Exposé - Identifying the Ideal Length of Time to Record Smartphone Data, in Order to Obtain Distinct Clusters to Predict Eating Crises

FH Salzburg

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Concept

Han, Pei, and Kamber (2011)[18, 32, 362, 363, 367] declare, that data mining is used to discover patterns and knowledge from data. Cluster Analysis is a type of machine learning algorithm known as unsupervised machine learning. It is used in data mining to divide data into groups (clusters). Each cluster contains data that is similar to each other, but dissimilar to the data allocated to other clusters. Cluster Analysis can be used to acquire knowledge on the distribution of the data, discover characteristics, detect outliers and reduce noise, or to pre-process data for other algorithms.

There are several different methods to create clustering. Han, Pei, and Kamber (2011)[362, 364, 366-367, 385, 392] explain, that objects are often arranged into clusters using distance measures (e.g. Euclidean or Manhatten distance measures). The authors divide the clustering algorithms into the following categories:

- Partitioning methods (examples: k-means, k-medoids)

- Hierarchical methods (examples: BIRCH, Chameleon)

- Density-based methods (examples: DBSCAN, OPTICS)

- Grid-based methods (examples: STING, CLIQUE)

Bermad and Kechadi (2016) introduce in their paper, how clustering can be used in digital forensics to provide information on all the events that led up to a certain crime. They used ascending hierarchical clustering to receive clusters of events (e.g. phone calls, SMS) ordered in time, thus creating a timeline of events leading up to the incident.

Dey and Chakraborty (2015)[1,2,6,7] give an example, where clustering was implemented to predict future weather. Air pollutant data was preprocessed and then arranged into clusters using (incremental) DBSCAN clustering. Finally, priority based protocol was used on them to

predict weather conditions and a temperature range. The accuracy of the technique, based on hit and miss times, was calculated to approximately 74.5%.

SmartEater [1] is an upcoming mHealth (mobile health) app, with the goal to provide the user with content-dependent feedback, to avert a food craving episode. The app will predict future eating crises based on the user's past behaviour. In order to reduce intense user input, the app records and uses various smartphone sensor data. With the help of data mining, machine learning algorithms, and pattern recognition, this recorded situational context data will aid in predicting stress. The following data is recorded by the app:

1. Background volume

2. Relative movement of the smartphone (gyro and accel)

3. Time and duration of phone calls (without storing the numbers)

4. Time of messages (e.g. SMS, WhatsApp) (without collecting identifying information such as content, addresses, numbers)

5. Screen activity (so-called touch events)

6. Screen-on-time (illuminated display)

7. Ambient brightness

8. Data volume per unit of time (summary value of all smartphone activities on the internet)

9. Switch-on and switch-off times of the smartphone

This sensor data will be recorded for different lengths of time. It is necessary to establish which time period will be most fitting to make accurate predictions for the future. This thesis will use cluster analysis to determine which time period is most significant.

According to Han, Pei, and Kamber (2011)[414], the above-mentioned clustering methods work well with data sets that are not high-dimensional and have less than 10 attributes. Since the SmartEater data set only has 9 dimensions, it is not considered high-dimensional. This paper will therefore utilise these clustering methods. Since different clustering algorithms can yield different results, multiple methods will be used and compared.

To reduce the size and amount of data, dimensionality reduction will be used. Han, Pei, and Kamber (2011)[93] define dimensionality reduction as a type of data reduction, which removes random attributes and creates a smaller data set with close to equal integrity. This thesis will use principal component analysis (PCA) to reduce the dimensionality. Furthermore, T-Distributed Stochastic Neighbor Embedding (t-SNE) will be employed to depict the data set in this thesis. Maaten and Hinton (2008)[2579] first introduce t-SNE, which is used to visualise data with a higher dimensionality.

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1. https://sites.google.com/site/eatingandanxietylab/resources/smarteater

The clustering methods will be implemented using a Python machine learning platform or library (e.g. Anaconda[2], scikit-learn[3]). Next, these will be implemented on the other time lengths. The resulting clusters of each time length will be compared to one another and evaluated. Berkhin (2006)[39] states, that the Silhouette Coefficient (Kaufman and Rousseeuw 2009)[87] can be used to measure the separation between clusters.

The introduction of the thesis will serve as an overview of the SmartEater project and explain how and why the subsequent experiment will be conducted. Secondly, existing work relating to this subject will briefly be presented. The following chapter will concentrate on the theory of data mining and cluster analysis. After covering these topics, the next section will describe the conducted experiment and its results. In the final sections, the findings of the experiment will be discussed and summarised.

Research Question

Which time delta for aggregation is ideal to construct high quality clusterings from smartphone sensor and usage data?

Outline

1. Introduction (500 words)

2. Related work (500 words)

3. Theory (4000 words)

    (a) Data mining

    (b) Cluster analysis

        i. Overview of clustering algorithms
        ii. Dimensionality reduction

4. Experiment (4000 words)

    (a) Preparation of the data set

    (b) Clustering

    (c) Clustering after dimensionality reduction

    (d) Comparison and evaluation of clusters of different time lengths

5. Discussion (1000 words)

6. Conclusion (500 words)

2. `https://www.anaconda.com/`
3. `https://scikit-learn.org/stable/`

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Schedule

- 31st January 2020 - Hand in this exposé

- February 2020 - Read papers and do research

- 24th February 2020 - Upload the final exposé onto FHSys

- March 2020 - Meet with supervisor, read literature, analyse and experiment with clustering algorithms and write a rough draft

- April 2020 - Meet with supervisor, finish the paper and print and review details

- 10th May 2020 - Submission of the bachelor thesis

Supervisor

I have discussed the thesis with FH-Prof. DI Dr. Simon Ginzinger, MSc. He is working on the SmartEater research project and suggested this subject to me.