

A State Transition Approach to Understanding Users' Interactions

Dong Hyun Jeong*
University of the District of Columbia

Soo-Yeon Ji†
Bowie State University

William Ribarsky‡
University of North Carolina at Charlotte

Remco Chang§
Tufts University

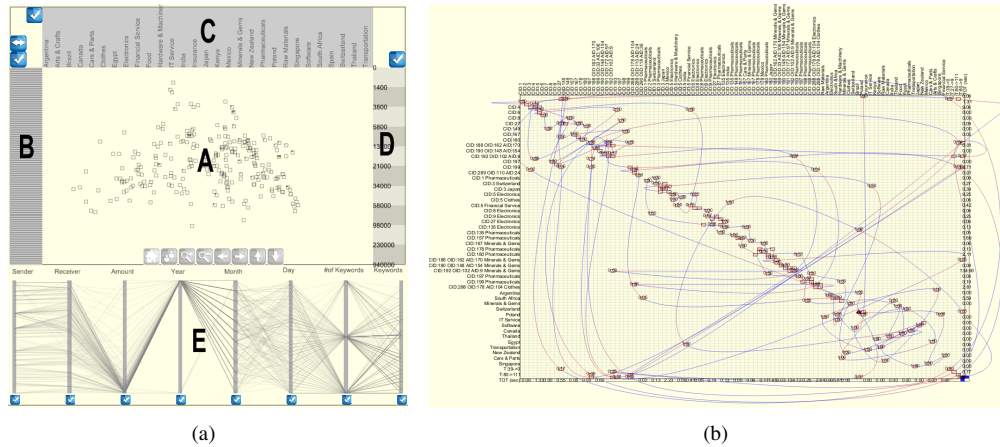


Figure 1: Overview of InteractionViz. It consists of two windows as a Relation Window (a) and a Transition Window (b). The Relation Window consists of multiple coordinated views to show the relationships between keywords, accounts, and transactions. Experts' findings on transactions are represented in the Relation Window and their overall semantic-level interactions (i.e. keywords, accounts, and transactions) are displayed in the Transition Window by following a state transition approach.

ABSTRACT

Understanding users' interactions is considered as one of important research topics in visual analytics. Although numerous empirical user studies have been performed to understand a user's interaction, a limited study has been successful in connecting the user's interaction to his/her reasoning. In this paper, we present an approach of understanding experts' interactive analysis by connecting their interactions to findings through a state transition approach.

1 INTRODUCTION

Although there are many useful visualization applications have been designed, how much the designed systems are useful in solving analytical questions is regarded as a research challenge. In visualization community, researchers discussed to find possible research directions in understanding users' interactions by connecting to their reasonings [1]. From the discussion, one of promising research directions was to use an eye-tracking device, with which a user's interaction can be analyzed by tracking one's visually processed visual elements. Although this approach is a quite promising research direction, how to connect the user's interaction to his reasoning and how to analyze the captured eye-tracking data is still unknown. In contrary to this approach, we performed an expert evaluation to see how user interactions encode experts' reasoning [4, 3]. From the study, we found that by examining financial analysts' interactions (semantic-level interactions), about up to 79% of their

findings can be recovered through the use of a visual analytical tool. This indicates that the user's interaction logs (e.g. semantic-level interactions such as keywords, accounts, and transactions) are somewhat connected to one's reasoning behind the analysis process. In addition, we observed that financial analysts have different opinions on each financial transaction. Although they have different ideas and sometimes contradict each other on determining each transaction as suspicious, unsuspecting, and inconclusive, we found that finding the evidence how they ended up with their ideas is difficult.

In this paper, we propose an approach to understand the analysts' interactions. To extract their interactions and discover the reasoning behind the analysis processes, we used a state transition approach by creating a state transition matrix (i.e. Markov Chain [5]). In here, each user-created interaction is regarded as a state. Depending on the number of semantic information, a $m \times m$ transition matrix is generated by referencing the overall user's interactions. With this transition matrix, the user reasoning can be recovered. This paper begins with describing the designed visual analytics system, then moves to explaining how the user's interactions can be analyzed by connecting them to his reasoning through the system.

2 SYSTEM DESIGN

In our previous study [4, 3], we performed an experts' user study based on a well-known financial visual analytics system (called WireVis [2]). From the study, we observed that financial analysts have different opinions on each financial transaction as suspicious, unsuspecting, and inconclusive. Since their decisions are often based on experiences, it is difficult to understand how they concluded with their decisions. To understand how they ended up with different ideas, we designed a system (called InteractionViz) by following a coordinated multiple views approach. As shown in Figure 1, InteractionViz consists of two windows as the Relation Window and the Transition Window. The Relation Window represents the relationship among accounts, keywords, or transactions.

*e-mail: djeong@udc.edu

†e-mail: sji@bowiestate.edu

‡e-mail: ribarsky@uncc.edu

§e-mail: rchang@tufts.edu

And the Transition Window shows how the user transits from one state to another while performing the visual exploration on the financial data.

2.1 Relation Window

The Relation Window is designed consisting of three views: the Projection View (Figure 1(a) (A)), the Information View (Figure 1(a) (B ~ D)), and the Data View (Figure 1(a) (E)). The Projection View represents a specific aspect of the financial transaction data that are coordinated in such a way that any interaction with one view is immediately reflected in all the other views (brushing & linking).

