TEC-V

Project Plan Semester 2

TEC-V (Topographic Exploration Cave Vehicle

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2. Faculty advisor from CSE:

- Marius Silaghi, *Professor | Electrical Engineering and Computer Science*
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3. Client: name and affiliation:

- 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 at 1 p.m.
- **Client Meetings:** Monday 1-19 at 5 p.m.
- **Advisor:** Friday 1-19 at 3 p.m.

5. Goal and motivation:

- In this semester, our primary objective is to create a comprehensive interface designed for the seamless control and operation of scanning controls developed in the preceding semester. This interface will not only streamline the management of existing controls but also facilitate the integration of our eagerly anticipated upgraded sonar system. The impending arrival of this advanced sonar adds an exciting dimension to our project. By providing an intuitive platform, our goal is to empower users with the ability to navigate and operate the craft effortlessly, ensuring a user-friendly experience even in the absence of coding expertise. This approach aims to optimize the scanning process and overall functionality, marking a significant advancement in our project's usability and performance.

6. Approach:

- The first step in our approach involves the implementation of the Omniscan 450 FS, a state-of-the-art sonar device specifically designed for forward-looking ROV applications. This device is well-suited for integration with our current remotely operated vehicle (ROV), enhancing its capabilities for underwater exploration and scanning.

- Concurrently, we aim to develop a novel user interface that streamlines the post-processing phase. Once the data is collected using the Omniscan 450 FS, users will be able to seamlessly input this information into our custom code. This code is designed to render and present a comprehensive three-dimensional view of the gathered data. This integration of data visualization into our interface is crucial for providing users with a clear and insightful representation of the underwater environment.

- A pivotal aspect of our approach is prioritizing user-friendliness. Throughout the development process, special attention will be given to ensuring that the user interface is intuitive and accessible. The goal is to make the entire operation, from controlling the ROV to processing and visualizing the data, easily manageable for users with varying levels of expertise. By incorporating user-friendly design principles, we aim to enhance the overall experience and usability of our system, making it accessible to a broader range of users.

7. **Algorithms and tools:**

- **Sonar Data Acquisition (Python):**
  - To retrieve and process data from the Omniscan 450 FS sonar device, Python will serve as a versatile and efficient language. Python offers various libraries for communication with hardware devices, and in this case, we can utilize libraries to establish a connection with the sonar device. The chosen algorithm will involve reading raw sonar data streams from the device and converting them into a usable format for further processing.

- **3D Visualization and User Interface (Java):**
  - Java, with its cross-platform compatibility and extensive GUI libraries like JavaFX, is a suitable choice for developing the user interface. Algorithms for 3D visualization will involve transforming processed sonar data into a format that can be rendered in a 3D environment. Java's graphics capabilities, along with potential integration with 3D rendering libraries such as Java 3D or LWJGL, will facilitate the creation of an interactive and visually informative interface.

- **Virtual Environment and Autonomy Testing (Gazebo):**
  - For testing the autonomy of the AUV in a virtual environment, Gazebo stands out as a robust simulation tool. Gazebo provides a physics engine, sensor simulations, and a realistic 3D environment. It allows the integration of algorithms for autonomous navigation, enabling the simulation of AUV behavior based on sonar input. Algorithms for path planning, obstacle avoidance, and decision-making can be tested and refined within the Gazebo simulation environment before real-world deployment.

- **Integration of Tools:**
  - The integration of these tools involves establishing communication between Python scripts responsible for sonar data acquisition and processing and Java-based components handling the user interface. Effective communication protocols will ensure seamless interaction between these components. Additionally, the simulated autonomy testing in Gazebo will involve integrating Java components for UI interaction with the simulated AUV's behavior.

- By leveraging these algorithms and tools, the project can achieve a cohesive and functional system, integrating the capabilities of the new sonar device, facilitating data processing and visualization, and enabling realistic simulations for testing autonomy in underwater cave environments.

8. Novel Features:

- Our project introduces features specifically designed for underwater cave mapping, setting it apart from conventional systems. One notable innovation is the integration of the Omniscan 450 FS, a sonar device renowned for its application in scanning the sea floor. Remarkably, to our knowledge, this advanced sonar has not been utilized extensively for underwater cave mapping, marking a unique approach in our project.

- The Omniscan 450 FS, originally designed for forward-looking ROV applications, provides a new opportunity for high-resolution scans in the challenging environment of underwater caves. Its historical usage predominantly in sea floor scanning underscores the nature of our project.

- Additionally, the collaborative functionality of our user interface is a unique aspect. While teamwork is often crucial in exploration missions, this collaborative feature sets our project apart by enabling one user to operate and analyze data simultaneously. This collective approach enhances efficiency and decision-making during underwater cave exploration.

- In summary, our project not only introduces a new application of the Omniscan 450 FS for underwater cave mapping but also diverges from the usual collaborative usage seen in ROV applications. This individualized approach is unconventional in the context of remotely operated vehicles, providing users with more autonomy in operating the system.

