3 Design

3.1 Design Context

3.1.1 Broader Context

This 3D data visualization application is being designed as a showcase piece for the Department of Electrical and Computer Engineering at Iowa State. It will provide an educational experience with one of the newest trends in visualization technology and hardware in order to highlight the university's commitment to research and innovation. The application is intended to attract and communicate to prospective students what their future at Iowa State can look like.

Area	Description	Examples
Public health, safety, and welfare	This project can allow the various users to learn and become aware of the circumstances and challenges that populations around the globe are facing.	Depending upon the data called by the program, we could alert users to dangerous weather patterns, virus hotspots or environmental pollutants.
Global, cultural, and social	The project will reflect the goals and values of the Iowa State University community. It will aim to showcase the potential of the education provided at the Department of Electrical and Computer Engineering and their research goals.	It will showcase the commitment to innovation and research of the ECpE by incorporating new technologies and ideas.
Environmental	Due to the small scale and software-based nature of the project, the environmental impact is minimal and limited to that of manufacturing the single unit Hololens 2 that will be used to run the project.	This project will require a manufactured Hololens 2 device to run and energy to recharge it periodically.
Economic	This project might factor into prospective students' decisions about whether to pursue their studies at Iowa State. This could potentially influence the university's enrollment numbers and therefore have an economic impact on it.	Product creates opportunities for the economic advancement of Iowa State University by targeting prospective students.

3.1.2 User Needs

- Prospective students need a way to see what sort of projects and education lies ahead if they were to come to Iowa State University and enroll in Electrical / Computer Engineering
- EE/CPRE faculty need a way to showcase their department's achievements and innovative practices to prospective students as well as visitors interested in the department
- Visitors need a way to physically see examples of what goes on in the EE / CPRE department because depending on who they are they could want to create business or educational connections with the department
- Current students need a way to learn about ongoing development of projects to make decisions on research, classes, and areas of study they want to pursue.

3.1.3 Prior Work/Solutions

The majority of visualization systems of global scale are 2D and only compatible with traditional computer monitors or touch screen displays. Those visualizers generally are limited to displaying one type of data such as weather, population, pollution, to serve a specific purpose. There are some 3D visualizers, such as Google Earth, that focus on displaying details of the earth and its geography. The application we found most similar to our application goal is MeteoEarth. This application displays a 3D globe on a 2D display with various weather data types. Through our research we were unable to find a Hololens application that will do the same real time data visualization that we intend to do.

The following is a Pros/Cons list describing how our target solution will stand against others.

Pros

- "Real" 3D as our solution will use the Microsoft Hololens 2. This will allow users to see the globe as it is in real life and see geographical phenomena on a proper and global scale.
- Multiple types of data streams visualized at once layering one over the other in a cohesive manner
- Extensive user interactivity involving the ability to move the hololens(display) around a stationary globe
- Scalable globe
- The ability to input any data type following our API standard to visualize on the globe
- Global scale and localized scale of visualization in the same application

Cons

- Using the HoloLens 2 as our primary display creates an expensive initial cost for a user
- The use of the Hololens 2 only allows one user at a time to see the visualization if a group doesn't have multiple headsets

3.1.4 Technical Complexity

The architecture of the 3D data visualization application has multiple subsystems that connect to create the cohesive whole. Each of these subsystems will involve different scientific, mathematical and engineering principles as part of the development solution.

Backend: Data Collection

- This component will require an understanding on efficient manipulation of large datasets to ensure that an acceptable level of system performance is maintained. It will also require investigation to find reputable data sources that meet the project criteria.

Backend: Custom API Layer

- Because the function of this subsystem is to standardize incoming data into a single source and format, it will require a strong understanding and analysis of scientific weather data and weather patterns. The creation of a custom API layer that accepts the importation of external data will require a lot of efficient and intuitive API design principles

Unity: Application Core Functionality

- This subsystem is a large percentage of the overarching system. The unity application needs to take geological data (coordinate-based data) and correlate that data to a 3d model of the globe. This will require mathematical principles in the field of geometry. It will also require an understanding of computer graphics for converting the individual data points into a cohesive visualization. We will need to create visual meshes that adhere to current standards in weather data visualizations, but also represent it in a 3D manner.

Unity: Application UI/UX

- This subsystem handles the interaction between the user and the program. Good UI/UX design will be required to make the program viable for our intended user base. This will need to involve principles in the areas of accessibility and usability.

