Otto-von-Guericke University Magdeburg

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Master Thesis Proposal

Working Title: Semi-automatic pattern detection in hierarchical tabular data with flat hierarchies

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Version 2
November 20, 2022

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Contents

1 Motivation

Data is becoming increasingly important especially, the use of tabular data in the field of visual analytics. Tabular data is highly preferred and is critical data management approach as it has been used by many application domains such as scientists, financial practitioners and policy-makers [1, 3]. Most of the existing studies focus on flat simple tabular data rather than hierarchical tabular data [6, 12]. Hierarchical tabular data are widely used, especially in statistical reports and research papers providing better capability of efficient data management [4]. Many research work focuses on diverse types of tabular data such genomic data [10], secRNA data [9], biome data [17], to find patterns. One of the example where tabular data is generated is visual storytelling taxonomies or narrative visualisation taxonomies. Such taxonomies provide a quantitative analysis of storytelling. One of the examples include [14], where authors create a taxonomy of journalism stories exploring 20 data-driven story telling techniques broadly categorized into 4 main categories creating a hierarchy; against 45 asynchronous data stories. Although authors visualize what techniques where used but does not highlight how often were these different techniques used.

Therefore, it would be great if we had a way to automatically find patterns in such hierarchical tabular data. However, often automatic algorithms depend on certain input parameters. Therefore, this inspires to integrate the execution of the automatic algorithms into an interactive application that allows to customize input parameters and visualize the output in more insightful and effective way [7].

2 Problem definition and Research Question

With such motivation in mind, this thesis aims to focus on:

- Investigate what kind of patterns can be extracted from the tabular data in general
- how would flat hierarchical structures among row or column headings affect pattern detection
- Research and analyse which algorithms exists to analyse and extract patterns from the given flat hierarchical tabular data
- Design and implement an application to analyze the tabular data using the most promising of the found algorithms.

3 Related Work

3.1 Interactive visual exploration and analysis of tabular data

Guozheng Li et al. have developed an interactive visual analysis tool for hierarchical tabular data which constructs a model which defines row/column headings as bi-clustering and hierarchical structures to explore relationships among the hierarchical row and column labels interactively and effectively [8]. Whereas, Eckelt et. al. proposes TourDino integrated in the Ordino [15], a drug discovery platform for the purpose of identifying new drug targets. TourDino provides a support view that helps users who are not experts in statistics to verify generated hypotheses and confirm insights through exploration and validation of statistical hypothesis using interactive visualisation on tabular data [5]. Interestingly, Furmanova et. al. provides scalable visualisation of tabular data, providing interactive analysis through hierarchical aggregation of subsets [6].

3.2 Automatic pattern detection in multi-variate tabular data

Related work shows a lot of research in the direction of using dimensionality reduction techniques for high dimensional data to reduce it into lower dimensions combined either with supervised learning tasks such as classification or cluster analysis. Chad A. Steed et al. creates a visual exploration system for multivariate data with heterogeneous type which helps understanding the input to algorithms such as neural network [13]. Xueli Xu et al. used t-SNE algorithm with Aitchson distance as dimentionality reduction and fed the low dimensional features to commonly used machine learning algorithms for compositional microbiome data [16]. Whereas, Ju Nam et al. describes the importance of cluster analysis using an interactive tool to control cluster parameters on high dimensional aerosol mass spectra data [11]. Zhang et al. diagnoses errors and finds patterns in machine maintenance heterogeneous and high-dimensional log data through machine leaning assisted visual analytics. Here, authors use data-type dependent dimensionality reduction techniques approach, such as they use contrasting clusters in Principal Component Analysis (ccPCA) for numerical data, contrasting clusters in Multiple Correspondence (ccMCA) for categorical data and Uniform manifold approximation and projection (UMPA) for dimension reduction for text data combined with clustering [18]. Zhou et al. address the spatial clusters of air-quality data using visual analytics tool and exemplifies factors responsible for the air-quality using MDS and Hierarchical clustering [19]. Devassy et al. shows t-SNE outperforming PCA for forensic document analysis done on hyperspectral imaging data [2].

4 Methodology and Evaluation

This thesis aims explore kind of patterns which can be found in hierarchical tabular data and also it intends to do a literature review on existing algorithms used to find patterns in hierarchical tabular data. After the review, thesis will implement suitable algorithms from the literature and would build an interactive R-Shiny based application. This thesis would also work on reviewing the literature for visualisation used to support detected patterns. To evaluate, a ground truth with known patterns will be validated against the developed application. This would validate the usefulness of found patterns in hierarchical tabular data. For usability validation on actual data, the application will be then checked by domain experts from the Chair of Visualization at Otto-von-Guericke, University.

5 Goals and benefits

Based on descriptive taxonomy generated by Stolper et. al. as an example, this thesis will examine types of patterns created on hierarchical tabular data and create a visual analytics application to semi-automatically find patterns in the hierarchical data. It will also explore how these flat relationships can be considered in detecting patterns. Therefore, I aim to explore how could patterns be found in hierarchical tabular data and what would flat hierarchical relationship of the columns in such forms of data signify. This shall serve as an guidance and helpful tool to for future researchers to effectively find patterns and analyze in hierarchical tabular data and serve as basis for future research in visualisation of such patterns with certain techniques in detail.

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