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# Gesture-driven Interactions on a Virtual Hologram in Mixed Reality

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**Abstract**

This paper describes a framework using the Microsoft Kinect 2 and the Microsoft HoloLens that can assist users in analyzing complex datasets. The system allows for groups of people to view a topological map as a virtual hologram in order to assist them in understanding complex datasets. In addition, the gestures that are built into the system were created with the idea of usability in mind. By allowing the user to resize, rotate and reposition the map, it opens up a much wider range of understanding the data that they have received. Custom gestures are also possible depending on the situation, such as raising or lowering the water level in a potential flood hot spot, or viewing graphs and charts associated with a specific data point.

**Author Keywords**

Mixed Reality; 3D Topological Mapping; Gesture Recognition; Immersive Analytics.

**ACM Classification Keywords**

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

**Introduction**

There are many existing programs that allow users to apply tools to analyze information on desktop computers. However, immersive analytics has the

potential to help groups understand and interact with complex datasets in the real world. This field explores the idea of future interaction technologies for analyzing data in a virtual, augmented or mixed reality environment. There have been different approaches, such as Kwan and Lee's 3D GIERS system [1]. While these approaches have their merits, we see immersive analytics as a combination between mixed or augmented reality in a spatial context, with intuitive gesture interactions to access more detailed analytic results. Our work is driven to support a specific application scenario: effective emergency response management. By providing a 3D model in mixed reality, users can move freely within a room, interacting directly with a hologram in order to make time critical decisions. It is also possible for users to customize interactions in order to simulate scenarios that would be difficult otherwise.

While real holograms would be preferred, they are currently not practically feasible. To bridge this gap, we are using a virtual hologram, produced by the Microsoft HoloLens. The HoloLens' mixed reality is a combination of "virtual holograms" with meaningful information superimposed on the real world, as well as additional interactions with the holograms. The user can have the feeling of immersion into a virtual space without being totally shut out from surrounding events and people. In addition, by using the HoloLens, it allows for multiple people to look at the same model to assist in collaborative planning to discuss analytic views that were not possible before.

Moreover, Head Mounted Devices (HMD) are built for mobility, thus allowing users to move in a space and look at the same data from different perspectives. Our

approach allows the user to interact directly with a 3D model of data, which in our application is a topological map of the Bow Valley area. By placing such models into a three-dimensional space, it allows for a more comprehensive view than 2D traditional paper maps or digital tabletops [2] for their abilities to convey a sense of depth and height. In addition of mobility, custom gestures are implemented, allowing natural actions to assist the user in viewing the data. All of these features are created to allow users to focus on effective emergency response situations and assist those people to plan for any disasters that may occur.

### **Motivation**

Our goal is to create an application that can be applied to multiple situations in order to assist groups of people in collaborating and understanding complex data sets on topological maps. Information should also be easily accessible and understood, along with intuitive gestures for controlling the model. By having interactions that are based on usability, we hope that it will allow for quicker analysis, fewer mistakes, and a deeper understanding of any and all situations dealing with complex data. In addition, by allowing users to interact with the data points present on the map, it can allow for further analysis, such as possible evacuation areas or terrain that may be difficult to navigate.

Also, since our model is placed in the real world, we allow for users to take advantage of the additional space that is provided and have the possibility for a large map to be accessible by multiple people at once. Since our data is from NASA's topological information, users could actually enlarge the map and walk through it, gathering additional intel and information that was difficult to glean through a 2D view.

