Data Imaging and Visualization Analysis

Team DIVA: Teddy Corrales, Erin Estes, Kevin Ho, Austin Hom, Mughil Muthupari, Justin Pan, Justin Shen
Mentor: Dr. Stephen Penny
Librarian: Dr. Kelley O’Neal
Overview

- Background
- Past Research
  - 2-D maps → 3-D maps
  - Our solution: Virtual Reality
- Research Questions
- Methodology (3 Phases)
  - Product Development (current)
  - Product Improvement
  - Product Evaluation
Motivation for Our Project

- Terabytes of climate data
- Current visualization and analysis methods are inadequate and not interactive
- Difficult to...
  - View multiple variables
  - Observe correlations
  - Zoom in on areas of interest
Past Research: Current Visualization Methods
2-D Color Maps

Mean Surface Temperature. Timeframe unknown (Potter at al., 2009).
Two-variable Colored Maps

2-D map of relative humidity and temperature (Teuling et al., 2011).
Glyph Maps

Glyph map of temperature across a region (Wickham et al., 2012).
3-D Globes

Tropical cyclone visualized in World Wind globe API (Liu et al., 2015).
Solution

Visualize and Analyze Data with Virtual Reality (VR)

[Image: People using a virtual reality headset to analyze data]

[Koutek, M., & Post, F., n.d.]
Research Questions
Research Questions

• In terms of computation time, feature selection, and storage, how can we most effectively design and create a Virtual Reality climate data visualization tool?

• What are the most user-friendly, aesthetically pleasing and informative ways for scientists and the general public to visualize climate data through VR?
Methodology
Phase I - Product Development: Oculus Rift Overview

- Most widely used VR device with cutting-edge capabilities
  - Head- and Position-tracking
- Enhanced interactivity of Oculus Touch
- Available in the MakerSpace in McKeldin

(Turbosquid, 2015)
Phase I - Product Development: System Overview

Control Flow for Cloud-based Climate Data Visualization Tool

**User’s Oculus**
Handles input from controller and output to screen.

User sends query (Climate data file, visualization parameters).

**Web interface**
Handles communications between user’s Oculus and remote GPUs.

Interface forwards query to GPU cluster.

**GPU cluster**
Handles processing of big data so that user’s machine does not have to.

The interface sends this image to user’s Oculus.

GPU cluster returns rendered image to interface in real time.
Unreal Engine 4 Overview

• Uses unmodified C++
• Advantages:
  • netCDF library written in C → simple integration
  • More potential for better graphics in visualization
  • “Blueprint” mode
• Disadvantages:
  • Resource intensive - especially processor speed and graphics
Phase I - Product Development: Current Progress

Current Progress

Able to read in and display an entire netCDF file of one variable

Future Goals

• Ability to display multiple variables
• Volumetric 3D rendering for height fields
• Tools to identify meaningful correlations among data
• Interface with maps and GIS data from library resources
• Adjustable color schemes
## Phase II - Product Improvement: Focus Groups

<table>
<thead>
<tr>
<th>First Focus Group</th>
<th>Second Focus Group</th>
<th>Third Focus Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Who</strong></td>
<td><strong>Who</strong></td>
<td><strong>Who</strong></td>
</tr>
<tr>
<td>5 graphics experts from UMD faculty</td>
<td>30 students from UMD&lt;br&gt;Broken into 5 groups of 6</td>
<td>10 climate experts from NOAA/NASA and UMD</td>
</tr>
<tr>
<td><strong>Goal</strong></td>
<td><strong>Goal</strong></td>
<td><strong>Goal</strong></td>
</tr>
<tr>
<td>To refine aesthetics and user interface</td>
<td>To get broad feedback on usability</td>
<td>To get feedback with respect to climate visualization</td>
</tr>
</tbody>
</table>
Phase III - Product Evaluation: Individual Surveys

- Convenience Surveys: Rate our product compared to a traditional visualization
  - 50 new participants from the general public
- Targeted Surveys: Given a specific task, record time required
  - 10 research experts
Future Plans
Future
- Senior Thesis
- Finishing last necessities