9. Technical Challenges:

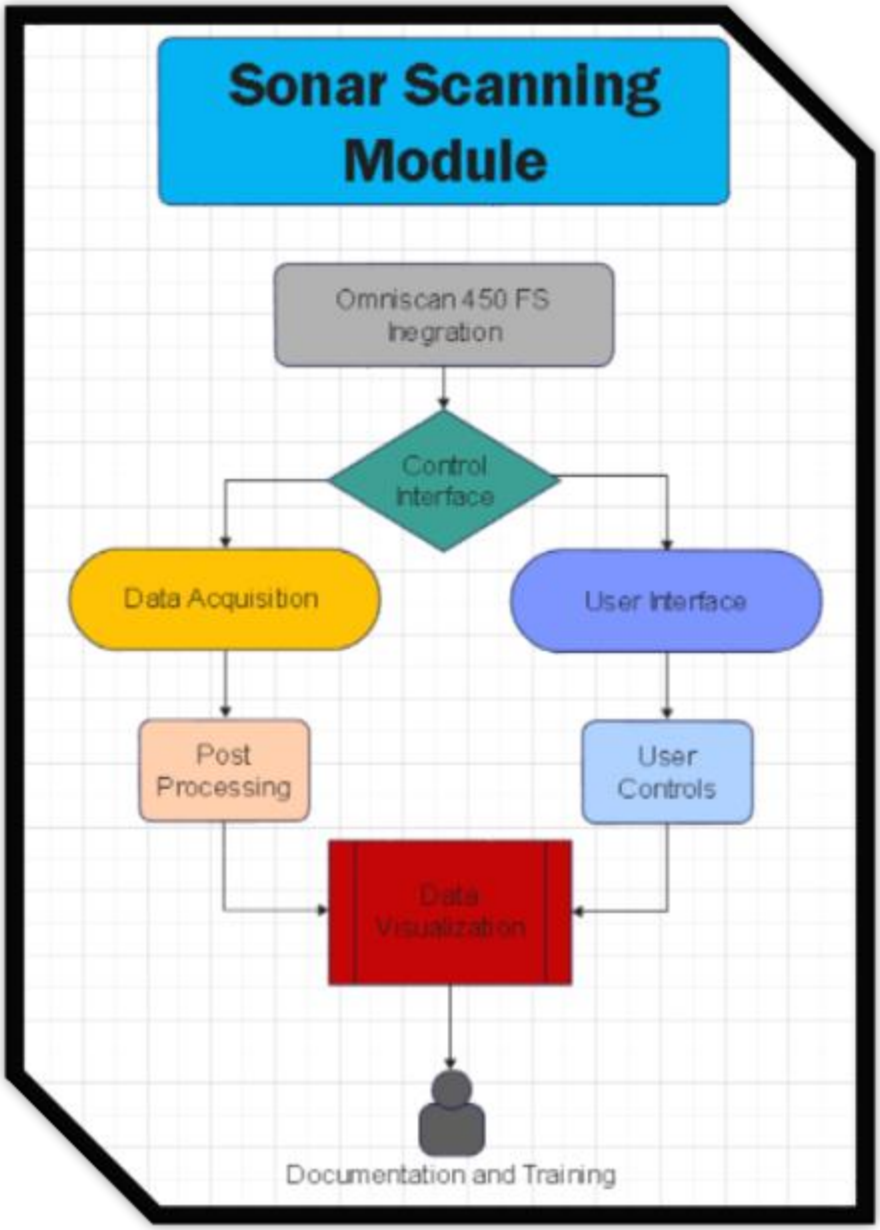
- One of the primary technical challenges we anticipate this semester is determining the optimal mounting location for the new sonar device on the ROV. The Omniscan 450 FS brings advanced capabilities, but its effective utilization relies on strategic placement. We need to carefully assess the ROV's structure and hydrodynamics to ensure the sonar's field of view covers the desired scanning areas. This involves not only finding a physically suitable location but also considering the impact on the ROV's balance and maneuverability.

- The second challenge involves efficiently extracting and interpreting data from the Omniscan 450 FS. While the sonar promises high-resolution scans, translating this raw data into meaningful insights requires robust data processing capabilities. We must explore suitable algorithms and data analysis techniques to derive valuable information about underwater cave structures. This challenge extends beyond mere data acquisition, emphasizing the importance of developing effective methods for information extraction and interpretation.

- Creating the outer hull of the craft using carbon fiber presents a third technical challenge. While carbon fiber offers advantages such as strength and lightweight properties, the process of designing and fabricating a streamlined hull involves intricate engineering. Achieving an optimal balance between structural integrity, buoyancy, and hydrodynamics is crucial. Additionally, considerations such as material thickness, layering, and reinforcement need careful attention to ensure the hull effectively withstands the underwater environment while minimizing drag for improved efficiency.

- The fourth challenge pertains to the development of a user interface (UI) that is accessible to non-coders. Designing a user-friendly interface requires a thoughtful approach to accommodate users with varying levels of technical expertise. We must explore intuitive design principles, implement clear navigation, and integrate simplified controls to ensure that individuals without coding backgrounds can effectively operate the system. Balancing functionality with simplicity is key to making the UI an inclusive tool for users with diverse skill sets.

