TEC-V

Milestone 4

TEC-V (Topographic Exploration Cave Vehicle

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2. **Faculty advisor from CSE: name and email address.**
    - o Marius Silaghi, *Professor | Electrical Engineering and Computer Science*
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3. **Client: name and affiliation**
- o Dr. Stephen Wood, *Professor | Ocean Engineering and Marine Sciences*
    - ❖ Program Chair for Ocean Engineering

4. **Date(s) of Meeting(s) with the Client for developing this Plan:**
    - ▪ **Team Meetings:** Mondays 12 p.m.
    - ▪ **Client Meetings:** Monday 2-12 at 12 p.m.
    - ▪ **Advisor:** Thursday 2-15 at 3 p.m.
- ▪ **Progress of current Milestone (Progress Matrix):**

Tasks	Completion%	Michael	Zealand	To Do
Cloud Plot Application	70%	70%	0%	**Finish CSS styling**
Application Functions	70%	70%	0%	**Implement more options for different file uploads**
False Data	90%	90%	0%	**Remove more false data**
Rotational compensation	50%	50%	0%	**Account for rotation of AUV**
Autonomy	30%		30%	**Implement Pathway Identification**

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6. Discussion (at least a few sentences, ie a paragraph) of each accomplished task (and obstacles) for the current Milestone:

- **Task 1: (Cloud Plot Application Development)**

    In this milestone, our primary objective was to establish an environment that enables users to visualize mapped sections derived from data effortlessly. Initially, we developed code to display this information in Unity using data stored in CSV files. However, this process proved to be time-consuming, taking several minutes from data retrieval to the visualization stage. To address this, we shifted our approach and developed a webpage that presents the data swiftly and accessibly. Utilizing the JavaScript library three.js, we created a virtual environment where users can upload a simple text file containing XYZ coordinates. This setup facilitated the creation of a virtual space equipped with various commands and scripts for functionalities such as object creation and orbital controls, allowing users to view rendered models from any desired angle. Shown in **image 1.**

- **Task 2: (Implementing Application Functions)**

    Our initial goals for the webpage included three fundamental functions:

    1. Uploading text files. **– Images 2 & 3.**
    2. Displaying spheres at each point specified in the text file.
    3. Enabling viewpoint manipulation to observe the point cloud from various angles.

    We were able to successfully incorporate the bare bones functions into the webpage with a simple layout. But now the issue remained, there needed to be more options. To accomplish this we then looked at what we may like to have, these functions consisted of the following

    1. **Sphere Size Adjustment:**
        a. To enhance the user experience and address visibility challenges associated with varying scales of data, we introduced a feature enabling dynamic adjustment of sphere sizes. Recognizing that when zoomed out, the separation between points could become difficult to discern, we implemented a user-controlled mechanism to resize spheres. This functionality ensures that users can maintain clear visibility of objects regardless of the dataset's scale or their zoom level, significantly improving the utility and accessibility of the visualization.

2. **Sphere Color Customization:**
   a. With an eye towards personalization and enhancing the aesthetic appeal of the visualization, we developed a feature allowing users to customize the color of spheres. This addition was driven by the understanding that color preferences can vary widely among users and that color coding can be a powerful tool in data visualization for distinguishing between different data points or sets. By enabling users to select sphere colors, we provided a means for them to tailor the visual appearance of the data to their liking or to highlight specific features of interest within the dataset. **– Image 4.**

3. **Mesh Color Differentiation:**
   a. The introduction of a mesh feature marked a significant enhancement in our application, enabling the visualization of connections between individual data points. To improve the clarity and effectiveness of this representation, we implemented the ability to differentiate the color of the mesh from that of the spheres. This color distinction ensures that the mesh, which represents the relationships or structures inherent in the data, stands out against the individual data points, facilitating a clearer understanding of the underlying patterns or forms within the data.

4. **Closest Points Connection:**
   a. In an effort to provide a more detailed 3D representation of the scanned objects, we developed an iteration of the mesh feature that connects a point to its eight nearest neighbors. This functionality enhances the model's fidelity, offering users a more accurate and informative visualization of the object's structure. However, this feature's implementation introduced significant latency issues, as the computational demand to calculate and render these connections in real-time was substantial. Addressing these performance challenges to optimize the feature's efficiency without sacrificing detail or accuracy will be a focus of our next development phase. **– Images 5 & 6.**

