Simulating Normative Agents

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ABSTRACT

The article discusses the sociological background and the general features of a new simulation toolbox, which was explicitly designed to describe, design and simulate multi-agent systems whose component agents are endowed with the capability to exchange norm invocations and to internalize norms, to develop codes of norms and to change them. This toolbox takes into account that normative behavior can only originate in the interpretation of norm invocations and the deliberate decision to abide by the emerging norms—otherwise what emerges is only a transitory regularity. Agents designed with the help of this toolbox are endowed with initial rule sets that they can vary over time, according to the experience gained.

Keywords: Adaptive Systems, Agent-Based Simulation, Artificial Intelligence, Cybernetics, Emergence, Immergence, Norm, Normative Behaviour, Self-Organisation, System

INTRODUCTION

The design of software-intensive systems may receive inspiration from diverse fields such as robotics, artificial intelligence, biology, economics and social sciences. For instance, these inspirations may help managing networks more effectively, and supplying services more reliably. Various simulation approaches of the past 15 years, mainly those of the multi-agent kind, dealt with modelling and simulating self-adapting and self-organising systems in quite different fields. Experience from these approaches can also be used in the development of new, artificial systems.

In this respect, self-organisation and self-adaptation have emerged as two promising facets of a paradigm shift. While self-organisation in a strict sense deals with the emergence of new structure out of a formerly unstructured aggregate, self-adaptation requires that a structured system already exists. Norm emergence and innovation is one of the processes that enable such a system to adapt to its environment and its element to adapt to each other.

Social and economic systems are usually endowed with self-adaptation as they seldom start from a “primordial soup”. If inspiration should come from the analysis of social and economic systems, this analysis must not come from more or less informal social and economic theory (as often in sociocinics, although sociocinics has brought about some first results in using patterns of self-adaptation in social and economic systems for design patterns in distributed systems engineering), but from the

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formal modelling of self-adaptive systems (as in sociophysics and econophysics, which on the other hand rather often use physical and biological metaphors instead of social ones).

The focus of the article is on intelligently acting agents instead of particles just interacting in and reacting on an environment that is modelled in terms of fields and gradients. In different terms, the focus of the article is on evolution of co-operation and communication in social and economic systems and what one can learn from these for setting up artificial systems. Real-world social actors are not only intelligent, but they communicate in a way no other living beings communicate, namely by a symbolic language instead by rather unspecified signals (e.g. pheromones), and even if the bees’ waggle dance can perhaps be interpreted as symbolic, the symbolic languages of human beings are far more elaborated. Thus learning from real-world social systems might be even more attractive for computer science than learning from other natural systems, as computer-based information systems are more often than not applied to fields in which they are part of socio-technical systems.

Successfully simulating self-adapting social or economic systems with multi-agent systems and distributed artificial intelligence (instead of “social force” and “social field” concepts) might lead to insights with which algorithms for self-adaptation can be constructed, as a (successful, validated) simulation model of a self-adaptive process in the real (social or economic) world is a self-adaptive software system.

The following sections first deal with human social systems which are more often than not nested systems or systems of systems. The third section gives an overview of traditional and more recent approaches to simulating human social systems, while the final section deals with the current development of a toolbox with the help of which normative behaviour of human actors and of software agents representing them can be described. The conclusion opens the view into new prospects.

**SYSTEMS OF SYSTEMS**

As many other natural systems, social systems are capable of adapting themselves to changes in their environments. Unlike many other natural systems, social systems can often react on changes in their environments very rapidly, as they do not need mutation and selection processes as in natural evolution where the adaptation usually lasts much longer than the individual lifetime of the system components. Organisations, for instance, can change their internal processes within a very short time as compared to the overall lifetime of an organisation, and more often than not enterprises and administrations even have specialised divisions or employ consultants who plan process reengineering once a need for adaptation is identified. This is mainly due to the fact—to be discussed in more detail after some terminological clarifications—that human social systems consist of “people ... routinely capable of detecting, reasoning about and acting on the ... emergent features ... of the societies of which they form part” (Gilbert, 1995, p. 151, original italics, this is what he later called “second-order emergence”, Gilbert, 2002, p. 6). The same applies to norms in less formal social systems: The regularities that emergence out of the communications can come about comparably soon and last for a very long time, as both the individuals and the system have long-term memories. Unlike other living systems whose regularities can only be changed in long-lasting evolutionary processes, human social systems can respond to external challenges rapidly but would keep their rules even when they external challenge has vanished.

Before the discussion of social and other natural systems—real-world systems as distinguished from conceptual systems—can continue, a few words about the concept of “system” will be in order, as there are so many different definitions of what a real-world system is like.

We follow here mainly definitions developed by Mario Bunge (1979) who described a system as consisting of a composition, i.e. a
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