Incorporating Tabletop Visual Analytics into the Decision-making Process: A Case Study of Retail Banking

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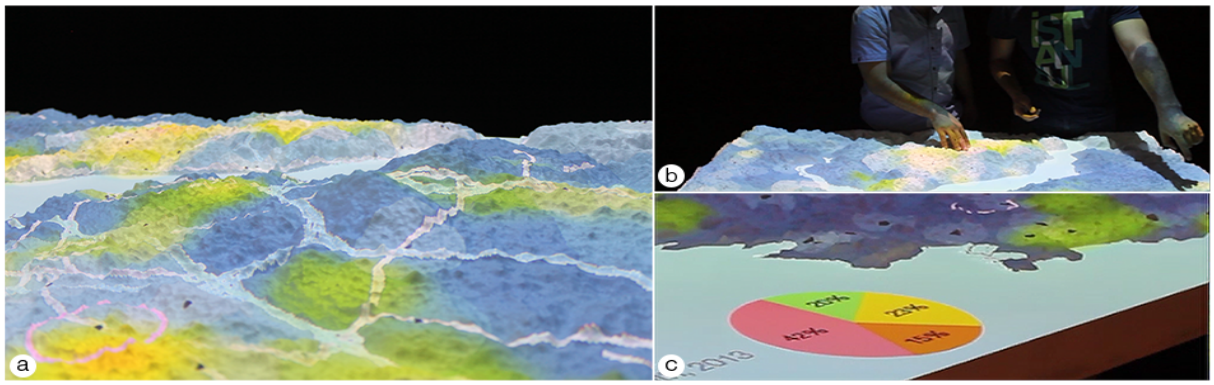


Fig. 1. A hybrid visual analytics system (a) has been implemented by employing physical visualization and projection of data visualization. This approach seems to (b) facilitate a collaborative data analysis space. The projected visualization can be augmented with (c) various visual elements that are bound to data.

Abstract—The large-scale use of office tools and statistical analysis applications indicates that they have sufficed well for some of the everyday tasks in our work cycles such as analysis, presentation, reporting, and decision-making. Nevertheless, they were designed in an era when business data was not big and complex enough. The ever growing avalanche of the data that we collect for our businesses compels us to find new means of understanding, sharing, and reporting the underlying ideas, and of making decisions for the future. We implemented a tabletop hybrid visual analytics system comprised of projection and physical visualization with the aim of supporting these tasks better by making the data physically available. We conducted a case study with an analysis team of a nationwide bank and completed a series of observations and interviews during their data analysis and decision-making sessions. Our study revealed that the hybrid visual analytics system approach promotes idea sharing and the contribution of all members of the group during the presentation sessions. This approach also seems to transform the common one-way structure of the communication in the presentation sessions into an alternative structure that encourages everyone to take the floor. Research questions that will be investigated in future work are also discussed.

Index Terms—Hybrid visual analytics systems, physical visualization, decision-making, data analysis, case study, retail banking

1 Introduction

The wide adoption of office and business applications such as data spreadsheets, presentation software, and statistical analysis tools shows that these applications seem to have sufficiently supported the organization and automation of business processes so far. The business data that we have collected has increased so much that various statistical analysis and reporting tools have become an inseparable part of day-to-day operations. Many employees make inferences and report their ideas over these tools seamlessly making them means of decision-making processes.

The diversity and uniqueness of the sources of our information increases our potential for innovation, especially in an age where collaboration is vital to address business tasks. Consequently, the quality and intensity of social interactions among the members of a group play an important role in creativity and productivity. In the age of Big Data, however, to what extent do our current business applications facilitate effective idea sharing? Are our channels for sharing information and engaging in decision-making, both socially and technically, able to convey what we extract from Big Data? Can we enhance human-to-human interaction by making use of the techniques available in the Big Data visualization and visual analytics realms?

