Automated Discovery of Innovative Tactics and Behaviors

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MITRE Sponsored Research

MITRE Technology Program

Problem

- Simulations play a key role in the analysis, evaluation, and implementation of new military concepts and capabilities.
- The set of all possible innovations in operational concepts and tactics, or potential threat responses, is too large to search exhaustively.

Can we use machine learning techniques to help automate some aspects of this discovery and evaluation process?

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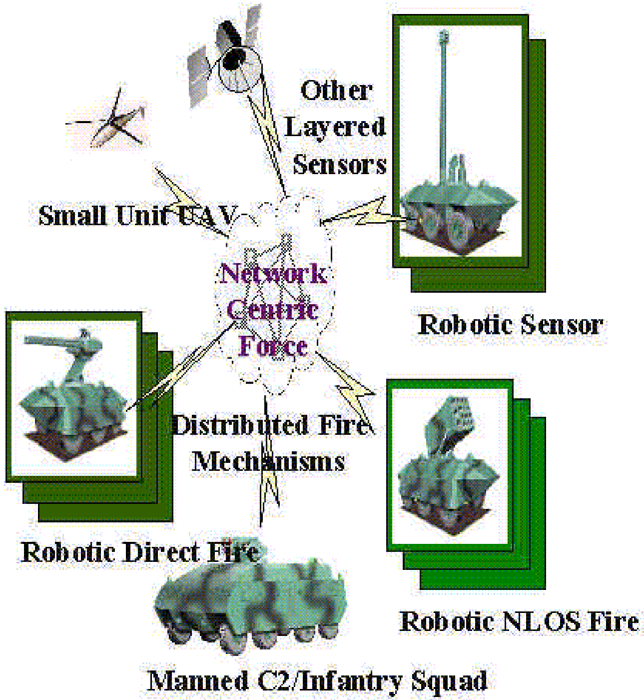
Background



Example: The Future Combat System (FCS)

- The FCS is envisioned as a distributed, network-centric ensemble of manned and unmanned combat systems.
- Coordinating the behaviors of (semi-)autonomous systems may be difficult, especially when communications are limited or frequently interrupted.
- How can a collection of distributed (semi-)autonomous behaviors be organized to facilitate control and achieve coordinated unit outcomes?

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Objective

- Develop efficient techniques to learn reactive, rule-based solutions to sequential decision tasks given feedback about outcomes (FY01)
- Extend the approach to learn simple distributed behaviors (e.g., requiring implicit cooperation) (FY02)
- Develop algorithms to learn tasks requiring more structured coordination and apply them to discover distributed tactical behaviors (FY03)

The emphasis in this MSR is on learning self-organized, goal-directed, reactive behaviors.

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Activities

- Evaluate algorithm performance
  - Experiments using the NEST 3-D Wasp Nest Simulator and the Micro Air Vehicle Simulation
  - Initial work looking at RoboCup soccer
- Continue to revise and improve learning algorithms
  - Represent continuous-valued features
  - Investigate “default hierarchies”
  - Public release of HERLA software
- Collaborations with external organizations (NRL, University of Michigan)

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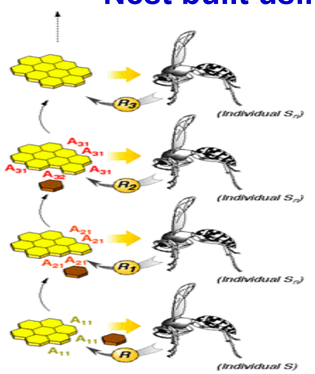
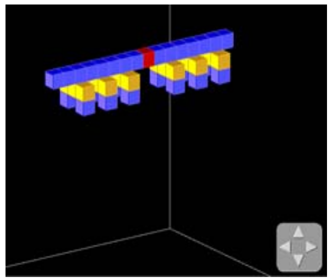
Highlight

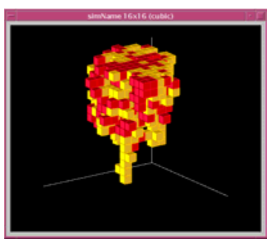
Nest built using simulator rules



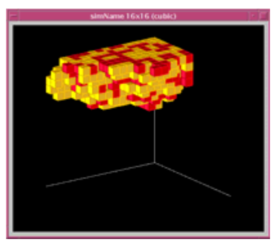


Trial 6000 (Fitness 0.0930)

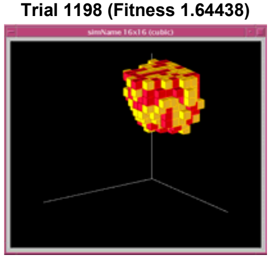
Nests built using rules we discovered



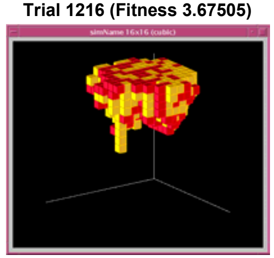
Trial 1198 (Fitness 1.64438)



Trial 1216 (Fitness 3.67505)



Trial 1474 (Fitness 2.88167)



Trial 1642 (Fitness 2.65755)

