Towards a Collaborative Experimental Environment for Graph Visualization Research in Virtual Reality

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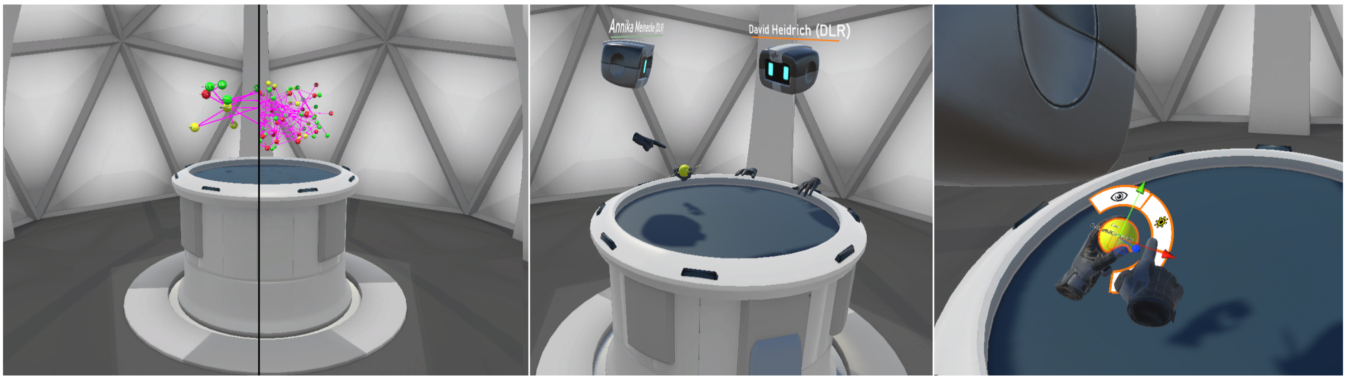

Figure 1: *The collaborative experimental environment; Left: The table with nodes floating above it; Center: Virtual avatars placed around the table talking to each other; Right: Virtual avatar interacting with a node using natural interaction.*

Abstract

Graph visualization benefit from virtual reality (VR) technology and a collaborative environment. However, implementing collaborative graph visualizations can be very resource consuming and existing prototypes cannot be reused easily. We present a work-in-progress collaborative experimental environment for graph visualization research in VR, which is highly modular, contains all fundamental functionality of a collaborative graph visualization, and provides common interaction techniques. Our environment enables researchers to create and evaluate modules in the same environment for a wide range of experiments.

CCS Concepts

• ***Human-centered computing*** → ***Virtual reality;*** *Graph drawings; Interaction techniques;* ***Collaborative and social computing systems and tools;*** • ***Software and its engineering*** → *Collaboration in software development;*

1. Introduction

An efficient and effective visual analysis of graph data often requires various experts from different locations working together. Immersive virtual reality (VR) technology can help overcome the boundaries of a specific place and create a collaborative virtual workplace [HC10, ŠSS*19]. In comparison to desktop-3D, wearing a head-mounted display (HMD) provides stereoscopy, gives additional depth information, and increases a user's visual angle, which can increase performance in graph visualization tasks [GPK14, WM08]. As a result, transferring graph visualization into VR is an objective in many research areas [DCW*18, HZBK08, OOKO15].

Comparing existing graph visualizations can be difficult, because different approaches tend to differ on multiple levels. Interaction techniques, the virtual environment, or virtual avatars can impact the user's experience and performance [BRD92, KH15]. Hence, for a valid comparison of different visualization approaches, researchers need experimental environments. By utilizing the same experimental environment and only changing individual modules (i.e., an independent variable), we can attribute measured differences to these modules. In line with the current trend of measuring the user experience of immersive information visualizations, we present a highly modular work-in-progress experimental environment for graph visualization research.

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2. Collaborative Experimental Environment

The experimental environment is implemented in C# using Unity 2021.0.1f1 and the SteamVR Unity Plugin v2.7.3. By utilizing SteamVR, we support most main stream HMDs from e.g. Oculus, HTC and Valve. We use the SteamVR Skeleton Input API for finger tracking and the Unity MLAPI for networking. The environment can import graphs from any Neo4j graph database using the Neo4j .NET Driver.

The environment consists of four different module types. Modules can be changed or added and multiple modules of the same type can be enabled at the same time. The example modules implemented by us are:

Virtual Environment (VE) Our VE for collaborative graph visualization consists of a futuristic room with a round table in its center (see Figure 1). The round table encourages collaboration [BMS00] and provides a stable frame of reference, reducing user disorientation and simulator sickness [MSZ*18, PDFr*99]. The room is 3×3 meters and thus ideal for natural walking in room scale VR. The table is narrow enough to allow users to reach everything displayed on or above it, without having to travel in the VE.

Graph Visualization The experimental environment connects to a graph database and imports the whole database on application start. Since graph visualization is a module that will probably be changed the most, we implemented a very simple visualization by representing nodes as floating colored spheres. The colors differ depending on the node type. Relationships are represented as magenta arrows connecting the corresponding spheres. The world position of the spheres is controlled by a force-directed layout, which places connected spheres closer to each other. The size of the spheres is adjusted automatically so that all spheres fit on the table initially.

Virtual Avatars The experimental environment is designed to be explored by multiple users at the same time in synchronous sessions [GG98]. Users are represented as virtual avatars consisting of a floating head and hands (see Figure 1). While speaking, the head shows a slight nodding movement. This attracts the attention of other users to the location of the speaker and provides additional visual feedback. By using finger tracking, the fingers of the virtual hands can move independently, which enables the use of hand gestures for non-verbal communication (e.g., to point at different objects). All users therefore can see and follow the actions of other users, thus building a social environment in which the graph visualization can be explored in a team. Each user is assigned a specific color when entering the collaborative space and their user name is presented above the virtual head. This should enable other users to address a person directly.

Graph Manipulation Users can interact with the graph using virtual hands and virtual ray pointers. This combination of interaction techniques has shown good user feedback in immersive analytics [WSN21]. When a node is selected (holding it both with the virtual hand or the ray pointer), a radial user interface appears around its center (see Figure 1). The interface consists of three buttons that can be pressed by touching it with a virtual finger or selecting it with the ray pointer. Using these buttons 1) highlights the current node, 2) shows/hides relationships of the current node, and 3) shows/hides node properties.

3. Conclusion and Future Work

Our work-in-progress collaborative experimental environment for graph visualization research in VR supports the creation of comparable graph visualizations. Utilizing the same experimental environment and only changing individual modules (i.e., an independent variable), allows experimenters to attribute measured differences to these modules. The modular approach lets developers concentrate on visualizing their graphs, thus reducing the development overhead. By providing an experimental environment that contains all fundamental functionality, we support the development of new virtual workplaces to explore graph visualizations in locally distributed teams—with increased demand while working from home during the COVID-19 pandemic.

Future work includes a refinement of the modules that will compose the experimental environment. The implemented modules will then be evaluated to ensure their usability for both researchers/developers and participants, as well as their suitability for immersive graph visualization. Additionally, we will focus on performance to ensure scalability for very large graphs. Lastly, we plan to make this environment open source and to use it to create and evaluate multiple graph visualization approaches in software engineering.

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