We argue that, in spite of their success in the past, current conventional applications fall short in terms of supporting the recall of inferences made from the analysis of business data, idea sharing, and decision-making processes. Widely used information visualization and analysis tools seem to fail from time to time in fulfilling idea sharing and decision-making tasks as they are prone to individual inadequacies. We speculate that the virtual availability of ideas and inferences through the displays of computing devices appears not to assist decision-makers as much as the physical availability of the phenomenon in question.

We propose that the combination of virtual and physical visualizations can augment data analysis and decision-making by utilizing the best of both worlds. We implemented a tabletop hybrid visual analytics system based on projection and physical visualizations with the goal of providing users insights about complex multivariate spa-

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Manuscript received 15 Aug. 2015; accepted 18 Sep. 2015; date of publication 25 Oct. 2015; date of current version 25 Oct. 2015.
For information on obtaining reprints of this article, please send e-mail to: tvcg@computer.org.

tial data by amplifying visual perception (Figure 1(a)). With the aid of this tool, spatial multivariate business data can be visualized and physically presented, a collaborative and social atmosphere can be established (Figure 1(b)), and visual elements coupled with the related data (Figure 1(c)) can be tailored to the very needs of the analysts. We believe that, to the best of our knowledge, this is the first visual analytics approach in which physical visualization and projection are used with the aim of multivariate data analysis, decision-making support, and idea sharing.

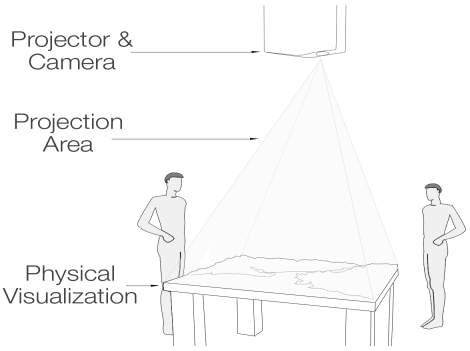


Fig. 2. We designed a tabletop hybrid visual analytics system comprising physical visualizations and projection with the aim of supporting the collaborative analysis of spatial multivariate data and decision-making processes.

Tabletop hybrid visual analytics systems bringing virtual and physical visualizations together may improve decision-making processes by encouraging users to share their opinions and take part in conversations. During our informal observations, we noticed that the users of our visual analytics system usually found themselves discussing the data being visualized. They often touched the physical visualization while they were explaining their ideas and inferences. These social interactions would seem to deserve an investigation as they may lead to increased creativity and productivity [7]. Hence, we conducted a case study with an analysis team of a nationwide Turkish bank. We visualized the data that they donated for the study with our visual analytics system (Figure 2). The analyst team conducted part of their routine analysis and decision-making sessions with our system in our laboratory. As we considered this approach as a novel concept, we conducted fly-on-the-wall observations as suggested by [16]. An elaboration of the justification for this research approach can be found in Section 4.

In line with our prior observations, these analysts tended to take part in conversations to a greater extent than they did previously with their own tools. Moreover, their statements during the post-study interviews revealed that the discussions on the inferences they made during the analysis were rarely interrupted by the factors related to the visualization tool. Furthermore, they reported feeling that they recall more of their findings from the analysis compared to prior discussion of the results over the presentation or spreadsheet applications. We have not collected evidence to quantitatively verify these findings; however, we have identified the research questions that might be of interest for future work. Preliminary findings regarding the benefits and challenges of our proposed system are discussed in Section 4.

This research has been supported by the Scientific and Technological Research Council of Turkey(TUBITAK) Project number 114E516.

2 Hybrid Visual Analytics System

We propose a hybrid visual analytics system with the purpose of supporting analysis and decision-making processes. Our current setup involves physical visualization, projection, and a set of preliminary interactions (Figure 2).

