

DARPA Agent Based Computing (ABC) Program, Taskable Agent Software Kit (TASK)

PI: Lee Spector, Hampshire College

Project: Multi-type, Self-Adaptive Genetic Programming for Complex Applications

Project URL: <http://hampshire.edu/lspector/darpa-selfadapt.html>

Personnel

- Requested and received approval for funding reallocation, primarily reallocating PI's Spring 2004 course release and summer funding to new personnel. Search for new personnel is now underway.

Specific Accomplishments Since July, 2003

- Continued work on integrated development/analysis plan for evolved UAV behaviors with the University of Massachusetts TASK group, oriented toward a TASK-wide demo in the summer of 2004. Hampshire College will provide and enhance the BREVE simulation environment as necessary. The University of Massachusetts will build the UAV simulation within BREVE to correspond to the OEF scenario as specified by the TASK group as a whole (principally by the Metron and Alphatech groups). Hampshire College will enhance the functionality of the UAVs via genetic programming technologies developed as part of this effort, developing a system called UAVolve. The University of Massachusetts will analyze the resulting system behavior using their Proximity relational knowledge discovery system. **CURRENT STATUS:** Several BREVE enhancements complete; first version of BREVE UAV simulator complete; first set of experiments on enhancing the functionality of the UAVs via genetic programming (UAVolve, using the Push programming language) now underway. The feature of UAV functionality that is being enhanced by genetic programming is the target allocation algorithm; we seek robustness in the context of various scenario alterations (new target areas, "hazard areas" that must be avoided, etc.).

- Continued work on revision and standardization of the Push programming language, which underlies much of the work in this effort. **CURRENT STATUS:** Revised language specification (for "Push2"), Lisp implementation of Push2, C++ implementation of Push2, and Push2 plug-in for the BREVE simulation environment are all nearly complete, with distribution expected in Fall,

2003. Major changes in Push2 include removal of TYPE stack and instruction overloading, along with standardized configuration, extension, and test mechanisms.

- **Best Paper Award** (AAAA Track), and presentation:

Spector, L., J. Klein, C. Perry, and M. Feinstein. 2003. Emergence of Collective Behavior in Evolving Populations of Flying Agents. In *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO-2003)*. Springer-Verlag. pp. 61-73.

- New book chapter published:

Spector, L. 2003. An Essay Concerning Human Understanding of Genetic Programming. In *Genetic Programming: Theory and Practice*, edited by R.L Riolo and W. Worzel, pp. 11-24. Boston, MA: Kluwer Academic Publishers.

- Obtained new results on the evolution of tag-mediated altruistic behavior, extending work by Riolo, Cohen, and Axelrod. Prior work on this topic has received wide attention, e.g. in *Nature*, and there are strong connections between this topic and the present project's results on the evolution of collective behavior. A publication on the new results is currently in preparation.

- PI gave a tutorial, "Quantum Computing for Genetic Programmers," at the 2003 Genetic and Evolutionary Computation Conference (GECCO-2003).

- Constructed 51-person program committee for the Genetic Programming track of the 2004 Genetic and Evolutionary Computation Conference (GECCO-2004), of which the PI is the chair.

- Major revisions to the BREVE simulation environment, which is now available for Mac OS X, Linux, and Windows. Version 1.7 was released, in both executable and source code distributions. See <http://www.spiderland.org/breve>.

- Continued work on adding morphological and developmental evolutionary mechanisms to the BREVE/Push/SwarmEvolve systems. Results expected in Spring, 2004.

- Began work on a book to be published by Kluwer, called *Automatic Quantum Computer Programming: A Genetic Programming Approach*. This book will feature Push-related genetic programming technologies that were developed in the present TASK project.

- Began supervising a student thesis project on evolution of adaptive group behavior in the *Quidditch* flying game from the popular *Harry Potter* books, implemented within BREVE. This was an idea developed early in the present TASK project, but shelved while work proceeded on SwarmEvolve and more literal UAV simulations. Currently no TASK funding is being allocated to this project, but it is feeding technologies back into the project (e.g., a neural network simulation

plug-in for BREVE) and further synergies are expected.

- Planned talk/visit at BBN, with BBN/MIT TASK group and others, on *Quantum Program Evolution*. This talk/visit is scheduled for November 10, 2003, and the possibility of a later talk/visit, on SwarmEvolve/UAVolve, is under discussion.

Current Plans

- Continue collaboration with University of Massachusetts TASK group on UAV simulation in BREVE, working toward the TASK-wide demo in the summer of 2004. Use genetic programming techniques to enhance the performance of the U. Mass UAVs (producing the “UAVolve” system).
- Continue investigation of the emergence of collective behavior and of MIT/BBN Elementary Adaptive Modules in SwarmEvolve. Enhance support for Elementary Adaptive Modules and evaluate their impact on evolvability and adaptation.
- Investigate the addition of morphology evolution in SwarmEvolve or a successor system. Upgrade existing experimental framework to use full physical simulation with evolved physical controllers.
- Develop software and protocols for distributed simulation/evolution runs on high-performance computer clusters.
- Continue to disseminate research results at conferences and in publications.