10. Design system architecture:



11. Evaluation:

1. **Speed:**
    - Measure the time it takes for the system to complete a full underwater cave scan.
    - Evaluate the efficiency of data processing and 3D model rendering in real-time.

2. **Accuracy:**
    - Assess the accuracy of the 3D models generated by the system by comparing them with ground truth data or known cave structures.
    - Conduct accuracy tests for the sonar scanning module, ensuring that it reliably captures detailed information.

3. **Reliability:**
    - Perform reliability tests by repeatedly running the system under various conditions (different underwater environments, varying sonar depths, etc.).
    - Track the success rate of achieving system goals over multiple trials (e.g., out of 10 scans, how many accurately map the cave structures).

4. **User Survey:**
    - Conduct a user survey to gather feedback on the user interface and overall user experience.
    - Use a rating scale (e.g., 1-5) to assess different features such as ease of use, intuitiveness, and effectiveness in achieving goals.
    - Include specific questions about the collaborative features, data visualization, and the ability of non-coders to operate the system.

5. **Documentation and Training Effectiveness:**
    - Evaluate the success of the provided documentation and training materials by assessing user comprehension and proficiency.

12. Progress Summary:

Feature		To Do
User Interface	**50%**	**Allow user to manipulate the environment**
Data Collection	**60%**	**Implement New Sonar Device (Omniscan 450 FS)**
Post-processing	**70%**	**Update settings for new sonar**
Autonomy	**10%**	**Create pathing algorithm**

12. Milestone 4 (Feb 19): Implementing the New Sonar Device

- Integrate the Omniscan 450 FS sonar device into the ROV, mounting it for optimal performance.
- Test svlog files we received from a developer on the device
- Utilize the sensors and create a simple pool simulation.

13. Milestone 5 (Mar 18): Developing a User-Friendly UI and User Testing

- Conduct rigorous testing to ensure seamless functionality and reliable data collection in various underwater conditions.
- Obtain real-world data through test runs to assess the sonar's capabilities in forward-looking ROV applications.
- Design and implement an intuitive user interface (UI) for easy post-processing of data collected from sonar scans.
- Initiate user testing to gather feedback on the UI's usability, effectiveness, and overall user experience.
- Incorporate user feedback to refine the UI, ensuring accessibility for users with diverse technical backgrounds.
- Generate comprehensive documentation to guide users through system functionalities and enhance user understanding.
- Train the model in different styles of surroundings.

14. Milestone 6 (Apr 15): Documentation Update and Code Refinement

- Update documentation based on feedback and refine it for clarity and completeness.
- Conduct a thorough review of the codebase, addressing any issues identified during testing phases.
- Enhance code efficiency and robustness, incorporating improvements for a streamlined and reliable system.
- Ensure the system is well-documented, refined, and ready for deployment, equipped with advanced sonar capabilities and an intuitive user interface.

15. Task matrix for Milestone 4:

Task	Michael	Zealand
Integrate Omniscan 450 FS sonar device	**Test optimal mount and attach sonar.**	
Data Collection	**Identify the data format so that it can be transcribed and manipulated.**	
Testing	**Conduct Scans of pool.**	
Autonomy		**Utilizing Gazebo as a testing ground for partial pathing using the current data sets we have.**

16. Description of each planned task for Milestone 4:

a. **Evaluate ROV Structure:**
   i. Thoroughly examine the physical structure of the ROV to pinpoint the most optimal mounting location for seamless integration of the Omniscan 450 FS sonar device.
   ii. Consider factors such as weight distribution, structural integrity, and accessibility to ensure an effective and practical placement of the sonar on the ROV.

b. **Design and Implement Mechanical Components:**
   i. Develop detailed mechanical designs that outline the necessary components for securely integrating the Omniscan 450 FS with the ROV's framework.
   ii. Implement these mechanical components with precision, ensuring a robust connection that withstands underwater conditions and minimizes any potential interference with other ROV functionalities.

c. **Maintain Stability and Maneuverability:**
   i. Prioritize stability and maneuverability by carefully assessing the impact of the sonar integration on the ROV's overall performance.
   ii. Implement countermeasures or adjustments as needed to mitigate any adverse effects on stability or maneuverability, ensuring the ROV remains agile and responsive underwater.

d. **Functional Testing:**
   i. Conduct functional tests to validate the successful integration and power supply to the Omniscan 450 FS sonar device.
   ii. Perform specific tests on basic sonar functionalities, including sending and receiving signals, to confirm that hardware components operate within expected parameters.

e. **AUV Cave Navigation Simulation:**
   i. Develop a simulation environment replicating underwater caves to assess the sonar's effectiveness in guiding an Autonomous Underwater Vehicle (AUV) through complex cave structures.
   ii. Integrate the sonar data into the simulation to evaluate its navigational capabilities within the simulated cave environment.
   iii. Analyze the AUV's performance in cave navigation based on the sonar input, identifying strengths and potential areas for improvement.

17. Faculty Advisor feedback on each task for the current milestone:

a. Represent uncertainty with gray sphere.
b. Integrate robot displacements from center based on the detected change.

18. 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 ---------

19. 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: __________