Project no.: FP6-502386

Project acronym: NEW TIES

Project title: New and Emerging World Models through Individual, Evolutionary, and Social Learning

Instrument: STREP

Thematic Priority: IST FET-OPEN

Publishable Final Activity Report

Period covered: from 01/09/2004 to 29/02/2008
Date of preparation: 27/03/2008

Start date of project: 01/09/2004 Duration: 42 months

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Project coordinator organisation name: Vrije Universiteit Amsterdam

1 Project execution

The project commenced on 1 September 2004 and was concluded on 29 February 2008. The contractors involved are the Vrije Universiteit Amsterdam, Department of Computer Science, Artificial Intelligence Section (coordinator), Eötvös Loránd University, Faculty of Informatics, Department of Information Systems, Napier University, School of Computing, Centre for Emergent Computing, The University of Surrey, School of Human Sciences, Centre for Research on Social Simulation, and the Stichting Katholieke Universiteit Brabant, Computational Linguistics, Induction of Linguistic Knowledge Group

The visionary goal of the project was to realize an evolving artificial society of virtual agents capable of exploring its virtual world and developing its own view of that world. The long-term target is to learn how to design agents that are able to adapt autonomously to, and then operate effectively in, environments whose features are not known in advance. This ambitious goal was converted into the following concrete project objectives:

1. Develop an artificial society with an emergent culture.
2. Realise a powerful "emergence engine" consisting of a well-balanced combination of individual learning, evolutionary learning, and social learning.
3. Develop, evaluate, and use a range of social learning mechanisms that allow sharing knowledge with other members of the population.
4. Solve two sociological challenges: Herders in a Semi-arid Area and Central Place Theory
5. Build a distributed platform to perform simulations.
6. Provide an open arena for others to participate in meeting the challenges and to specify their own.

Objectives 1 through 3 were part of the original Description of Work (technical Annex), objectives 4 through 6 have been added in the Adjusted Work Plan, written after the second period.

The research is carried out in computer simulations, the environments are abstractions of reality. Our main premise is that given a demanding environment (that only allows survival of agents with specific knowledge and skills) and sufficiently powerful adaptation mechanisms, a population of agents will develop the required skills to survive. As concrete drivers behind the development of a society of agents we included so-called challenges. A challenge in this context is a demanding situation or environment, inspired by sociology, where staying alive requires the development of certain agent behaviour (the solution), for instance trading or herding. The main pillars of the envisioned research are *world models* and the *learning mechanisms* generating these. As explained in the original Description of Work, we did not plan to implement specific training facilities or feedback systems rewarding the learning of world models or some desirable behaviour. Instead, we were interested in emergent phenomena powered by a basic survival game. The envisioned "emergence engine" driving population development is based on three algorithmic building blocks: evolution, individual learning, and social learning. To give rise to interesting emergent features, we were to work on a very large scale with respect to the size of the agent population and agent complexity and planned to enable this by creating a distributed (p2p) software infrastructure.

1.1 Period 1

The main priorities of year 1 were the environment and challenge design, the agent design, the p2p infrastructure, and the specification of the interfaces between different components. The achievements can be considered along different dimensions: conceptual development, technical development, dissemination. As for the conceptual development, we made design decisions and specifications of the environment and the agents therein. We decided to work with discrete time (time steps) and discrete space in the form of a grid world, and to use plants to supply energy in the world. Concerning the agents we gave them an energy-based metabolism and postulated that agents with zero energy or a maximum age will die. As for their controllers we chose to use decision trees, thus symbolic rather than neural representation. This choice enables smooth interfacing with language evolution. Additionally we decided to use two levels of situation descriptions. The low level belongs to the agents' perceptions, as they directly perceive the raw data describing the world through the basic features of all possible objects. This makes the perception state space extremely large. The high level belongs to the agents' decision making procedure. The agents aggregate the raw perception data into so-called categories and concepts, and the decision trees use such high level situation descriptors. This makes the decision state space much smaller than the direct perception state space. We decided to use a genetic programming based approach to the evolution of controllers and to use reinforcement learning as the main mechanism behind individual learning. We created a link between individual learning and evolutionary learning through allowing that some behaviours are influenced by both learned and inherited parameters. We also started with developing the language evolution capabilities and the definition of an interface between the language evolution module and learning.

