



DATA MINING

Project Report

Bremen Big Data Challenge - Edition 2019

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Abstract

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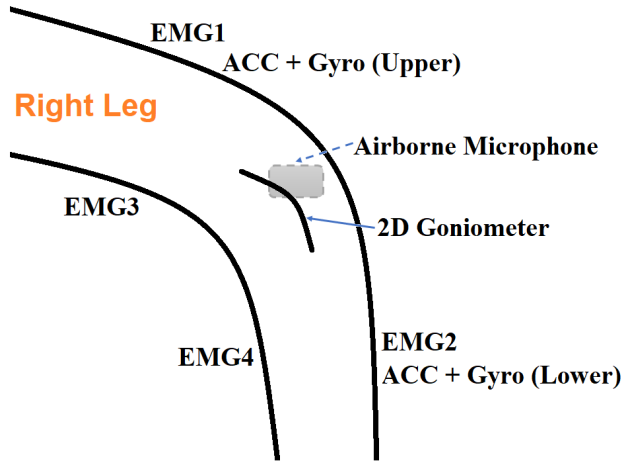


Figure 1: Wearable sensor placement for data measurements. (source: part of the provided data)

1 Introduction

2 Background of the Data

2.1 Data Source

Provided by "The Bremen Big Data Challenge 2019" Organizers, the collected data are based on daily athletic movements [bbdc]. Using wearable sensors above and below the knee (See Figure 1) of the individual (athletic), a dataset of 19 individuals, mainly identified as *subjects*, has been recorded. And as the competition requires, the data of 15 out of the total number of subjects are used as the training dataset and the remaining part as the testing dataset. The dataset is publicly available online on the official website: [BBDC](https://bbdc.csl.uni-bremen.de/index.php/2019h/28-aufgabenstellung-2019) or by simply browsing through the following URL: <https://bbdc.csl.uni-bremen.de/index.php/2019h/28-aufgabenstellung-2019>.

2.2 Description and Format

The data comprise the following 22 movements:

- Race ('run')
- Walking ('walk')
- Standing (standing)
- Sitting ('sit')
- Get up and sit down ('sit-to-stand', 'stand-to-sit')
- Up and down stairs ('stair-up', 'stair-down')
- Jump on one or both legs ('jump-one-leg', 'jump-two-leg')
- Run left or right ('curve-left-step', 'curve-right-step')
- Turn left or right on the spot, left or right foot first ('curve-left-spin-Lfirst', 'curve-left-spin-Rfirst', 'curve-right-spin-Lfirst', 'curve-right-spin-Rfirst')
- Lateral steps to the left or right ('lateral-shuffle-left', 'lateral-shuffle-right')

Subjects	Datafile	Label
Subject02	Subject02/Subject02_Aufnahme000.csv	<i>curve-left-step</i>
Subject02	Subject02/Subject02_Aufnahme001.csv	<i>curve-left-step</i>
Subject02	Subject02/Subject02_Aufnahme002.csv	<i>stand-to-sit</i>
...
Subject19	Subject19/Subject19_Aufnahme438.csv	<i>curve-right-step</i>
Subject19	Subject19/Subject19_Aufnahme439.csv	<i>curve-right-spin-Rfirst</i>

Table 1: Tabular visualization of the "*train.csv*" dataset

Subjects	Datafile	Label
Subject01	Subject01/Subject01_Aufnahme000.csv	<i>X</i>
Subject01	Subject01/Subject01_Aufnahme001.csv	<i>X</i>
Subject01	Subject01/Subject01_Aufnahme002.csv	<i>X</i>
...
Subject15	Subject15/Subject15_Aufnahme438.csv	<i>X</i>
Subject15	Subject15/Subject15_Aufnahme439.csv	<i>X</i>

Table 2: Tabular visualization of the "*challenge.csv*" dataset

- Change of direction when running to the right or left, left or right foot first ('v-cut-left-left', 'v-cut-left-right', 'v-cut-right-left', 'v-cut' right-Rfirst ')

The entire data are available as CSV files, or Comma-Separated Values, and partitioned as training and testing data, respectively represented by the "*train.csv*" and the "*challenge.csv*" files. Starting with the training dataset file (*train.csv*), it contains *UTF-8*¹ character-encoded, line-wise plain texts, whose first line identifies the feature names followed by the feature values. This file contains a total of 6402 lines, which include both the feature names and the feature values. The feature names are *Subjects*, *Datafile*, *Label*, and the feature values map respectively each feature name. For instance, the first feature values of the file are: *Subject02*, *Subject02/Subject02_Aufnahme002.csv*, *stand-to-sit*. Table 1 illustrates a lightweight version of the data partition of the training dataset file.

Similarly, the testing dataset file (*challenge.csv*) is formatted using the same structure with the exception of the *Label* column, which is unknown and marked with an *X*. The datafile contains a total of 1739 lines counting both the feature names and feature values. Table 2 displays a lightweight version of the data partition of the testing dataset file.

Important: Recalling that the dataset is divided into training and testing data, the subjects "*Subject01*, *Subject10*, *Subject14*, *Subject15*" are the selected ones that are used as testing data to assess the solutions. Note the difference in the starting and ending rows of Tables 1 and 2.

As observed in both Tables 1 and 2, each line corresponds to a recording of a movement. The columns have the following meanings:

- **Subject:** The ID of the subject
- **Datafile:** Path of the file containing the sensor data for this recording. For each subject, there is a folder in which individual data files contain the sensor data for individual motion recordings.
- **Label:** The movement that was recorded

Particularly, the *Label* column of the testing dataset contains repeatedly the letter "*X*" to indicate that this value is not present. That is, at the time of submitting solutions, the submission should

¹Unicode Transformation Format, extended ASCII, variable-width encoding.

exactly match the testing data, where each X will be replaced by a label. This label corresponds to the classification result of a specific movement. It is important that the spelling (including upper / lower case) of the textual labels matches exactly the spelling of the labels in the training data.

