Activity Classification

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***Abstract*—This paper is report on the project that was conducted to predict motor activity like running, walking, climbing and jumping using the concepts of signal processing, machine learning and neural networks. We propose to create a model that predicts the motor activity using the data collected by the sensors like accelerometer and gyroscope.**

I. Introduction

The use of on-body wearable sensors is widespread in several academic and industrial domains. Of great interest are their applications in ambulatory monitoring and pervasive computing systems; here, some quantitative analysis of human motion and its automatic classification are the main computational tasks to be pursued.
The information on the human physical activity is valuable in the long-term assessment of bio-mechanical parameters and physiological variables.

In this paper we present a novel approach on using the information gathered from the sensor data such as accelerometer and gyroscope to predict the activity performed by the individual

II. Dataset

Dataset is one of the most important part to apply machine learning.
To get data, we used sensors like accelerometer and gyroscope. So to gather most accurate data we use sensors from different mobile devices containing different hardware for accelerometer and gyroscope. This will help in providing huge variance in the dataset which will help in increasing accuracy of the resulting model by decreasing over-fitting to a particular sensor hardware.
Using the accelerometer and gyroscope we formed data-set with the following attributes.

Data Attributes Collected

- timestamp
- activity
- acceleration-x
- acceleration-y
- acceleration-z
- gyro-x
- gyro-y
- gyro-z

Here the acceleration-x, acceleration-y and acceleration-z is the acceleration of the phone in x-direction, y-direction and z-direction captured by accelerometer. Similarly the gyro-x,gyro-y and gyro-z is the angular velocity of the phone in x-direction, y-direction and z-direction captured by gyroscope. Here is how x, y and z direction for a phone is defined:

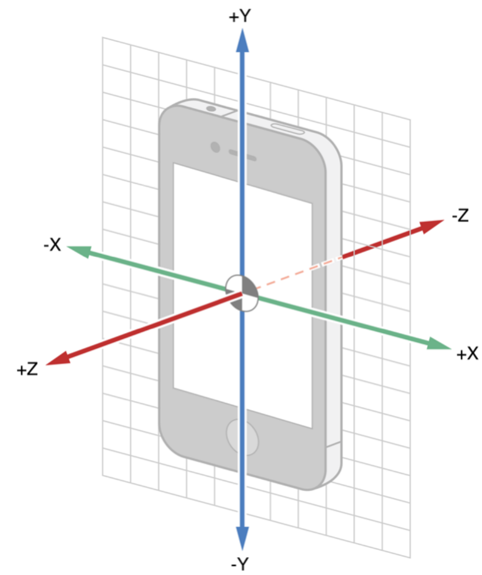

Fig. 1. x, y and z direction for a phone

Activity column is the label describing the activity that corresponding data belongs to.

TABLE I
Activity and it's corresponding label

Activity	label
Climbing	0
Jumping	1
Walking	2
Running	3

III. Data Visualization

Data visualization is an approach to analyze data-set and summarize their main characteristics through some form of visualization.
We gathered data from sensors like accelerometer and gyroscope while performing different activities such as running, walking, jumping and standing. Here are the plots of data gathered from different sensors for different activity.