## Related Work

As Morrison et al. [3] showed, mixed reality and Augmented Reality (AR) in particular are superior tools over traditional 2D models for both their more accurate rendering of the real world, and their tendencies to push users to collaborate to achieve adequate results. AR forces the users to negotiate and work together. It also allows for full body movements which can be further explored thanks to HMD devices. Kwan and Lee [1] for their part support that 3D GIS-based Intelligent Emergency Response Systems (GIERS) are of great help in emergency response by reducing response time in critical situations. This correlates with the del Rocio Fuentes Fernandez et al. [4] study showing the usefulness of Augmented Reality combined with HMD in medical triaging. In addition, virtual spaces and tool are better controlled by hand gestures according to Rautaray and Agrawal [5] especially when wanting to resize or move the 3D models. Those hand gestures can be taken from the most common agreed upon movements by users from Piumsonboon et al. [6] user-defined gestures for Augmented Reality.

For further collaborative work, it is beneficial, to associate one user wearing a HoloLens placed on field, with another on-site companion that could remotely access the data seen and recorded by the HoloLens [7].

Our current system is a holographic model which can allow for collaborative work to occur during hectic situations. It takes AR to a higher level by allowing the user to be immersed to a certain extent, but not completely replacing their reality. By creating our system based on the usability of hand gestures in a 3D space, it also allows for quicker and easier interactions than on a 2D space or through a computer.

## System Design & Implementation

### Overview

As stated previously, immersive analytics explores the idea of future interaction technologies. However, with the current HoloLens, only two actual gestures are possible. Our project allows for actions that were not possible previously by integrating the Microsoft Kinect 2 to assist in tracking the human body. People can use gestures that are natural, rather than being limited by the hardware of one device. The Kinect actions are full body motions, compared to the restricted hand gestures of the ones provides solely by the HoloLens, allowing for a less rigid interaction with the hologram. The integration of the Kinect is possible through Society of Devices (SoD) [8]. The idea of SoD is to allow for a message to be sent out from a device and then have it possible to be received by other equipment that is also connected to the server. As such, if the Kinect receives a certain action, the HoloLens is notified and can relate to this action, changing the model in accordance to the

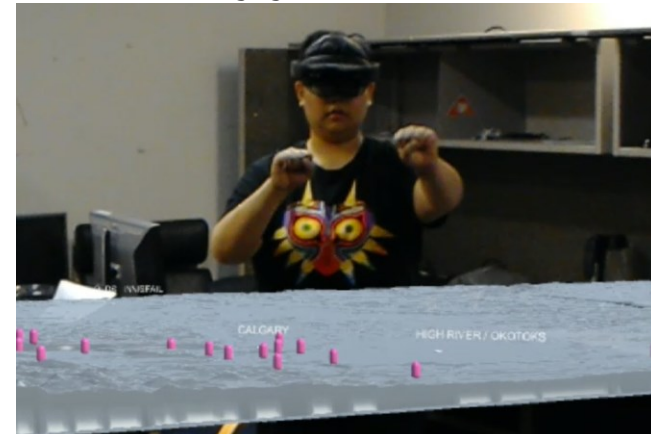


Figure 1. The user is wearing the HoloLens and using Kinect gestures to change the rotation of the model.

user's gesture. Figure 1 displays the user of the Kinect while wearing the HoloLens.

Our GIERS model also provides the ability to create a topological map in 3D space, allowing users to view an area in much more detail than before. By using NASA's topological information, any region can be modelled if it requires extensive analysis. Additional data points can also be placed onto the map if the user wishes to view this information, along with charts and graphs to assist in quicker decision-making. In the application scenario of the Bow River, our system assists users by modeling water levels at a specific hot spot, as well as providing numerical analysis and charts from weather stations.

#### *Interaction with the GIERS*

The HoloLens allows the user to interact with the GIERS in several ways, the most significant being to manipulating the terrain through the use of a Kinect. For specific scenarios, users could create custom gestures for each individual case to assist in understanding the possible dangers that could occur. An overview of these actions include resizing, rotating and repositioning the model, selecting specific data points, as well as any custom gestures to simulate natural disasters.

