Information Visualization and Visual Analytics at IVU Lab

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Abstract. This paper summarizes some works performed in Information Visualization and Visual Analytics in the last two decades at the IVU Lab (Interaction, Visualization and Usability and UX Laboratory) of the University of Bari Aldo Moro. This Lab has a long tradition in HCI. At the IVU Lab, Paolo Buono is the coordinator of the Information Visualization and Visual Analytics activities and he (co)authored the publications that resulted from the research on this topic.

Keywords: InfoVis · Data analysis · Predictive Visual Analytics

1 Introduction

The work performed at IVU Lab on Information Visualization (InfoVis) and Visual Analytics (VA) is mainly motivated by the increasing need, in many fields, of tools that help people to make rapid and effective decisions. Presenting data through proper visualizations has a great potential of improving their understandability, as well as their analysis, but requires a lot of work when data amount is huge (Big Data) and/or change dynamically. In the following, some of the works performed at IVU Lab are briefly reported. Figure 1 shows some of the visualization techniques that were developed.

"Visual analytics combines automated analysis techniques with interactive visualizations for an effective understanding, reasoning and decision making on the basis of very large and complex data sets" [18]. The main focus at IVU Lab is on the human side of the data analysis. Effective interactive visualizations enhance the innate human ability to visually perceive patterns and trends to effectively understand, reason and make decisions. The techniques and tools we develop aim at enabling effective data navigation and interpretation, preserving user control, thus enabling users to discover interesting or unusual patterns,

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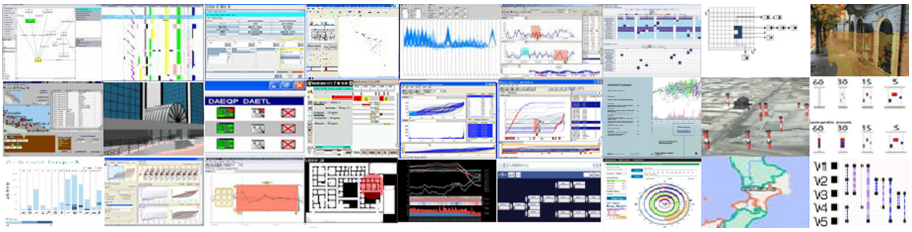

Fig. 1. Visualizations techniques developed at IVU Lab.

even without the need to know in advance what kind of phenomena should be observed.

2 Visual Analytics

VA often involves Data Mining (DM) methods to process data in order to reduce the complexity and size of big data before presenting them to the user. A challenge faced at IVU Lab has been the visualization of the results of DM methods, such as Association Rules and Clustering. In most cases, DM methods produce thousands **Association Rules** that the user must analyze. We provided a visual strategy that exploits a combination of graph-based and parallel coordinates techniques to visually present the results of association rule mining algorithms [3]. Data miners get an overview of the rule set they are interacting with and can deeper investigate inside a specific set of rules. The developed tools were embedded in a framework for data analysis, called DAE [8], which was developed within the scope of the FairsNet EU Project. Some DM methods produce Multilevel Association Rules that introduce further complexity, related to the level of abstraction of the rules. A solution that allows the navigation across two dimensions: a) the abstraction levels and b) rule granularity levels were presented in [2]. An association rule can be visually encoded as antecedent and consequent, each of them is a node composed of a set of atomic values, the relation between such nodes can be represented as graphs, so the visualization is based on the classic node-link approach, while other graph visualization techniques are proposed in the literature. At IVU Lab, in collaboration with foreign colleagues, in particular J.-D. Fekete and C. Plaisant, we are investigating on novel approaches for **visualizing dynamic hypergraphs**, which pose very challenging issues, such as the visualization of network topology changes over time, providing techniques and tools to enable users to detect patterns and inconsistencies [20]. This research has been appreciated by the community. In particular, two further papers report how to visualize dynamic hypergraphs, using the PAOHVis technique, in an ordered, clean and understandable way,

that avoids intersections and allow to see the topology evolution over time [21]. The Digital Humanities users we interacted with, during the development of the PAOHVis technique needed to label data and reorganize them, possibly in clusters. We then realized an enhancement of the PAOHVis tool that allows users to cluster data according to a mixed-initiative approach, where, in accordance with the VA strategy, the human and the machine are interleaved in the analysis. The approach is called PK-Clustering and visualizes all clustering algorithm results on the screen, by allowing the user to select which algorithm best fit the data at hand [19].

