This project implements a Hierarchical Reinforcement Learning (HRL) system for autonomous underwater vehicles (AUVs) in a capture-the-flag scenario. The system is built using the PyQuaticus environment, which simulates underwater robotics competitions.

Key Components:

1. **Hierarchical Structure**:
    - High-level "options" (behaviors) like capturing flags, guarding, patrolling, attacking, and defending
    - Low-level policies that execute specific actions to achieve these behaviors
    - A meta-policy that selects which option to execute based on the current state
2. **Core Features**:
    - **Options System**: Pre-defined high-level behaviors that can be composed and sequenced
    - **PPO-based Learning**: Uses Proximal Policy Optimization for training the policies
    - **Multi-agent Support**: Handles multiple AUVs working together or in competition
    - **Memory and Attention**: Tracks past experiences and focuses on relevant state features
    - **Curiosity-driven Exploration**: Encourages agents to explore novel states and transitions
3. **Technical Implementation**:
    - Built on Ray RLlib for distributed reinforcement learning
    - Uses PyQuaticus for the simulation environment
    - Implements various utility classes for:
        - Option memory and attention
        - Reward shaping
        - State processing
        - Experience buffering
        - Option termination and initiation
        - Debugging and visualization
4. **Testing and Evaluation**:
    - Comprehensive test suite for individual options and full system
    - Visualization tools for analyzing agent behavior
    - Performance metrics tracking
    - Debugging capabilities for option execution

The system is designed to be:

- **Modular**: Easy to add new options or modify existing ones
- **Scalable**: Can handle multiple agents and complex scenarios
- **Interpretable**: Provides insights into why agents make certain decisions
- **Robust**: Includes safety mechanisms and error handling

This project could be particularly useful for:

- Autonomous underwater robotics research

- Multi-agent coordination studies
- Hierarchical reinforcement learning experiments
- Underwater competition preparation