5. **Connected Points:**
   a. Our initial approach to visualizing connections within the point cloud was to create a basic mesh by connecting each point to the subsequent one. This method proved instrumental in identifying potential anomalies or errors in the data, as the continuous line made it easier to trace the data acquisition path. However, this also resulted in a visually cluttered and sometimes confusing representation, making it challenging to discern the true structure of the scanned object. Balancing the utility of this feature with the need for a clear and understandable visualization remains an ongoing area of refinement. **– Image 7.**

6. **Grid Functionality:**
   a. The integration of a grid into the visualization environment provided a reference scale, greatly enhancing the user's ability to gauge the size and distances within the point cloud. By setting the grid to represent 5-meter intervals, we aimed to offer a consistent and intuitive metric for understanding the scale of the visualization. This feature, while seemingly simple, significantly contributes to the user's spatial orientation and comprehension of the dataset, with the added flexibility of toggling the grid's visibility to suit individual user preferences or specific analytical needs. **– Image 4.**

7. **Sphere Deletion:**
   a. Developing the ability for users to delete specific spheres was a complex but necessary enhancement aimed at improving data accuracy and visualization quality. Users often encounter erroneous or outlier data points that can distort the overall representation or analysis. By allowing users to select and remove these points, we provided a tool for refining the dataset directly within the visualization environment. Initially, removed spheres were simply hidden, which proved problematic for subsequent analyses. Our solution involved dynamically updating the array of displayed points upon deletion, ensuring that the visualization and underlying data remain synchronized. **– Images 8-12.**

8. **Export Updated Text File:**
   a. Following the implementation of sphere deletion, we recognized the need for users to export their refined datasets for further use or analysis. This functionality extends the application's utility beyond mere visualization, allowing users to iteratively improve and utilize their datasets. By enabling the export of the updated array of coordinates, users can now easily save and share their cleaned datasets, facilitating ongoing work and collaboration. **– Image 12.**

Each of these enhancements reflects our commitment to providing a comprehensive, user-friendly, and versatile cloud plot visualization tool. As we move forward, we will continue to refine these features, address emerging challenges, and explore new opportunities to the user experience and expand the application's capabilities.

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- **Task 3: (Addressing False Data Identification and Removal)**

    Initially, our approach to mitigating the impact of erroneous data involved deploying a comparison algorithm. This algorithm aimed to identify outliers by evaluating each data point's proximity to its immediate neighbors—specifically, comparing a given point against the two preceding and two succeeding points within the dataset. Points that deviated beyond a predetermined threshold from their neighbors were excluded from visualization in the cloud plot. While this method was effective in filtering out certain anomalies, it fell short of actually eliminating these data points from the dataset, merely hiding them from view.

    To enhance the application's capability for data refinement, we introduced a deletion feature. This functionality empowers users with direct control over the dataset, enabling them to manually identify and remove specific points deemed inaccurate or irrelevant. By integrating this feature, we not only provided a solution to the limitations of the automatic outlier detection algorithm but also added a layer of user interactivity and precision to the data cleaning process. This development represents a significant step forward in our efforts to offer users a robust tool for managing and visualizing their data with greater accuracy and flexibility.

- **Task 4: (Rotational Compensation)**

    Admittedly, the challenge of rotational compensation received only preliminary consideration during the current phase and has yet to be fully addressed. As we progress towards our next milestone, our ambition is to broaden the application's capability to support various file formats. This enhancement is particularly aimed at facilitating the integration of sonar and telemetry data files. The envisioned feature will intricately analyze the compass headings and timestamps contained within these files, enabling the application to intelligently overlay the datasets. By doing so, it aims to compensate for any rotational discrepancies that might have occurred between scans. This advancement is expected to significantly refine the accuracy of our visualizations, offering a more faithful representation of scanned environments by accounting for the dynamic conditions under which data is captured.

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- **Task 5: (Implementing Autonomy in the Robotic Simulation)**

    The development of a robotic simulation featuring integrated sensor technology marked a significant achievement in Milestone 4. Utilizing Gazebo—an open-source robotics simulator known for its robust yet occasionally challenging performance—we successfully created a virtual robot equipped with advanced sensory capabilities. Despite Gazebo's known glitches, which presented obstacles during testing phases, it was determined to remain the most suitable platform for our project needs after a comprehensive evaluation of alternative software.

    The simulated robot is outfitted with three distinct types of sensors, each playing a crucial role in obstacle detection and navigation:

    1. IMU Sensor: The Inertial Measurement Unit (IMU) is pivotal for determining the robot's orientation by providing quaternion outputs. It also measures angular velocity across three axes (X, Y, Z) and tracks linear acceleration, facilitating precise movement control.