On the technical level, we have made a draft peer-to-peer infrastructure, a software platform for experimentation with a graphical user interface and inspection tools (i.e., experiment monitors), and an implementation of our agent design with the most essential features. The project has performed beyond expectations concerning dissemination. NEW TIES has generated much interest from public media, resulting in radio broadcasts, newspaper and magazine articles, and Web-based articles in 7 countries: Belgium, Denmark, Hungary, The Netherlands, Russia, United Kingdom, and the Unites States.

1.2 Period 2

While the priorities in Period 1 concerned mainly design and development issues, in Period 2 they shifted to development and testing, the latter one including experimentation for scientific research objectives. Experimentation, in turn, immediately directs the focus to data analysis tools, or "emergence detectors" in our case. By the end of year one a prototype system was in place, but from a software engineering point of view it was not well structured. In the beginning of year two, this was fixed by completely rethinking the logical structure, (re)designing interfaces, and partly re-implementing the NEW TIES code. This caused a delay in achieving the stage of stable code. Consequently, tests and scientific experiments towards project objectives suffered a delay too.

Scientific experiments with NEW TIES agents have been carried out concerning evolutionary learning and the evolution of language. Experiments with evolving populations in NEW TIES faced a serious stability problem, i.e., exploding or imploding populations. Extensive tests were required to reveal that NEW TIES is inherently based on what we named "natural reproduction", that natural reproduction combined with natural selection inevitably leads to varying population sizes, and that there are no available calibration and control methods for this type of evolution. As for language learning, the first goal was the creation of a common lexicon in a group of NEW TIES agents. Using an explicit meaning transfer that provides a form of supervised learning, the agents were able to reach a common lexicon of 50 words (all nouns) with 97% of accuracy, but with an unsupervised learning, which we aim for, accuracy barely exceeded 60%.

Another line of activities can be catalogued as building pre- and post-experiment facilities. In particular, the scenario generator is to specify the actual NEW TIES world and the visualization and inspection tools are to present data generated through a simulation to the experimenter. It is important to note that data analysis plays a crucial role in detecting the emergence of culture, or, in the phrasing of the Technical Annex, in "monitoring the development of world models". An essential agreement was that the discovery of emergent phenomena will happen through giving the user a prominent place in the loop. This emphasizes that visualization and inspection take place already during an experiment, i.e., in run-time, not only afterwards. To facilitate advanced data analysis without much development effort we have chosen to use the popular Weka library and built a bridge between NEW TIES and Weka.

Much effort has been put into the next version of the distributed infrastructure for NEW TIES. Through these efforts we realized that the fully p2p-based system, as envisioned in the original project plan, is far more difficult than anticipated. This is largely because of an earlier design decision that made the world a two-dimensional grid, instead of the graph world originally anticipated. The distribution of processing for a world with this geometry is troublesome, and little previous research has been carried out in this area. A further challenge that was not fully anticipated originally is the need for scaleable and filterable methods for communicating information back to a single machine for visualization and processing. This information needs to be available at a variety of resolutions and in both a pull and push configuration. Significant extra resources have been targeted at this area and the basis for a fully configurable "Historical Data Module" has been built.

By the end of Period 2 there were two unresolved issues lying on the critical path of NEW TIES. First, the individual learning mechanism. Right at the beginning of the project, Reinforcement Learning (RL) has been chosen to realize the individual learning feature in NEW TIES. Unfortunately, RL does not scale up well with the size of the search/state space. In our case, the perception state space, determined by what a NEW TIES agent can see and hear, can easily contain 10^{30} points. The decision making state space, determined by the concept-based situation descriptors in the agent controllers, is much smaller, but this advantage has not been utilized. By the end of year 2 there were no experiments with a population of NEW TIES agents that adapt through Reinforcement Learning in a NEW TIES scenario. This also had an effect on social learning, being the mechanism that distributes individually acquired "knowledge bits": if there are no knowledge bits learned by individual agents, there is nothing to be distributed. The second issue was that of running times. We have always been aware of the fact that the system we envision is computationally very demanding, because of the large number of agents, the high complexity of agents, the long periods (virtual time) we want to simulate in our experiments, and –depending on the actual scenario– because of the complexity of the virtual environment. The evolutionary experiments provided hard evidence that such a 4-tier scale-up really requires a distributed computing platform that is resizable and has a good load balancing system.

