Data Exploration and Visual Analytics in AI era

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ARTICLE INFO

Keywords:
Human-AI Collaboration
Human-Data Interaction
Human-Centered AI
Visualization

1. Introduction

Artificial intelligence is reshaping how users access, explore, and interpret data, as well as how human–centered systems are designed. The emergence of technologies such as large language models and vision-language models has expanded analytical capabilities beyond structured datasets, enabling systems to process large volumes of unstructured and multimodal information, including text, images, audio, and video. At the same time, visualization and visual analytics are becoming increasingly important in helping users explore complex information, interpret AI-generated results, and interact effectively with analytical systems.

These developments are transforming human–AI collaboration by enabling users to engage more actively with intelligent systems throughout exploratory and analytical processes, creating new requirements for human–data interaction systems. The non-deterministic behavior of contemporary AI models and their potential to produce biased or inaccurate results, make verification and continued human involvement essential. Furthermore, an end-to-end design approach is needed, in which data management, AI components, interfaces, and visualization are developed as interconnected elements of the same analytical environment [1].

Latency and scalability represent major challenges, as delays and performance limitations can disrupt users' reasoning and restrict effective data exploration. Interfaces must also support multimodal, adaptive, and action-oriented forms of interaction through natural language, gestures, immersive technologies, and progressive feedback. At the same time, visualization should function as an active component that guides exploration, supports interpretation, communicates uncertainty, and strengthens trust in AI-assisted results. Addressing these requirements calls for sustained interdisciplinary collaboration across AI, databases, information visualization, human–computer interaction, computer graphics, and cognitive science [1].

Additionally, the growing influence of AI has prompted a reassessment of established and emerging research challenges in human–data interaction and visual analytics. A recent study compares long-standing challenges with those that have emerged in the AI era and assesses their current relevance and importance [2]. The findings indicate that, although several established challenges (e.g., scalability and efficiency) [3] remain important, advances in AI have introduced new concerns related to the reliability, interpretability, and responsible use of intelligent systems. The findings also reveal a growing emphasis on accessible, scalable, and adaptive analytical environments capable of supporting diverse users, complex data, and emerging forms of interaction. Future research must therefore address both persistent limitations and the broader challenges associated with AI-assisted analysis.

This special issue contains extended versions of selected papers from the 7th International Workshop on Big Data Visual Exploration and Analytics (BigVis 2024), held in conjunction with the 50th *International Conference on Very Large Databases* (VLDB 2024) in Guangzhou, China.[1]

2. Articles

In *Techniques for Interactive Visual Examination of Vessel Performance* [5], Natalia Andrienko and co-authors examine how visual analytics methods can be applied to maritime movement data at different scales. Drawing on both a small experimental dataset from autonomous vessels and a much larger collection of ferry trajectories recorded using the Automatic Identification System (AIS), the study demonstrates how computational processing and interactive

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[1]Further details about the BigVis workshops can be found in [4].

visualization can be combined to identify unusual behavior, assess the consistency of repeated trips, and examine vessel movements within their spatial and temporal contexts. The article proposes a workflow that supports analysis at scale while retaining the ability to inspect individual cases in detail. It also demonstrates the importance of expert knowledge in interpreting detected anomalies because apparent deviations may result from missing data, routine traffic maneuvers, or compliance with navigation rules rather than genuine operational problems.

In *Tangible Progress: Employing Visual Metaphors and Physical Interfaces in AI-based English Language Learning* [6], Mei Wang and co-authors explore how visual and tangible forms of feedback can improve the experience of AI-supported language learning. The proposed system combines automated essay scoring with a tree-based visual metaphor that represents different aspects of writing performance, while printable postcards allow learners to maintain a physical record of their progress. The system was evaluated through expert interviews and a three-stage study involving English-language learners. Participants generally found the visual feedback clear and engaging, and the postcards encouraged many of them to practice more frequently and remain engaged in the learning process. The results suggest that combining AI assessment with intuitive visualizations and tangible feedback can make learning progress easier for students to understand and can increase their motivation.

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