Initial Evaluation of Immersive Gesture Exploration with GestureExplorer

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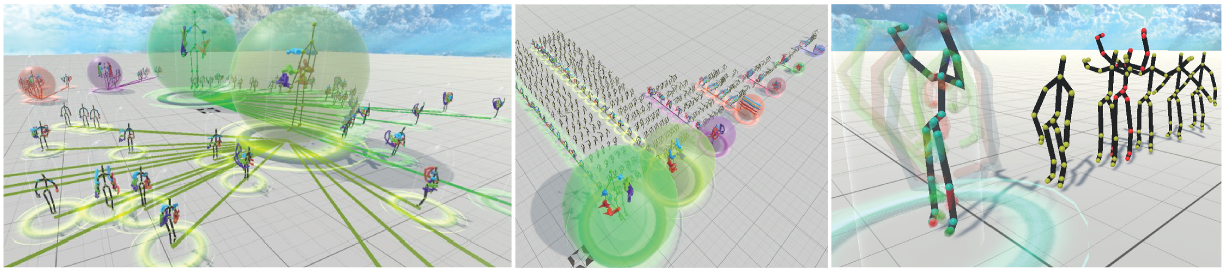

Figure 1: GestureExplorer supports immersive exploration of gesture data. Gestures are clustered by similartiy and can be spatially arranged by similarity distance to each cluster (left), or in sorted order (middle). We provide several interactive features for exploring individual gestures such as trajectory visualisation, small multiples, and animation (right).

ABSTRACT

This paper presents GestureExplorer, which features versatile immersive visualisations to grant the user free control over their perspective, allowing them to gain a better understanding of gestures. It provides multiple data visualisation views, and interactive features to support analysis and exploration of gesture datasets. A pair of iterative user studies provides initial feedback from several participants, including experts on immersive visualisation, and demonstrates the potential of GestureExplorer for providing a useful and engaging experience for exploring gesture data.

Index Terms: H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities;

1 INTRODUCTION

The design of intuitive gestures for new interactions has received much recent attention from researchers and gesture designers. Gesture elicitation studies (GES) are a popular way to elicit common gesture patterns that embody user preferences [7]. These studies have typically recorded elicited gestures in videos, which restricts their use to relatively small data sets given the time-consuming manual analysis they needed. Reserachers have recently introduced tools that support the process of pattern analysis in GES through automation and visualisation [1, 2, 4]. However, the visualisation in these tools is implemented as a 2D projection, which obscures some information from the original 3D gesture data.

The emergence of Immersive Analytics (IA) provides new opportunities for gesture data analysis. IA exploits immersive environments to preserve the 3D nature of data to reduce cognitive effort of mentally manipulating 2D view.

In this paper, we present GestureExplorer, an immersive tool to facilitate the analysis and exploration of gesture data. GestureExplorer builds on prior work on gesture analysis tools by providing multiple interactive 3D gesture visualisations in a large virtual space to promote physical exploration. We conduct an iterative sequence of two user studies with experts to evaluate the visualisations and interactive features. The outcomes confirm the potential of GestureExplorer for boosting gesture understanding and the process of exploration.

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2 BACKGROUND

Existing studies preprocess the dataset by grouping it into small clusters, then visualise each cluster instead of each isolated data using: 1) node representations for the clusters and links connecting nodes for the representation of the relationship between them [2]. 2) a flat layout of all clustered data [1], in which a scatter plot or a density graph is drawn to provide an overview of the dataset. Some other studies attempt to overlap data together [6], which takes less space to display the entire dataset and meanwhile enables swift identification of agreements and differences among data. As for the visualisation of individual gesture data in a dataset, common approaches include: 1) drawing a static trajectory of that motion [5], and 2) picking frames of the gesture based on a fixed time interval, then the poses of the gesture at the selected frames are visualised as small-multiple plots. A variation to this is to link a series of preprocessed gesture poses to represent that motion [1]. 3) providing playback animation of the gesture data represented by a skeleton ontology [1, 4]. Our tool allows users to choose either approach, and provides a novel feature combining all.

3 GESTUREEXPLORER: THE PROTOTYPE SYSTEM

GestureExplorer employs K-means clustering on gesture data sets, reducing manual efforts in identifying the common gesture pattern. It provides various visualisations for both gesture clusters and the individual gesture data within them - the former is visualised using a bubble metaphor, embedding an average gesture calculated from its member gestures while the latter is visualised as skeletons with motion trajectories drawn for each body joint (figure 1 left). However, our tool is not limited to full-body gestures, it could be potentially used for other kinds of gestures, too.

