FIESTA: A Free Roaming Collaborative Immersive Analytics System

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Abstract
We present FIESTA, a prototype system for collaborative immersive analytics (CIA). In contrast to many existing CIA prototypes, FIESTA allows users to collaboratively work together wherever and however they wish—untethered from mandatory physical display devices. Users can freely move around in a shared room-sized environment, author and generate immersive data visualisations, position them in the space around them, and share and communicate their insights to one another. Certain visualisation tasks are also supported to facilitate this process, such as details on demand and brushing and linking.

Author Keywords
Immersive analytics; data visualisation; collaboration; collaborative immersive analytics; virtual reality

CCS Concepts
•Human-centered computing → Visualization systems and tools;

Introduction
Immersive analytics explores how augmented and virtual reality (AR/VR) technologies can be used to support data visualisation, analytical reasoning, and decision making [4]. Collaborative immersive analytics (CIA), by extension,

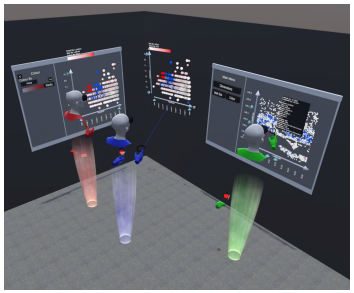

Figure 1: Multiple users can simultaneously work together to visualise data and find insights in FIESTA.

explores how multiple users collaborate in co-located and remote settings [1].

Current research has mainly demonstrated prototypes which combine AR head-mounted displays with physical display panels. Augmented Reality over the Tabletop [2] combines a multi-touch tabletop with an AR 3D parallel co-ordinates visualisation positioned orthogonally from the table. Multiple co-located users can stand around the table-top and configure and adjust the visualisation using touch controls. DataSpace [3] includes an array of 15 adjustable display panels attached to robotic arms. These are integrated with AR, VR, and other mobile devices to visualise and analyse large and complex datasets in a room-sized environment.

CIA has the ability to transform the way users work collaboratively to find insights. What is promising is the concept of a workspace where users can freely choose where and how to work unrestricted from physical limitations. For example, a group may decide not to sit around a stationary conference table, but instead work more actively and take advantage of the space around them using AR/VR technologies. In this sense, the only restriction is the actual size of the room.

We take this concept and develop FIESTA: the Free-range Immersive Environment to Support Team-based Analysis. FIESTA allows an arbitrary number of users to synchronously work together to visualise and find insights in a multivariate data set. These users are placed in a room-sized environment where they are untethered and can freely move in the space around them. In this, they can author and generate immersive data visualisations, position them in the space around them, and share and communicate their insights to one another (Figure 1).

Figure 2: The visualisation authoring panel used to generate visualisations. In this case it is configured to facet-by "YearBuilt", creating filtered small multiples between fixed yearly intervals.

System Design

Implementation

FIESTA was developed as a VR prototype in Unity3D using HTC Vive Pro headsets, controllers, and wearable backpack PCs to achieve tetherless VR. We chose to use VR as current AR technologies are limited in aspects such as field of view and performance. Because of this, users instead see each other as simplified Oculus Avatar[1] models with each user a unique colour. FIESTA is intended to be used in a co-located environment, with positional tracking correctly synchronised to minimise collisions, but it can very easily be adapted to be used in remote collaborative settings. While it can support an arbitrary number of simultaneous users, we found that three works comfortably in terms of performance, usability, and practicality.

[1] https://developer.oculus.com/documentation/avatarsdk/latest/concepts/

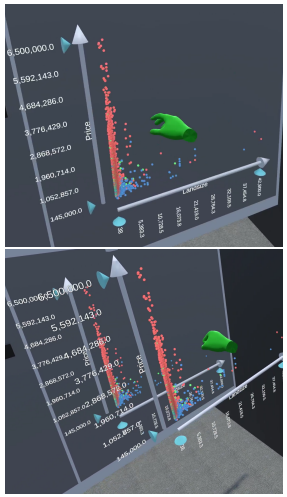

Figure 3: FIESTA uses a "tear-out" metaphor to duplicate visualisations from panels, and these can be freely positioned either in space or on the surfaces of the virtual room.

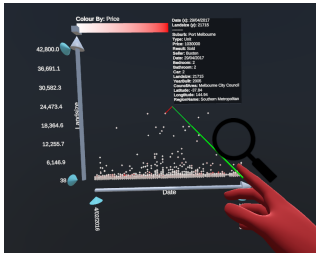

Figure 4: Users can easily get details on demand for individual data points using a laser pointer.

