Report for Project in EE327

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1 Introduction

Pedometer is a measuring instrument for recording the number of steps taken in walking.And it plays an important part in our indoor localization system.

2 Project Purpose

1. By programming we learn to familiarize the calling methods of mobile platform sensors.
2. Do the analysis of the result and improve the accuracy of the whole system.

3 Possible future work after this project

1. Use the gyroscope to measure the pattern of the person in the X, Y and Z axis directions and the scalar value of the sensor.
2. Display the results more beautifully on the screen.
3. Do the research when the phone is put in the pocket.

4 Main Method

Since I am responsible for the pedometer part in the indoor localization, and our group member are Han Yutong, Xing Yucheng and me. So in this lab, I will perform more than the requirement. And the code is mainly made by Han Yutong, I do the theory analysis part and filtering design part in this job.

There are many mobile step-counting methods but the best method is not found yet.

A typical acceleration scalar graph is showned below.

Self-designed methods are encouraged in this step and the display of the results on the screen in real time is required.

We can use the threshold filtering method. When the acceleration is higher or lower than the threshold, we can treat it as a step's beginning or ending. We also need to consider the waveform and the acceleration of walking is not a simple single-peak waveform.

We first use the Kalman Filter but it does not work very efficiently and correctly, so we just modify it to the simple LPF, and luckily , it works well.

```
public void onSensorChanged(SensorEvent event) {
  String message = new String();
  if (event.sensor.getType() == Sensor.TYPE_ACCELEROMETER) {
```

```
    float X = event.values[0];
    float Y = event.values[1];
    float Z = event.values[2];

    // Low-Pass Filter
    lowX = X * FILTERING_VALUE + lowX * (1.0f - FILTERING_VALUE);
    lowY = Y * FILTERING_VALUE + lowY * (1.0f - FILTERING_VALUE);
    lowZ = Z * FILTERING_VALUE + lowZ * (1.0f - FILTERING_VALUE);
  }
}
```

5 Analysis Part (Main Part in Our Lab)

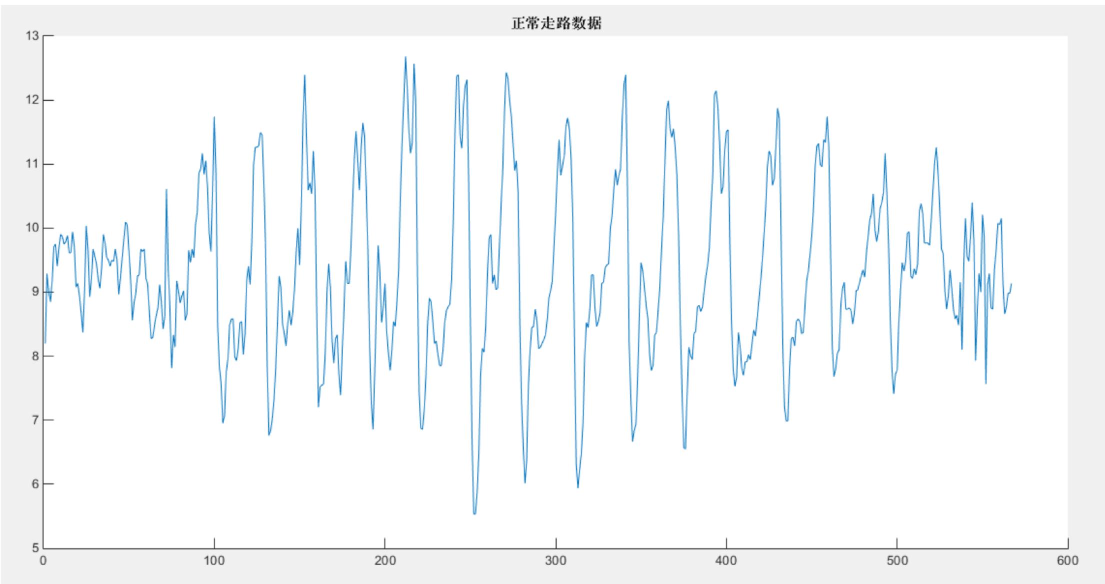
So I will focus on my analysis point:

We just combine the three methods to do the localization, the first one very simple the accelerator sensor, next one gyroscope the last one the earth magnetic field.

Basically, we use the earth magnetic field method to locate the first position of your spot, which means the origin location. Then we use the gyroscope to do the direction detect, finally we use the quadratic deviation algorithm to do the analysis, and we just lock the Z-axis sensor when some situation meets.