In the virtual reality environment of GestureExplorer, users can move around gesture views and navigate the larger space using continuous movement via the controllers and select clusters or gestures using raycast. Users can unfold a cluster for its member gestures and inspect their animation or small multiples. Additionally, GestureExplorer offers users the option to playback the animation along with a second animated view overlaid on small multiples that indicates the current time frame of the animation.

Users can arrange gestures in different rationales for a better understanding of the relationship between gestures within and among clusters (figure 1 left and middle). Furthermore, users can change the cluster of a gesture to another cluster where they think it belongs, which will consequently trigger an update of the placement of each gesture and cluster under current arrangement.

GestureExplorer also allows users to stack gestures for a fast identification of similarities and differences among the motion trajectories. Meanwhile, a heat map view can be applied to the stacked gestures to highlight the areas with the greatest amount of motion using additive blending. To reduce visual occlusion, users can filter out trajectories they do not want to observe and focus only on interesting ones.

Our tool is implemented with an Oculus Rift S in Unity 3D version 2020.3.17f1. We implemented all features conceptually described above. Multiple features can be activated on an object at the same time. For instance, the user can observe the trajectory stacking view while using trajectory filter to isolate trajectories for a particular body part.

4 Evaluation

We conducted a user study using an iterative design in 2 rounds with experts in immersive visualisation from 3 universities across 3 countries to evaluate our tool. Due to the impact of the COVID-19 pandemic, all user studies were conducted remotely online.

Participants first got a clone of the tool on their local machine. Via a slide presentation shared on a video conference call, they were then introduced briefly to the background of our research, the visualisations, UI, and features implemented in our tool, as well as how to apply features to visualisation objects. Then, participants were asked to explore an example dataset with given tasks which could be resolved by using the features implemented in our tool. We collected the demographic information of our participants via questionnaires. They were also asked to fill in an assessment questionnaire featured with Likert-based questions (scale 1-5) and some short-answered questions about various aspects of our tool.

Overall, the responses we collected from the feedback questionnaire were positive. Participants generally agreed that our tool helped them in gaining the understanding of gesture data, and the various gesture visualisations could help them better understand not only the individual gestures but also similarities between gestures and clusters. Most participants also indicated that they would prefer to use our immersive tool over a similar desktop tool for gesture exploration - "I felt very entertained using this tool to explore and analyse gestures, and I think in this case it is one of the very good point of using VR."

5 Discussion and Future Work

One interesting outcome of our evaluation was a reflection on the potential benefits and limitations of immersive 3D data visualisations relative to 2D views. While 3D views provide a more 'complete' picture of the 3D gesture data, there were mixed preferences about the spatial arrangement of gestures in 3D virtual space. Some participants indicated the potential of using the immersive view as a companion to existing 2D tools. Conversely, additional 2D views can be integrated into the immersive space to provide the benefits of both in a single tool, for instance by placing a large 2D dashboard on one wall of the virtual space. Since these participants had a background in 2D data visualisation, which may inflict a legacy bias when rating our system. Hence we plan to recruit a group of participants without relevant background as comparison to explore the potential impact.

Nonetheless, we see value the availability of a large 3D space for allowing participants to navigate among 3D gesture representations as part of the exploration process. Our implementation was motivated by DataHop [3], which proposed the use of space to help users track their analysis history. However, there is further research needed to investigate the potential benefits of kinaesthesia and spatial memory to enhance such analysis tasks in a large virtual space. Besides, we would like to enhance the ability to compare gestures from different clusters and therefore we are planning to introduce new arrangement options for gestures by employing dimensional reduction algorithms like PCA, MDS and t-SNE.

Another aspect deserving further exploration is the potential to further integrate embodied interaction into immersive systems such as GestureExplorer. Other features could further involve user activity in the analysis process, for instance by guiding users in recreating various gestures to better understand the body motions involved. Such features would be enhanced by additional tracking information of other body parts such as the torso, feet, head and fingers, as well as other physiological data such as electromyography (EMG) readings to understand muscle activity.

We would also like to investigate GestureExplorer with other types of gesture data, such as hand tracking data, or user motion over larger areas of space. These future investigations may reveal other potential applications of GestureExplorer beyond gesture elicitation studies, which motivated this work.

6 Conclusion

We presented GestureExplorer, an immersive system for exploring gesture data. Our prototype tool presents multiple immersive visualisations with interactive features to help users explore and gain a better understanding of gesture datasets. In a pair of iterative user evaluations, participants confirmed the potential value of such a tool, and provided suggestions for improvement.

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