Other significant activities have been performed with environment experts to identify interactive visual tools suitable for their purposes [9]. We exploited KNIME to visually **model the process and transform the data** in the format they need. In the context of air quality monitoring, we developed a system that allows decision makers to monitor the state of **air quality** [1]. Recently, an ongoing work is proposing a novel user interface to analyze pollution data by first applying **clustering** algorithm, then visualizing data and clustering results on a geographic map using different visualization techniques.

A study addressing **big data** has been made, by analyzing one year of highway traffic data, characterized by an elevated number of vehicles traveling on the highway and the temporal aspect [12]. Moreover, we started a collaboration with a company (Links SpA) and Enrico Bertini (New York University) in the **Predictive Visual Analytics** field. We developed an interactive visual tool that allows for an easy comparison of multiple prediction models, in order to select the one that best fit the data under investigation [16]. With the company, we aim to transfer knowledge to Public Administration (PA) employees, to allow them choosing adequate visualization tools, in order to rapidly perform complex analyses. Related to this, we also focused on supporting the work of PA evaluators when performing usability tests to evaluate websites [7].

3 Time Series

The work on Time Series started at the Human-Computer Interaction Lab (HCIL) of the University of Maryland, coordinated by Ben Shneiderman. A first paper that reviews the state of the art on **time series visualization**, focuses on techniques that enable users to visually and interactively query time series [6]. The developed tool, TimeSearcher, allows people to explore multidimensional data using synchronized tables and graphs; it includes mechanisms to get overviews of data as well as details, to filter in order to reduce the scope of the search, to select patterns and find similar occurrences, etc. Search algorithms allows for easy comparison. Since time series, often describe a phenomenon, which can be repetitive and can, thus, be predicted, an obvious extension of TimeSearcher is towards predictions. Therefore, a subsequent work on time series was performed to define a data driven **forecasting method** and an interface called Similarity-Based Forecasting (SBF) that displays graphically, as a river plot, statistical information about the SBF subset [13]. A forecasting preview interface allows users to interactively explore alternative pattern matching

parameters and see multiple forecasts simultaneously. Time series are typically visualized as line chart and linear timeline. But there are alternatives that in some case can be more effective. We proposed a **novel circular visualization technique** to analyze domestic energy consumption [4]. This technique was also used in different domains, for example when quantifying self (see [17]) is relevant [5], and also to support **awareness in distributed teams** by exploiting collaborative traces of team members [10]. The circular visualization has several advantages: in particular, in the latter case, it makes easy to identify the time zones where different people work.

4 Other Topics and Research Directions

IVU members developed a visual technique and a tool for video summarization to analyze long videos and identify interesting scenes. Compared to the literature, the analysis mainly relies on humans' interaction, since the tool allows users to quickly perform complex queries by simply selecting relevant parts of a video through point&click [11,14]. A similar approach has been adopted also to extract video sequences in surgery videos [11]. A study that falls in cybersecurity visualization was conducted to understand how to visualize possible threats in android mobile apps [15]. Mobile applications are now widely distributed, they can be a source of a wealth of data revealing many personal data of their owner. Cybersecurity visualization is one of emerging areas where it is worth spending efforts to make more comprehensible and robust systems. Other directions could be towards the visualization of evolution of relationships among people, which has been recently found very relevant since the COVID disease has appeared.

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