1.3 Period 3

Period 3 of the project consisted of 18 months, the originally planned 12 and a 6 months no-cost extension. The extension was motivated by the delay observed by the project evaluators at the end of Period 2. The most important sources of this delay were the software engineering problems and the lack of lifetime learning mechanisms (Reinforcement Learning and social learning) in NEW TIES. After the first 24 months of the project we could only run simulations with evolution as the sole adaptation mechanism and the experiments took a very long time, which hindered the production of scientific research data. Following the recommendations of the project evaluators the consortium produced an Adjusted Work Plan for the last period with three concrete targets that accompany the original project objectives. These targets are shown as objectives 4, 5, and 6 in the introduction.

By the end of Period 3 the software problems were solved, the system contained all envisioned adaptation mechanisms (evolution, two versions of Reinforcement Learning, and social learning), we have produced a user friendly software platform to specify and execute experiments easily, and a distributed middleware that supports scale-up for NEW TIES experiments. Furthermore, we solved two sociology-motivated challenges, i.e., we engineered worlds, agents, and adaptation mechanisms, such that we could observe emergent phenomena regarding the emergence of trade and trading settlements, respectively the behaviour of nomadic herders in a semi-arid area. Additionally, research in language evolution resulted in novel mechanisms (using joint attentional interactions, perspective taking, cross-situational learning and a form of mutual exclusivity) that achieved a sufficient level of communicative accuracy to allow agents teach each other skills and we collected much experimental knowledge about combining evolution, Reinforcement Learning and social learning mechanisms in NEW TIES.

The first solution the curse of dimensionality problem for Reinforcement Learning (RL) respects and exploits earlier design decisions on decision trees as agent controllers. The reduction of the search/state space is inherent in NEW TIES because agents aggregate raw input data into higher level situation descriptors and the standard NEW TIES decision trees are composed from such high level descriptors (used as test nodes in the tree). A natural adaptation of RL to NEW TIES agents, enriched with our so-called Pivotal test Insertion mechanism proved to work well in different scenarios and was successfully applied for solving the trading and the central place theory challenge. The second solution requires a different controller representation in the agents. It is based on the factorial description that the agents develop. Factored description admits that state space is limited for each action and thus it restricts combinatorial explosion. On the other hand, it requires either the learning or the engineering of (approximate) factors. We have engineered the factors in NEW TIES and successfully applied the method for solving the trading challenge.

Using combinations of adaptation mechanisms in NEW TIES has led to new results about their interactions. Our way of combining evolution and RL for decision trees allows these two mechanisms influence each other. On the one hand, RL can affect evolution by regulating the agents' preferences for all actions, including mating, thus making the evolutionary engine working more intensively (more MATE actions) or just the opposite (fewer MATE actions). A series of experiments demonstrated that using the straightforward energy-based RL rewards RL unlearns reproduction because it does costs energy to the agents individually, while the benefits (maintaining the population) are manifested on group level. We have also shown that this problem can be solved by a special reward for the MATE action, which is always positive disregarding the costs. As it happens, we rediscovered "orgasm", Nature's solution to this problem. On the other hand, evolution can affect RL if each agent has its own RL parameters (here: rewards for various actions) and these parameters are inheritable (subject to crossover and mutation). This combination has been also tested and shown to work well in the trading scenario. We see two advantages in such a combined system. First, it liberates the user from having to specify some of the system parameters. Second, it makes the system more flexible, enabling a wider range of simulation results than using a fixed set of predefined parameter values. Phrasing both aspects in one, we can say that this approach gives more way to emergence.