The model of the terrain can be resized, rotated, or repositioned. Since the GIERS uses real life satellite data to model the topological map, users also may want to have a more detailed look at certain regions of the map to gain insight on elevation and terrain. To do this, grabbing with both hands and moving them together or outwards will change the size of the model. By grabbing with both hands and rotating in either a clockwise or counter-clockwise direction, the model will

follow suit, rotating in whichever direction the user wishes to move the model. This allows for multiple views into a certain area, providing the best way to mobilize a team to provide assistance, or the most effective way to evacuate an area.

However, an important point to stress is that the Kinect is simply a tool to assist in HoloLens gestures, and does not replace the precise actions that is already provided. By performing an "air-hold" with the HoloLens, a manipulation cube can be opened to reposition the model with precision, allowing the user to place it where it would be most useful, providing functionality that would not be possible through a computer screen.

These simple interactions allow the user to be standing or sitting, and therefore has a wider freedom of body movement without affecting the efficiency of the system. This is particularly important for field work, such as an emergency situation where a chair and desktop setting might not be available, or would inconvenience the user.

The following interactions are created specifically for our example dataset, which is the Bow River area. In this scenario, it is possible to change the water level of the Old Man river, Bow river, and the Red Deer river. By predicting flooding in particular areas, it can assist people in more thorough evacuation plans that can be executed in a shorter amount of time. In order to raise or lower the water of the three rivers, the user can simply perform the "air-hold" gesture, then move their hand up or down, receiving immediate feedback with the water rising or falling and having affected city names turn red. While this is applicable to our application scenario, these gestures can also be

replicated in multiple ways, such as determining disaster zones that require evacuation. Changing the water level is one of many ways in which custom gestures could be applied to emergency response situations.

When analyzing complex data, oftentimes users need to view individual data points. While we use weather stations with elevation and water level data in our scenario example, it would be possible to place information centers which are gathering other important geospatial information into the model. For our scenario example, the weather stations are pink pills placed on the topological map and selectable via gestures. The user performs an “air-tap”, which is similar to the mouse click on the computer. Once selected, a panel displays numerical data above the map to be analyzed by users. This large panel is readable and understandable at a glance of an eye, allowing the users to access the information with ease. Also, charts and graphs can be displayed, allowing for a more diverse use of the application in multiple emergency response situations. An example of this is in Figure 2, where data on drainage is displayed in charts on the left, with the weather station information on the right.

All these interactions are created to be intuitive and easy to use. By implementing gestures that are natural to the user, it provides a sense of ease, allowing them to quickly understand the situation and further resolve any issue that may have occurred. Users can also customize their requirements according to their complex data, and create different gestures in order to simulate different disasters.

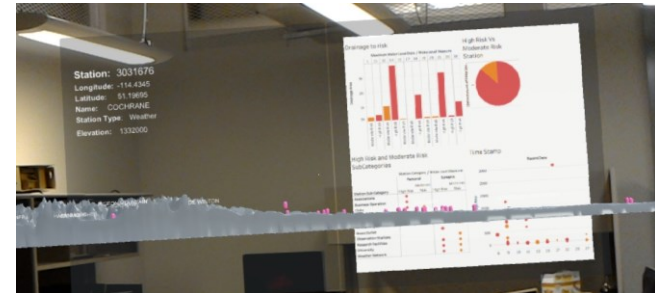


Figure 2. User is viewing charts made in Tableau about drainage on the left, as well as individual weather station data on the right.

#### *Coloured Feedback*

In addition to simple gestures, a colour-based feedback system is also implemented. Due to the fact that emergency situations can be noisy, sound-based systems would be inappropriate for both commands and feedback. Especially in hectic situations, it is important to provide users with consistent feedback in order to help their understanding and clarity of the system when analyzing complex data sets.