3.2 Design Exploration

3.2.1 Design Decisions

1. Display as a Hololens 2 AR application
2. Use the Unity Game Engine for development
3. Use of OpenWeather API

3.2.2 Ideation

When choosing our platform, we considered the following options:

- VR (Virtual Reality Interface)
- AR (Augmented Reality Interface)
- Sphere Display (Gakken WorldEye)
- 3D Monitor / Projection
- Touch Screen Device/Computer Monitor

We individually did research for APIs, display hardwares, and design softwares. We compiled all the information we found and discussed them. This allowed us all to share our own ideas and learn about more opportunities available to us.

3.2.3 Decision-Making and Trade-Off

We discussed all of our options and listed out our pros and cons for each. We then narrowed our options down to three and presented them to our client. Based on his recommendations, we chose an AR interface: the Microsoft HoloLens 2.

VR

- Pros
  - No physical bounds for visualization
  - Within given budget
- Cons
  - Limited to one user at a time
  - Software heavy/does not take advantage of other skill sets
  - Not providing a physical device

AR (Augmented Reality Interface)

- Pros
  - No physical bounds for visualization
  - Easier access for the everyday man
  - Within given budget
- Cons
  - Not as innovative as other options
  - Restricted to device resolution and specifications
  - Software heavy/does not take advantage of other skill sets

Sphere Display (Gakken WorldEye)

- Pros
  - Unique displays allows for global viewing
  - Includes interesting hardware
- Cons
  - Low Resolution (on the Gakken display)
  - Details/Data hard to display
  - Out of budget (on the vast majority of solutions)

3D Monitor / Projection

- Pros
  - Large scale viewing options
  - Multi-user interactable
  - No glasses/headset required
- Cons
  - Limited viewing angles w/ some equipment
  - Not as innovative as other options
  - Software heavy/does not take advantage of other skill sets
  - Out of budget (on the vast majority of solutions)

Touch Screen Device/Computer Monitor

- Pros
  - Easier than most solutions
  - Within given budget
- Cons
  - Most display are not convex
  - Similar to Google Maps or MeteoEarth
  - Software heavy/does not take advantage of other skill sets

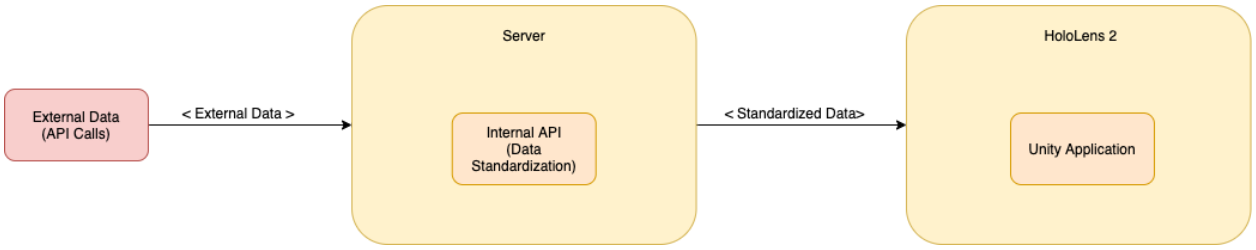
3.3 Proposed Design

Currently, the team is trying to implement a Unity project and use the Microsoft HoloLens emulator. We have been researching how to make calls to our chosen API's. Previously, we got access to a Hololens device and verified that it meets the expectations for the display. So far, our research and trials have indicated that our design decisions are viable and a good fit for the project.