The unsupervised language development mechanism implemented in Period 2 did not yield the results anticipated due to a number of factors. Agents' physical behaviour was not coordinated with the agents' linguistic interactions, which resulted in the construction of poor (i.e., complex and erroneous) learning situations that the learning mechanism could not deal with. The final implemented solution includes a dialogue controller that works on top of the standard controller, and that controls joint attentional and perspective taking mechanisms. In addition, the mechanisms for learning word-meaning mappings have been adjusted to the most straightforward methods (cross-situational learning and mutual exclusivity) required to develop a shared lexicon in the given environment. The current unsupervised mechanisms allow a population of up to 250 agents develop a shared lexicon with an accuracy of 80-90%. This is sufficient for our social learning mechanisms to be successful. These social learning mechanisms allow agents to transfer "knowledge bits" (parts of their controller) to other agents using the evolved lexicons, but with predefined syntax that reflects the structure of the controller. Agents receiving knowledge bits can decide to incorporate these into their own controller by inserting the knowledge and/or adapting parameters that increase the chance of using them, thus learning from the sending agents. Experiments in which some agents (teachers) were given a predefined controller to survive in a relatively simple scenario, while other agents (students) were given a semi-random controller, have shown that social learning works highly robust and provides a knowledge repository that allows the cultural spreading of knowledge. This finding has been confirmed with experiments in which social learning (using a predefined language), individual learning and evolutionary learning were combined.

The consortium also solved the two challenges from the Adjusted Work Plan, the Central Place Theory and the Herders in a Semi-arid Area. By 'solving the challenges', we meant that we would specify a scenario in the NEW TIES framework that had some features analogical to those found in simple human societies, develop agents with learning mechanisms that were able to survive within such a virtual environment, and observe features of the population of agents that demonstrated that the agents had collectively succeeded in solving the challenge implicit in the scenario. To solve the central place scenario we took three steps: first, we developed a scenario and corresponding agents that were able to distinguish different types of objects (that is, poisonous and nutritious plants). Without this capability, there is no meaning to exchange and trade. Second, we developed a trading scenario in which agents were forced by the scenario to exchange different types of plant in order to survive. The agents also had to learn to locate trading partners by moving in a goal-directed fashion across the landscape. Third, by creating a scenario in which resources (plants) were distributed across the landscape according to their type, and using agents that were, as before, required to obtain more than one type of plant in order to survive, we were able to show that spatial patterns of agent concentration emerged, in a way that was consistent with the predictions of central place theory. To model the Herders challenge, a world in which the 'rainfall' varied spatially was created, and the plants modified so that the energy they provided when eaten was proportional to the amount of rain that had fallen on them. This gave a spatial variation. Then the amount of rainfall was made to fluctuate, with the standard deviation of the quantity of rain controlled. Agents (that is, the 'herders') thus found themselves in territories which had a sufficient carrying capacity to support them averaged over the long term, but in some seasons had insufficient rain and therefore insufficient nutrition. They had to learn a solution to this challenge if they were to survive. The solution that the agents learned was to develop 'sharing agreements' with agents in neighbouring territories where the rainfall was greater. It would be expected that the number of such agreements would increase as conditions became more variable, that is, as the temporal fluctuations in rainfall increased in scale, and indeed that is the result that emerges from experiments with this scenario.

A distributed system has been delivered which allows processing over large numbers of ordinary PCs. These PCs might be running any number of operating systems – so long as those operating systems support Java. A version of the system optimised for single machine use has also been produced – this uses exactly the same programming interface enabling NEWTIES code and experiments to be developed on a single machine and then transparently ported to a multi-machine architecture. Training materials to support the system have also been delivered. In addition to the original goals a system for collecting and transporting data from the distributed environment back to a central NEWTIES viewer or database has been provided. While this system is called the "historical data manager" to emphasise that fact that in a distributed system there is no clear concept of what is happening “now” in the NEWTIES world, it should be noted that the system transports the data in real-time so that plug-in viewers can display whatever is the most up-to-date “now” available. The resultant system can cope with in inhomogeneities of the environment and the differences among the PCs used. The obtainable efficiency gain depends strongly on the nature of the experiment being undertaken. For example, an experiment that involves small numbers of simple agents which can see over wide distances is likely to distribute very inefficiently. However, an experiment with large numbers of highly complex agents with distance-limited vision re likely to approach 100% efficiency - the communications and distribution overhead is negligible compared to the amount of NEWTIES computation being carried out. The system can also effectively handle churn, that is, processors can be added to an experiment, or taken away from that experiment while that experiment is running (assuming that the experiment was started with the distributed version of NEWTIES). This means that an experiment can run for several days and then more processing power can be added without losing the effort undertaken so far.

