**Intelligent Algorithm-Based Decision Making for Swarm Robotics in Search and Rescue**

Problem Formulation

Swarm robotics has shown great potential in Search and Rescue (SAR) missions due to decentralized coordination and adaptability. However, Intelligent Algorithm-Based Decision Making in dynamic and unpredictable environments such as search and rescue zones is still a challenge. The main issues are:

* Dynamic Environment Adaptation: Traditional swarm algorithms like Particle Swarm Optimization (PSO) struggle with real-time changes, while Reinforcement Learning approaches like Q-learning and Deep Q-Networks (DQN) require extensive training and lack adaptability in real-time.
* Efficient Task Allocation: Existing methods like market-based auctions and behavior-based approaches do not efficiently allocate tasks in large-scale, multi-target SAR scenarios.
* Collision Avoidance & Coordination: Ensuring collision-free navigation in GPS-denied or cluttered environments is difficult. Methods like Velocity Obstacle and Artificial Potential Fields suffer from local minima and high computational costs.
* Scalability & Robustness: Traditional approaches like Ant Colony Optimization and Genetic Algorithms struggle with scalability in large swarm deployments and real-world unpredictability.

This research proposes a hybrid intelligent decision-making algorithm that integrates Particle Swarm Optimization with Reinforcement Learning to overcome these limitations.

Thesis Objectives

1. **Develop a Hybrid PSO-RL Algorithm**: Combine Particle Swarm Optimization with Reinforcement Learning to enhance real-time adaptation and decision-making in dynamic SAR environments.
2. **Optimize Task Allocation**: Train RL agents to assign exploration or rescue tasks based on swarm proximity, optimal resource utilization and victim priority, reducing redundant coverage.
3. **Enhance Real-Time Decision-Making**: Implement lightweight RL policies using local sensor data (LiDAR and UWB) to navigate cluttered environments without global coordination.
4. **Test Algorithm Performance**: Test the algorithm in simulated SAR scenarios using frameworks such as Gazebo and ROS, to compare its performance against traditional models in terms of task completion, scalability, and robustness.

Thesis Propositions

* A PSO-RL hybrid algorithm will improve real-time adaptation and task allocation compared to standalone PSO or RL.
* Using reinforcement learning for task allocation will make victim detection better than victim detection using auction-based methods by prioritizing high-risk zones and minimizing energy waste.
* Using Reinforcement learning decentralization will outperform Velocity Obstacle methods in computational efficiency in performing collision free navigation in unpredictable environments using only the LiDAR and UWB data.