Immersive Analytics of Graphs in Virtual Reality with GAV-VR

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Abstract

The design space for interactive graph visualisation in immersive environments creates opportunities to improve on established solutions in traditional desktop settings. Exploiting this potential requires careful analysis of achievable benefits, required tradeoffs, and disadvantages for particular designs and use-cases. GAV-VR is a modular and user-extensible framework for graph visualisation and analysis in Virtual Reality (VR). It provides the platform to easily create interactive graph visualisations, facilitating both applied graph analysis and evaluation of approaches and methods for visualisation of and interaction with graphs in VR.

2012 ACM Subject Classification Human-centered computing → Visualization systems and tools; Human-centered computing → Visual analytics; Human-centered computing → Virtual reality

Keywords and phrases Networks, Immersive Analytics, Software

Digital Object Identifier 10.4230/LIPIcs.GD.2024.57

Category Software Abstract

Funding We acknowledge funding by Deutsche Forschungsgemeinschaft (DFG), under Germany's Excellence Strategy – EXC 2117 – 422037984 and DFG project ID 251654672 – TRR 161.

1 Introduction

Interactive 3D graph visualisation, especially in VR, has shown potential in enhancing graph structure understanding and analysis across various applications [3]. The large design space for graph representation and interaction in VR offers significant opportunities for improving analysis processes. Features such as stereoscopic 3D visualisation, user tracking, and direct interaction need to be properly investigated and integrated into efficient designs in order to make use of these opportunities. The effort to implement a VR-based graph visualisation from scratch, but also to re-assemble basic functionalities for each new project, is a large obstacle for quick prototyping and design comparison and distracts researchers and practitioners from their main focus, e.g. graph analysis or evaluation of methods [1].

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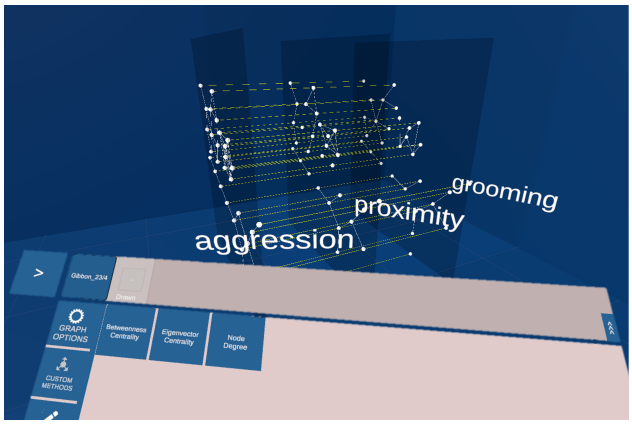

Figure 1 Screenshot of a multilayer network visualisation in GAV-VR, with parts of the user interface in the foreground.

We demonstrate *Graph Analysis and Visualisation in VR* (GAV-VR) [2], a framework designed for interactive graph visualisation and analysis in VR. The framework facilitates prototyping, method comparison, and interactive graph analysis. GAV-VR's modular architecture supports various VR headsets, data formats, and visualisation methods, enabling easy integration of new functionalities.

2 GAV-VR Structure and Use

GAV-VR serves two types of users: *analysts* and *contributors*. Analysts use the system to investigate graphs with a pre-implemented build that requires no coding but includes ready-to-use features for graph analysis in VR. Contributors enhance GAV-VR by developing new features within a modular Unity C# environment. They utilise abstract classes and pre-defined routines without needing a deep understanding of the entire framework.

The architecture of GAV-VR includes a *core* that handles core functionalities and manages modular features, and *modules* that represent the custom content added by contributors. The core provides user interfaces and controls for interaction with graphs, edges, and vertices. Modules can be script-based, implementing new methods and features through C# classes, or file-based, altering object representations through prefab files.

Script-based modules extend functionalities such as file parsing and movement modes, using abstract classes to integrate new features. File-based modules modify visual aspects such as vertex and edge representations, which are automatically integrated into the UI. To integrate modules, contributors either add C# files for script-based modules or place custom prefab files for file-based modules.

In GAV-VR, graphs are visualised as node-link diagrams. The representation of vertices and edges can be customised. The UI is adjustable and supports raycast point-and-click interactions. Users can manipulate graphs directly, e.g. through rotation and translation. Data handling and analysis are managed by the core, which ensures data integrity and validates file formats. Graphs are saved in a simple, human-readable ".gavvr" format that captures essential attributes. Performance varies with interactive and non-interactive modes, supporting up to 2,000 objects interactively and 20,000 objects non-interactively, depending on hardware capabilities.

3 Conclusion

The GAV-VR framework offers a robust solution for interactive graph visualisation and analysis within VR environments. By supporting both *analysts* and *contributors*, GAV-VR caters to diverse user needs. The architecture ensures seamless integration of new features while maintaining core functionality. With its support for both script-based and file-based modules, GAV-VR allows extensive customisation, from adding new graph analysis methods to modifying visual representations. Licenced under the GNU Affero General Public License V3, GAV-VR promotes open, non-commercial use, fostering innovation and collaboration in the field of graph visualisation.

References

1 Stefan P. Feyer, Bruno Pinaud, Stephen Kobourov, Nicolas Brich, Michael Krone, Andreas Kerren, Michael Behrisch, Falk Schreiber, and Karsten Klein. 2D, 2.5D, or 3D? an exploratory study on multilayer network visualisations in virtual reality. *IEEE Transactions on Visualization and Computer Graphics*, 30(1):469–479, 2024. doi:10.1109/TVCG.2023.3327402.

2 Wilhelm Kerle-Malcharek, Stefan P. Feyer, Falk Schreiber, and Karsten Klein. GAV-VR: an extensible framework for graph analysis and visualisation in virtual reality. In Jean-Marie Normand, editor, *ICAT-EGVE 2023 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments*, pages 131–139, Eindhoven, 2023. The Eurographics Association. doi:10.2312/egve.20231321.

3 Matthias Kraus, Johannes Fuchs, Björn Sommer, Karsten Klein, Ulrich Engelke, Daniel Keim, and Falk Schreiber. Immersive analytics with abstract 3D visualizations: A survey. In *Computer Graphics Forum*, volume 41(1), pages 201–229. Wiley Online Library, 2022. doi:10.1111/CGF.14430.