Further to enhance the usability of the NEW TIES software, an advanced GUI has been developed that allows the user to configure experiments without having to delve into the inner workings of the system. This GUI, called SimConfig, provides a unified point of entry for experimentation with the NEW TIES software and allows novice users easy access to the most important parameters without limiting more experienced experimenters: it keeps simple things simple and makes complex things possible. For instance, SimConfig provides sufficient flexibility to define the concepts used in the decision trees (thus specifying the agent controllers), details of the evolutionary mechanism (e.g., crossover and mutation operators), details of the Reinforcement Learning mechanism (e.g., action rewards, learning rates), details of the social learning mechanism (e.g., communication initiation strategy, knowledge bit integration strategy), and offers a variety of methods for capturing and analyzing the data produced by the simulations. SimConfig has been tested by about 80 users including some project members, VUA Master students, and participants of the Evolving Synthetic Societies workshop (Leiden, February 25-26, 2008). All in all, the final NEW TIES system supports research activities at three levels. Users can directly manipulate the source code and, for instance, add agents with neural network controllers or new individual learning mechanisms. Less intrusively, experimenters can use xml files to configure the system at a very detailed level, and finally, one can use the predefined options offered by SimConfig.

Period 3 also generated insights on a high conceptual level. All those experiments with different worlds, agents, and adaptation mechanisms taught us to refine our view on what we call emergence engineering, that is, the art of making a system that shows some predefined emergent behaviour. In the beginning of the project we tacitly expected a more or less linear workflow, consisting of environment engineering (specifying the challenge to solve), agent engineering (defining the agents to solve the challenge), and adaptation engineering (specifying the emergence engine that would drive the population to a solution). However, making agents discover skills to survive in a world is not the same as making them develop the behaviours the experimenter had in mind. The environment strongly determines what behaviours are viable and hence “emergeable” and what behaviours are not. Hence, the set of possible lines of development and so the set of possible experimental outcomes, is to a large extent determined by the environment. Clearly, the same holds for the agents themselves and so it is impossible to predict a priori the effects of environmental and agent properties on the behaviours to emerge. As a consequence, the linear approach of defining the environment, then defining appropriate agents, then playing around with adaptation mechanisms to deliver the targeted emergent behaviour (solution to a challenge) is unlikely to work. In practice, it takes many iterations of engineering the environment, the agents, and the adaptation mechanisms (the emergence engine) to generate some desired emergent behaviour. In this light, the aim of developing an artificial society with some unforeseen, emergent culture does not match very well with a challenge driven working procedure. Knowing what we know now, we would recommend approaching the development of an artificial society with emergent culture in a much less goal-oriented, bottom-up fashion. Given an interesting environment, flexible agents, and powerful adaptation mechanisms, one could just monitor the development of the population, trying to detect shared world views and/or behaviours that could be interpreted as (proto-) culture. These could be consolidated, by user intervention if needed, and the experiment could continue on the next level. In the long run, one might obtain complex societies of complex agents, i.e., emergent culture.

Summarizing, by the end of the project we have met objectives 2 through 6 and have gained knowledge that gives hints on how one could proceed towards objective 1.

2 Dissemination and use

The overview of dissemination activities includes past and future activities. The overview of past activities covers the full project duration, the overview of future activities contains activities foreseen and planned at the moment.

2.1 Past activities

Media:

Planned/actual Dates	Type	Type of audience	Countries addressed	Partner responsible /involved
Continuous refreshing	Project web-site	Scientific community and general public	Global	All
21-22/10/2004	Conference poster	Research	NL + BE	All
5-7/12/2004	Conference poster	Research	Global	All
14/12/2004	Radio	General public	NL	VUA
25/03/2005	Radio	General public	HU	VUA
11-15/04/2005	Conference	Scientific community	Global	All
15/04/2005	Web	General public	EU + Global	All
28/04/2005	Press	General public	BE	VUA
30/04/2005	Radio	General public	DK	VUA
05/05/2005	Press	General public	HU	VUA
07/05/2005	Web	General public	HU	VUA
24/05/2005	Press	General public	NL	VUA
27/06/2005	Web	General public	Global	Napier + UniS
06/07/2005	Conference	Research	Global	UniS
14/07/2005	Web	General public	Global	Napier + UniS
20/07/2005	Radio	General public	NL	VUA
26/08/2005	Press + web	General public	RU	VUA + Napier
31/08/2005	Web	General public	Global	Napier + UNIT
06-09/07/2005	Conference	Research	Global	UniS
November 2005	Conference	Research	Global	All
31/08/2006	TV	General public	HU	ELU
22/07/2006	Newspaper	General public	HU	ELU
08/06/2006	TV	General public	UK	UniS
20/05/2006	Newspaper	General public	BE	VUA, UNIT
19/05/2006	Web article	General public	UK	UniS
16/02/2006	Radio	General public	NL	VUA, UNIT
10/11/2005	Magazine	Higher education	NL	VUA, UNIT
21/08/2006	Dutch radio	General public	NL	VUA, UNIT
18/03/2008	Press conference	General public	HU	ELU