2.1 Physical Visualization

We have manufactured a 3-dimensional map of Istanbul on a CNC machine with rigid plastics. Specifically, we have physically visualized the southern central part of Istanbul, where the population density and thus the data density are high. The size of the physical map was 108 cm long, and 143 cm wide. The map uses a scale of 1:11.244. Altitude and geographical data has been acquired from ASTER GDEM V2[1] and OpenStreetMap[2], respectively. The altitude data in the physical visualization was interpolated so that the outcome of the CNC manufacturing was rather a representation of altitude formations than a high resolution plan of a city. Large landmarks such as Bosphorus bridges and stadiums can be identified whereas the smaller structures such as buildings cannot be distinguished.

2.2 Projection

A high resolution projector is positioned over the physical visualization so that it faces the physical visualization orthogonally as shown in the Figure 2. The calibration and alignment of the projector with the physical visualization has been achieved so that virtual elements (e.g. shore lines, roads) are projected exactly on their physical counterparts. The projection of spatial data visualization on physical medium forms the basic version of our proposed spatial display. The projection does not only realize the visualization of data onto the physical visualization, but also it serves as a base on which augmented reality features and various interaction methods can be applied.

2.3 Interaction

In spite of the limitations posed by the stasis of the physical visualization, spatial display of our visual analytics system provides opportunities for various kinds of interactions. In our current implementation we adopted Kinect[3] in order to implement basic actions such as moving the cursor, resizing visual elements, feature filtering, and selection. Swiping hands horizontally to the right or left side causes the cursor to hop from a visual element to another. Vertical upward or downward hand movement increases or decreases the value of a visualization parameter (e.g. size of circles), respectively.

3 Case Study: Retail Banking

Results of our prior informal observations lead us to conduct a case study in order to identify problematic areas and formalize research questions.

3.1 Purpose of the Case Study

As articulated in [16], the description of a new phenomenon can be accomplished through ethnographic methodologies such as observations, surveys, interviews, and focus groups. Investigation of new concepts and ideas usually starts with incomplete information; however, case studies can provide early feedback and insights about the solutions, and they can help the formalization of research questions [12]. In particular, informal case study approaches can be adopted to decide whether "a new idea is worth pursuing" or to acquire an initial understanding of a new problem domain. Informal case studies can relax the necessity of a theoretical background and some of the guidelines and procedures. Similarly, in order to better understand the use of tabletop visual analytics combining physical visualization and projection with the purpose of multivariate data analysis and decision-making, we conducted an informal case study. Our goals for the study were (a) to gain deeper insight on the effects of our novel concept on the decision-making processes, (b) to infer future design implications, and (c) to formulate research questions as the starting points for further research on the hybrid visual analytics approach. We did not intend to make rigorous comparisons of the hybrid approach and the previous systems and to make general claims.

[1] asterweb.jpl.nasa.gov/gdem.asp
[2] www.osm.org
[3] https://www.microsoft.com/en-us/kinectforwindows/

3.2 Case Study Conduct

We conducted a case study with the participation of a group of analysts of Akbank, a nationwide bank of Turkey, to explore whether and how our novel visual analytics approach enhanced analysis and decision-making processes. For the purposes of the study, we prepared our visual analytics system according to the needs of the bank's analysis team. Preparations involved the implementation of visualizations such as catchment areas and density maps, and interaction. Upon training, the banks analysis team conducted a number of catchment area analyses with our hybrid visual analytics system, during which we assisted with the interaction and usage of the system. As they visualized and investigated various summaries of their data, we observed their discussions about the inferences they extracted from the data. We also videotaped their brainstorming sessions and how they communicated their findings and decisions to their managers.

3.3 Catchment Area Analysis

The domain problem investigated in this case study is the catchment area analysis of bank branches. Typically, banks have a number of branches located in a region such that they collectively cover the geography and the customer demand within. Whether or not the customer catchment areas of these branches have the most *correct* coverage, the locations of new/moving branches, and optimal distribution of workforce across the catchment areas are common problems for retail banking. The catchment area of a bank branch refers to the area around each bank branch that represents an effective customer catchment radius of the branch, and the goal is to find out how well these areas align with where the customers of the bank usually transact. Hence, we resort to using our visual analytics system for an assessment; the more the two catchment areas overlap, the closer the bank is to its customers and thus has greater opportunity to do business with them.

