Data Imaging and Visualization Analysis

Teddy Corrales, Erin Estes, Kevin Ho, Austin Hom, Mughil Muthupari, Justin Pan, Justin Shen

Mentor: Dr. Stephen Penny
Librarian: Dr. Kelley O'Neal

Overview

- Motivation
- Past Research
- Research Questions & Hypothesis
  - Our solution: virtual reality
- Methodology (3 Phases)
  - Product Development (current)
  - Product Improvement
  - Product Evaluation
- Challenges, Team Dynamics, and Advice

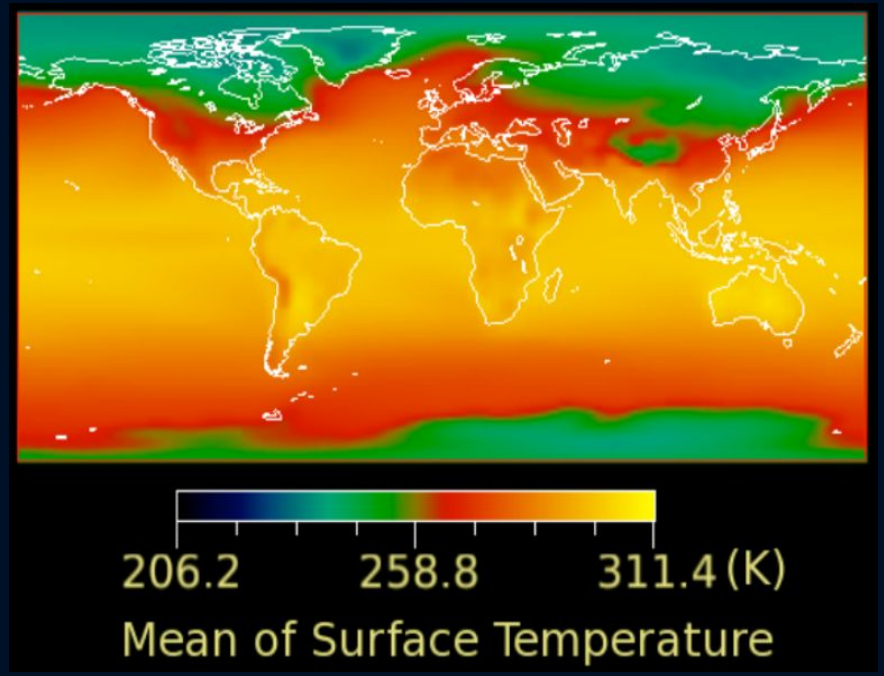
Motivation

- 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

(NASA, n.d.)

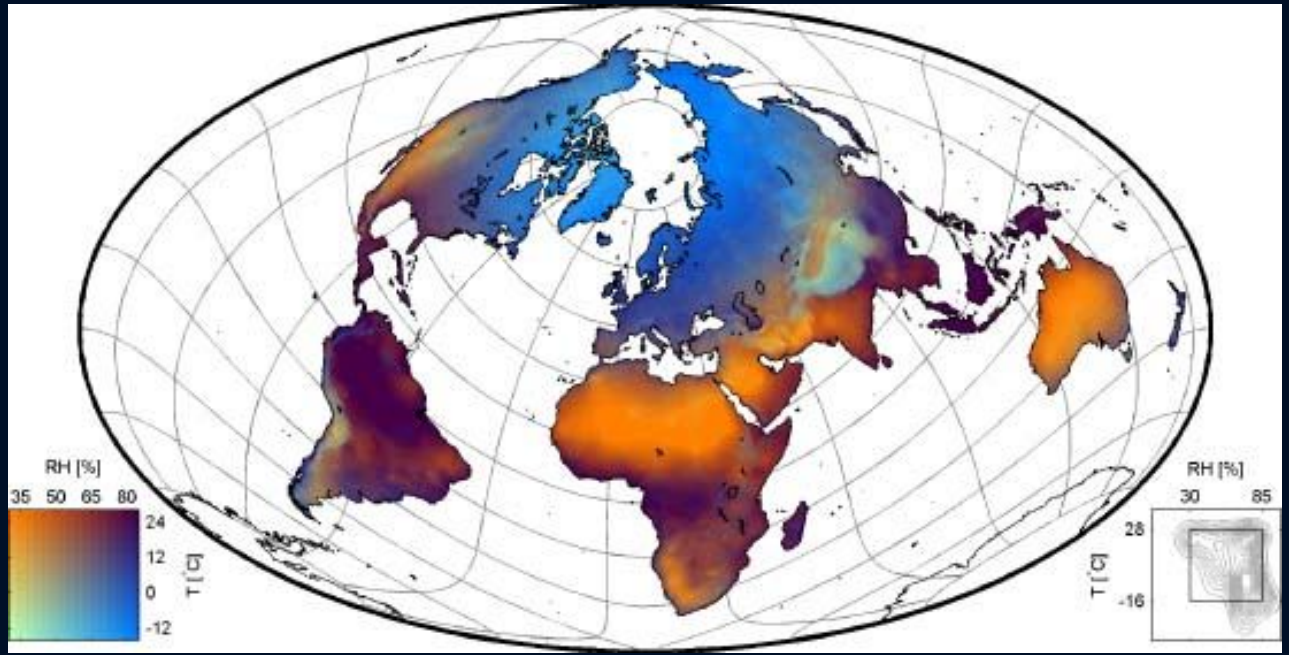
Past Research: Current Visualization Methods

