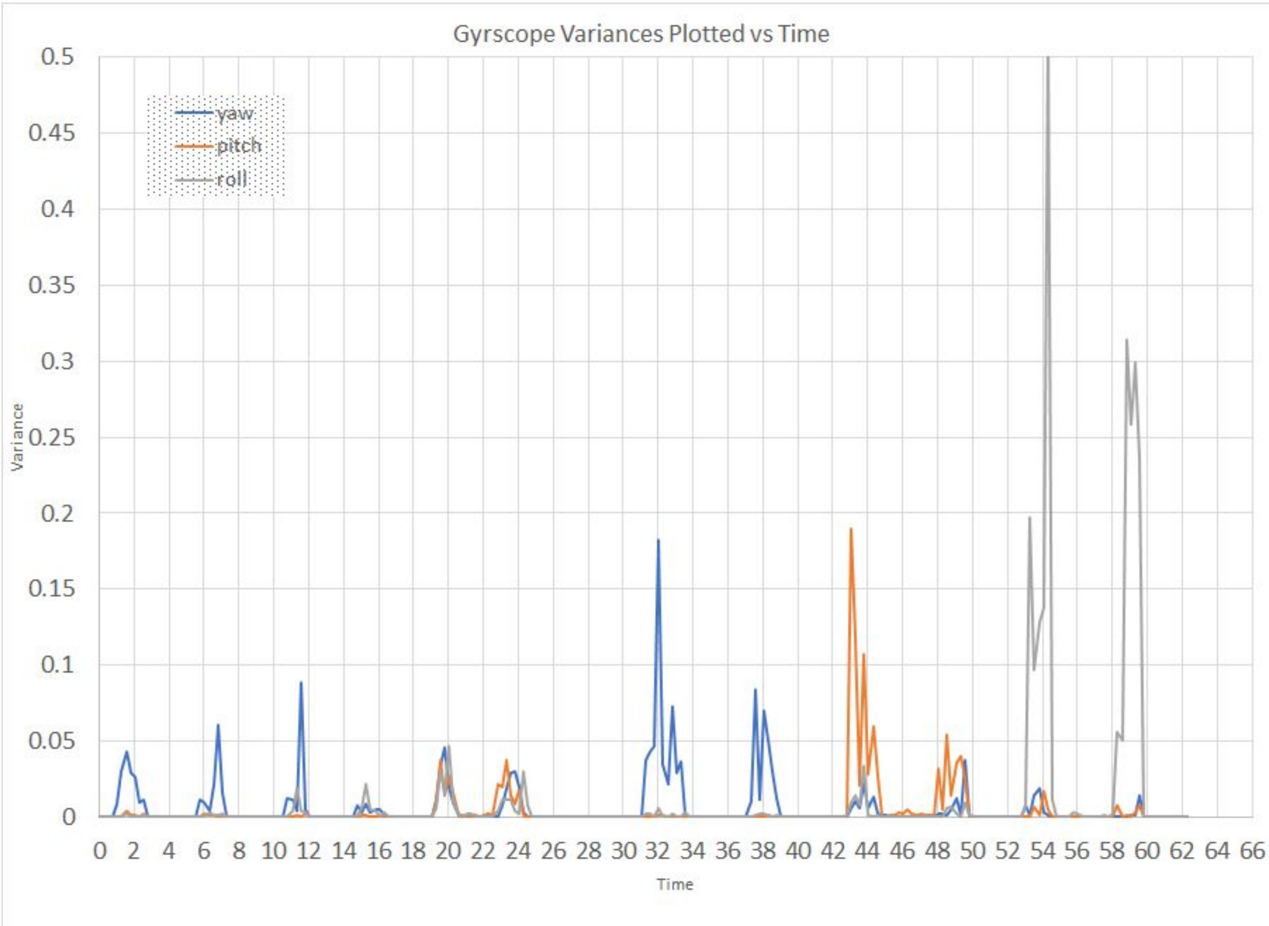

Figure 2: Graph of gyroscope variances (window of 5)

Count	Time Detected	X	Y	Z	Pitch	Yaw	Roll
1	2.80	9.013130	-13.477593	-0.487431	-1.081165	-1.414456	-0.569297
2	7.30	10.771978	-25.487310	2.565305	0.147555	1.243428	-1.310938
3	12.05	-1.117057	1.406139	4.142650	-0.195437	-1.511160	-0.737510
4	15.05	-4.644092	2.770180	-0.200212	-0.180054	-1.069355	0.233151
5	15.55	1.367781	2.066640	0.127235	-0.180718	0.631749	-0.326804
6	16.55	-5.968837	-3.750638	-1.429531	0.108624	0.167693	-1.027150
7	20.55	-5.052000	5.243783	6.141903	9.742957	-4.380013	5.833568
8	24.55	-23.932413	28.350107	0.701784	-9.872066	3.338743	-9.615731
9	33.55	-42.283318	18.829905	3.861921	2.629681	89.461250	0.045555
10	39.05	-9.153464	8.065416	-3.403507	-0.209510	-88.145409	-0.169862
11	44.80	-6.092330	-93.428192	97.025429	91.219490	-3.993823	-4.546361
12	49.80	0.533266	95.987915	-89.630760	-90.103561	2.994999	2.637384
13	54.80	97.088066	3.244504	119.906296	0.080634	-3.196188	94.853294
14	59.80	-86.646332	1.625059	-105.124504	-2.193380	2.716893	-91.527176

Table 1: Table of motion across 6 axes for each period of detected motion