Simulation and Analysis of Shared Extended Mind* (extended abstract)

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Some types of animals exploit patterns created in the environment as external mental states, thus obtaining an extension of their mind. In the case of social animals the creation and exploitation of such patterns can be shared [1], which supports a form of shared extended mind or collective intelligence. This paper explores this shared extended mind principle for social animals in more detail.

Clark and Chalmers [2] point at the similarity between cognitive processes in the head and some processes involving the external world. This similarity can be used as an indication that these processes can be considered extended cognitive processes or extended mind. We will call this the 'isomorphism' criterion. As the patterns in the external world have to be created and sensed, interaction with the external world will be more intensive, compared to the case where internal mental states are created and exploited.

This paper includes a case study in social ant behaviour in which shared extended mind plays an important role. The analysis of this case study comprises multi-agent simulation based on identified local dynamic properties, identification of dynamic properties for the overall process, and verification of these dynamic properties.

Dynamic properties can be specified at different aggregation levels, varying from (local) dynamic properties for the basic mechanisms and (global) properties of a process as a whole. This paper introduces local dynamic properties for the basic mechanisms; they are used to specify a simulation model. The world in which the ants live is described by a labeled graph as depicted in the Figure below. Locations are indicated by A, B,…, and edges by

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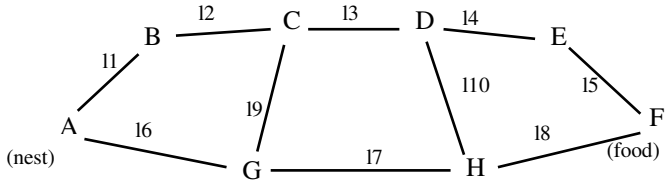
l1, l2,… The ants move from location to location via edges; while passing an edge, pheromones are dropped. The objective of the ants is to find food and bring this back to their nest. In this example there is only one nest (at location A) and one food source (at location F).



A special software environment has been created to enable the simulation of executable models. Based on an input consisting of dynamic properties, the software environment generates simulation traces. Experiments have been performed with a population up to 50 ants.

The paper also addresses dynamic properties of a global nature, and their verification. Such properties for example include the successfulness of food delivery, returning to the nest and food being delivered to the nest by multiple ants. These and a number of other global properties have been formalised and using a checking software environment have been (automatically) verified in simulation traces.

In [2], four criteria are given for extended mind: (1) the external information is a constant in the agent's life - when the information is relevant, he will rarely take action without consulting it; (2) the external information is directly available; (3) the agent endorses retrieved external information; (4) the external information has been endorsed at some point in the past, and is there as a consequence of this endorsement. Our investigation reveals insights into how far these criteria apply to the ants case. For the first one, indeed an ant always senses the pheromone before choosing a direction. Secondly, at each location the pheromone is immediately accessible for sensing. Thirdly, the decision for the direction indeed is always based on the pheromone. Finally, the external information is endorsed in the past: the pheromone was dropped at the direction from which one or more ants came.

References

[1] Bonabeau, J. Dorigo, M. and Theraulaz, G. (1999). Swarm Intelligence: From Natural to Artificial Systems. Oxford University Press, New York, 1999.

[2] Clark, A., and Chalmers, D. (1998). The Extended Mind. In: Analysis, vol. 58, 1998, pp. 7-19.