2-D Color Maps



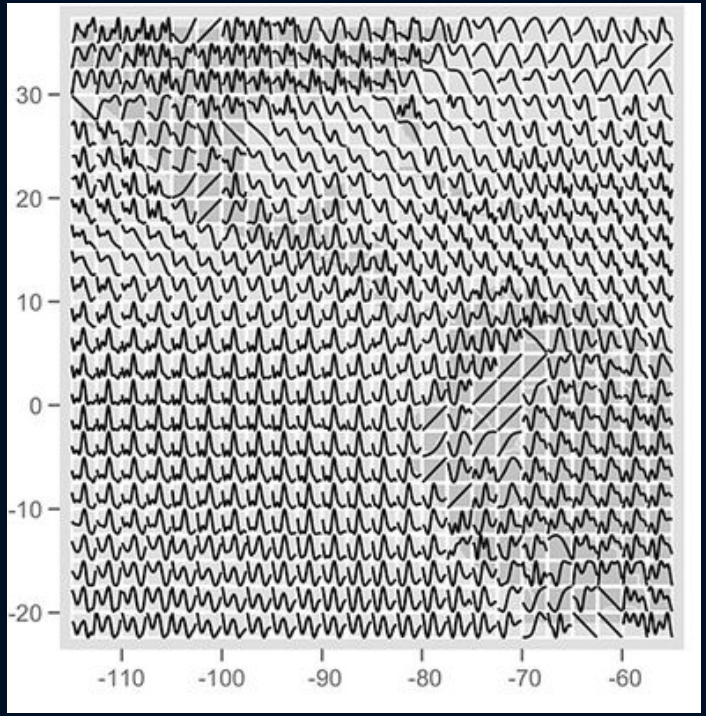
Mean Surface Temperature. TImeframe unknown (Potter at al., 2009).

