PROTECTION ALGORITHMS USING FAULT RESILIENT FISH SWARMING BEHAVIOR

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1. INTRODUCTION

- Robot swarms have the ability to sense and perform actions over large areas.
- Swarms have the downside of losing individuals due to faults. This leads to unexpected and unwanted behavior.
- Mathematical models: fault-tolerant path planning algorithms using an artificial potential field (APF) module and Kalman filters[4].
- Nature-inspired models: using cell cross-regulation to detect faults[5], a fire-fly-inspired algorithm with pulse-coupled oscillators[6].
- Fish flocking approach in combination with genetic learning in order to create a fault resilient protection algorithm.
- The faults lead to the other challenge of this research which implies target protection through the action of flocking around faulty prey when predators are attacking.

2. OBJECTIVE

- Study the flocking behavior of fish in a scenario where faults and predators are introduced.
- Develop protection algorithms based on the behavior that emerges from resilient fish flocking as a response to predatory attacks.

3. METHODOLOGY

- Fish behavior simulated using Boids[1]
- Boids flocking based on boid rules(Figure 1)
- Two flocking instances: Prey-Predator, Missile-Target
- Using the Prey-Predator instance a protection algorithm is developed
- The algorithm is optimized using genetic learning techniques
- The algorithm is then tested in the Missile-Target instance

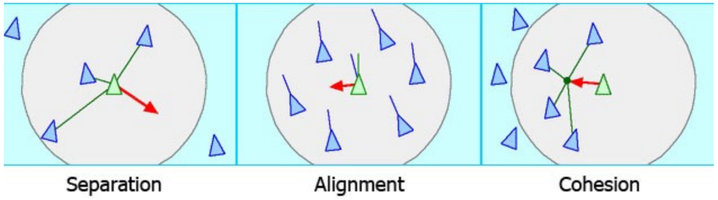

Figure 1: Boid rules

4. RESULTS

Prey-Predator Instance:

- Instances of 7 predators and 70 prey(Figure 2).
- Three prey configurations were tested:
  - Baseline
  - Improved with heuristics
  - Improved with genetic weights

Missile-Target Instance:

- 10 defensive Boids protect a target(Figure 3).
- The same attack and protection strategies were used.
- Each game instance ends when the target is hit by the missile and is scored based on time.

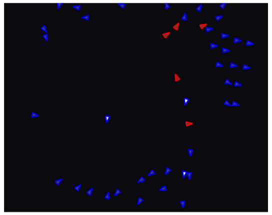

Figure 2: Prey Predator instance

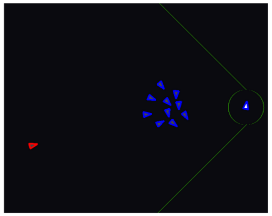

Figure 3: Missile Target instance

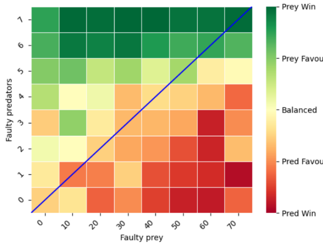

Figure 3: Baseline prey configuration

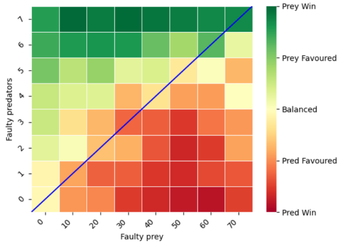

Figure 4: Heuristics prey configuration

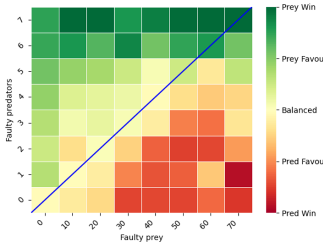

Figure 5: Genetically improved prey configuration

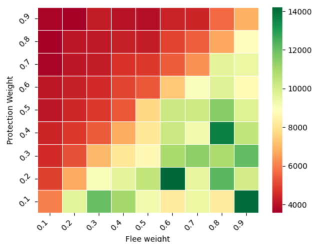

Figure 6: Target-Missile instance with weight classification

5. ANALYSIS

Protection Strategy:

- Based on Figure 6, it can be argued that there is no protection without a good evasion tactic.
- Two performing strategies: low protection-high evasion and the genetic fish prey.
- No improvements when using heuristics(Figure 3 and 4).
- As the number of faults increases, the prey Boids have better performances.

Attacking Strategy:

- Predators overrun the Prey in Figure 4.
- Flocking behavior paradoxically attracts predators.
- Unoptimized Prey weights give predators an advantage.

Optimization with Genetic Learning:

- Behaviors can be tweaked in order to reach a balance between protecting, fleeing or attacking.
- Optimizing the weights improved prey performances.
- There is a clear correlation between the genetic weights and the analysis in Figure 6.

6. CONCLUSION

- The action of flocking is indeed a protection mechanism against predation.
- Good protection mechanisms where robots can use similar escape patterns to those that emerge in nature are feasible[3].
- Even if cluster flocking does not provide absolute protection.
- In real-life implementations, the algorithm can be used to protect points of interest rather than escape predatory attacks.

Further work:

- Improve the hunting and protection capabilities.
- Add an extrapolation of the simulation to a three-dimensional space.
- The Missile-Target scenario could be extended.

RELATED LITERATURE:

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