    2. Contact Sensor: Integrated into the wall, this sensor triggers an alert upon making contact with another object. This feature is instrumental in collision detection, enabling the robot to identify and respond to physical barriers in its immediate environment.

    3. Lidar Sensor: Standing for "Light Detection and Ranging," the Lidar sensor is essential for obstacle detection. It measures the distance to surrounding objects, including walls, allowing the robot to navigate its environment with heightened awareness and accuracy.

    Building on the foundation laid in Milestone 4, Task 5 focuses on advancing the robot's autonomy. The integration of IMU, contact, and Lidar sensors has set the stage for implementing sophisticated autonomous behaviors. The next step involves developing algorithms that allow the robot to not only detect obstacles but also to intelligently navigate around them without human intervention. This will include the creation of decision-making processes that leverage sensor data to guide the robot through complex environments, effectively avoiding collisions and optimizing its path to a given destination.
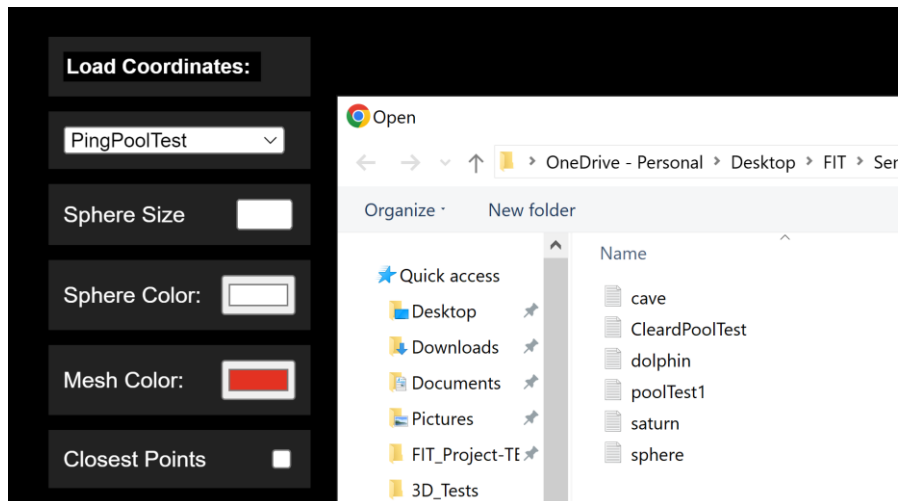
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Image 1: ()
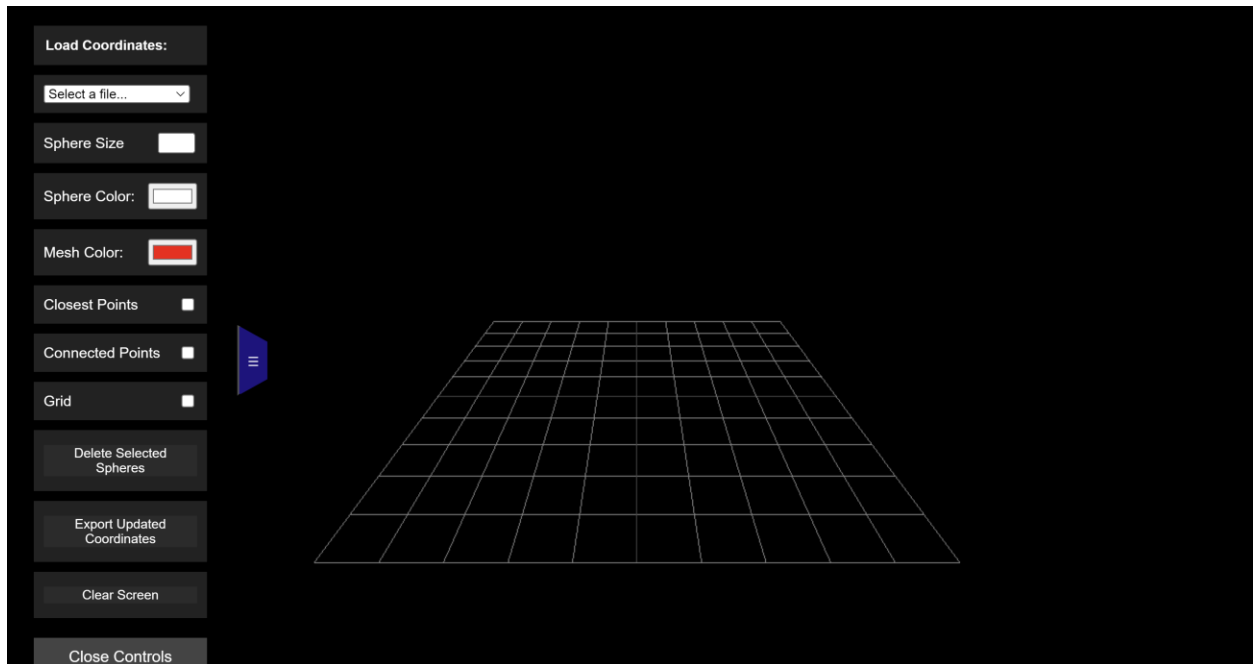
- Simple layout for rendering environment.