2018
- Second Focus Group (Spring)
- Final prototype (Spring)
- Third focus group (Spring – Fall)
- Product evaluation (Fall)

Fall 2017
- First focus group (Fall)
- Launch UMD campaign (Fall)
- Beta Prototype (Fall-Spring 2018)

2017 Spring
- Software Development (Spring)
- Alpha Prototype (Spring-Fall)
Acknowledgements

Dr. Stephen Penny (Mentor)
Dr. Kelley O’Neal (Librarian)
Dr. Kristan Skendall, Dr. Frank Coale, Vickie Hill (Gemstone Staff)
The Library Spaces at UMD
Questions?
References

Image Sources:


<table>
<thead>
<tr>
<th>Expenses</th>
<th></th>
<th>Unit Price</th>
<th>Quantity</th>
<th>Costs</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oculus VR Device (w/Oculus Touch)</td>
<td>$ 800.00</td>
<td>1</td>
<td>$ 800.00</td>
<td>Fall 2017</td>
<td></td>
</tr>
<tr>
<td>Oculus VR Device (w/Oculus Touch)</td>
<td>$ 800.00</td>
<td>1</td>
<td>$ 800.00</td>
<td>Spring 2017</td>
<td></td>
</tr>
<tr>
<td>Graphic Designer Focus Group Refreshments</td>
<td>$ 30.00</td>
<td>1</td>
<td>$ 30.00</td>
<td>Fall 2017</td>
<td></td>
</tr>
<tr>
<td>Student Focus Group Refreshments</td>
<td>$ 5.00</td>
<td>5</td>
<td>$ 25.00</td>
<td>Fall 2017 / Spring 2018</td>
<td></td>
</tr>
<tr>
<td>Student Focus Group Compensation</td>
<td>$ 15.00</td>
<td>30</td>
<td>$ 450.00</td>
<td>Fall 2017 / Spring 2018</td>
<td></td>
</tr>
<tr>
<td>Climate Expert Focus Group Refreshments</td>
<td>$ 30.00</td>
<td>1</td>
<td>$ 30.00</td>
<td>Spring 2018 / Fall 2018</td>
<td></td>
</tr>
<tr>
<td>Student Survey Refreshments</td>
<td>$ 2.00</td>
<td>50</td>
<td>$ 100.00</td>
<td>Fall 2018</td>
<td></td>
</tr>
<tr>
<td>Student Survey Compensation</td>
<td>$ 5.00</td>
<td>50</td>
<td>$ 250.00</td>
<td>Fall 2018</td>
<td></td>
</tr>
<tr>
<td>Travel Expenses / Conferences**</td>
<td>$ 800.00</td>
<td>4</td>
<td>$ 3,200.00</td>
<td>Spring 2019</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>$ 5,685.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revenue</th>
<th></th>
<th>Unit Price</th>
<th>Quantity</th>
<th>Costs</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library Award</td>
<td>$ 1,000.00</td>
<td>1</td>
<td>$ 1,000.00</td>
<td>Spring 2017</td>
<td></td>
</tr>
<tr>
<td>Launch UMD**</td>
<td>$ 3,500.00</td>
<td>1</td>
<td>$ 3,500.00</td>
<td>Fall 2017</td>
<td></td>
</tr>
<tr>
<td>Gemstone Funding*</td>
<td>$ 600.00</td>
<td>1</td>
<td>$ 600.00</td>
<td>Fall 2016</td>
<td></td>
</tr>
<tr>
<td>Gemstone Funding*</td>
<td>$ 600.00</td>
<td>1</td>
<td>$ 600.00</td>
<td>Fall 2017</td>
<td></td>
</tr>
<tr>
<td>Gemstone Funding*</td>
<td>$ 600.00</td>
<td>1</td>
<td>$ 600.00</td>
<td>Fall 2018</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>$ 6,300.00</td>
<td></td>
</tr>
</tbody>
</table>

* Goes away after every school year
** Very rough estimate