Report for Test Case #5

Objective

To implement a classifier for phone placement recognition using mobile phone sensor.

Dataset

15 datasets combining 5 different phone states are shown in figure 1. Each dataset contains three types of measurements: the accelerometer, gyroscope, and gravity, respectively. In addition, the data-hand-landscape-2 dataset also contains magnetometer and barometer values that are not recorded in the test datasets. Therefore, these two values are removed before the feature extraction.

Figure 1

Methodology

Figure 2 gives the overall framework of phone placement recognition method.

Preprocessing

The first step is preprocessing of data, including magnitude merge and noise filtering. The three-dimensional input signals (X, Y, Z) was first merged into one acceleration magnitude by taking the Euclidean magnitude of the three individual values. The aim of magnitude merge is to simplify the compute of following feature extraction process. The next step is the smoothing of input signal. A local window with a size of 5 rows are processed through the dataset, and the smoothing type is averaging. In other words, the smoothing algorithm calculates every point to be the average of itself and four nearest neighbors: the two points before and two points after.

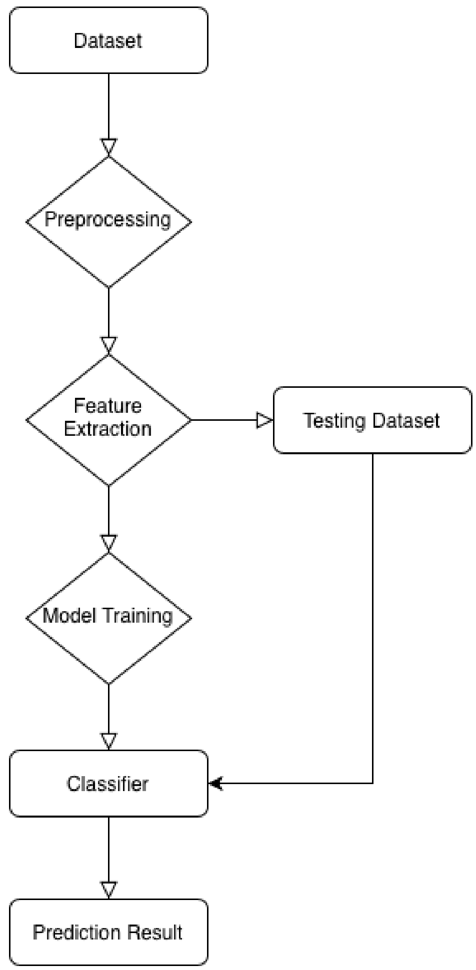

Figure 2

Feature Extraction

10 features are extracted from the dataset using sample window of 256 samples with 50% overlap. Since the accelerometer measurement in the dataset included gravity already, the gravity value can be ignored in this method (Zeng et al., 2015). From both magnitude of acceleration (accelerometer) and rotational information (gyroscope), the following features are extracted from the merged signals, resulting in total of 10 features:

- Mean: the average value of the magnitude samples over a time window.
- Standard deviation (std): the average of the squared differences of the sample values from the mean value over a time window.
- Root mean square (rms): the root mean square is the square root of the sums of each datum over a window, divided by the sample size.

- Absolute difference (dif): the differences between the max and min of magnitude sample
- Energy Signal: the frequency domain energy extracted by using Short Time Fourier Tranasform.

Model Training

Random forests algorithm is used to classify the data in five different phone states: ear, hand landscape, hand portrait, hand swinging, and pocket. Random forests is a supervised learning algorithm. It is the most flexible and easy to use algorithm. Random forests create decision trees on randomly selected data samples, gets prediction from each tree and selects the best solution by means of voting. In this method, the random forest classifier from scikit-learn package in Python is implemented. The parameter n_estimators is set to 100, which means that 100 trees is used in the forest.

Result and Discussion

The result of test dataset prediction is saved in the result.csv. The .csv file has two columns: the *time (ms)* column showing the timestamp in ms and the *label* column showing the phone placement.
Since the volumn of data is limited, all the 15 dataset are used to train the classifier. It is recommended to split the dataset into training data and testing data, so the model performance can be presented by applying on testing data. Also, the extraction features can be various based on the placement types. Only 5 features are used in this implementation, while features such as zero-crossing rate, first 5-ft coefficient, percentiles and log energy can be used in the future for better classification performance. Besides random forest classifier, other classifiers such as SVM, MLP, J48 and KNN classifier, or deep learning methods can be utilized and compared to reach higher classification accuracy.

References

Zeng, Q., Zhou, B., Jing, C., Kim, N., & Kim, Y. (2015). A novel step counting algorithm based on acceleration and gravity sensors of a smart-phone. *International Journal of Smart Home*, *9*(4), 211-224.