Planned/actual Dates	Type	Type of audience	Countries addressed	Partner responsible /involved
21/1/2008	Press release	General public	UK	UniS
21/02/2008	Dutch radio	General public	NL	VUA, UNIT

Publications:

- B.G.W. Craenen and B. Paechter, "Peer-to-peer networks for scalable grid landscapes in social agent simulations", in *Proceedings of the Socially Inspired Computing Joint Symposium* (AISB 2005), B. Edmonds, N. Gilbert, S. Gustafson, D. Hales, N. Krasnogor, Eds., 2005, pp. 64-71, The Society for the Study of Artificial Intelligence and the Simulation of Behaviour (AISB).
- F. Divina and P. Vogt, "Perceptually grounded lexicon formation using inconsistent knowledge", in *Proceedings of European Conference on Artificial Life* (ECAL2005), M. S. Capcarrere, A. A. Freitas, P. J. Bentley, G.G. Johnson, J. Timmis, Eds., 2005, pp. 644-654, Springer.
- N. Gilbert, S. Schuster, M. den Besten and L. Yang, "Environment design for emerging artificial societies", in *Proceedings of the Socially Inspired Computing Joint Symposium* (AISB 2005), B. Edmonds, N. Gilbert, S. Gustafson, D. Hales, N. Krasnogor, Eds., 2005, pp. 57-63, The Society for the Study of Artificial Intelligence and the Simulation of Behaviour (AISB).
- A.R. Griffioen, M.C. Schut, A.E. Eiben, Á. Bontovics, Gy. Hévízi and A. Lõrincz, "New Ties Agent", in *Proceedings of the Socially Inspired Computing Joint Symposium* (AISB 2005), In B. Edmonds, N. Gilbert, S. Gustafson, D. Hales, N. Krasnogor, Eds., 2005, pp. 72- 79, The Society for the Study of Artificial Intelligence and the Simulation of Behaviour (AISB).
- P. Vogt and F. Divina, "Language evolution in large populations of autonomous agents: issues in scaling", in *Proceedings of the Socially Inspired Computing Joint Symposium* (AISB 2005), B. Edmonds, N. Gilbert, S. Gustafson, D. Hales, N. Krasnogor, Eds., 2005, pp. 80-87, The Society for the Study of Artificial Intelligence and the Simulation of Behaviour (AISB).
- Nigel Gilbert, Matthijs den Besten, Akos Bontovics, Bart G.W. Craenen, Federico Divina, A.E. Eiben, Robert Griffioen, Gyorgy Hévízi, Andras Lõrincz, Ben Paechter, Stephan Schuster, Martijn C. Schut, Christian Tzolov, Paul Vogt and Lu Yang (2006) Emerging Artificial Societies Through Learning. *Journal of Artificial Societies and Social Simulation* vol. 9, no. 2. http://jasss.soc.surrey.ac.uk/9/2/9.html.
- Divina, F. and Vogt, P. (2006) A hybrid model for learning word-meaning mappings. In P. Vogt, Y. Sugita, E. Tuci and C. Nehaniv (Eds.) *Symbol grounding and beyond: Proceedings of Emergence and Evolution of Linguistic Communication III* Springer.
- Divina, F. and Vogt, P. (2006) Modelling language evolution in a complex ecological environment *ILK Research Group Technical Report Series no. 06-01.*
- Vogt, P. (2005) Stability conditions in the evolution of compositional languages: issues in scaling population sizes. In P. Bourgine, F. Kepes and M. Schoenauer (Eds.) *Proceedings of the European Conference on Complex Systems.*
- Acerbi, A. and Marocco, D. and Vogt, P. (In press). Social Learning in Embodied Agents, editorial for Special Issue in *Connection Science*.
- Acerbi, A. and Marocco, D. and Vogt, P. (2007). (Editors) Proceedings of Int. Workshop on Social Learning in Embodied Agents, ECAL 2007 Workshop.
- J.A. Bekker, **A.**E. Eiben, A.R. Griffioen, & E. Haasdijk (2007). Balancing quality and quantity in evolving agent systems. In D. Thierens et al. editors, Proceedings of the Genetic and Evolutionary Computation Conference (GECCO 2007), ACM Press, 2007, 335.
- E. Eiben and A. R. Griffioen and E. Haasdijk (2007). Population-based Adaptive Systems: concepts, issues, and the platform NEW TIES. In Proceedings of ECCS 2007.
- A.R. Griffioen, S.K. Smit, & A.E. Eiben (in press). Learning benefits evolution if sex gives pleasure. In IEEE Congress on Evolutionary Computation 2008 (CEC 2008).
- V. Gyenes, Á. Bontovics , A. Lõrincz (submitted) Factored Temporal Difference Learning in the New Ties Environment.
- E. Haasdijk, P. Vogt, and A. E. Eiben (in press). Social Learning in Population-based Adaptive Systems. In IEEE Congress on Evolutionary Computation 2008 (CEC 2008).
- S.K. Smit, A.R. Griffioen, and M.C. Schut (in press). A controller architecture for the evolution of state-persistent controllers: Behaviour Oriented Decision Tree (BODT). In IEEE Congress on Evolutionary Computation 2008 (CEC 2008).
- Vogt, P., Haasdijk, E. (2007). Social learning of skills and language. In Acerbi, A. and Marocco, D. and Vogt, P. (Eds) Proceedings of Int. Workshop on Social learning in embodied agents.
- Vogt, P. and Divina, F. (2007). Social symbol grounding and language evolution. *Interaction Studies vol. 8(1)*,