Image 2: ()
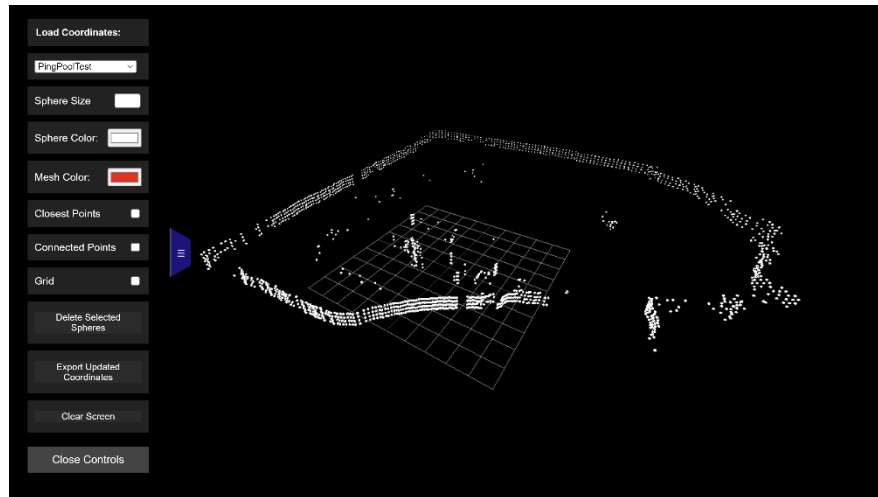

- When the button load coordinates is pressed it will bring you to your files so you can select a .txt extension file.
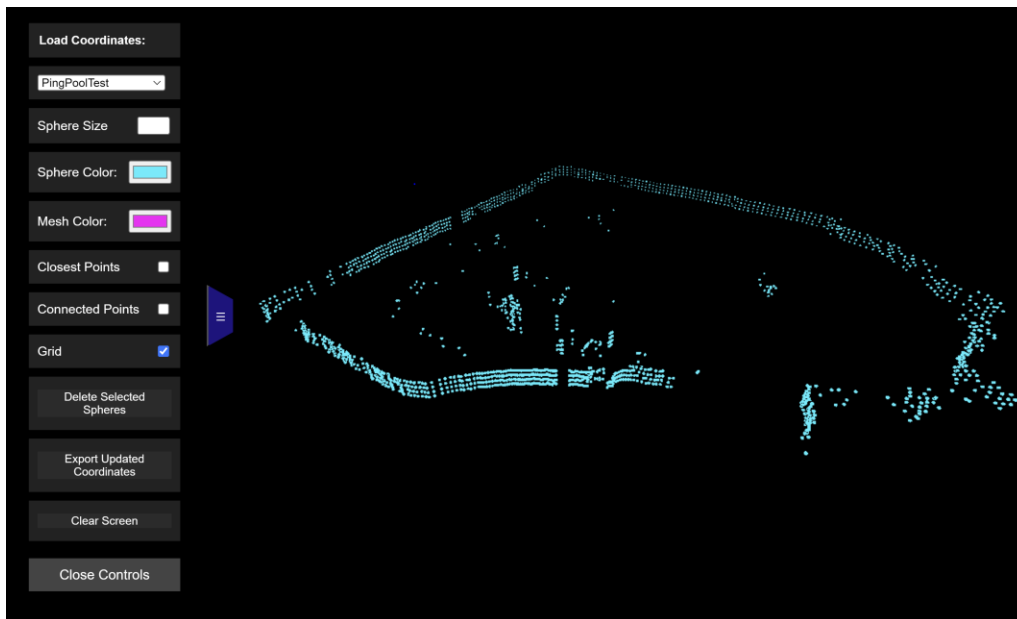
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Image 3: ()