Two-Variable Colored Maps



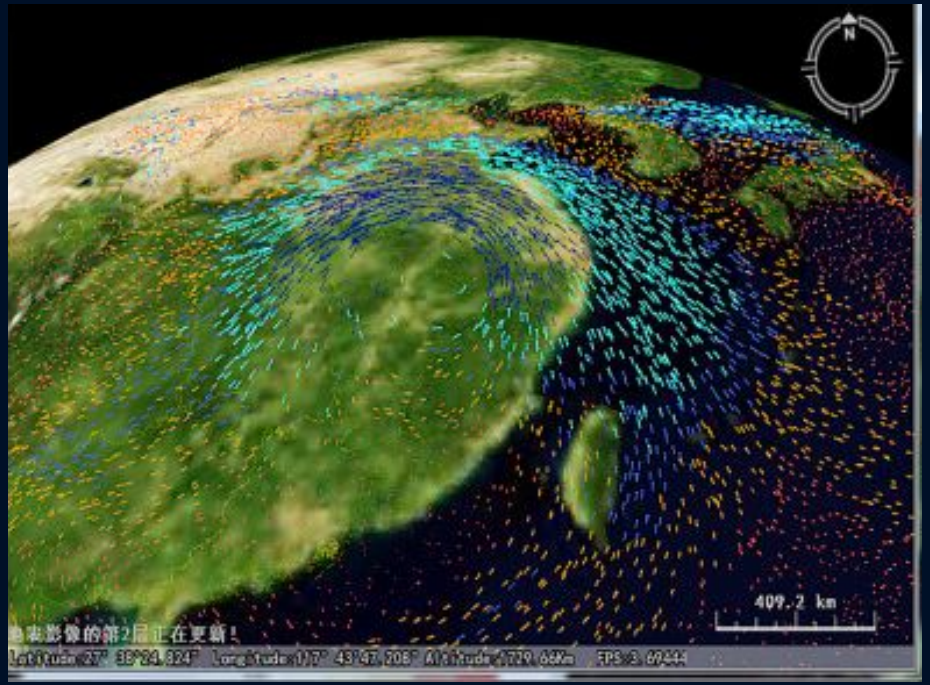
2-D map of relative humidity and temperature (Teuling et al., 2011).

Glyph Maps



Glyph map of temperature across a region (Wickham et al., 2012).

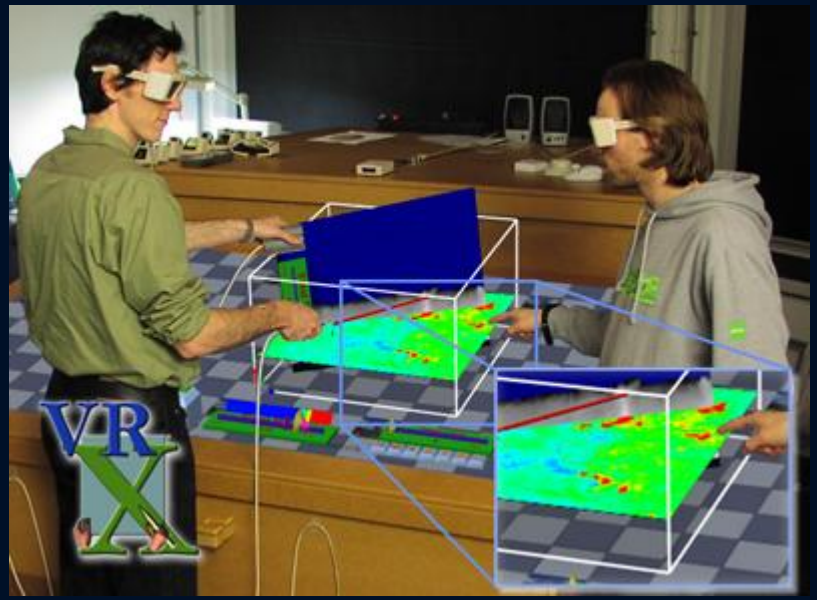
3-D Globes



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

Solution

Visualize and analyze data with virtual reality (VR)



(Koutek, M., & Post, F., n.d.)

Research Questions & Hypothesis

Research Questions

- In terms of computation time, feature selection, and storage, how can we most effectively design and create a VR 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?