31-52, 2007

- Szita I and Lőrincz A. Learning to play using low-complexity rule-based policies: Illustrations through Ms. Pac-Man, Journal of Artificial Intelligence Research, 30. 659-681 (2007).

Presentations:

- F. Divina, The NEW TIES project, 16th Belgian-Dutch Conference on Artificial Intelligence, Groningen, NL, 21-22 October, 2004
- A.E. Eiben, The NEW TIES project, EUROPEAN CONFERENCE ON COMPLEX SYSTEMS, TORINO, DECEMBER 5-7, 2004
- 11-15/04/2005: AISB 2005: Social Intelligence and Interaction in Animals, Robots and Agents conference, Socially Inspired Computing Joint Symposium: Memetic Theory in Artificial Systems and Societies, Emerging Artificial Societies, Engineering with Social Metaphors (organized by all partners). All partners held a presentation.
- B.G.W. Craenen, "Peer-to-Peer Networks for Social Agent Simulations", Centre for Emergent Computing Seminar, 20 January 2005.
- N. Gilbert, Presentation about NewTies, International Sociological Association, Stockholm, 6-9 July 2005
- Nigel Gilbert – "Putting the social into social simulation", invited talk to the first World Congress on Social simulation, Kyoto, Japan, 24th August 2006 (WCSS 2006)
- B.G.W. Craenen and B. Paechter, "Peer-to-peer infrastructures in the NEW TIES project", *e-Infrastructures for Social Simulations workshop*, Manchester, 26 October 2005
- Vogt, P. Stability conditions in the evolution of compositional languages: issues in scaling population sizes. *Presentation at the European Conference on Complex Systems, held in Paris on 14-18 November 2005.*
- Vogt, P. Modelling language evolution in robots: issues in compositionality. *Invited seminars at:*
    - DSP and Speech Technology Laboratory, Electrical Engineering Department, Chinese University of Hong Kong, 9 December 2005.
    - Ikegami Lab. The University of Tokyo, Japan. 12 December 2005.
    - Laboratory for Behavior and Dynamic Cognition, and Laboratory for Biolinguistics, Riken Brain Science Institute, Wako City, Saitama, Japan. 13 December 2005.
    - Hashimoto Lab. Japan Advanced Institute of Science and Technology. Kanazawa, Japan. 15 December 2005
- Vogt, P. and Divina, F. Symbol grounding and language evolution in a complex ecological environment. *Invited speaker at the External Symbol Grounding workshop, held in Plymouth, U.K. on 3-4 July 2006.*
- A.E. Eiben. Balancing quality and quantity in evolving agent systems. IEEE Congress on Evolutionary Computation 2007 (CEC 2007). London, England, July 2007.
- Á. Bontovics, V. Gyenes, B. Pintér and A. Lõrincz. 2007. Simulations in the New Ties Environment: Cognitive Architecture and Emergent Strategies. IRFIX 2007 , Budapest, Hungary, 2007.
- A.R. Griffioen. Population-based Adaptive Systems: concepts, issues, and the platform. EUROPEAN CONFERENCE ON COMPLEX SYSTEMS, Dresden, October 1-4, 2007
- P. Vogt. Emergent logics in artificial societies. Symposium on`Logic and Cognition', Groningen (NL), June 2007.
- P. Vogt. Social learning of language and skills. First Int. Workshop on Social Simulation and the Analysis of Artificial Societies (SSASA), Barcelona, Spain, May 2007.
- N. Gilbert. NewTies: and introduction and overview. First Int. Workshop on Social Simulation and the Analysis of Artificial Societies (SSASA), Barcelona, Spain, May 2007.
- P. Vogt. Social learning of language and skills. Seminar at Language Evolution and Computation Research Unit, University of Edinburgh, U.K. September 2007.

