TEC-V

Project Proposal

TEC-V (Topographic Exploration Cave Vehicle

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2. **Faculty advisor from CSE: name and email address.**
   - 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:** Wednesdays at 5 p.m.
   - **Client Meetings:** Mondays at 5 p.m. on the first and third week of the month.

5. **Goals and Motivation:**
   - Complete rebuild of the current control system
   - Open Architecture Design
   - Integrate Sensor Packages
   - Basic Autonomous Navigation
   - Simple Topographic Mapping

6. **Approach (key features of the system): Discuss at least three key features/functionalities that your system provides for the users to help achieve the overall goal.**

   - **Modularity and Extensibility**
     - **Objective:** Design the software with a modular architecture to enable easy integration of new sensors, algorithms, and control strategies.
     - **Rationale:** This feature allows users to customize and adapt the software for various underwater robot platforms, promoting flexibility and scalability.
   - **Machine Learning Integration**
     - **Objective:** Incorporate machine learning techniques for improved underwater navigation and decision-making.
     - **Rationale:** Using machine learning algorithms can enhance the robot's adaptability to changing underwater conditions.
   - **Safety and Collision Avoidance**
     - **Objective:** Develop safety features and collision avoidance mechanisms.
     - **Rationale:** Prioritizing safety is crucial, and our solutions will mitigate risks in autonomous underwater navigation.
   - **Simulation and Testing Environments**
     - **Objective:** Provide a comprehensive simulation environment for testing navigation algorithms and strategies.
     - **Rationale:** This feature accelerates research and development by allowing users to validate their solutions in a controlled virtual environment.

7. Novel features/functionalities:

- **Hybrid Navigation Strategies**
  - **Objective:** Combine traditional navigation methods with advanced techniques like SLAM for enhanced accuracy and reliability.
  - **Novelty:** This hybrid approach is novel and addresses the challenge of navigating complex underwater environments effectively.
- **Real-time 3D Mapping**
  - **Objective:** Develop capabilities for real-time creation and updating of high-resolution 3D maps of the underwater environment.
  - **Novelty:** This feature aids in obstacle avoidance and path planning, marking a significant advancement in autonomous underwater navigation.
- **Energy-efficient Navigation**
  - **Objective:** Optimize energy consumption during underwater navigation.
  - **Novelty**: The development of unique algorithms to conserve energy is a novel contribution, especially for extended missions.

8. Technical Challenges: Discuss three main CSE-related challenges.

- **Understanding Current Program Architecture:**
  - **Challenge:** We must gain a deep understanding of the existing software architecture to seamlessly integrate our autonomous navigation system.
  - **Rationale:** A solid comprehension of the current program is vital to ensure compatibility and avoid conflicts during the implementation phase.
  - **Methodology:** Conduct thorough code reviews, collaborate with existing developers if possible, and document architecture components.
- **Automation and Machine Learning:**
  - **Challenge:** Implementing automation and machine learning techniques for underwater navigation is a significant undertaking.
  - **Rationale:** These technologies are novel in our project, and understanding them is crucial for achieving the desired level of autonomy and adaptability.
  - **Methodology:** Engage in online courses, workshops, and hands-on projects to build expertise in these areas.
- **Robotics Expertise:**
  - **Challenge:** For one of our team members, working in the field of robotics is entirely new.
  - **Rationale:** To successfully integrate the software with the hardware, this team member will need to acquire knowledge in robotics, including understanding the hardware components and their interaction with the software.
  - **Methodology:** Study relevant knowledge and collaborate with experienced team members to bridge knowledge gaps.
- **Sensor Understanding and Data Mapping:**
  - **Challenge:** To enable simple topographic mapping, we need to learn how sensors, including sonar, operate.
  - **Rationale:** A solid grasp of sensor technology is essential to gain accurate data, and developing our own or incorporating existing software for data mapping is a critical component of our project.
  - **Methodology:** Conduct in-depth research, experiment with sensor hardware, and research software development projects related to data mapping.

9. **Milestone 1 (Oct 2): itemized tasks:**
    - Gain a comprehensive understanding of the current software architecture, assess its compatibility with the project goals, and evaluate the feasibility of implementing autonomous navigation within the existing framework.
    - **Tasks:**
        - Conduct a detailed analysis of the current software architecture.
        - Identify potential integration challenges and areas requiring modification.
        - Assess the feasibility of incorporating automation and machine learning components.
        - Produce a feasibility report outlining the findings and proposed modifications if necessary.

10. **Milestone 2 (Oct 30): itemized tasks:**
    - Successfully integrate the open architecture software with the underwater robot's hardware components, ensuring seamless communication and manual controls.
    - **Tasks:**
        - Develop and implement communication protocols between the software and hardware components.
        - Test the integration in controlled environments to ensure stability and reliability.
        - Address any issues or discrepancies in hardware-software interaction.
        - Ensure that the robot can be controlled and monitored through the software interface.

11. **Milestone 3 (Nov 27): itemized tasks:**
    - Develop and demonstrate a functional prototype of the autonomous navigation system.
    - **Tasks:**
        - Implement automation and machine learning algorithms for autonomous navigation.
        - Develop and integrate sensor data processing and mapping capabilities.
        - Conduct extensive testing in real or simulated underwater environments.
        - Demonstrate the robot's ability to autonomously navigate, and avoid obstacles.

12. Task matrix for Milestone 1 (teams with more than one person)

Tasks	Michael	Zealand
Research Current Operations System:	100%	100%
ArduSub	50%	50%
Blue Robotics OS	50%	50%
Topside Laptop	50%	50%
Overall report of the three current software systems	50%	50%
Create New Architecture Design	50%	50%
Begin Construction of new Control Architecture	50%	50%
Test New Architecture with spare components	50%	50%

13. **Approval from Faculty Advisor**

- "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."
- Signature: _____ Date: 09/05/23