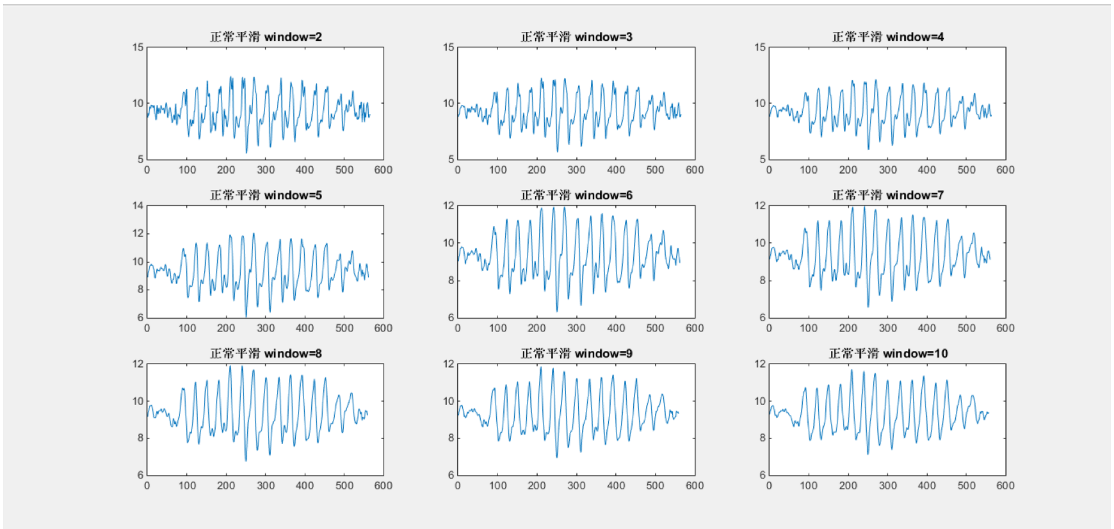
Previously, indoor positioning sensor group completed a preliminary analysis of data collected mainly by normal walk and two cases of jitter components. In the analysis phase, we mainly collected data after some processing carried out in the time domain using MATLAB to draw the corresponding acceleration of time-domain diagram analysis and intuition.

The first is the case of a normal walking:



For general Android pedometer, are relying on the use of algorithms to detect the peak achieved, however, by drawing a time-domain diagram can be found, there will still be some unnecessary slight jitter in normal human walk, although our algorithm has set up a certain threshold, but it will still affect the accuracy of the algorithm to a certain extent. The purpose of our analysis is, to a certain process to eliminate these jitter.

Our first thought was to set up a sliding window of data smoothing, by trying different length of the sliding window in the time domain to obtain the following diagram:

