Guest Editorial: Special Issue on Interactive Visual Analysis of Human and Crowd Behaviors

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The analysis of human behaviors has impacted many social and commercial domains. How could interactive visual analytic systems be used to further provide behavioral insights? This editorial introduction features emerging research trend related to this question. The four articles accepted for this special issue represent recent progress: they identify research challenges arising from analysis of human and crowd behaviors, and present novel methods in visual analysis to address those challenges and help make behavioral data more useful.

CCS Concepts: • **Information systems** → **Information systems applications**; • **Human-centered computing** → **Human computer interaction (HCI)**; **Interaction design**; **Collaborative and social computing**; **Visualization**; *Applied computing*;

Additional Key Words and Phrases: Visual analytics, interactive visualization, behavioral data, social network analysis, human mobility, crowd behaviors, social dynamics

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Every aspect of daily life can be impacted by the new strengths we have in data analysis, from the cereal we have for breakfast to how our governments supply emergency relief during a natural disaster. In addition, the analysis of human behaviors has impacted many academic and commercial domains, ranging from business, health, and security to education, smart government, and disaster management. With the proliferation and accumulation of human behavioral data, marketers now analyze customers' Web site surfing and shopping transactions to identify potential marketing targets, and healthcare providers can augment clinical data with patients' social networking behavior to improve health plans and clinical outcomes. Although many statistical techniques have been developed for data analysis, people often find them insufficient to provide behavioral insights, especially into how individuals or crowds will behave and why, because most statistical analyses neglect to provide or consider the behavioral context. Interactive visual analytic systems that couple

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interactive design with data analysis to reveal analytic results with their behavioral contexts have provided new ways to study and predict human behavior. In this special issue, we feature work in this emerging area, which we expect will benefit society and business greatly in the near future.

This special issue includes four articles that identify research challenges arising from analysis of human and crowd behaviors, and present novel methods in visual analysis to address those challenges and help make such data more useful. The implications of these works span a range of domains, including healthcare, education, human mobility, and scholarly impact analysis. Their contributions cover three major themes:

- (1) New visual analytics that leverage machine learning techniques to generate meaningful behavioral signatures
- (2) New system and interactive designs that support behavioral analysis, such as summarizing behavior patterns, detecting behavior anomalies, and seeking particular behavioral signatures
- (3) Incorporation of domain expertise into the design and evaluation processes to ensure the interpretability and utility of new systems.

In addition, each of these works puts forward a new suite of interactive visual analysis tools and techniques that are well suited for the specific domain problem under study while also being applicable to general behavioral analysis applications such as ego-centric and social network analysis, event sequence analysis, crowd movement analysis, and social group and conversation analysis. The unique contributions of these works are summarized as follows.

The first article, “Chronodes: Interactive Multifocus Exploration of Event Sequences” by Polack, Chen, Kahng, de Barbaro, Basole, Sharmin, and Chau, gives a representative example that simultaneously covers all three aforementioned themes. The authors present a visual analytic system to support the exploratory data analysis of longitudinal mobile health (mHealth) data. The advent of mHealth technologies challenges the capabilities of current visualizations, interactive tools, and algorithms. For electronic health records and mHealth data in particular, aggregating the event data of multiple patient timelines into a single timeline can be difficult to interpret, because the order of events in one timeline is completely uncorrelated to events in another. Moreover, each patient’s timeline can extend across multiple days, may include multiple data sources, and can involve repeating behaviors, any of which may be of interest to health data analysts.

To address these challenges, the authors propose “Chronodes,” which utilizes frequent sequence mining to extract and visualize frequent sequences of events, thereby revealing chronological patterns across multiple patient timelines of mHealth data. Their method enables users to define cohorts of patients constructively: rather than specifying cohorts for comparison and viewing their sequences of events, it allows cohorts to be specified according to an arrangement of the events themselves. By pairing this functionality with the ability to select events of interest and to view their adjacent events, Chronodes enables the user to fluidly explore cohorts and their associated chains of events in tandem. It further combines novel interactive visualization techniques to enable multifocus event sequence analysis, permitting health researchers to interactively define, explore, and compare groups of participant behaviors using event sequence combinations. In addition, a pattern recognition tool is provided for users to interactively convert quantitative data patterns into discrete events.