- **Tactical swarming can be effective without using rigid plans or explicit communications (a form of stigmergy).**
- **Lattice Swarm models (e.g., wasp nest building) provide a good abstraction for studying this problem.**
    - **The NEST 3-D Wasp Nest Simulator has a built-in capability to learn local "micro-rules" for wasp behavior.**
    - **In a typical run, the best nest discovered after 6000 trials had a fitness of only 0.0930.**
    - **Our algorithms quickly discover nests with fitness more than an order of magnitude better.**

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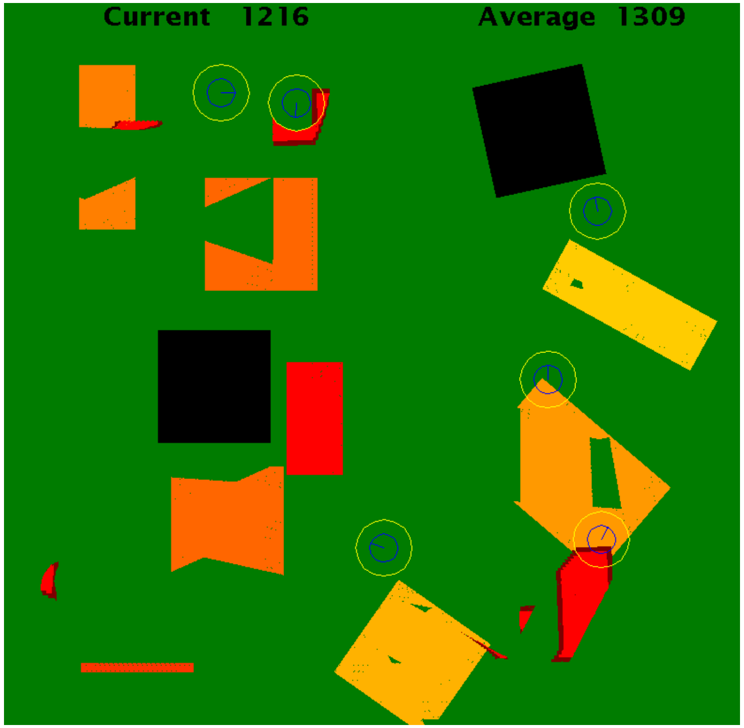
Demonstration



Micro Air Vehicle Simulation

(MAVSIM)

- **MAVSIM was developed at NRL to study simple surveillance and reconnaissance tasks**
- **Ground features:**
  - Static or dynamic regions, low (yellow) to high (red) interest
  - Obstacles (black)
- **Simulated vehicles:**
  - Sensors: 8 range values, best visible region, previous region, previous turn rate
  - Actions: change turn rate

We have learned rules to control MAVs in various benchmark scenarios.

Impacts

- **Academic/R&D community**
  - **Published papers on classifier system framework. Co-edited book *Perspectives on Adaptation in Natural and Artificial Systems*.**
  - **Collaborative efforts with NRL and University of Michigan. Other collaborations pending.**
- **Customer operational mission: Sponsors will be able to use simulations to examine a broader range of candidate tactics and threat responses**
- **Developing work program: Participation in workshop and conference on tactical swarming sponsored by JFCOM and ASD(C3I)**

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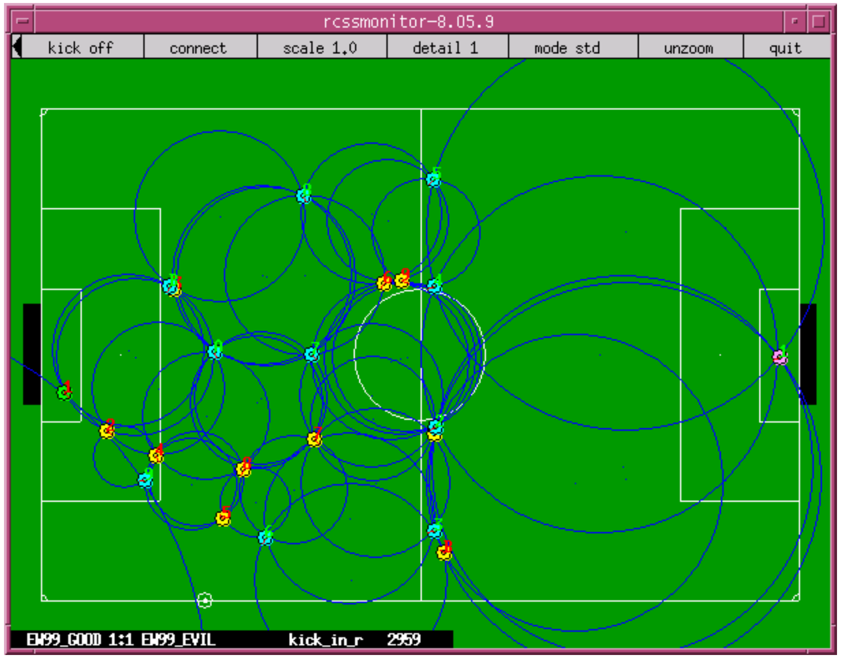
Future Plans



RoboCup Soccer simulation, showing results of MITRE algorithm that computes open areas in real time

- RoboCup Soccer is an international competition between simulated teams.
- This provides a rigorous test of autonomous, distributed, coordinated tactical behaviors.
- We will use our learning algorithms, together with previous work on tactical reasoning, to build behaviors for a MITRE team.

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