DTEK0086 Biosignal Analytics

Human activity recognition using accelerometer and gyroscope

Background
Human activity recognition (HAR) aims to classify the sequence of acceleration data into well-defined movements (e.g., lying, standing, and walking). The data are collected via motion sensors, such as accelerometers, gyroscopes, and magnetometers. Thanks to the advancements in wearable devices and smartphones, such data can be collected from individuals ubiquitously and be utilized in different use cases in the health sector. For example, HAR can be exploited in elderly monitoring, enabling prevention and early intervention services [1]. Different studies have thus far proposed the use of machine learning algorithms in HAR tasks [2].

Objective
The objective of this project is to perform HAR leveraging features derived from the 3-axial linear acceleration and 3-axial angular velocity data. Using machine learning, you need to differentiate the records into six classes: i.e., lying, sitting, standing, walking, walking upstairs, and walking downstairs. The analysis should be done in Python (more details in the Instruction Section).

For this course project, you need to:

1. Submit your Python script and your report of the observations, graphs, and conclusions made upon analyzing the given signals. It is suggested to submit a Jupyter Notebook file, including your code and report.
2. Give a 20-minute presentation about your work. Your presentation should include descriptions of
    a. The problem and the data
    b. The steps in your analysis: e.g., what pre-processing methods you use, which features you extract, which machine-learning algorithms you use
    c. The results that you obtain: e.g., the accuracy of two machine learning methods
    d. Your evaluation and conclusion on the findings and methods

Data collection setup
The 3-axial linear acceleration and 3-axial angular velocity data were recorded from 30 different subjects using Samsung galaxy S II smartphone. The subjects were asked to place the smartphone on the waist during the measurements. The data were collected with a constant rate of 50 Hz. The data annotation was performed by human experts -using videos recorded during the experiments. The data is extracted from the Smartphone-Based Recognition of Human Activities and Postural Transitions dataset.

Structure of the data
The project includes the data of 30 subjects (i.e., 20 for training and 10 for test). Each record (i.e., file) consists of 5 seconds of data, and it corresponds to lying, sitting, standing, walking, walking upstairs, or walking downstairs activity. The dataset includes separate “Train” and “Test” folders. The folders contain six subfolders as “lying,” “sitting,” “standing,” “walking,” “walking_upstairs,” and “walking_downstairs.” Each record is saved as a CSV file, including six columns corresponding to the accelerometer X, Y, and Z and gyroscope X, Y, and Z. The filename includes

the event number, experiment number, and the subject ID. For example, 7 is the event number, 2 is the experiment number, and 1 is the subject ID in “sample_ID1_exp2_7.csv.”

Instruction

For the analysis, you should:

1. Use pre-processing techniques (such as filtering) if necessary.
2. Extract relevant time-domain and frequency-domain features from the accelerometer and gyroscope data (e.g., summary statistics, power, and powers of frequency bands).
3. Standardize your data: i.e., use the mean and standard deviation of the training data to standardize the training data and the test data.
4. Select two (multiclass) supervised machine learning algorithms and train two classifiers using the training set. Each classifier should classify the data into lying, sitting, standing, walking, walking upstairs, or walking downstairs.
5. Compare the two classifiers by evaluating the results using the test set.
    a. Obtain the confusion matrix, accuracy, precision, recall, and F1-score. These can be calculated from the predicted and true values.

Hint: You can utilize packages such as scipy, tsfresh, and tsfel for the pre-processing and feature-extraction steps, and packages such as scikit-learn for the machine-learning step.

[1] Schrader, Lisa, et al. "Advanced Sensing and Human Activity Recognition in Early Intervention and Rehabilitation of Elderly People." Journal of Population Ageing (2020): 1-27.

[2] Bayat, Akram, Marc Pomplun, and Duc A. Tran. "A study on human activity recognition using accelerometer data from smartphones." Procedia Computer Science 34 (2014): 450-457.