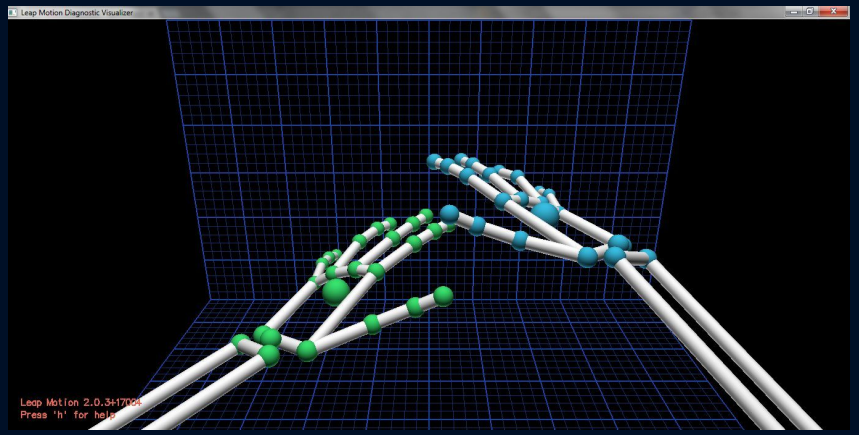
Hypothesis

The use of VR to visualize climate data will create a more immersive, intuitive, and comprehensive experience for users and allow them to draw more meaningful conclusions from data than previous data visualization tools.

Methodology

Phase I - Product Development: Oculus Rift Overview

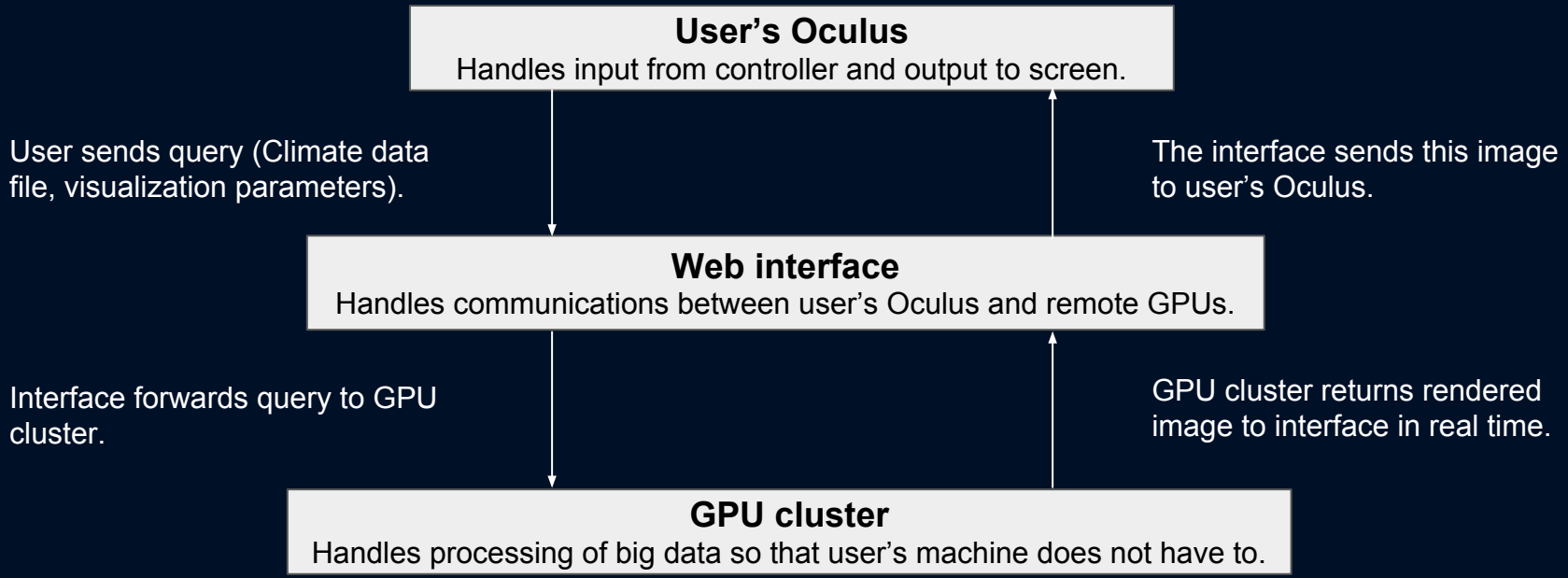
- Most widely used VR device with cutting-edge capabilities
- Enhanced interactivity of Leap Motion Kit
- Easy to use with Unreal Engine 4



(Leap Motion,. 2014)