- After uploading the txt file it will read each point and display them.
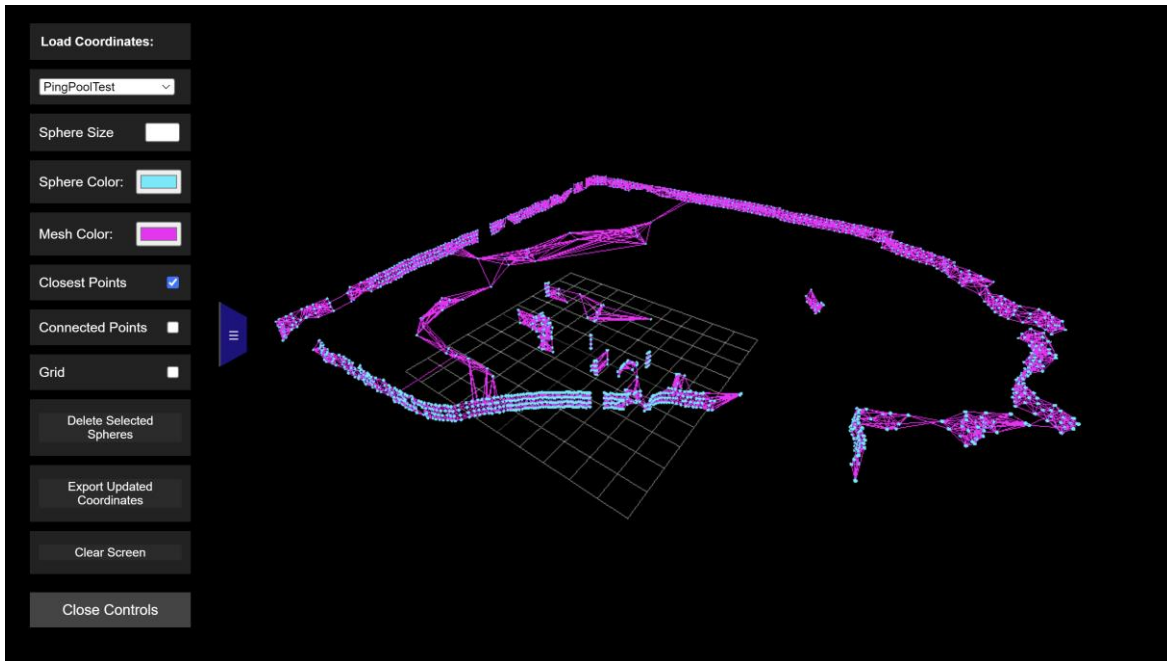
Image 4: ()

- This image shows how the color of the spheres can be changed and when selected the grid will no longer be visable.
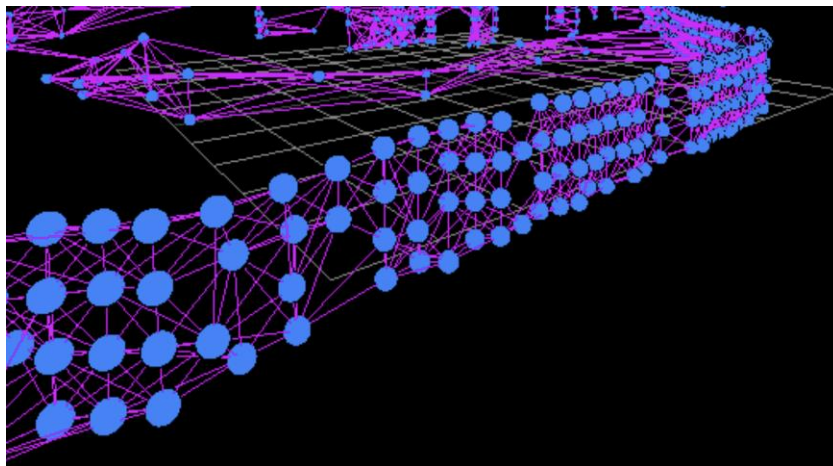
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Image 5: ()