Tutorials given at conferences or workshops:

- A.E. Eiben, A.R. Griffioen, & P. Vogt. Demonstration NEW TIES. platform Conference Simulation of Adaptive Behaviour 2006 (SAB 2006).
- N. Gilbert Talk on NewTies at the DECOI International Summer School on Collective Intelligence and Evolution, 20-24 August 2007
- J.A. Bekker. Tutorial SimConfig at International Summer School on Collective Intelligence and Evolution (DECOI 2007).

Organised Workshops

- Organized by all partners, AISB 2005: Social Intelligence and Interaction in Animals, Robots and Agents conference, Socially Inspired Computing Joint Symposium: Memetic Theory in Artificial Systems and Societies, Emerging Artificial Societies, Engineering with Social Metaphors
- P. Vogt. September 2007: Workshop organisation Social Learning in Embodied Agents, in collaboration with

Alberto Acerbi and Davide Marocco (ECAgents).
- Nigel Gilbert. Workshop Evolving Synthetic Societies 25-28 February 2008. Leiden, The Netherlands.

Education

- Practicum assignment for the course Evolutionary Computing, 2006/2007 by A.E. Eiben, R. Griffioen, at the Vrije Universiteit Amsterdam.
- Practicum assignment for the course Evolutionary Computing, 2007/2008 by A.E. Eiben, R. Griffioen, and S. Smit at the Vrije Universiteit Amsterdam.
- Computational Social Science: Masters module at the University of Surrey, 2006, 2007 and 2008 by N. Gilbert

2.2 Future activities

Planned/actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
2008/2009	Education	Students	NL	50	VUA
2008/2009	Education	Students	UK	50	UniS
2008/2009	Education	Students	HU	50	ELU
2008	Journal (EI)	Scientific community	Global		VUA
2008	Conference (ECCS)	Scientific community	Global		VUA
2009	Conference (CEC)	Scientific community	Global		VUA + UTIL
2008	Conference	Scientific community	Global		UniS + ELU
2008	Conference	Scientific community	Global		UniS + ELU
2008	Summerschool	Students	Europe		VUA
2008	Journal (Alife)	Scientific community	Global		UTIL
2008	Conference	Scientific community	Global		UTIL
2008	Project	Research	NL + UK		UniS + UTIL
2008	Journal (IEEE TEC)	Scientific community	Global		Napier + VUA
2008	Project (Symbrion)	Research	D, AT, B, NL, UK, FR		VUA
2008	Project (EACRS)	Research	UK		VUA