Phase I - Product Development: System Overview

Control Flow for Cloud-based Climate Data Visualization Tool

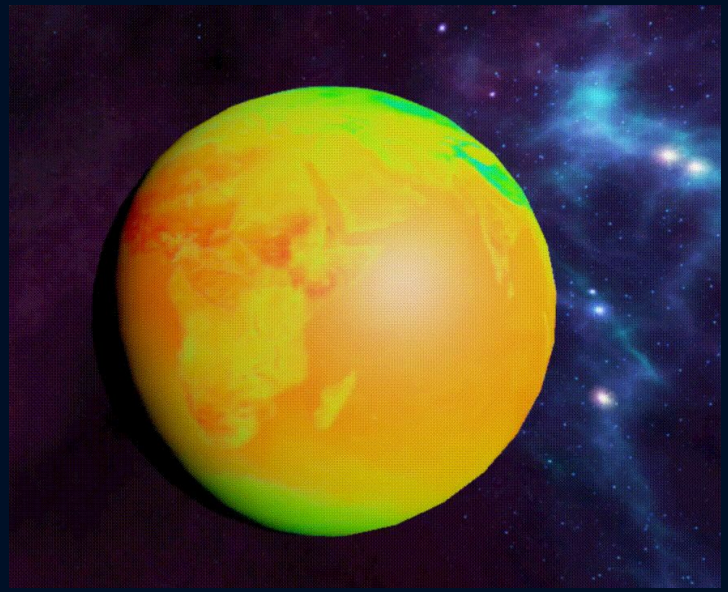


Unreal Engine 4 Overview

- 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: Spring Recap

Basic Visualization

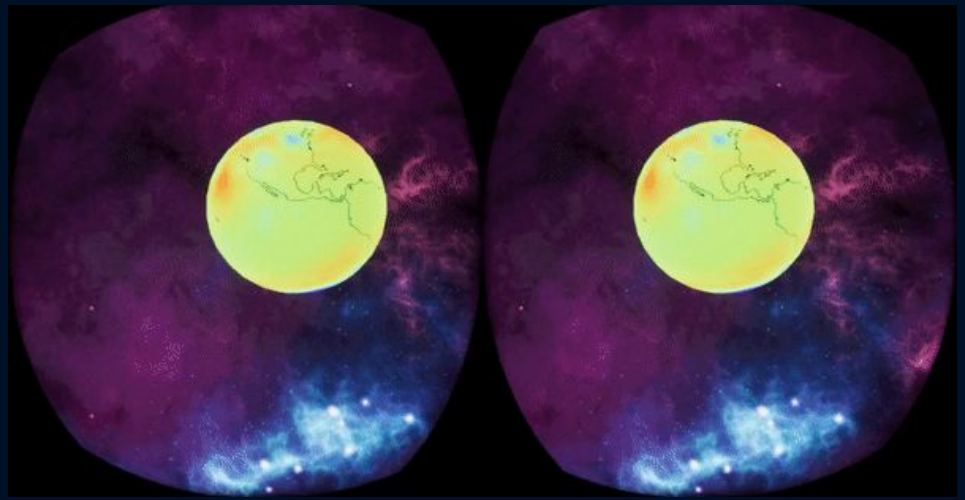


Spring 2017

- Ability to read in and display entire netCDF file of one variable
- Limited user interactivity with globe
- Only in Unreal Editor environment

