Social Instruments for Convention Emergence (Extended Abstract)

Daniel Villatoro
Artificial Intelligence Research Institute (IIIA)
Spanish National Research Council (CSIC)
Bellatera, Barcelona, Spain
dvillatoro@iiia.csic.es

Jordi Sabater-Mir
Artificial Intelligence Research Institute (IIIA)
Spanish National Research Council (CSIC)
Bellatera, Barcelona, Spain
jsabater@iiia.csic.es

Sandip Sen
Department of Mathematical and Computer Science
University of Tulsa
Tulsa, Oklahoma, USA
sandip-sen@utulsa.edu

ABSTRACT

In this paper we present the notion of Social Instruments as a set of mechanisms that facilitate the emergence of norms from repeated interactions between members of a society. Specifically, we focus on two social instruments: rewiring and observation. Our main goal is to provide agents with tools that allow them to leverage their social network of interactions when effectively addressing coordination and learning problems, paying special attention to dissolving metastable subconventions. Finally, we present a more sophisticated social instrument (observation + rewiring) for robust resolution of *subconventions*, which works dissolving Self-Reinforcing Substructures (SRS) in the social network.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent Systems

General Terms

Experimentation

Keywords

Artificial social systems, Social and organizational structure, Self-organisation, Emergent behavior

1. INTRODUCTION

The social topology that restricts agent interactions plays a crucial role on any emergent phenomena resulting from those interactions [1]. In the literature on emergent behavior in MAS, one active topic is *convention or norm emergence* as a mechanism for sustaining social order, increasing the predictability of behavior in the society and specify the details of those unwritten laws. Conventions help agents to choose a solution from a search space where potentially all solutions are equally good, as long as all agents use the same.

In *social learning* [2, 3] of norms, where each agent is learning concurrently over repeated interactions with randomly selected neighbours in the social network, a key factor influencing success of an individual is how it learns from the "appropriate" agents in their social network. Therefore, agents can develop subconventions depending on their position on the topology of interaction. The problem of subconventions is a critical bottleneck that can derail emergence of conventions in agent societies and mechanisms need to be developed that can alleviate this problem. [1] Subconventions are facilitated by the topological configuration of the environment (isolated areas of the graph which promote endogamy) or by the agent reward function (concordance with previous history, promoting cultural maintenance). Assuming that agents cannot modify their own reward functions, the problem of subconventions has to be solved through the topological reconfiguration of the environment.

Agents can exercise certain control over their social network so as to improve one's own utility or social status. We define *Social Instruments* to be a set of tools available to agents to be used within a society to influence, directly or indirectly, the behaviour of its members by exploiting the structure of the social network.

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2. OUR SOCIAL EQUIPMENT

Rewiring.

Rewiring allows agents to "break" on runtime the relationships from which they are not receiving any benefit and try to substitute intelligently those links by new ones. We have developed three different methods: *Random Rewiring (RR)* (randomly selected agent from the population), *Neighbour's Advice (NA)* (agent recommended by a neighbour), and *Global Advice (GA)* (most similar strategy agent from the whole population).

Observation.

In a social learning scenario, allowing agents to observe the strategy of other agents outside their circle of interaction can provide useful information to support the convention emergence process.

We propose three different observation methods: *Random Observation (RO)* (random agents from the society), *Lo-*

[1]Subconventions are conventions adopted by a subset of agents in a social network who have converged to a different convention than the majority of the population.

cal Observation (LO) (immediate neighbours), and *Random Focal Observation (RFO)* (neighbours of one random agent) After the observation process, the agent will choose the majority action taken by the selected observed agents and will reinforce it.

3. EXPERIMENTAL RESULTS

In order to test our social instruments, we test them in the same simulation framework used in [5].