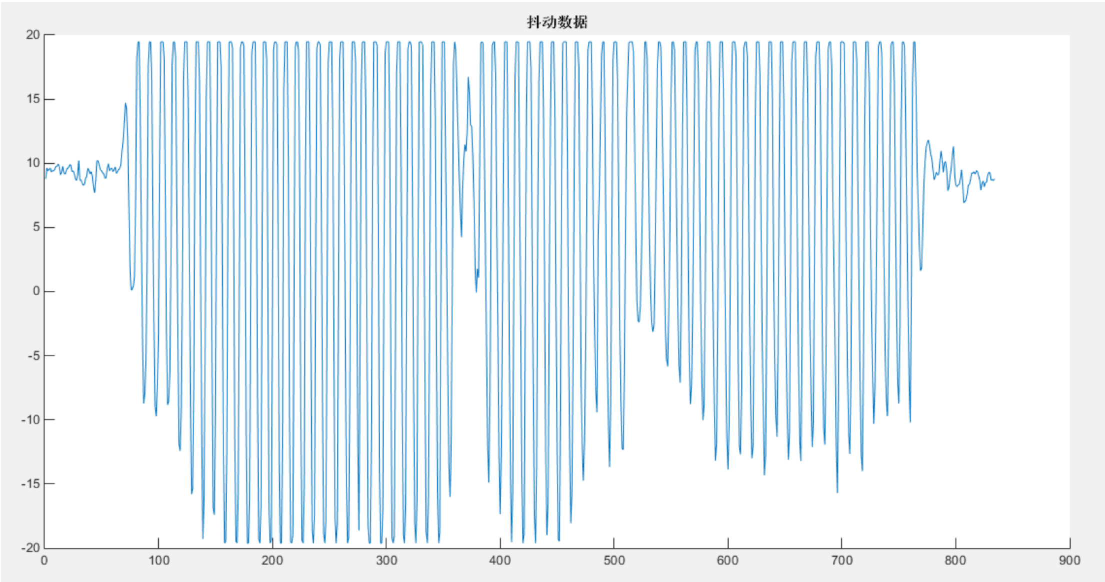


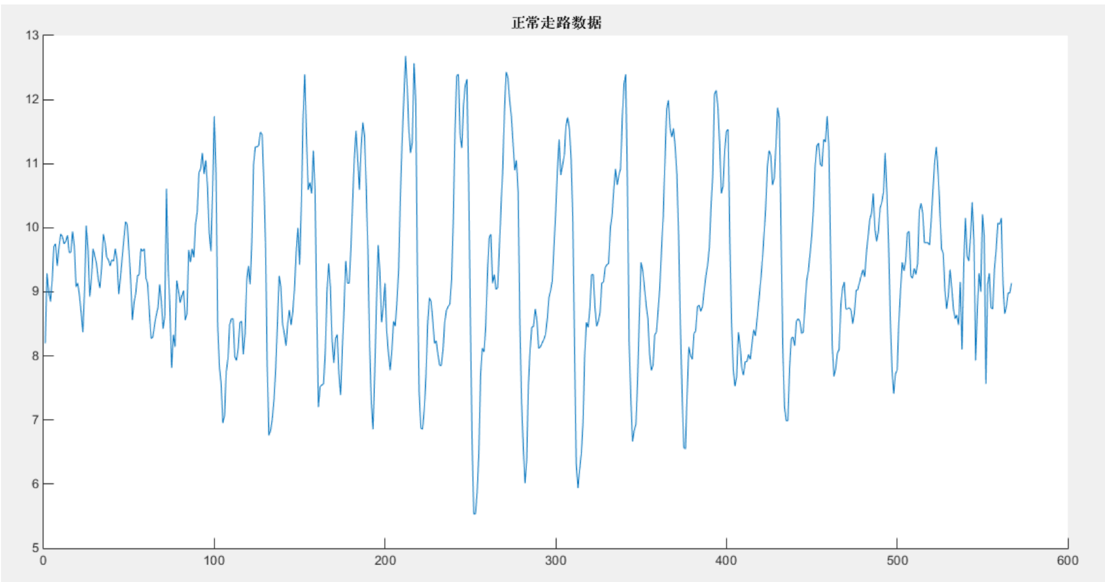
Basically when the window at 4:00 has been able to get a relatively good results.

Of course, we an also set the sampling time on the threshold to filter out unnecessary data (i.e. unnecessary jitter). However, select the time threshold is quite dependent on the frequency step size of. To achieve this goal, we have two kinds of snyc by measuring the frequency of data, you can better set this time threshold. Follow-up work or to consider more cases, in order to obtain better results.

For peak detection by searching, I see someone proposes a new method, the waveform and the stock market when walking similarity, combined with the stock k-line technology to analyze, above the average may be the peak, below the average may be trough. Every 50ms acceleration take a simple poing as a trading: If two consecutive trading days remain above the moving average, the upward trend established, it may be the peak; if two consecutive days maintained below the moving average, the downward trend established, may It is a trough. Although not yet know how to effect, but the authors provide a new way of thinking.

In addition, we also collect and draw the acceleration sensor domain dither state:


抖动数据
20
15
10
5
0
-5
-10
-15
-20
0
100
200
300
400
500
600
700
800
900


正常走路数据
13
12
11
10
9
8
7
6
5
0
100
200
300
400
500
600

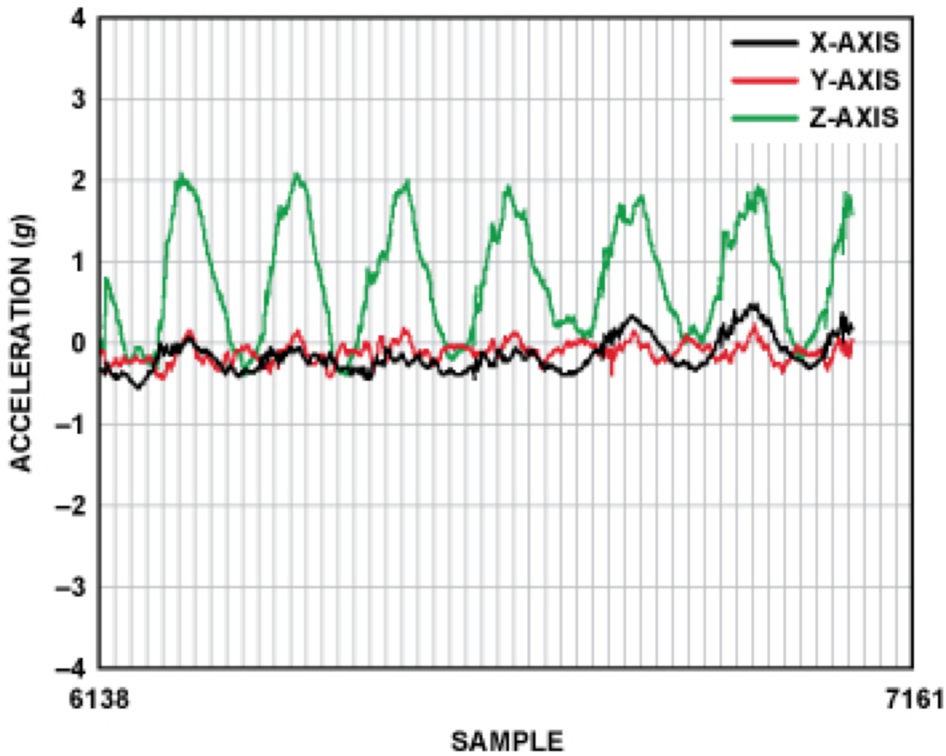
For ease of comparison we again list the time-domain diagram in the normal state:

By comparison difficult to find, although both the acceleration in the initial state are around 10, approximately gravitational acceleration, but acceleration in the normal walking state is not particularly large, presenting substantially symmetrically to the axis 10; in contrast, in the state of dithering, great acceleration values that exceed the scope of our testing of the sensor, the result is the entire time-domain diagram fills range $[-20, 20]$.

Of course, the general situation is more complicated, shaking the phone when the frequency, different amplitudes, normal walking stride frequency and stride are different, it still has a chance to confusion, visual analysis may not distinguish, so it needs a more systematic analysis of the follow-up means.

After the work is to explore the different major step counting algorihtm, now only statistical algorithm Z-axis acceleration sensor changes by exploring the next three-axis accelerometer, with reference to some relevant literature, completing optimization.

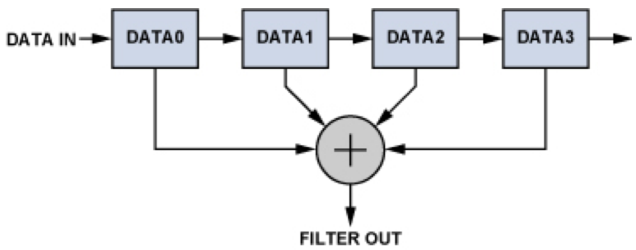
Since we are not actually related triaxial measurement data obtained from the literature in brisk walking, it tends to produce the following acceleration values.



A cursory look almost as if x and y axes have little impact (i.e. relatively flat irregularities) on the final results, but only a three-axis algorithm compared to the z-axis view with the elimination of jitter on the natural superiority. Because we tend to short-range accurate pedometer, compared to the traditional sense of what is considered long distance pedometer has a smaller sliding window requirements and smaller error tolerances. Therefore, we consider that if the wanton jitter, the data will become more than just the Z axis varies greatly irregularity, the x-axis and y-axis and also will become so, this will run and walk normally when the x-axis and y-axis data make a big difference! This feature is the use of the reverse, we can rely on the x-axis and y-axis data to determine non-normal times is not to enter a new pedometer or a meaningless jitter.

In order to facilitate data analysis or data to the two columns and then listed, found that the jitter data fluctuations, fluctuations anxious, imagine if the three axes of acceleration is such, we will get what? We can use three squares and as a filter condition, we can see, at the time just walking and running, x-axis and y-axis is very gentle, but when the three-axes will shake violently up.

So the use of $\lambda = x^2 + y^2 + z^2$ will be better monitor human walking pattern, which can be made into paper filter design reference. Digital filter: First, the signal waveform becomes smooth, requires a digital filter. You can use the four registers and a summing unit, as shown below. Of course, you can use more registers to make the acceleration data smoother, but the response time will be slower. (What we come to effect smooth Baqun four windows from the data, but also derive support this theory).

