Project W13: Telehealth - Fall Detection

(Due 06/05/2022, 17:00)

Instructions:

1. Prepare a single PDF report that describes your analyses/results and presents your source code in an Appendix.
2. The report should be typeset, and text/code should be selectable (i.e. no scanned/screen-captured text or code).
3. Show all the steps of your work clearly: unclear presentation or unjustified answers will be penalized.
4. Use Matlab/Python for data analysis, and prepare a single (.m/.py) code file.
5. Code should be commented, code for different parts should be clearly separated.
6. Codes that return an error during runtime will NOT be evaluated.
7. Upload both the PDF report and the code file onto Moodle through the alloted links.

Parts	Points	Your Score
Part A	40	
Part B	60	
TOTAL	100	

Assignment

The World Health Organization (WHO) defines falls as involuntary events resulting in an individual coming to rest at a lower level after initial impact. Falls pose a public health threat across proad populations including the elderly, children, disabled individuals and patients with orthopedic or neurological disorders. While external factors that raise potential for falls might be controlled, it is often impossible to eliminate the intrinsic physiological factors. As such, there is a pressing need for technology that reliably detects falls in real time to minimize occurence of related injuries and healthcare costs. Wearable sensors offer a promising avenue in this regard by allowing unrestricted wireless monitoring of subject movements.

In this assignment, you will be analyzing wearable-sensor data from a group of subjects performing either a fall action (F) or non-fall action (NF; i.e. basic motor activities of daily living such as walking, standing, ascending, descending). Wearable-sensor data are provided in the file `falldetection_dataset.csv`, which contains 566 samples of motor actions along with respective action labels ('F' or 'NF') presented as rows. The 306 features from the sensors that reflect various properties including velocity, acceleration, temperature and pressure are presented as columns.

Part A) [40 pts]
Exploratory data analysis via clustering can serve as an a priori step prior to targeted model fits. In this step, we would like to infer whether samples of sensor data form segregated clusters in the space spanned by the sensor features. Since the number of features are relatively large to visualize, first perform principal components analysis (PCA) on the 566×306 feature matrix to extract the top two PCs, noting how much variance they capture. Using the projections of 566 data samples onto the first and second PCs, run k-means clustering (or another method of choice) to separate data into clusters. Try different numbers of clusters (N), and state your assessment on a proper number of clusters. Taking the clusters obtained when N=2, check the degree of percentage overlap/consistency between the cluster memberships and the action labels originally provided. Comment on whether fall detection is possible based on these measurements.

Part B) [60 points]
Once the exploration is complete, we can proceed onto the supervised learning stage. In this step, the goal is to build a classifier that detects the action label (fall or non-fall) with high accuracy. We will be testing two separate models for this purpose: a support-vector-machine (SVM) classifier and a multi-layer perceptron (MLP) classifier. Freely experiment with various hyperparameters included in these models to maximize classification accuracy. To do this, however, you need to implement a cross-validation procedure with a three-way split of data into non-overlapping training/validation/testing sets (e.g., 70%, 15%,15%). The models with various different hyperparameters are fit on the training set, the parameter selection is performed based on the validation set, and the final classification accuracy is reported on the testing set. Show/report all intermediate results, and comparatively evaluate SVM and MLP models. Comment on the success of fall detection based on wearable sensors.