Simulating Norm Formation – An Operational Approach

[Extended Abstract]

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ABSTRACT
This paper gives an outline of the design of an agent model for simulating norm formation processes. The model is based on a scientific theory of norm innovation, provided by the FP6 project EMIL (EMergence In the Loop: Simulating the two-way dynamics of norm innovation).

General Terms
Design, Experimentation, Theory.

Keywords
Norm innovation, Social simulation, Normative agents, Traffic scenario, Emergence, Immergence.

1. INTRODUCTION
This paper sketches an agent-based simulation approach which describes the process of norm innovation. It is part of the FP6 project EMIL (EMergence In the Loop: Simulating the two-way dynamics of norm innovation) as an example of simulating emergent properties in complex social systems. It is funded by the EU (FP6, no. 033841) in the framework of the initiative "Simulating Emergent properties in Complex Systems". The model design is based on a scientific theory of norm innovation, provided by EMIL [1]. Using this theoretical framework, an agent-based norm innovation model is designed and implemented, which can be embedded in multiple simulation scenarios. Dynamic model analysis is supported by a graphical user interface.

2. THE THEORETICAL FRAMEWORK
The EMIL project is especially focussed on understanding and analysing norm innovation processes in social systems, which can be seen here as a special case of complex systems, composed of many different interacting intelligent autonomous agents. In general, including norms in multiagent models seems to be a promising concept of understanding human (and artificial) agent cooperation and co-ordination. Therefore, the design of agents with normative behaviour (i.e. normative agents) is of increasing interest in the multiagent systems research [3].

Due to the fact that norms can be seen as a societal regulation of individual behaviour without sheer pressure, special attention in modelling and analysing norm innovation processes should be given not only to the inter-agent behaviour but also to the internal (mental) states and processes of the modelled agents (intra-agent) [5]. Following this, the dynamic of norm innovation in EMIL can be described mainly by two processes:

- **emergence**: process by means of which a norm not deliberately issued spreads through a society → inter-agent
- **immergence**: process by means of which a normative belief is formed into the agents' minds [2] → intra-agent

3. THE ARCHITECTURE OF A NORMATIVE AGENT IN EMIL
The model of a norm innovation process introduces normative agents, which are able to learn rules by observation and experience and save them as internalized norms explicitly. Following the general requirements for an appropriate agent architecture described in EMIL [1], the process of norm innovation can be conceptually differentiated between inter-agent processes and intra-agent processes.

The communication between agents (inter-agent processes) is based on a *message concept* in which norm-related agent inputs (events and actions) can be described by different message types (assertions, behaviours, requests, deontics, valuations, sanctions). These external inputs together with individual agent properties will be evaluated (by the intra-agent processes) and supports the identification of three main categories of norm innovation:

- **Norm extension/adaption:** Extending norms to new entities or social category
- **Norm instantiation:** Perceiving/Establishing a new norm
- **Norm integration:** Determining norms by integrating conflicting norms

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3.1 Static Agent Structures

Generically, a simulation scenario can be described by finite sets of events and actions, and the specification of dependencies between events and action.

The dependencies are represented by Event-Action-Trees, a special form of decision trees. For each event an arbitrary number of action groups are defined. Each action group represents a number of mutually exclusive actions. The edges of the tree are attached with selection probabilities for the respective action groups or actions.

A distinction between two classes of events is necessary: Firstly, **environmental events** originating from the agent perception, and secondly, **norm invocation events** that occur when an agent receives a notification or valuation from another agent. In the same way actions are classified as environmental when influencing the environment directly, and as norm invocation when sending valuation messages to other agents.

If considering this type of description (i.e. event-action trees with selection probabilities) as a kind of language that enables agents to converse about an environment, this approach is sufficient to provide a symbolic description of the simulation scenario. Additionally, this implies that the modeller has to provide a "real" environment, in which (environmental) events have to be generated by perceptive processes, while (environmental) actions are transformed into actions influencing the particular environment.

On basis of this language, a general simulation process can be defined. This process requires two kinds of agent-internal memories: Firstly, an **event board** (or fact base), memorizing a history of incoming events including the conducted actions. And, secondly, a **normative frame** (or rule base), holds regularities and norms, derived from the event board as a result of the simulation. Additionally, a global **normative board** is used by all agents together to store or to look up for the emerged common norms.

3.2 Agent Dynamics

Figure 1 gives an overview of the normative intra-agent process. There are four sequential processing stages shown, which are triggered by an incoming environmental or norm-invocation message.

Each incoming event first passes a **pre-processing module** where the addressee of the event is checked and the agent role (i.e. observer or actor) regarding this event is determined.

The task of the **norm recognition module** is to find out whether there exist rules in the normative frame which describe similar environmental situations as sequences of events in the recent perception history.

According to the result from the previous stage the **norm adoption** process performs different actions. If no matching rule is found and the trigger was a norm invocation event, a rule is generated from the current event sequence and stored into the normative frame. The rule generation involves the merging of the event-action trees for all events occurring in the event sequence. On the other hand, if matching rules are found in the normative frame, one of them is chosen, modified by a learning sub-process and afterwards passed to a decision making stage.

Finally, the **action planning module** selects and launches actions according to the agent role and the probabilities attached to the event-action tree, which is extracted from the rule.

The diagram shows two state variables: The variable **Mode** is a flag that mirrors the type of current event (environmental or norm invocation). The other state variable **Role** determines the current role of the agent. Each agent can behave as an actor and perform environmental actions, or as an observer with the responsibility for sending norm-invocation messages.

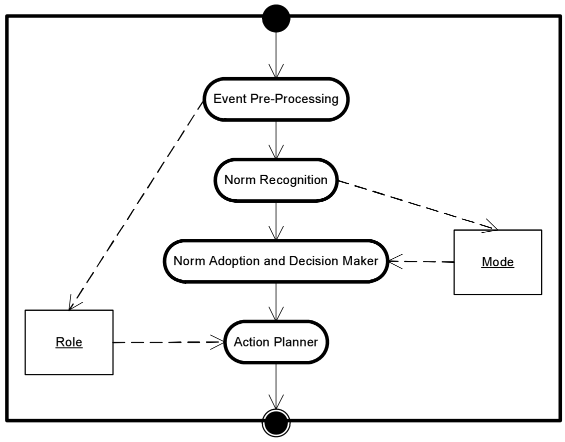

Figure 1. Activity diagram of the intra-agent process.

4. IMPLEMENTATION REMARKS

Actually, the described approach was implemented in Java as a component that can be used as an add-on in combination with simulation models based on Repast, TRASS or other tools. It was successfully tested with a TRASS-based traffic scenario, where the emergence of norms affecting the interaction between pedestrians and car drivers are explored [4].

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