Phase I - Product Development: Current Progress

VR Visualization

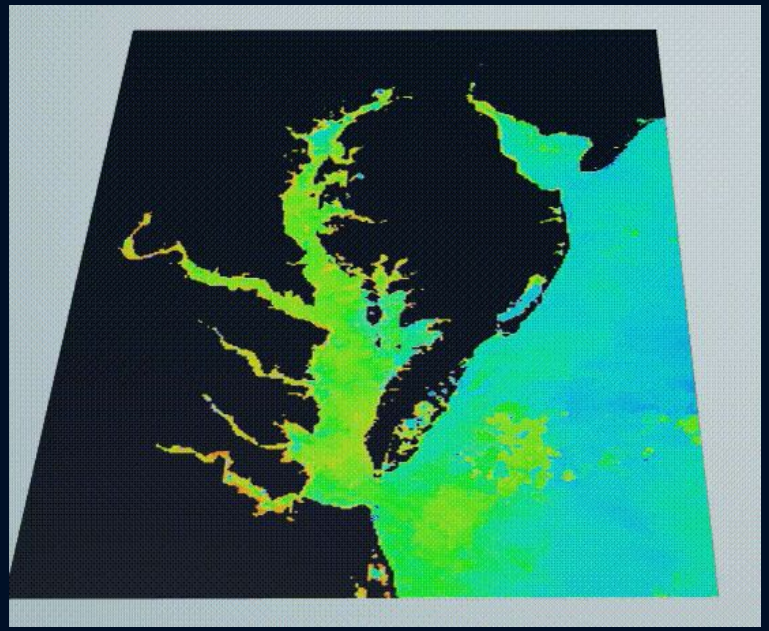


Core Functionality

- Ability to visualize dataset in virtual environment
- Data processing through Python libraries
- Interactive gestural interface — focus group upcoming

Phase I - Product Development: Current Progress

Chesapeake Bay Visualization

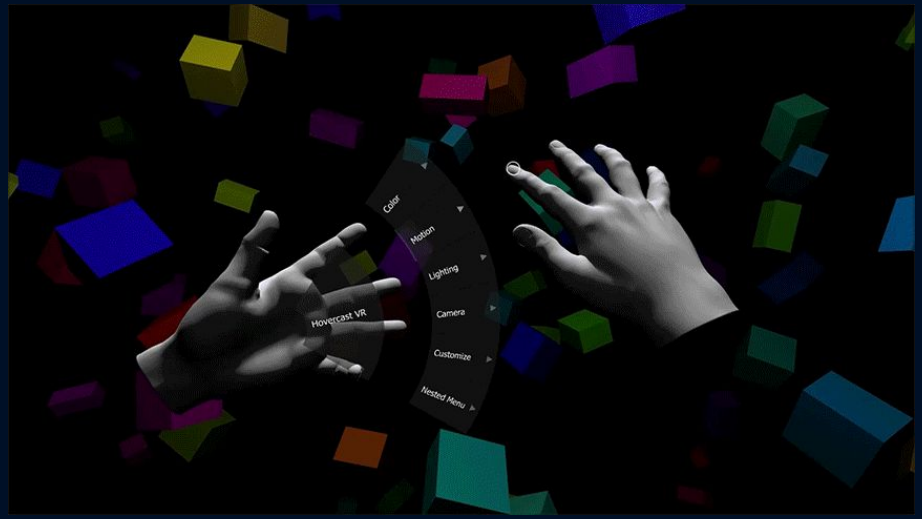


Ready for Close-up

- Load in high resolution data of a specific region
- Allow for more in-depth analysis of a specific region at desired time

Phase I - Product Development: Future Goals

Hovercast UI



(Kinster, 2015)

Future Goals

- Multivariable display
- Tools to identify meaningful correlations between datasets
- Topography/Bathymetry implementation
- Volumetric 3D rendering
- Improve overall interactivity
- Adjustable color schemes

Digital (RGB)

Perceptually Uniform Color Spaces

- Standard RGB color space used by computers is digital
- Perceptually Uniform - linear change in the space equals exact linear change in our eye's perception
- Intuitive for the human eye to observe linear changes in data

Perceptually Uniform (LAB)

Phase II - Product Improvement: Focus Groups

First Focus Group

Who

5 graphics experts from UMD faculty

Goal

To refine aesthetics and user interface

Second Focus Group

Who

30 students from UMD

Broken into 5 groups of 6

Goal

To get broad feedback on usability

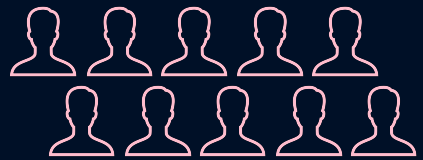
Third Focus Group

Who

10 climate experts from NOAA/NASA and UMD

Goal

To get feedback with respect to climate visualization



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

Challenges, Team Dynamics, and Advice

Challenges

- Previous Challenges
  - Coordinating integration of subteam tasks
  - Becoming familiar with new technologies (Unreal Engine, Leap Motion)
  - Less than adequate computational power
- Future Challenges
  - Portability and accessibility
  - Fine tuning gesture control
  - Lack of climatology expertise