3.4 Analyzed Data

The data visualized for our case study comprises an anonymized transactional database of credit card purchases made in Istanbul, and the locations of the bank branches. The dataset does not include the transactions of online purchases. In both datasets, locations are given in latitude and longitude form. Each row in the transaction dataset includes anonymized *identification* of the customer making the purchase, the *timestamp* of the purchase with date and time information, the *location* of the purchase, and the *value of the transaction*. The bank branch dataset includes the *street address* and the *location* of the branch. There exists no relationship between the transaction dataset and the bank branch locations meaning that none of the transactions by no means can be linked to a bank branch. Transaction data spans over three months with more than 400.000 anonymous account owners, and it contains more than 4 million transactions in total. As our extent was limited within the central part of Istanbul, the branch data contained only over 140 branches.

3.5 Visualization and Interaction

In order to assist the catchment area analysis, we have visualized transaction pattern of bank customers by employing a kernel density map representation along with the circular bank catchment areas. The first layer of the visualization, namely the density map, was generated by using the transaction data. Two variants of the density map have been generated based on the monetary value and density of the transactions. The density has been encoded to color spectrum starting from green, transitioning into yellow, and then ending at red. Tones of green indicate lower density of transaction or lower average transaction value. And in contrast, tones of red indicate the opposite situation. If there exists no transaction for a given time period and region, only the background color is shown.

The second layer holds the catchment areas that were drawn as white circular areas centered at the bank branch locations which are marked as black dots (Please see Figure 1c and 3). The opacity of the circular area represents the density of the credit card purchases falling into the catchment area of the corresponding branch. As the radii of the catchment areas change, the opacity of the circular areas are updated depending on the transactions caught.

The south-west corner of the visualization covers a portion of the Marmara Sea where physical visualization has a flat surface since the altitude is zero. By utilizing this opportunity, we placed short data summaries of the selected branches on this area. As shown in the right side of Figure 3, the catchment areas are selected with a circular magenta cursor. Moreover, the visualization supports animation along the time dimension so that the analysts could track transaction pattern changes over time. The borders of the districts, highways, and arterial roads are also shown to aid the analysis endeavour.

The analyst team members could move the cursors from one branch to another by waving their hands horizontally from left to right or in the opposite direction. Branch data summary is updated whenever the cursor is moved. If the size of the catchment areas is increased or decreased, the size of the cursor is also updated accordingly. The radii of catchment area could be altered interactively by raising hands up and down. Users could also toggle some other visual features such as roads, district borders, and branch marks.

4 Related Work and Discussion

Accepted as a subfield of computer-supported cooperative work (CSCW) [10], collaborative visualization, like all other CSCW scenarios, can be investigated from space (co-located vs. distributed) and time (synchronous vs. asynchronous) aspects [3, 9]. Moreover, Isenberg et al. [10] categorizes collaborative visualizations based on different levels of engagement with the visualizations, namely viewing (e.g. PowerPoint), interacting and exploring (e.g. CPOF [8]), and sharing and creating (e.g. ManyEyes [17] and Tableau Public [1]). As our co-located visual analytics system physically supports different views of visualization and enables social interaction space through which findings can be exchanged, it could be considered as a sharing and creating system.