The second article, “VisForum: A Visual Analysis System for Exploring User Groups in Online Forums” by Fu, Yang, Bi, Guo, and Qu, also covers all three themes. In this article, the authors present a visual analytic system for exploring the behaviors of user groups based on online forum data. User interaction in asynchronous online forums is a common form of human social behaviors. For example, people with similar backgrounds or shared interests like to join the same group

discussions. As tens of thousands of archived conversational posts accumulate, forum administrators and analysts find it important to effectively explore user groups across large-volume threads to gain meaningful insights into the hierarchical discussions. Identifying and comparing groups in discussion threads are nontrivial tasks, as the number of users and posts increases with time and noise may hamper the detection of members of various user groups. Currently, the results obtained from most data mining techniques are not intuitive and make it difficult for users to explore the details.

To overcome this, the authors present “VisForum,” a visual analytic system allowing people to interactively explore user groups in a specific forum. The authors worked closely with two educators, who have released MOOC courses, to compile a list of design goals to guide the design. They then designed and implemented a multicoordinated interface, as well as several novel glyphs, to capture group behavior at different levels of granularity. The proposed method includes group detection, sorting, and ranking schemes for users to identify high-impact forum members. Two case studies using real-world datasets demonstrate the usefulness of the system and the effectiveness of those novel glyph designs. Furthermore, they conducted an in-lab user study to verify the usability of VisForum.

The article “A Visual Analytics Framework for Exploring Theme Park Dynamics” by Steptoe, Krueger, Garcia, Liang, and Maciejewski contributes to both the first and the second themes. The authors present a visual analytic system for exploring visitor mobility data in a theme park, but the system has the potential to address larger challenges in understanding spatiotemporal data. In the past, spatial measurements were relegated to single snapshots in time with Decennial Population Censuses and other statistics collected by the government providing the basis for analysis. However, the current influx of data, from Twitter feeds to traffic patterns to home electricity consumption, now provides real-time updates at fine-scale spatial resolutions. The translation of such data into a visual form allows users to quickly see patterns, explore summaries, and relate domain knowledge about underlying geographical phenomena that would not be apparent in a tabular form. Yet as multivariate dataset sizes grow larger, cartographic representations are likely to become more complex.

In this article, the authors seek to enable users to explore such large complex spatiotemporal data through the development of a visual analytics framework for exploring theme park dynamics. This framework clusters individual trajectories, links these to semantically meaningful geographic locations, and enables analysts to use this information to determine how the underlying urban form (in this case a theme park) is being used by the community it serves (the theme park visitors). The ability to explore movements and interactions within a theme park is broadly applicable to any trajectory dataset, and these techniques can inform a wide audience from readers interested in smart cities to urban planning to emergency response and evacuation.

The article “Visualizing Research Impact Through Citation Data” by Wang, Shi, Li, Tong, and Qu contributes to both the second and the third aforementioned themes. In this article, the authors present a visual analytics system for exploring and summarizing scholars’ research impact using citation datasets. The citations accumulated by research papers represent a very interesting type of collective behavior, which exhibits how scholars from academic communities develop new ideas or approaches based on others’ discoveries. Evaluating research impact is important in many applications. For example, scholars may want to know their own or others’ influence on a research direction, funding bodies need to check the research impact of applicants, and journal editors are interested in the quality of papers published in their journal. Citation metrics are one of the most popular ways to quantify research impact, indicating the influence of a scholar, a journal, or a conference in a research field. Statistical metrics such as h-index, citation count, and impact factor

are mostly aggregated by nature and sometimes biased, hindering people from understanding a scholar's research impact in a more comprehensive manner.

In this work, the authors propose "ImpactVis," an interactive and scalable visual analysis system to help users easily explore the possible factors influencing research impact, its temporal evolution, and the researchers and fields actually influenced by a specific piece of work. A novel and compact visual design using augmented matrix representation is introduced, and its effectiveness and usability are demonstrated through case studies and in-depth expert interviews.

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