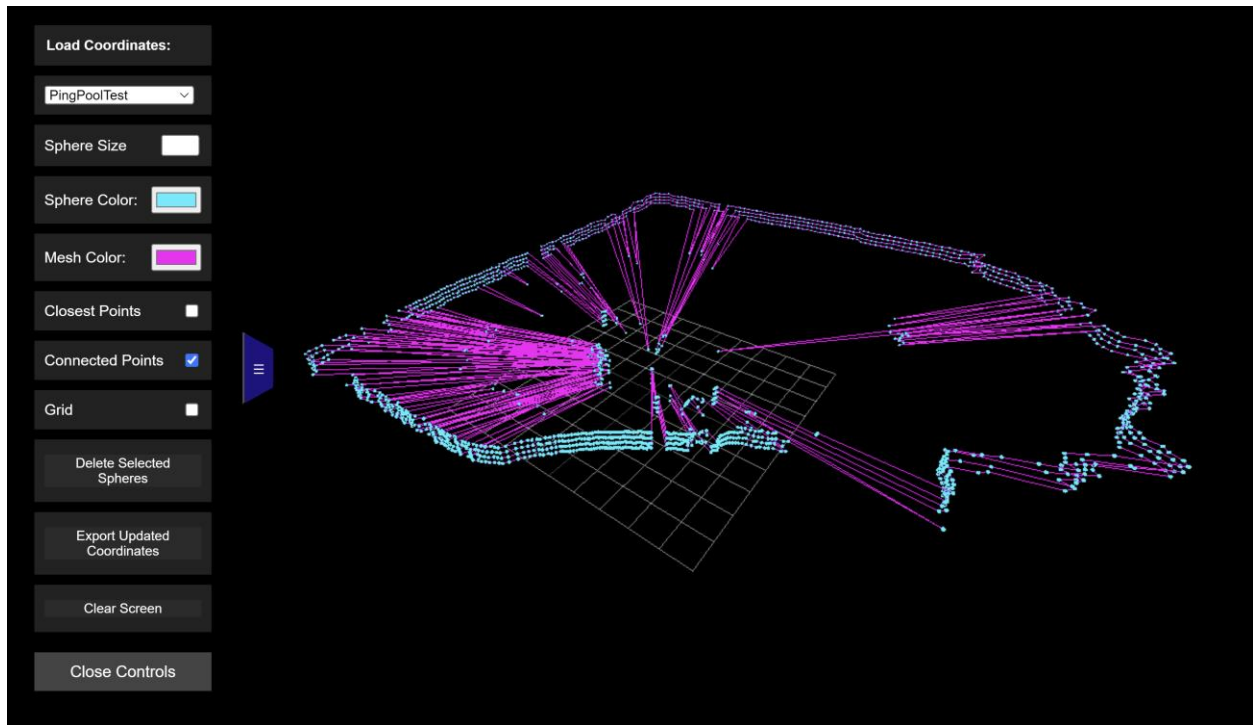- When selected the "Closest Points" option will compare and show lines between the 8 closest points.

Image 6: ()

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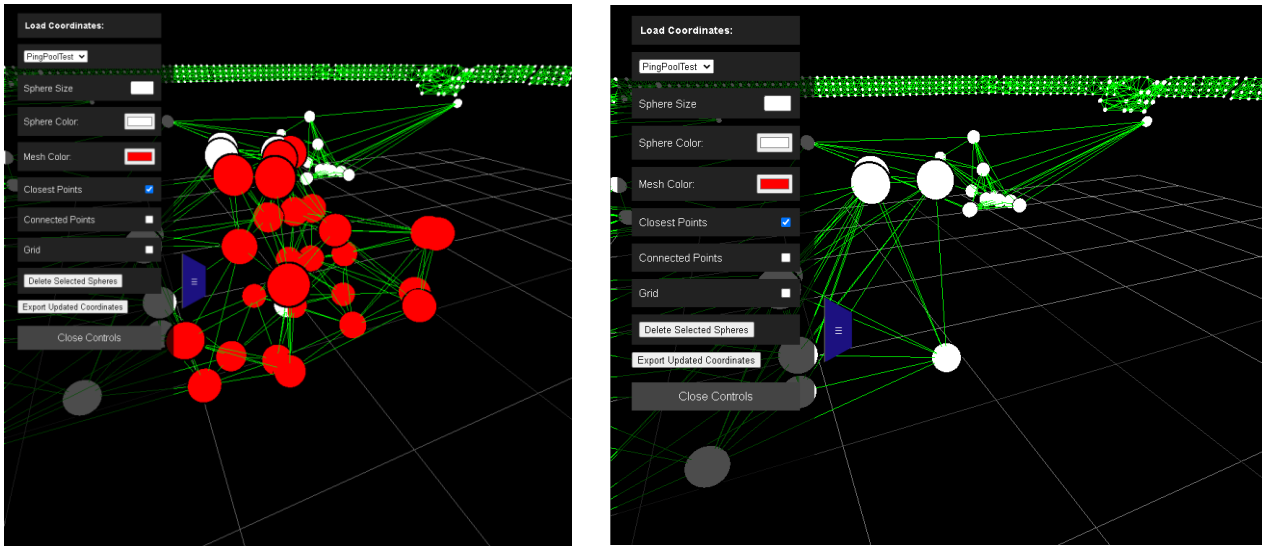
Image 7: ()