Many visualization and analysis systems have been designed and developed for collaborative information processing activities. Lissermann et al. introduce the concept of Permulin [14], which comprises a large touch surface and shutter glasses providing private and shared space for the users. The use of a head-mounted device limits natural face-to-face communication, which seems not to be the case in our system. Another example of two-dimensional tabletop approaches, OrMiS [4] supports collaborative analysis, planning, and interaction for simulation-based training purposes. These examples of tabletop visual analytics approaches are similar to our system in that they facilitate a base for collaborative analysis and idea sharing. In order to extend these valuable contributions, we incorporate the physical aspect to the visualization as evidence demonstrates that the physical representations of the data can augment perception. In their experimental work, Jansen and Dragicevic [11] report that physical visualizations are superior to their virtual counterparts in information retrieval tasks. The ability to touch the data and perfect visual realism of physicalism facilitates the successful extraction of inferences from the data. The benefits of data physicalism were also utilized in CityScape [2], and Relief [13]. An obvious advantage of these tabletop approaches is the active physical visualization that can be adapted to various parameters of the visualization. However, the dynamism of the physical visualization leads to a low resolution in the spatial aspect of the data due to technical constraints. In contrast, the continuous (thus high resolution) form of static physical visualizations seems to outperform from this perspective.

Static physical visualizations have numerous limitations due to their passive nature. One of the obvious inherent constraints is the lack of support of very basic actions such as zoom in and out. Compared to the improvements in the two-dimensional tabletop visualizations such as the zoom lense enhancement on OrMiS [5], the stasis of physical visualizations may seem as an irresolvable problem. However, we argue that, with the support of peripherals such as transparent displays or mobile devices equipped with cameras, the techniques available in the augmented and virtual reality fields can aid the alleviation of the problem. For example, we can zoom into the regions of interest in sep-

arate views that can be generated in the scopes of transparent displays. Alternatively, the details of data can be viewed through the cameras of wearable computing devices or of mobile phones [18].

In the case study, we focused on three retail banking processes; the innovative analysis of transaction data, idea flow and brainstorming between the members of the analysis groups, and the communication of findings to decision-makers. During our preliminary investigations, the bank personnel reported that these processes were conducted via commercial analysis tools and reported by conventional tools such as presentations and spreadsheets. Not surprisingly, some of the personnel reported that the summaries or charts of vast amount of transactional data lead to missing details as well as misunderstandings. Moreover, the dashboards and branchwise representation of information degrades the recollection of previously discussed issues. As the presenter highlights the important aspects of a particular topic, previously presented information remains out of sight, and leads to a discontinuity in the big picture.

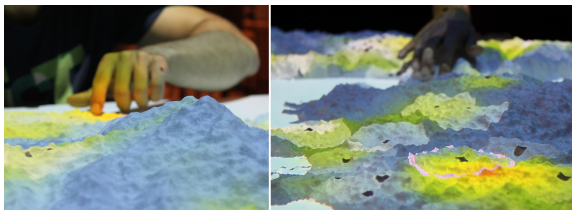


Fig. 3. Physically availability of the data augments the realism of the subject matter attracting attention and promoting conversation.

The results of our preliminary interviews show that analysts and decision-makers seemed to have issues with their conventional analysis and information representation methodologies. The reason was likely due to the bandwidth of their communication channel where they shared their ideas and information. Based on our preliminary observations, we formed our research questions as follows:

RQ1 Are the analysis, idea sharing and decision-making processes involving conventional methods (such as spreadsheets, presentation, statistical analysis tools) and interactions (such as 2D displays, mouse, and keyboard) sufficient to effectively discuss extensive and complex scenarios?

RQ2 From which perspectives do new intra-group interactions, conversational hierarchy, and idea flow emanating from hybrid visual analytics systems differ from those conventional ones?

RQ3 What are the feasible means for telepresence during analysis and idea sharing processes other than rooms with large displays supporting multimodal communication?