For the Rewiring Instrument, in general the *Global Advice (GA)* rewiring method produces the best convergence time due to its centralized nature and access to global information. Nonetheless the decentralized methods, specially the *Neighbour's Advice (NA)* method, also show good performances. The *NA* method improves the *Random Rewiring (RR)* method as it more expediently resolves the subconventions that appear in the one-dimensional lattices during the convention emergence process. These results are reaffirmed for the scale-free networks, although the final number of components is increased. We have also observed that rewiring performs better in low clustered societies, producing a stratified population which results in significant reduction in convergence time.

As for the Observance, in general we have noticed that a small percentage of Observation drastically reduces convergence times. Comparing the results from the three Observation methods we observe that the Random (RO) and the Random Focal Observation (RFO) methods are the most effective ones, and have very similar results, when compared with the Local Observation (LO) method. The reason for this phenomenon is to be found on the frontier effect. When agents use the LO method, they observe their direct neighbours. If the observing agent is in the frontier area, then, this observation is pointless. However, observing different areas gives a better understanding of the state of the world, and hence the RO and the RFO methods perform better.

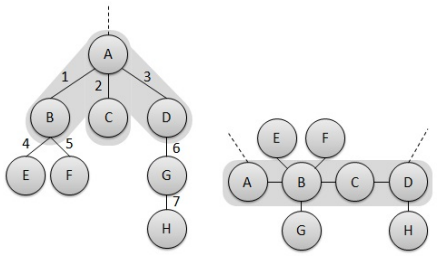
4. SOLVING THE FRONTIER EFFECT

After experimenting with simple social instruments (like rewiring or observation) we observed that subconventions need to be resolved in what we defined to be the "frontier" region [5].

Theoretically, a subconvention in a regular network is not metastable, but unfortunately, slows down the process of emergence. On the other hand, in other network types, such as random or scale-free subconventions, they seems to reach metastable states[2].

We have designed a composed instrument for resolving subconventions in the frontier in an effective and robust manner. This composed instrument allows agents to "observe" when they are in a frontier, and then, apply rewiring, with the intention of breaking subconventions. To effectively use this combined approach, agents must first recognize when they are located in a frontier. We have previously defined a frontier as the group of nodes in the subconvention that are neighbours to other nodes with a different convention and that are not in the frontier with any other group.

[2]By experimentation, we have observed that around 99% of the generated scale-free networks do not converge (to full convergence) before one million timesteps with any of the decision making functions used in [3, 4, 5].



(a) Claw (b) Caterpillar

Figure 1: Self-Reinforcing Structures

In irregular networks (such as scale-free) we have identified *Self-Reinforcing Substructures (SRS)* (the *Claw* and the *Caterpillar* in Fig. 1). These substructures, given the appropriate configuration of agents' preferences, do maintain subconventions. These two abstract structures can be found as subnetworks of scale-free and random networks.

By giving agents the opportunity to identify (with Observation) and to dissolve (with Rewiring) these SRS, an important improvement (43% on average with different rewiring tolerances) is observed for convergence times when using the composed instrument (with the recognition of SRS) on irregular networks.

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6. REFERENCES

[1] J. E. Kittock. Emergent conventions and the structure of multi-agent systems. In *Lectures in Complex systems: the proceedings of the 1993 Complex systems summer school, Santa Fe Institute Studies in the Sciences of Complexity Lecture Volume VI, Santa Fe Institute*, pages 507–521. Addison-Wesley, 1993.

[2] P. Mukherjee, S. Sen, and S. Airiau. Norm emergence in spatially contrained interactions. In *Proceedings of ALAg-07*, Honolulu, Hawaii, USA, May 2007.

[3] S. Sen and S. Airiau. Emergence of norms through social learning. *Proceedings of IJCAI-07*, pages 1507–1512, 2007.

[4] Y. Shoham and M. Tennenholtz. On the emergence of social conventions: modeling, analysis, and simulations. *Artificial Intelligence*, 94:139–166, 1997.

[5] D. Villatoro, S. Sen, and J. Sabater-Mir. Topology and memory effect on convention emergence. In *Proceedings of the International Conference of Intelligent Agent Technology (IAT)*. IEEE Press, 2009.