A Multi-Agent Simulation of Primate Social Concepts

Sébastien Picault

A Multi-Agent Simulation of Primate Social Concepts

Sébastien Picault[1]

Abstract. In this paper, we present both an overview of our work on Primate Societies simulation, and our preliminary results with a first Social Cognition model. We first show the close connection between the complexity of social organization among primates and classical issues of Distributed AI or Multi-Agent Systems design. Then, we describe our Cognition Model, in which we assume that some social concepts should be reproduced by focusing on the interactions between the agents, instead of using an individual-based model. Finally, we discuss our results and propose extensions and applications to Multi-Agent Systems design.

1 FROM PRIMATE SOCIAL ORGANIZATION TO DAI'S ISSUES

In this section, we show the relation between primate social competences and common issues of Distributed AI.

1.1 Primate social competences

Unlike most other species, primates (especially Monkeys and Apes) have the cognitive capacity to *recognize* social relations between their conspecifics ([3] demonstrates this capacity). These relations are for instance *kinship*, *dominance* (which shapes the social structure of the group, usually a *linear*, or *transitive*, hierarchy), or *affiliation* (which allows mutual assistance).

Because of this social perception, primates can form coalitions to consolidate or overthrow the social structure. Thus, unlike other species, the social hierarchy does *not* only depend on physical power, but mostly on alliance networks. These networks emerge from affiliative links, through a reinforcement process: the probability of having an affiliative interaction with a conspecific (typically, a "grooming" activity) correlates with the duration of past interactions of the same kind. Moreover, primates do not only fight to shape the social structure: dominant individuals can use threat signals, to which their dominated conspecifics must respond with submissions ones.

A few species exhibit more complex behaviours, such as "tactical deception", which is defined by Byrne and Whiten [2] as "*acts from the normal repertoire of the agent, deployed such that another individual is likely to misinterpret what the acts signify, to the advantage of the agent*".

1.2 From primates to agents

We can now see that primate social organization addresses the following issues, which are very close to DAI's:

- How can *concepts* (such as "dominance" or "affiliation") emerge from interactions between agents, or how to build a symbolic representation of the conspecifics ?
- Which mechanisms are implied in coalitions or alliances formation ? This is a highly challenging point in order to design dynamical methods for team work, cooperation, coordination in Multi-Agent Systems.
- Which cognitive abilities are required to produce deceptive behaviours ? "Innate" behaviour rules (for instance, as a product of Natural Selection), or a Theory of Mind ? The understanding of deception could provide DAI with mechanisms to prevent or fight fraud in Multi-Agent Systems.

To answer these questions, we prefer to start our work on social cognition simulation by testing parsimony hypotheses regarding social cognition models, in order to find quite simple mechanisms which could be used to shape the organization in other Multi-Agent Systems. In the following section, we report the firsts results of such an approach.

2 A DISTRIBUTED COGNITION MODEL TO SIMULATE SOCIAL CONCEPTS

2.1 Our hypotheses

Byrne [1] and Worden [9] propose a symbolic learning theory for social complex behaviours, but it only focuses on a *single* agent. According to Occam's Razor, we prefer, as far as possible, to start with very simple agents, attaching importance to their *interactions* (instead of their internal structure), to produce complex collective behaviours. We should not increase their individual complexity until such a model proves incomplete.

We assume in our work that the distinction between three organization levels reduces the complexity of the study. These levels (defined by Collinot's *Cassiopeia* Method [4]) are a *domain-dependent* one (responsible for individual competences), a *relational* one (involved in affiliation or dominance), and an *organizational* one (allowing coalitions and alliances).

2.2 Social cognition: the pheromone model

Our work uses a simulation platform in which the behaviours of the agents, called *tasks*, are fixed action patterns, with preconditions (see [7] for more details).

Insects lay down or diffuse molecules in the environment to share information about "domain-dependent problems" (such as foraging, nest building, eggs care), and such "reactive" mechanisms can be used in problem-solving [5, 6]. In the same way, the model we propose uses the environment as a social medium, defining "*social pheromones*" as follows:

[1] LIP6, University of Paris 6, 4 place Jussieu, 75252 Paris Cedex 05, FRANCE. e-mail: Sebastien.Picault@lip6.fr

ECAI 98. *13th European Conference on Artificial Intelligence*
Young Researcher Paper
Edited by Henri Prade
Published in 1998 by John Wiley & Sons, Ltd.

A given social interaction is linked with a particular kind of stimulus, called "social pheromone", which is emitted in the environment; this stimulus, when perceived by an agent, causes a modification in his relational and/or organizational behaviours or knowledges.

The purpose of this model is to reproduce the recognition of social proto-concepts; for instance, the dominance relation. In this context, each agent diffuses a social pheromone (called "rank") and, instead of memorizing fight outcomes, he maintains sensitivity thresholds to his conspecifics' stimuli (see figure 1). The intensity of the emitted stimulus is the average of the sensitivity thresholds, thus we ensure a direct feedback between the threshold set and the corresponding stimulus of an agent.