Team Dynamics and Advice

- Three Subteams
  - User Interface
  - Visualization
  - Data Processing
- Set internal deadlines and frequently communicate
- Accommodate everyone’s schedule
- Ability to perform remote work outside meetings

Acknowledgements

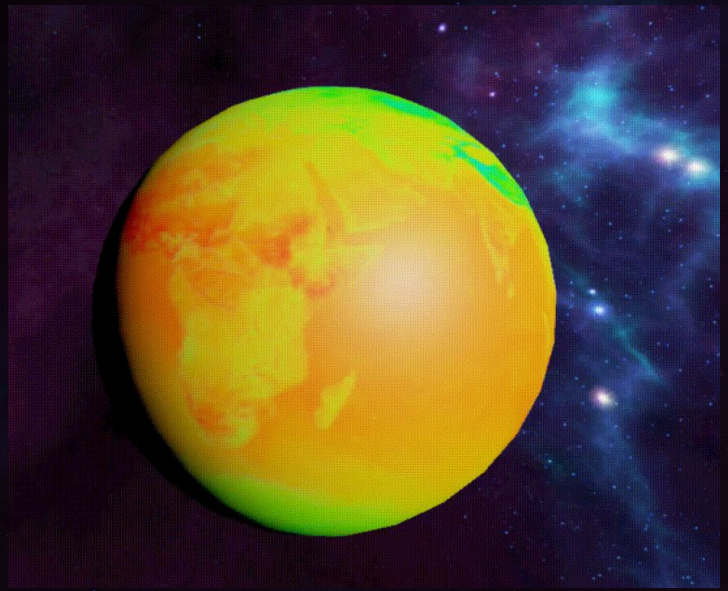
Dr. Stephen Penny (Mentor)

Dr. Kelley O’Neal (Librarian)

Dr. Kristan Skendall, Dr. Frank Coale, Vickie Hill (Gemstone Staff)

FedCentric Technologies

Questions?



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Perceptually Uniform (LAB)

References

Image Sources:

Koutek, M., & Post, F. (n.d.). Virtual Reality for Data Visualization. Retrieved November 06, 2016, from http://graphics.tudelft.nl/~michal/vr_demos/

