Curiosity-Driven Autonomous Game Agent: Emergent Behavior Without Rewards

Master's Project Proposal | Northeastern University | January 2026

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Problem Statement

Traditional game-playing AI requires carefully engineered reward functions that are brittle, prone to exploitation, and impossible to specify comprehensively for open-ended environments. Modern deep learning approaches achieve performance at the cost of interpretability—we cannot understand why they make specific decisions.

Core Hypothesis

Novelty-seeking behavior alone is sufficient to drive emergent intelligent behavior. An agent that simply finds unpredicted state changes "interesting" will naturally explore, discover interactive elements, and develop purposeful actions—without any external reward signal.

Approach

We build an autonomous agent for Pokémon FireRed using interpretable perceptron networks (not deep learning) where the sole learning signal is prediction error magnitude. The system runs at 50 FPS via BizHawk emulator with persistent spatial memory stored in JSON.

Key Mechanisms Implemented:

- **Tile-based interaction probing**: Systematically try all directions at each tile, track success rates, mark exhausted tiles
- **Multi-scale debt systems**: Penalize revisiting areas at map, region, and local levels to ensure coverage
- **Transition bans**: Prevent oscillation between connected areas with positional and vicinity-based restrictions
- **Self-correction**: Pattern detection, stagnation penalties, and adaptive mode switching

Results To Date

Without any reward specification, the agent has learned to: leave the starting house, obtain a starter Pokémon, win the rival battle, use healing items strategically, return to Mom for party healing, flee dangerous encounters, and progress through Route 1—all emerging purely from curiosity about state changes.

Proposed Extensions (Three Parallel Threads)

Thread	Focus	Research Question
1	Navigation & Curiosity	What parameters optimize exploration coverage?
2	Human Teaching	Can demonstration learning accelerate emergence?
3	Vision Enhancement	Does richer visual input improve state discrimination?

Expected Contributions

1. Empirical demonstration that reward-free learning produces coherent behavior in complex environments
2. Design principles for interpretable curiosity-driven architectures
3. Framework for integrating self-learning, human teaching, and perception enhancement
4. Open-source codebase for community extension