As mentioned above, the datafiles are references to other CSV files. For example, the path file `Subject02/Subject02_Aufnahme000.csv` is a CSV file itself within a folder named *Subject02* located in the root path (i.e., the current directory of the downloaded zip files). The CSV file itself is dataset with a proper format. Basically, the file has a set of comma-separated numbered-values that looks like this: *32688,32224,32991,32609,32790,33048,37168,34610,27374,29068,29264,28408,31784,28133,29295,29244,33216,37140,34736*.

Each line represents the sensor values measured at one time (sampled at 1000 Hz). The columns represent the individual wearable sensors recording the human activities (see Figure 1):

1. EMG1
2. EMG2
3. EMG3
4. EMG4
5. Airborne
6. ACC upper X
7. ACC upper Y
8. ACC upper Z
9. Goniometer X
10. ACC lower X
11. ACC lower Y
12. ACC lower Z
13. Goniometer Y
14. Gyro upper X
15. Gyro upper Y
16. Gyro upper Z
17. Gyro lower X
18. Gyro lower Y
19. Gyro lower Z

The size of the CSV datafiles vary inappropriately. That is, in most cases, due to inaccurate measurements, random initialization states, mechanical flaws, computational and processing cost, and so on.

3 General comments

3.1 Notation

Let us defined a modeling procedure as a function $\mathcal{P}(\Theta) : \mathbb{R}^m \longrightarrow \mathbb{R}^k$ where m is the number of features, k is the number of classes, and $\Theta : \{Feature_{extraction}, Statistical_{Tecnique}\}$ is a set representing parameters. Giving this abstraction Θ modifies the structure \mathcal{P} but always takes a *feature vector* $X \in \mathbb{R}^m$, and returns a *Probability vector* $Y \in \mathbb{R}^k$ where each component $\in [0, 1]$.

It is clear that the $\mathcal{P}(\Theta)$ that represents exactly the reality regarding athletics movements is unknown to us, which let us to defined a measure of the amount of veracity that a giving \mathcal{P} has compare to reality.

$$accuracy = \frac{\sum Correct_{classification}}{N} \quad (1)$$

3.2 Cross validation

Guys please explain here what cv is, why is important to use, that is what is the shit with variance and bias, why overfit may occurs. In general terms. why is a good stimator of the test error over unseen data.

3.3 Curse of dimensionality

Guys please explain this also. remember to say the 10 feature rule thumbs and cited jaeger lectures notes.

4 Data Preprocessing

Two *feature extractions* procedures were implemented.

Preprocessing procedure 1:

1. Take a **subject file**(each file contains a class movement). It can be viewed as $[19 \times N_{fr}]$ matrix composed by 19 columns vectors $S_{data} \in \mathbb{R}^{N_{fr} \times 1}$ where number of records in file is $N_{fr} \in \mathbb{N}^{>0}$.
2. Transpose each S_{data} into a row vector, concatenating them into one single vector $S_{concat} \in \mathbb{R}^{1 \times 19 * N_{fr}}$
3. Repeat step 1 and 2 for every subject file.
4. Create a dataset with the rows of step 3 with it according it corresponding label (extracted from the name of the file). This data set is a matrix D of dimensions $[6401 \times (19 * N_{fr})]$. For $N_{fr} = 56810$ D is $[6401 \times 1079390 + 1]$.

Preprocessing procedure 2:

1. Take a **subject file**(each file contains a class movement). It can be viewed as $[19 \times N_{fr}]$ matrix composed by 19 columns vectors $S_{data} \in \mathbb{R}^{N_{fr} \times 1}$ where number of records in file is $N_{fr} \in \mathbb{N}^{>0}$.
2. For each S_{data} decomposed as $s_{data} = \mu + \omega$ where μ is a smoothed version of s_{data} calculated using lowess with tree points average weighted linear regression. A complete derivation of this algorithm can be found in [1]. Having s_{data} and μ calculate $\omega = s_{data} - \mu$.
3. Create a vector $\mu_{sta} \in \mathbb{R}^3$ with first tree statistical moments of μ , that is, the average, the variance, and the steepness.

4. calculate the discrete Fourier transformation of ω , extract the first five coefficients and put them in a vector $\omega_{fft} \in \mathbb{R}^5$. A complete derivation of this algorithms can be found in [2].
5. take μ_{sta} and concatenate it with ω_{fft} into a row vector $S_{data} \in \mathbb{R}^{1 \times (3+5)}$
6. Repeat steps 1 to 5 for every **subject file** and stack the vectors S_{data} with its corresponding label.
7. This dataset D is $[6401 \times 8 + 1]$

For procedure 1 the parameter N_{fr} had to be set, since each **subject file** had different number records. By observing a 100 random sample of files, we concluded rather arbitrarily that $N_{fr} = 56810$ was reasonable number of records. In case a particular file did not meet this requirement, the signal per sensor would repeat itself until the desired N_{fr} was reached. The idea with procedure 2 was to capture the general properties of the movements(using μ_{sta}) in term of properties of the distribution of the signal. On the other hand, we also attempted to capture information about the periodicity of the movement using ω_{fft} .

5 Data Exploitation

6 Data Analysis

7 Results and Discussions

8 Conclusion

References

- [1] Cleveland, W.S. (1979) "Robust Locally Weighted Regression and Smoothing Scatterplots". Journal of the American Statistical Association 74 (368): 829-836.
- [2] Oraintara, S., Chen, Y. J., & Nguyen, T. Q. (2002). Integer fast Fourier transform. IEEE Transactions on Signal Processing, 50(3), 607-618.