- ▪ When selected the function "Connected Points" will show the point prior and after from the array.
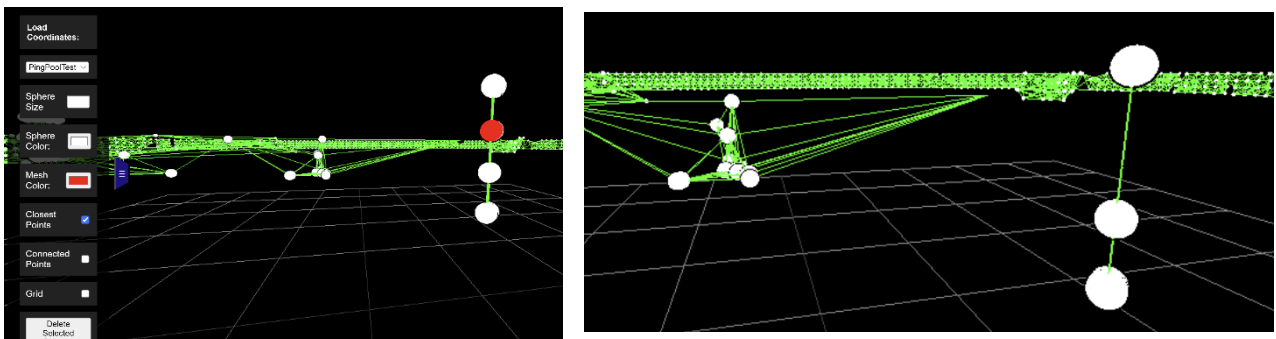
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Image 8 & 9: ()

- The second iteration of the delete function. When selected it will erase the selected spheres from the environment and new array. Then it will update the scene with the new array while maintaining the prior enabled functions and colors.
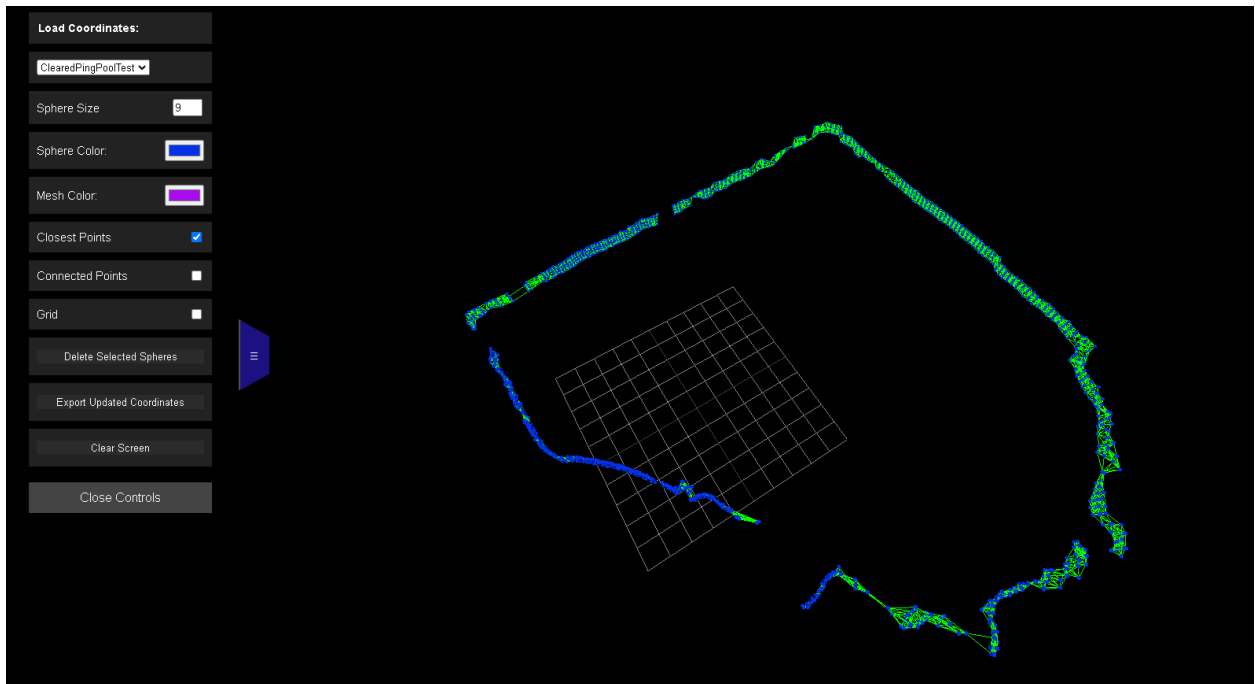
Image 10 & 11: ()

- The original implementation of the delete function where it just turned the sphere black.