The Projection View projects all transaction data points onto a two-dimensional coordinate system based on Principle Component Analysis (PCA). The Information View has three information panels as accounts ((Figure 1(a) (B))), keywords (Figure 1(a) (C)), and the amounts of the transactions (Figure 1(a) (D)). Relevant information of highlighted or selected transactions are visualized in these panels as connected lines. The Data View shows a parallel coordinates visualization of all transactions in the original data dimensions. There are about 8 dimensions in financial transaction data as sender account, receiver account, the amounts of the transactions, date information (year, month, and day), number of keywords, and actual keywords related to each transaction.

2.2 Transition Window

The Transition Window represents the user’s semantic interactions by creating a state transition matrix. As we mentioned above, each interaction is regarded as a state that indicates the user’s interaction with visual elements. The changes of state indicate transitions with the the probabilities associated with various state-changes. The set of all states and transition probabilities in the state transition matrix completely characterizes a Markov chain. Since the WireVis represents 380 accounts (including account clusters), 29 keywords, 249 transactions, and 11020 account \times keyword combinations, roughly 11680 \times 11680 transition matrix is created. Since all states cannot be visited by the user, non-visited states are removed from the transition matrix to increase readability of represented visual elements. In the transition matrix, y-axis indicates current state and x-axis represents future transition state.

How much time the user looked at each state is measured in seconds and mapped with a gradient blue color. Darker blue indicates the user spent more time proportionally to other states. Additionally, the user’s continuous interactions are represented as a spline curve (see Figure 1(b)).

3 CONNECTING THE USERS’ FINDINGS TO INTERACTIONS

By investigating wire transactions, financial analysts often determine the investigated transaction(s) as suspicious, unsuspecting, or inconclusive. To show how they ended up with their decisions, InteractionViz is designed as the Relation window shows the user’s decisions (i.e. findings) and the Transition window represents the user’s interactions (i.e. reasoning).

All expert analysts’ decisions (i.e. findings(see Figure 2(a))) and their interaction logs (i.e. semantic-level interactions) from the previous study [3] are used. As shown in Figure 2, the analysts’ diverse opinions on each transaction are displayed inside the Projection View and colored as red (“suspicious”), blue (“unsuspicious”), and green (“inconclusive”).

In Relation Window, the user can move the mouse over the data in the information panels and projected data elements in the Projection View. This allows the user to focus on specific transactions and observe which accounts are transacting over what keywords and amounts. Such tightly integrated interactions are supported in the Information View, the Projection View, and the Data View. The

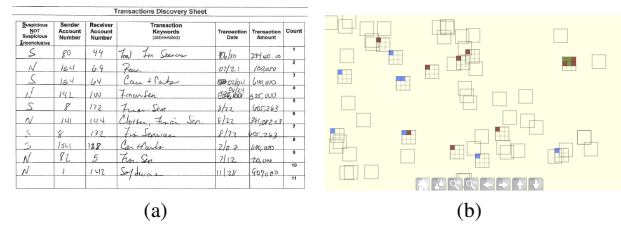


Figure 2: During the experts evaluation, financial analysts were requested to write down their final findings in transaction discovery sheet. Figure (a) shows an expert’s transaction discovery sheet. Experts’ findings in transaction discovery sheets are displayed within each transaction in the Projection View (b). By selecting a finding in the Relation Window, interaction log corresponding to the selected finding is represented as a state transition matrix in the Transition Window.

ability to select data items in one view and immediately see the corresponding items highlighted in the other coordinated views helps the user to understand the relationship between selected items in more than two views. After finding an interesting findings in the Relation Window, corresponding user’s interactions (i.e. semantic-interactions) are represented as a transition matrix in the Transition Window. To increase the ability of understanding the represented visual elements in the two windows, interaction techniques (such as selecting, highlighting, and zooming) are supported.

4 CONCLUSION AND FUTURE WORK

In this paper, we propose an approach of understanding financial analysts’ interactions through a visual analytics application. By exploring and examining both wire transactions and the user’s interaction, it is possible to find how each expert ended up with decisions on transactions as suspicious, unsuspecting, and inconclusive. The provided set of interaction and representation techniques are useful to perform interactive exploration as well as examination on the user’s interactions and wire transactions. Since experts’ decisions are diverse and sometimes contradictory to each other, tracing their reasoning can be an important process to understand their analytical procedures of finding and understanding wire transactions.

We believe that the system is well designed to address the analysts’ overall analytical processes. However, it is necessary to conduct an evaluation to validate the system as well as our idea of preserving all users’ findings in visualization. Specifically, we are going to focus on recovering the analysts’ reasoning by observing the transition matrix.

REFERENCES

- [1] BELIV '10: *Proceedings of the 2010 AVI workshop on BEyond time and errors: novel evaluation methods for Information Visualization*, 2010. Conference Chairs-Enrico Bertini, Heidi Lam, and Chair-Adam Perer.
- [2] R. Chang, M. Ghoniem, R. Kosara, W. Ribarsky, J. Yang, E. Suma, C. Ziemkiewicz, D. Kern, and A. Sudjianto. Wirevis: Visualization of categorical, time-varying data from financial transactions. In *Visual Analytics Science and Technology, 2007. VAST '07. IEEE Symposium on*, pages 155–162, 2007.
- [3] W. Dou, D. H. Jeong, H. R. Lipford, F. Stukes, R. Chang, U. Charlotte, and W. Ribarsky. Recovering reasoning processes from user interactions. *Computer Graphics and Applications*, 2009.
- [4] D. H. Jeong, W. Dou, H. Lipford, F. Stukes, R. Chang, and W. Ribarsky. Evaluating the relationship between user interaction and financial visual analysis. In *Visual Analytics Science and Technology, 2008. VAST '08. IEEE Symposium on*, pages 83–90, 2008.
- [5] S. Meyn and R. Tweedie. *Markov Chains and Stochastic Stability*. Springer, first edition, 1996.