Authoring Visualisations

A key component of FIESTA is the ability for users to author and generate visualisations to then place in the space around them. To minimise learning time, we use conventional UI designs—buttons, dropdowns, sliders, etc.— which the user interacts with to change visualisation parameters. We organise this interface using a panel metaphor, as seen on the left side of Figure 2. The right side has the resultant visualisation that is updated to reflect the chosen parameters. The panel itself is a kinematic 3D object which the user can grab and move around the environment and position wherever they see fit, analogous to them moving their workspace.

Once a visualisation is deemed to be finished, the user can create a copy of a panel's visualisation by simply grabbing hold of it and pulling away from it, invoking a "tear-out" metaphor (Figure 3). This copy can now be re-positioned in the space around them in a manner similar to the panel. If a user wants to keep working on an already duplicated visualisation, they can "load" a visualisation onto a panel by holding and releasing a visualisation on top of it, in which the panel will reconfigure its buttons such that it matches the loaded visualisation. If they want to destroy a visualisation, they can simply "throw" it at the ground.

Visualisations are generated using the Immersive Analytics Toolkit (IATK) [5]. As multiple users can each simultaneously create multiple copies of visualisations, it is crucial for them to be as optimised as possible. While IATK can create visualisations with three-dimensional axes, we purposefully choose to restrict them to two-dimensions in order to minimise learning and confusion. Numerous parameters are available to customise these visualisations on the panel, such as size-by, colour-by, facet-by (small multiples), and mapping discrete colour palettes to a dimension.

Visualisation Tools

FIESTA also supports a selection of common visualisation tools. For example, users can resize visualisations, rescale maximum and minimum ranges along axes, inspect specific points for details on demand using a laser pointer, and brush points to make linked selections. Inspection is performed by holding down the touchpad on the dominant hand which enables a laser pointer, then pointing it nearby any data point (Figure 4). Brushing is accessed using a spin menu [6] on the non-dominant hand, with two brushing modes: private and shared. This invokes a toolbox-like metaphor, as the user then chooses which mode they wish to use by using the dominant hand. Private selections are only visible to the user (shown in yellow) while shared selections are visible to everyone (shown in the owner's avatar's colour). Selections and deselections made with either mode are automatically linked to all other visualisations in the environment.

Shared Environment

Users are placed in a virtual room that is slightly smaller than the actual size of the room they are in (Figure 5). In general, this room contains four virtual walls, which both acts as a visible boundary to prevent collisions, and allows users to "pin-up" visualisations on the wall. To do this, users can either hold and release or throw visualisations directly onto any wall, after which it will snap neatly into position. These surfaces can aid users in organising their visualisations should they so desire (Figure 6).

We consciously made everything in the environment visible and interactable by everyone—there is no concept of privacy nor are there locking mechanisms in FIESTA. This means users can freely walk over and use other panels or even interrupt one another while working.

Figure 5: The real-life perspective of FIESTA being used by three users at once. The virtual room is set to be slightly smaller than the real room.

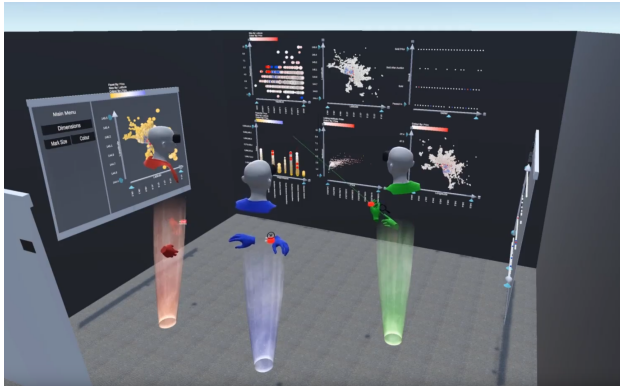

Figure 6: The walls in FIESTA can facilitate group discussion and presentation.

Conclusion and Future Work

This paper introduces FIESTA: the Free-range Immersive Environment to Support Team-based Analysis. It is a CIA prototype which allows multiple users to freely move around in a shared room-sized environment and collaboratively gather insights in data using immersive visualisations.

We plan to publish the results of an in-depth exploratory study using FIESTA with groups of users solving data visualisation tasks in a future paper. There are also many possible improvements we can make to the system. One option is to allow users to create and destroy their own surfaces at will, such as flat tabletops or moveable "whiteboards", which may open up whole new collaboration styles. We are also looking into supporting 3-dimensional visualisations, however we expect this would necessitate major design changes to both the panel-like interface and the laser pointer interaction methods.

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