3.3.1 Design Visual and Description

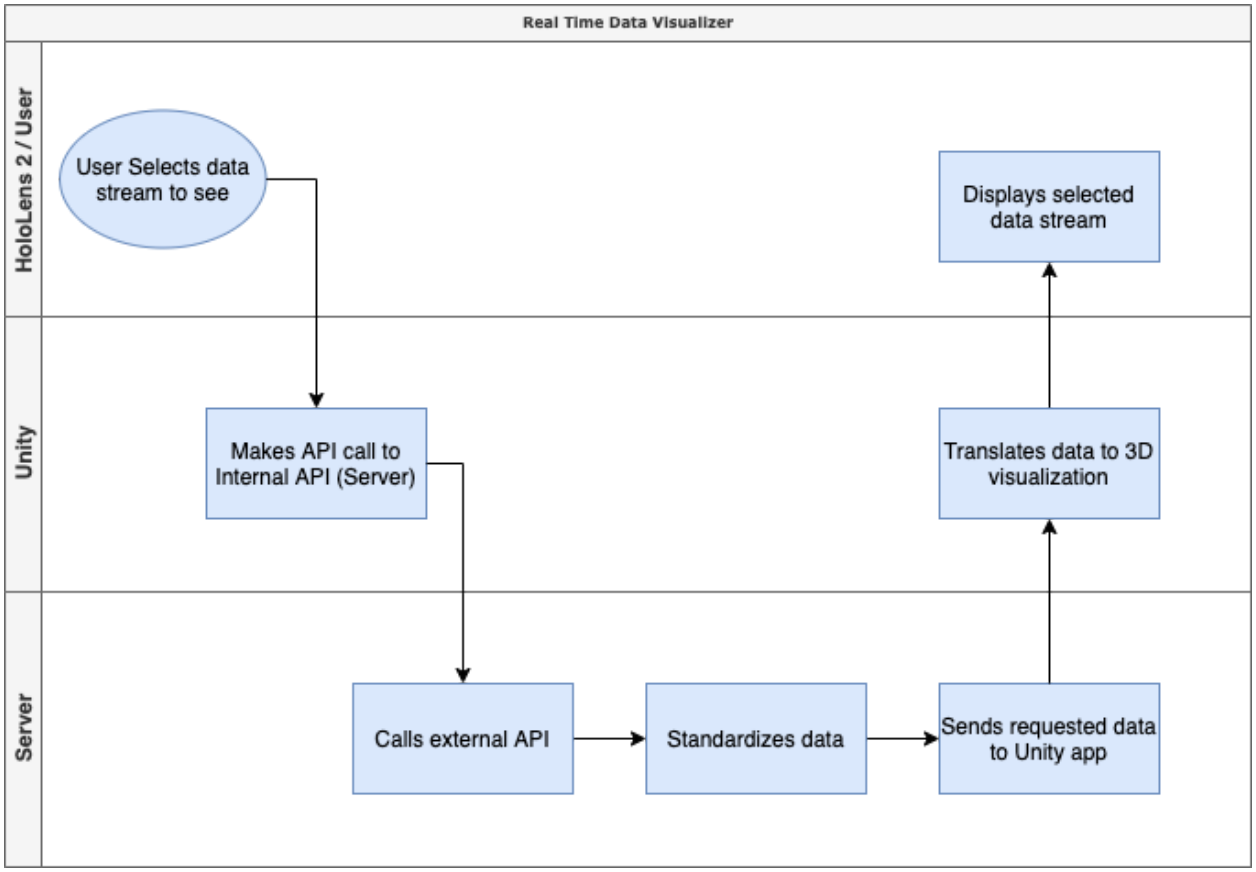
Include a visual depiction of your current design. Different visual types may be relevant to different types of projects. You may include: a block diagram of individual components or subsystems and their interconnections, a circuit diagram, a sketch of physical components and their operation, etc.

FLOW OF DATA DIAGRAM



1. External data comes into the server through API calls
2. The server organizes and standardizes the data to our internal API specifications
3. The unity application calls our internal API and receives the standardized data
4. The unity applications translates the data into a 3D visualization
5. The HoloLens 2 displays the visualization for the user

TIMELINE OF EVENTS DIAGRAM (Swim lane)



3.3.2 Functionality

Expected usage sequence:

1. Users are instructed on the project's background, purpose, and what they are about to see and interact with by the person supervising the demo.
2. Users are walked through putting on the Hololens 2 device and securing it to their head with any necessary adjustments.
3. The program is started by the users and they are left to experiment with it with the supervising person available for any questions or difficulties.

The current design would satisfy the requirements by meeting the client's and potential user's needs.

3.3.3 Areas of Concern and Development

The primary concerns are making sure the product adequately manages to show the intended data in a way that is easy for users to understand and navigate without frustration. This is meant as a demonstration piece for the visualization hardware and techniques, so the quality of the user experience is fundamental to its purpose.

The immediate plans for addressing those concerns are to rely on well-researched UX and UI techniques, do early functional testing with people in the user group, and prioritize performance for a smooth viewing experience.

Questions for the client and faculty advisor include:

1. Approximately how long should it take a user to try out every viewing mode in the application?
2. How much time is a user intended to spend interacting with the application?
3. What is the main takeaway a user should have from the experience?

3.6 Citations

- Google Earth
- MeteoEarth.com - Interactive 3D globe brings weather to life
- Ames, IA Weather and Radar Map - The Weather Channel | Weather.com
- GIS Mapping Software