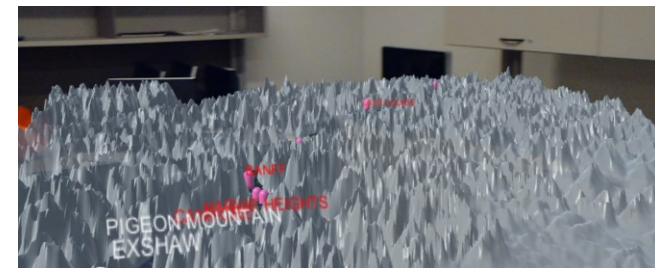


Figure 3. Shows pink pills which are the weather stations, as well as the cities which have turned red due to danger of flooding from the information gathered.

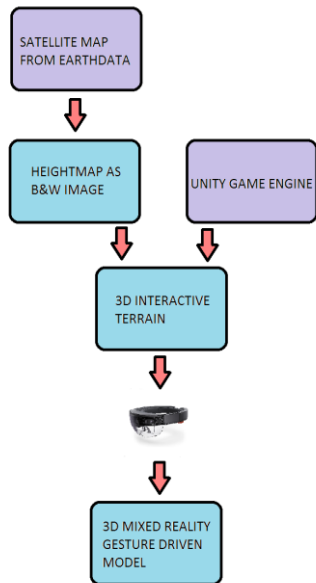


Figure 4. Process to acquire and model topological terrain from satellite image to 3D model.

For our scenario example, the stations will change to purple when the HoloLens cursor hovers over the object, and the cities will turn red if the water has affected them. This is shown in Figure 3, where the user is looking at the cities that have the possibility of being in danger. By having drastic changes in the colours, it allows for easier and quicker interactions by the user. Since such simple changes are instantaneous, they are a good fit in stressful settings where training may not be available and reducing delays is key.

#### *Scenario Application Process*

The best way to render a replica of the environment was to obtain a heightmap from NASA's Earthdata project, then proceed to apply it to the Unity Game Engine's terrain object. This process is shown by Figure 4. By plugging in the image, a model is generated using the greyscale as a channel to interpret the distance of displacement. However, one of the challenges that we encountered is that the terrain is extremely costly in terms of performance. To overcome this problem, we exported the terrain as a regular GameObject, which is much less costly in terms of performance due to the lack of textures. By reducing the need to process such a high-cost object, it became possible to link SoD to the HoloLens, providing the capability to also use the Kinect for gesture recognition. This technique can be applied to any heightmap that is uploaded into Unity, providing a framework for other maps that users may want to view in the HoloLens.

For our scenario application, we also had to add the Bow river, the Old Man river, and the Red Deer river as water physical objects. The rivers were placed according to the geographical knowledge and followed the shallowness of riverbeds. This water physical object

can be applied to multiple different topological maps, allowing a more realistic view for certain areas that require such immersive analytics.

Lastly, our weather stations and cities are placed on the map according to latitude and longitude locations. By locating the coordinates of the four corners of the map, the system can place multiple objects in places where they should be in the real world, thus allowing further analysis to be done. This is also extremely helpful in predicting city evacuations for emergency response individuals, or analyzing data that is a subset of the model that they are provided with.

#### **Conclusion**

The benefit of immersive analytics is the ability to be "immersed" in your data, providing the additional capability of interactions that would not normally be possible. By creating a framework that provides increased usability in the mixed reality world, it allows for a deeper understanding that could greatly impact analyzing complex datasets. Our system contributes to the emergency response field in two major ways; allowing collaborative work over a 3D terrain map, and creating natural gestures to assist in analyzing complex data sets. By placing the model in a mixed reality environment, users can be immersed in their workspace, but also still collaborate with the people around them, allowing for sharing of information that was not possible. By providing easy to use gestures, it allows users to react quickly during an emergency situation where time is of the utmost importance and delays could cause major disasters.

### Future Work

The next step would be to actually place our system into use and gather user feedback. Case studies could be done comparing ease of use with these abilities, and how users truly interact with our system during a stressful time period.

Another addition would be to also view our model solely through AR, which would be implemented using the Google Tango. If multiple users could collaborate using their preferred devices, there is the possibility of increased reaction time in assisting multiple people.

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