Dogfight AIsteroids: Adversarial AI in Space Combat

Arye Mindell – CMSI 5998: AI Game Development

Blending aerospace dynamics, robotics, & game AI research

Project Proposal – Key Features Delivered

- F1: New Weapon Types ✅
  - Laser guns for precision combat
  - Homing missiles + lock-on targeting
- F2: Health & Damage System ✅
  - Hull + shield mechanics, physics-based damage
- F3: 'Dummy' Enemy AI ✅
  - Behavior Tree baseline for comparisons
- F4: RL Enemy Pilot ✅
  - PPO-trained continuous-action agent

Why This Project Resonates with Me

- Aerospace/Engineering/Sci-Fi
- Academic Curiosity
  - Deep RL & control in physics-heavy environments
  - Signal processing mindset from DSP coursework
- Creative Passion
  - 7+ years music production – crafted spatial audio & SFX for the demo
- Portfolio Goal
  - Showcase Unity ML-Agents & optimization skills for future aerospace + game AI roles

Technical Architecture Highlights

- Modular Command Pattern
  - Player Input | Behavior Tree | RL Agent
- Multi-Arena RL Training
  - Parallel arenas → fast PPO convergence
- Physics & Systems Layer
  - Asteroid fragmentation, weapon subsystems, physics-based damage system

Implementing the AI

- Behavior Tree (Baseline)
  - States: Idle → Patrol → Evade → Attack
  - LOS caching & modular actions
- Reinforcement Learning (PPO)
  - 20-float observation: self, enemy, asteroids, bounds
  - Continuous thrust/strafe/yaw + discrete fire actions
  - Reward shaping: kill +1, death -1, dmg dealt/taken -1 for exiting Arena

Playtesting & Metrics

- Validation Tests
  - Unity PlayMode for weapons, damage, AI
- Combat Balance
  - 5 players vs Dummy AI difficulty tiers

Most Challenging Aspects

- ML-Agents Integration
  - Normalized obs, reward balance
- Performance Optimization
  - Batched RaycastCommand, object pooling, async asteroid spawn
- Design Balance
  - Realistic physics vs enjoyable combat feel

Extensions & Career Relevance

- Advanced RL
  - Self-play curriculum, hierarchical controllers
- Control Systems Applications
  - Transfer RL pilot to drone sims
- Research & Publication
  - AI believability, training optimization
- Career Showcase
  - Demonstrates Unity, optimization, and RL expertise

In-Class Playtest Instructions

- Participants: 4-5 volunteers, 10 min total
- Controls Tutorial (30s)
  - Left stick move, right stick rotate, RT laser, RB missiles
- Scenario 1: Dummy AI (1 min)
- Scenario 2: RL Agent (1 min)
- Data Collected
  - K/D ratio, survival, fun & intelligence ratings
- Success Targets