During both informal observations and the case study, we observed that the users of the tabletop visual analytics system tend to communicate their ideas to or start a discussion with other users around the table. More surprisingly, this usually occurs without any intervention. One analyst participating in our study reported that he found the visualization and the capability of touching the data aesthetically appealing and, thus, it promoted conversation and idea sharing among the analysts, which led to new questions and discussions. Another analyst supported this reasoning by stating that the physical existence of visualization and the facilitation of all team members in a natural social setting encouraged social interactions. To this respect, we state that visual analytics system involving physical visualizations may significantly enhance the decision-making process since the increase of idea flow and conversation positively affect the creativity and productivity of the group as articulated in [15].

Statistical analysis applications, office applications, reporting software, and presentation tools have been serving efficiently for the support of business processes for more than three decades. Summarization of sales, charts of productivity, and various reports specialized according to the needs of the companies have been effectively used to spread information and explain ideas to other employees. However, the data that has to be dealt with has accumulated so much that it requires wider channels and new means of conveying valuable inferences. Big data is not only big, it is also complicated in the sense that new analysis methods need to be developed to make better sense of it. Statistical methods seem to fall short in dealing with the high dimensionality of the data. The exploratory analysis of the data might benefit from humans sophisticated visual skills to make the judgements. That said, we argue that recent improvements in human-computer interaction and the visualization worlds can be employed to build visual analytics systems that enhance the capabilities of our current tools. Can we use tabletop systems, large displays or physical visualizations accompanied with state-of-the-art interaction techniques to create hybrid visual analytics systems that enhance collaborative analysis? Would that improve our retention rate at the end of analysis sessions if we were able to interact with the data with our senses such as sight and touch? After our observations, we had enough evidence demonstrating that research for answering these questions might reveal valuable insights.

The rate of the idea flow in a group of people directly indicates decision-making and strategy refining processes [15]. Flow of ideas seems to be critical in any group of people in a sense that the creativity and productivity depends on this social phenomenon. One of the data analysts participated to our study reported that they use presentation or data visualization provided by their analysis tools during decision-making processes. However, he also added that the physical visualization made them communicate more compared to when they use other conventional techniques. Moreover, the physical visualization not only improved the occurrences of conversations but also helped to form a conversation network in which all participants took part. We believe that the physical availability of data enabled analysts to view the data from different perspectives and led to diverse ideas. Besides several factors such as the susceptibility of individuals to new ideas, the contribution of group members to the communication is essential. From this perspective, our hybrid visual analytics system seems to have an important role in the conduct of idea flow.

Whether hybrid visual analytics systems can also affect the structure of the conversation during the decision-making processes, particularly during the presentations of findings to the relevant audience, remains as an interesting question. For example, in a common setting where a presentation is made over a common presentation application, an audience tends not to interrupt the presentation by keeping their feedbacks or criticism to a predefined time slot. This situation seems to form a one-way communication structure where the presenter has an implied control of the setting. On the other hand, we have observed a slightly different situation where communication during all phases of this study was two-way. This observation implies that physically available data and its visualization might change the habitual behaviours that we adopt during presentations and briefings, which we will explore in one of our future studies.

Telepresence plays an important role in remote collaboration and decision-making as the companies are getting increasingly global. Being one of the blessings of the digital age, remote collaboration via video conference and large displays are current telepresence systems widely employed by many organizations; however, face-to-face communication, in which individuals are able to make more use of voice prosody, facial expressions, gaze, hand and bodily gestures to convey the intended messages, remains as a golden standard [6] of communicative effectiveness. From this point of view, making all aspects (users, data, inferences) of remote analysis and collaboration activities as physically available as possible is an important step towards the golden standard of communication. The use of techniques available in the spatial augmented reality with physical visualizations can lead to design of tools that substantially enhance remote collaborative analysis. For example, we can illustrate visual elements such as bar or pie charts over a landmark on physical visualization in the virtual space in which we can browse through the lenses of our computing devices. Then we can obviously send our inferences to our colleagues so that they can view them via their own devices supporting browsing in the virtual space. This kind of communication primitives can help us build more sophisticated and engaging telepresence systems that are more realistic compared to their conventional counterparts.

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