When an agent perceives a dominance stimulus, he compares its intensity to the threshold allocated to its emitter, and the result determines the agent's relational behaviour: if the stimulus is low enough, then the agent acts as he would dominate the pheromone's emitter. Therefore, the higher an agent's thresholds are, the less the agent responds to his conspecifics' stimuli; at the same time, his own stimulus has a strong intensity, and probably a great impact on the other agents.

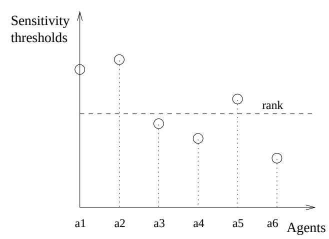

Figure 1. This graph illustrates an agent's social representations of his conspecifics (abscissa: a1–a6). Each agent maintains such a set of sensitivity thresholds to determine wether or not he dominates his conspecifics, i.e. wether or not he reacts to his conspecifics' "rank" stimulus. The average of these thresholds gives the intensity of the agent's own dominance pheromone.

When a domain-dependent role has an influence on relational roles, the thresholds are being adjusted according to the outcome of the interactions. For instance, when a fight occurs, the winner (W) and the loser (L) modify their respective thresholds: $T_W(L)$ increases while $T_L(W)$ decreases (where $T_i(j)$ refers to agent i's sensitivity threshold toward agent j's dominance stimulus). The amplitude of the correction is proportional to the former threshold for the loser, and inversely proportional to it for the winner. Therefore, the outcomes of interindividual interactions have an additional influence on the intensity of the winner's and the loser's emitted pheromone, so that their conspecifics may be sensitive to it.

Thus, no individual representation is the mirror of the whole social structure, but the interaction between them makes it emerge. That is why this model is a *Distributed Social Representation*.

3 RESULTS, DISCUSSION, FUTURE WORK

In this section, we report our results and propose applications of our work in other Multi-Agent Systems. More details about our experiments are given in [8].

3.1 Results and interpretation

With our model, the agents succeed in estimating the rank of their conspecifics, even if they have very few interactions with them. We also show that "erroneous social beliefs", due to insufficient updating, are responsible for new fights and thus modification of the social structure. In fact, two concepts are modelled: "*prejudice*" (under the meaning of "erroneous social beliefs" due to unsufficient updating), and "*self-confidence*" (a positive feedback that doesn't act directly on the outcome of conflicts but on relational knowledge).These results seem to confirm our hypotheses regarding the distinction of organization levels and the relevance of a pheromone-like model to process relational information.

3.2 Future work

For the moment, we have focused on one aspect of social cognition, which is enough to confirm some hypotheses but is too restrictive to provide a real simulation of primate societies. Now, we have to extend our work through three directions: first, our social cognition model is to be experimented more widely on other relational roles and compared to biological facts. The second point would be to abstract some of our simulation mechanisms to propose engineering principles which could be implemented into other multi-agent systems. Finally, social phenomena simulation raises stakes that go far beyond biology. In fact, complex behaviours, such as tactical deception, could interest economical or political simulations, since primate behaviours are very close to human ones in this very domain. The simulation of primate social behaviours not only allows to test biological hypotheses and understand collective behaviours, but also has repercussions on other fields in social sciences.

ACKNOWLEDGEMENTS

This Ph.D. research is supervised by Anne Collinot (LIP6/CNRS) and supported by a grant from the French Department of Higher Education and Research.

REFERENCES

[1] Richard W. Byrne, 'A formal notation to aid analysis of complex behaviour: Understanding the tactical deception of primates', *Behaviour*, (127 (3–4)), 231–246, (1993).

[2] Richard W. Byrne and Andrew Whiten, *Machiavellian Intelligence: social expertise and the evolution of intellect in monkeys, apes and humans*, Clarendon Press, Oxford, 1988.

[3] Dorothy L. Cheney and Robert M. Seyfarth, 'Vocal recognition in free-ranging vervet monkeys', *Animal Behavior*, (30), 362–367, (1980).

[4] Anne Collinot, Alexis Drogoul, and Philippe Benhamou, 'Agent-Oriented Design of a Soccer Robot Team', *Proceedings of ICMAS'96*, (1996).

[5] Alexis Drogoul, 'When Ants Play Chess (Or Can Strategies Emerge From Tactical Behaviors?)', *From Reaction to Cognition, Lectures Notes in AI 957, Springer Verlag*, 13–27, (1995).

[6] Alexis Drogoul and Christophe Dubreuil, 'A Distributed Approach to N-Puzzle Solving', *Proceedings of the Distributed Artificial Intelligence Workshop*, (1993).

[7] Steffen Lalande, Alexis Drogoul, and Bernard Thierry, 'MACACA: a Multi-Agent Computer simulation of Animal Communities based on Alliances', *Proceedings of Simulating Societies Symposium*, (1995).

[8] Sébastien Picault and Anne Collinot, 'Designing Social Cognition Models for Multi-Agent Systems through Simulating Primate Societies', *Proceedings of ICMAS'98*, (1998).

[9] Robert P. Worden, 'Primate Social Intelligence', *Cognitive Science*, (20), 579–616, (1996).