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Image 12: ()

- This image showcases a thorough deletion of all the "false data". It was then exported and placed back into the webpages preloaded files to showcase the difference.

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7. Discussion (at least a few sentences, ie a paragraph) of contribution of each team member to the current Milestone:

<u>Mike Dowling:</u>

1. **Creation of Application:** Designed and coded individual files to create the webpage for the cloud plot application.
2. **Function Implementation**: Implemented various functions within the webpage, including uploading text files, displaying spheres, enabling viewpoint manipulation, and integrating additional features like sphere size adjustment, color customization, and mesh differentiation.
3. **Styling of Webpage:** Contributed to the aesthetic appeal and user interface of the webpage, ensuring a user-friendly and visually engaging experience for users interacting with the cloud plot application.

Zealand Brennan

1. **Autonomy:** Utilized Gazebo as a testing ground for partial pathing using current datasets, laying groundwork for autonomous navigation algorithms in the robotic simulation.

8. Plan for next Milestone:

Task	Michael	Zealand
Multi Fild Upload	Have the ability to upload different file types simultaneously	
Styling	Make the webpage more user friendly.	
Forward Facing Sonar	Retrieve data from new sonar and save the information.	
Autonomy		Utilizing Gazebo as a testing ground for partial pathing using the current data sets we have.

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9. **Discussion (at least a few sentences, ie a paragraph) of each planned task for the next Milestone or "Lessons Learned" if this is for Milestone 6**

- **Task 1: Multi File Upload**

  o **Objective:** Enable the simultaneous upload of multiple files to accommodate vehicle rotation or movement.

  o **Approach:** Utilize two files: Upload the CSV file containing stored data from the sonar and compare timestamps with the telemetry file to determine current heading and compass orientation. This comparison allows for overlaying and combining different scans effectively.

- **Task 2: Styling**

  o **Objective:** Enhance user experience and professionalism by improving webpage aesthetics and button design.

  o **Approach:** Data Identification: Identify crucial data manipulation functions to provide users with more control and optimize the presentation of the cloud plot.

- **Task 3: Forward-Facing Sonar**

  o **Objective:** Integrate the new forward-facing sonar with the ROV, understand data retrieval methods, and manipulate data formats as needed.

  o **Approach:** Python: Implement data retrieval from the "Omniscan 450 FS" sonar onboard the ROV using Python, similar to the approach used for the previous "Ping 360" sonar. Referencing API documentation, adapt data retrieval to accommodate the new sonar's data collection method and variables.

- **Task 4: Autonomy**

  o **Objective:** Implement the above tasks into the AUV simulation environment, potentially facing challenges due to physics simulation constraints.

  o **Approach:** Implement the above tasks into the AUV simulation environment, recognizing potential challenges in adapting real-world data and physics to the simulation. Additionally, aim to recreate a testing pool environment similar to past in-real-life AUV testing scenarios.

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10. Client Feedback on the current milestone:

- Client feedback for this milestone has been highly satisfactory, as they now find it much easier to visualize their scanned data without navigating convoluted processes. They particularly appreciate the various functions implemented, notably the ability to manipulate the cloud plot by viewing it from different angles, zooming in and out, and selectively deleting individual spheres. Additionally, the option to export the file itself for further analysis has proven to be a valuable asset. Overall, the client is pleased with the user-friendly interface and the range of features that enhance their data visualization experience.

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11. Faculty Advisor feedback on each task for the current milestone:
- **a.**
- **b.**
- **c.**
- **d.**

12. Approval from Faculty Advisor
- a. "I have discussed with the team and approved this project plan. I will evaluate the progress and assign a grade for each of the three milestones."
- b. Signature:_____ Date:

----- on a separate page ---------

13. Evaluation by Faculty Advisor
- a. Faculty Advisor: detach and return this page to Dr. Chan (HC 214) or email the scores to pkc@cs.fit.edu
- b. Score (0-10) for each member: circle a score (or circle two adjacent scores for .25 or write down a real number between 0 and 10)

Michael Dowling	0	1	2	3	4	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
Zealand Brennan	0	1	2	3	4	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10

- ▪ Faculty Advisor Signature: _____ Date: _____