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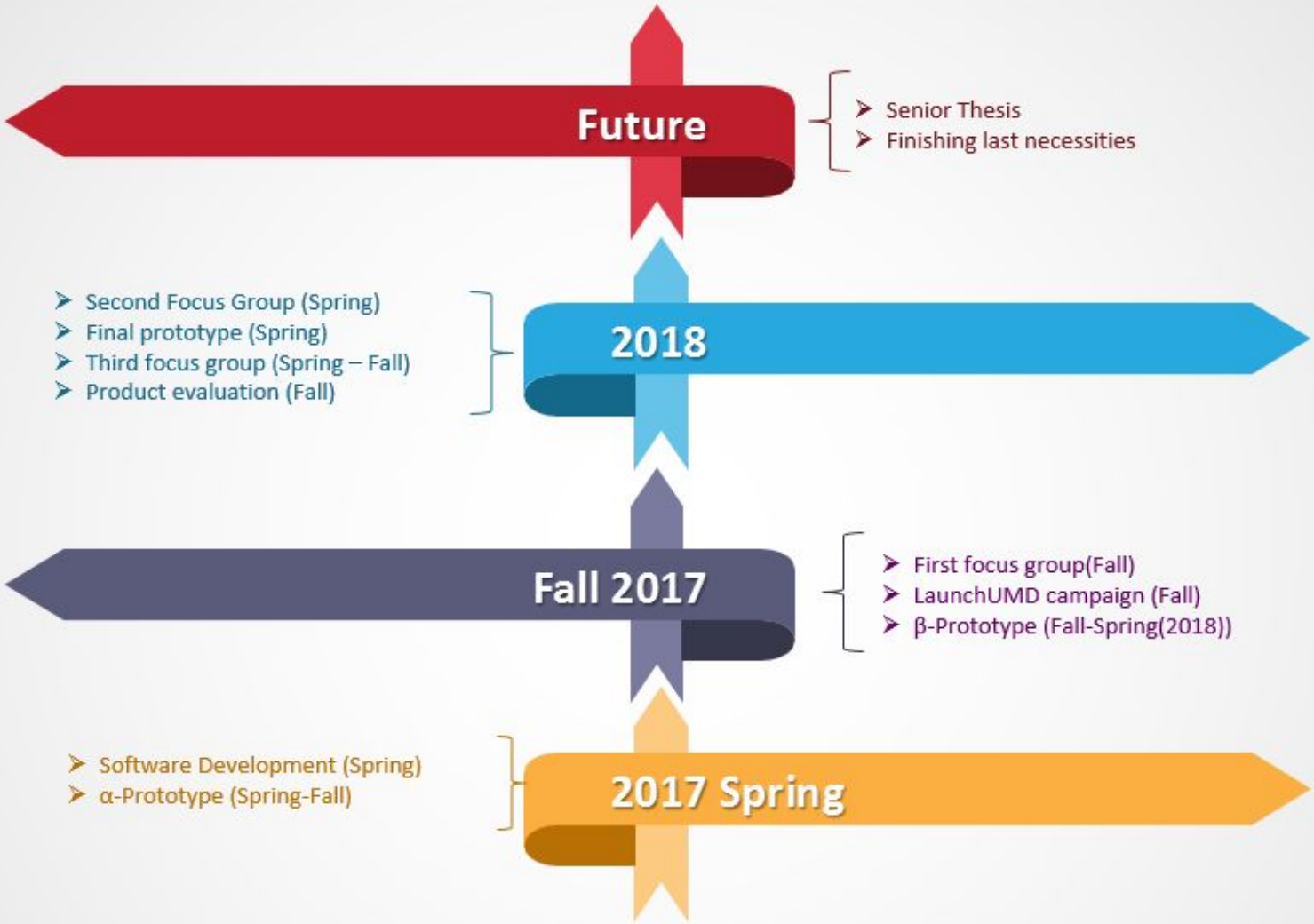
Wickham, H., Hofmann, H., Wickham, C., & Cook, D. (2012). Glyph-maps for visually exploring temporal patterns in climate data and models. Environmetrics, 23(5), 382-393.

	Name	Unit Price	Quantity	Costs	Expected Date
Expenses					
	Oculus VR Device (w/Oculus Touch)	$ 800.00	1	$ 800.00	Spring 2017
	Oculus VR Device (w/Oculus Touch)	$ 800.00	1	$ 800.00	Fall 2017
	Leap Motion	$ 100.00	1	$ 100.00	Fall 2017
	Graphic Designer Focus Group Refreshments	$ 50.00	1	$ 50.00	Fall 2017
	Student Focus Group Refreshments	$ 5.00	5	$ 25.00	Fall 2017 / Spring 2018
	Student Focus Group Compensation	$ 15.00	30	$ 450.00	Fall 2017 / Spring 2018
	Climate Expert Focus Refreshments	$ 50.00	1	$ 50.00	Spring 2018 / Fall 2018
	Student Survey Refreshments	$ 2.00	50	$ 100.00	Fall 2018
	Student Survey Compensation	$ 5.00	50	$ 250.00	Fall 2018
	Travel Expenses / Conferences**	$ 800.00	4	$ 3,200.00	Spring 2019
Total				**$ 5,825.00**	
Revenue					
	Library Award	$ 2,000.00	1	$ 2,000.00	Spring 2017
	Launch UMD**	$ 3,500.00	1	$ 3,500.00	Spring 2018
	Gemstone Funding*	$ 600.00	1	$ 600.00	Fall 2016
	Gemstone Funding*	$ 600.00	1	$ 600.00	Fall 2017
	Gemstone Funding*	$ 600.00	1	$ 600.00	Fall 2018
Total				**$ 7,300.00**	
	*** Goes away after every school year**				
	****Very rough estimate, LaunchUMD Money would go towards travel**				


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)
LaunchUMD campaign (Fall)
β-Prototype (Fall-Spring(2018))
2017 Spring
Software Development (Spring)
α-Prototype (Spring-Fall)