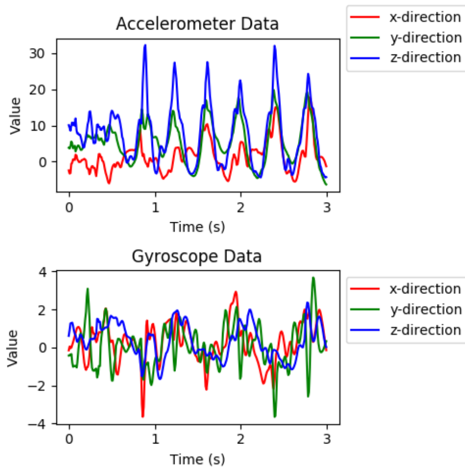

Fig. 2. accelerometer and gyroscope values while running

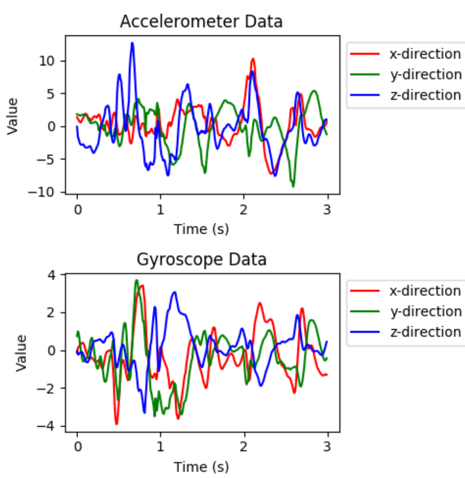

Fig. 3. accelerometer and gyroscope values while walking

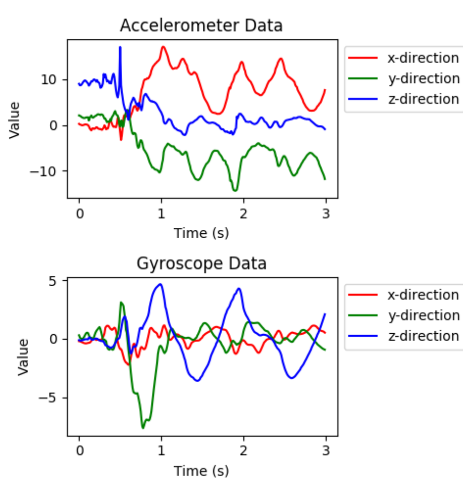

Fig. 4. accelerometer and gyroscope values while climbing

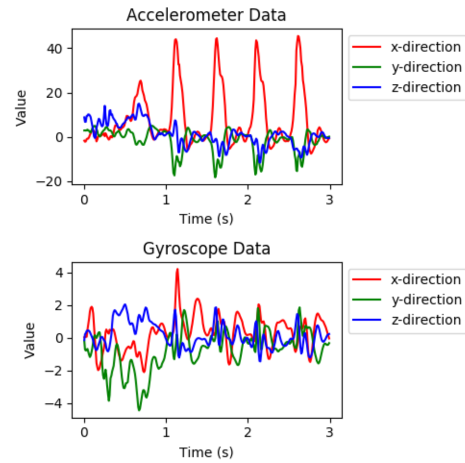

Fig. 5. accelerometer and gyroscope values while jumping

Looking at the plots of each motor activity, we can clearly see features in each of them that that can help us in visually differentiate between the activities.
Like if we take accelerometer plots for all the four activity, we can see that for

- Running, the variance in z-direction is high compared to that of the x and y direction.
- Walking, the variance in x, y and z is almost the same
- Climbing, value of acceleration in x direction ¿ acceleration in z direction ¿ acceleration in y direction
- Jumping, the variance in x-direction is high compared to that of the y and z direction.

IV. Feature Engineering

Now the questions arises that how can we predict the type of activity using the sensor data.
The data provided by the accelerometer is the acceleration of the sensor in x, y, and z direction at a given time and data provided by gyroscope is the angular velocity of the sensor in x, y, and z direction at a given time.

Now for training a model we need to provide data-points with certain features. Feeding the model a single sample of the sensor value is not feasible, but taking into account multiple data samples of the sensor value will make it achievable to predict a pattern.
Now to consider multiple samples, we took 20 samples for each feature (acceleration-x, acceleration-y, acceleration-z, gyro-x, gyro-y, gyro-z) and considered them one data-point (**Note: This 20 samples are of one particular activity, it can not have samples of more than one activity**). The training data was collected with a sampling frequency of 100Hz, making 20 sample points as data collected for 0.2 seconds.

This is, however, not acceptable, since an input for a model must be a column matrix and not an *m* by *n* matrix. It

meant that the idea of combining data from all sensors in a single learning iteration was not achievable and, so, we had to use 6 separate models: for 2 sensors * 3 axes each.
So now we have 6 different data-sets (3 for accelerometer axes + 3 for gyroscope axes) each having 20 columns plus 1 column stating the activity label (0:-climbing, 1:-jumping, 2:-running and 3:-walking). This 20 columns represent samples values collected by that sensor for that axis for 0.2 seconds.

```
In [4]:  df.head()
Out[4]:
```

	0	1	2	3	...	17	18	19	y
0	0.262824	0.126360	0.073690	-0.017286	...	-0.692422	-0.824097	-0.814521	0.0
1	-0.687634	-0.472165	-0.493711	-0.730727	...	0.791919	0.935566	0.796708	0.0
2	0.301129	-0.139385	-0.393159	-0.326125	...	1.850111	1.888417	2.269078	0.0
3	2.453424	1.866870	1.548455	2.130221	...	8.259113	8.939038	9.688390	0.0
4	9.973289	9.961318	10.033141	10.236639	...	14.158174	14.409554	15.055960	0.0

5 rows × 21 columns

Fig. 6. First 5 rows of the data-set of x-axis, of accelerometer (there are 6 such data-sets)

V. Model and Training

Using the 6 data-set (3 for accelerometer axes + 3 for gyroscope axes), 6 different models were generated using KerasClassifier. KerasClassifier is a neural network with 3 hidden layers and 22 units each that takes in the data-set of a particular sensor axis and generates a model to classify one of the four activity.

After the 6 models are generated, predictions are made by taking the test data and continuously taking 20 sample points using a window of size 20 and feeding the 20 values of a particular axis of a particular sensor to the corresponding model.
After getting prediction from all the 6 models, the final prediction for that 0.2 seconds of data is calculated by taking mode of this 6 predictions.

Conclusion

After generating all the six models and passing it to the test dataset, the confussion matrix came out to be like this:

TABLE II
Confussion Matrix of the Generated Model

	Activity 0 Prediction	Activity 1 Prediction	Activity 2 Prediction	Activity 3 Prediction
Activity 0 Actual	412	2	0	16
Activity 2 Actual	5	351	1	13
Activity 3 Actual	0	5	429	1
Activity 4 Actual	22	4	0	519

Most important attribute is the accuracy of the model. Accuracy is the fraction of predictions that a classification model got right. In multi-class classification, accuracy is defined as follows:

$$accuracy = \frac{CorrectPredictions}{TotalNumberOfExamples} \times 100$$

The accuracy of this model came out to be 96.12 percent