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

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Time Frame

The grant was awarded effective February, 2001. The assignment to the TASK program was made in March, 2001. Orientation to the details of the program (including the Research Experimentation Frameworks—REFs) occurred at the April, 2001 PI meeting in Santa Fe, New Mexico. The present report (late April, 2001) therefore documents only the initial gear-up phase of the project.

Facilities and Staffing

The grant is supporting the acquisition of a 16-node Beowulf-style computer cluster. A primary activity during the first phase of the effort was product research, configuration, and purchasing of the cluster. All components of the cluster have now been delivered and installation and testing of the system is scheduled for May 2–4.

The grant includes funds to pay undergraduate research assistants. This first year these funds will be used as partial compensation for a graduating student who will stay on campus for another year to work on this effort. The student has completed a senior thesis on the topic of the grant and is superbly qualified to assist in the effort.

Research Experimentation Framework and Collaborations

The Santa Fe PI meeting provided initial exposure to the Research Experimentation Frameworks (REFs) within the TASK program. A decision was made that the most appropriate REF for the present effort would be Control and Adaptation in Heterogeneous, Dynamic Environments (CAHDE). The rationale for this decision includes the following:

1) The CAHDE tasks and scenarios are closely related to the PI’s dissertation work on reasoning and acting in complex, dynamic environments (Spector, 1992). While the explicit task in the dissertation work was to control an intelligent household robot, the CAHDE REF tasks of controlling autonomous vehicles (and future 3D extensions of these tasks) are formally very similar.

2) The CAHDE tasks and scenarios are also closely related to dynamic control problems to which the PI has previously applied genetic programming techniques such as those that are the subject of this effort (Spector, 1996; Luke and Spector, 1996). In particular, this prior work examined the use of genetic programming for the evolution of multi-agent communication, coordination, and collaboration.

3) The testbeds described and to some extent already implemented by other groups in the CAHDE REF may provide particularly quick routes to the testing of the new techniques developed in this effort. A testbed with performance metrics in a particular task environment can often be quickly modified to provide a fitness function for genetic programming to produce agents in that task environment (Spector, 1997).

Three groups within the CAHDE REF are working in areas particularly well suited to collaboration with this effort: the ALPHATECH/SAIC group (Tiffany Frazier, Andrew Newman, Larry Roszman, Greg Frazier), the Dartmouth group (George Cybenko) and the MIT/BBN group (Oliver G. Selfridge and Wallace Feurzeig). Two of these groups (MIT/BBN and Dartmouth) are also in close geographical proximity to the PI. Plans for a visit with the MIT/BBN group are currently being worked out.

Research Theme

The theme of the contribution of this effort to the TASK program and to the CAHDE REF is to examine the automatic programming of agents in complex, dynamic, multi-agent environments. The goal is to develop the fundamental science and techniques of multi-type, self-adaptive genetic programming while testing the developed techniques within dynamic and heterogeneous environments that require control and adaptation of multiple agents.

Research Products

Significant progress has been made on the development of the fundamental techniques and a paper describing these results is now in press (Spector, 2001), and a presentation of this paper will be made at the Genetic and Evolutionary Computation Conference (GECCO-2001) this summer. A copy of the paper is attached to this report. A journal article on this work, coauthored with the student mentioned above, is in preparation for the journal *Genetic Programming and Evolvable Machines* (for which the PI is an associate editor). This progress is fully in line with the objectives for the initial phase of the effort as described in the proposal.

A primary focus of the next phase of the effort will be to develop a new testbed environment and a set of testing scenarios that are appropriate to the CAHDE REF. Existing testbed scenarios built by the ALPHATECH team and the MIT/BBN team will be examined for applicability. At the Santa Fe PI meeting the Program Manager's expressed a strong interest in more general and 3-dimensional environments, and to this end additional testbed environments are being

considered. Candidates being discussed include simulations of air-vehicle traffic, deep-sea exploration, insect nests, and three-dimensional games.

Research Plans

Following are the specific goals for which results are expected in the next 6 months to 1 year:

1) Develop and test interfaces to permit distribution of runs of the extended system across the new Beowulf-style computer cluster.

2) Begin testing the system on the integer sequence induction and quantum computation problems described in the proposal.

3) Meet with CAHDE collaborators at MIT/BBN to discuss test scenarios and other possible opportunities for collaboration. Possibly also meet with teams at Dartmouth and ALPHATECH.

4) Begin development of CAHDE-oriented testbed and/or integration of existing CAHDE testbed and conduct initial tests in this environment.

5) Complete preparation of journal article(s) on current results as described, in preliminary form, in (Spector, 2001).

References

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