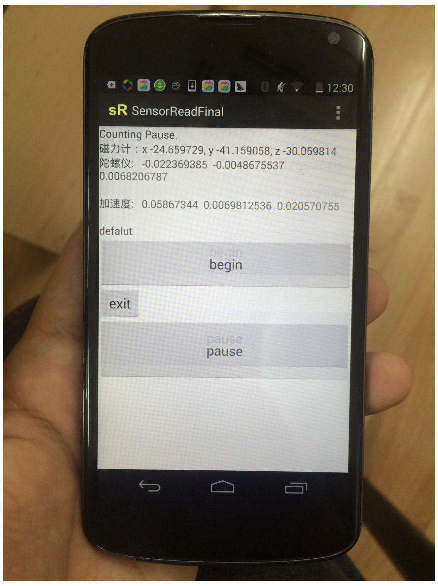


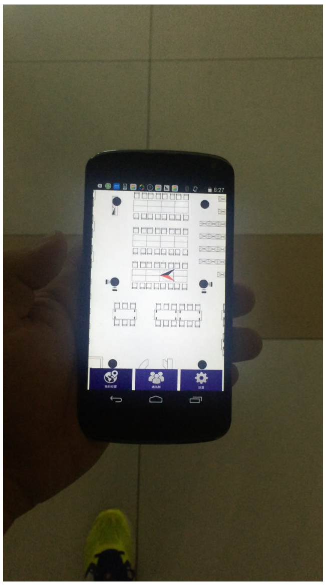
Step counter use this algorithm can work well, but sometimes it seems to sensitive. When the pedometer reasons rather than walking or running very fast or very slow vibration, the step counter will think it is the space. To find the real rhythmic pace, we must exclude such invalid vibration. The use of "time window" and the "counting rules" can solve this problem.

Wherein the time window is what we call the threshold and the front of the report has been given a general narrative, counting rules means:

Pedometer algorihtm acclaimed fitbit adoption is not a step on the increase. But first a few steps away when the judge what pattern, if it is jitter, discarded, is walking, first endured, into the cache, and other conditions are met smoothing mode, enter it, then enter the smooth made step-plus-one. Unfortunately, however, our pedometer algorithm does not support this pattern, because we are in the library, no conditions have been found to enter the smooth mode destination, the number of steps for detecting such a short distance from the small, we also need to further to discover its good way.

6 Result Showing Part





7 Possible Questions

1. Why we need low pass filtering ?

   Solution. Because we can find the meaningless vibration, which means we can tell the difference between them. □

2. What are the differences made by the filtering? Make a contrast.

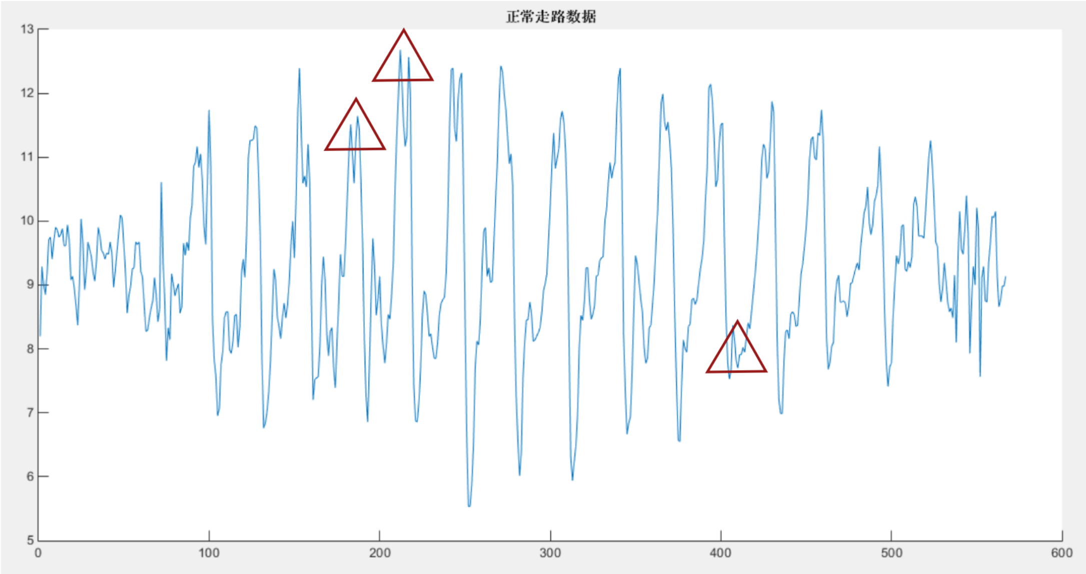
   Solution. Kalman Filtering does not work, because the former position is not accurate, and the former position is not the key part in this work. □

3. Can we estimate the stride length using the acceleration oscillogram?

   Solution. Yes, but you should do the filtering (sliding window filtering). □

4. What's the meaning of your work?

   Solution. Pedometer is a measuring instrument for recording the number of steps taken in walking.And it plays an important part in our indoor localization system. □



8 Conclusion

In this project, we did some job in the indoor localization work in System Group, and thanks a lot to Han Yutong to write the code, I can do the extra analysis part in the pattern of the person walking, which is the bonus part in this experiment. And during this time, I spend more than 3 times to the code time to read the paper and do our experiment like filtering job.