Extending NormLab to Spur Research on Norm Synthesis
(Demonstration)

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\textbf{ABSTRACT}

On-line norm synthesis is a widely used approach to facilitate co-
ordination in MASs. In \cite{2} we introduced NORMLAB, a computa-
tional framework to support research on on-line norm synthe-
sis. That framework provides functionalities to model, simulate
and analyse norm synthesis algorithms in an agent-based simula-
tion environment. Here we present several extensions to that work,
providing a benchmark for research on norm synthesis in MAS.

\textbf{Categories and Subject Descriptors}

1.2.11 [Artificial Intelligence]: Distributed Artificial Intelligence
---Multiagent Systems

\section{INTRODUCTION}

Multi-agent systems (MAS) research has investigated two ap-
proaches to the use of norms to coordinate multi-agent interactions:
off-line and on-line. While off-line approaches aim at designing
norms at design time, on-line approaches aim at synthesising norms
at runtime. On-line approaches do not require designers to know
the agents’ behaviour or the system state space beforehand, and can
adapt norms as the system executes. For these two reasons, on-line
norm synthesis seems to be more appropriate for open systems.

To support the study of on-line norm synthesis in MASs, in \cite{2}
we introduced NORMLAB, a domain-independent computational
framework for the development and analysis of norm synthesis. It
incorporates a portfolio of different state-of-the-art norm synthesis
strategies. It provides an API and components to support the devel-
opment of new norm synthesis strategies, which can be executed
in an agent-based simulator of a traffic scenario, enabling the study
of norm synthesis in domains where the space of norms is rela-
tively small. To analyse norm synthesis performance, NORMLAB
provides tools to monitor simulations along with synthesis metrics.

This demo (available at \cite{3}) explores the extended functional-
ities of NORMLAB. First, we incorporate a realistic multi-agent
simulator of an on-line community to support the study of scal-
ability and norm synthesis on domains with large spaces of norms.
The introduction of this simulator opens the possibility of study-
ing the domain independence of norms synthesis strategies, since

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{normlab.png}
\caption{NORMLAB’s initial menu.}
\end{figure}

it enables their execution in different scenarios. Second, we extend
the portfolio of norm synthesis strategies with a novel state-of-the-
art strategy introduced in \cite{1}. In doing so, we offer a benchmark
of state-of-the-art norm synthesis algorithms. Third, we provide a
richer collection of metrics to perform a more precise analysis of a
norm synthesis process. Fourth, we extend NORMLAB’s monitoring
 capabilities with new visual tools for the analysis of the norm
synthesis space, normative systems and generalisation relationships
between synthesised norms. Finally, we incorporate a new API and
components, along with a tutorial and examples that together ease
the rapid development of new norm synthesis strategies.

\section{NORMLAB EXTENSION}

A realistic on-line community simulator. We endowed NORMLAB
with a novel simulator for an on-line community of users exchang-
ing contents. In this scenario users are modelled as agents that
upload and view contents. Similarly to real on-line communities,
users are able to complain about those contents they consider to
be inappropriate. Based on users’ complaints, a norm synthesis
strategy synthesises norms that prevent users from uploading in-
appropriate contents. Figure \ref{fig:normlab} depicts NORMLAB’s initial screen.

It gives the choice of executing either the traffic simulator or the
on-line community simulator (cf. icons on the right). This simu-
lator supports the study of new norm synthesis problems that are
inherent to on-line community scenarios. While the traffic simula-
tor included in NORMLAB allows researchers to investigate norm
synthesis on small norm spaces, the new on-line on-line community
simulator allows research on much larger norm spaces.

\footnote{Additional simulators can be included by applying minor changes.}

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Richer portfolio of strategies. We extended NORMLAB’s norm synthesis strategies portfolio with LION (Liberal On-line Norm Synthesis), a novel strategy aimed at maximising agents’ autonomy by synthesising liberal normative systems. The resulting portfolio includes three strategies (i.e., IRON, SIMON and LION), which are compliant with both simulated scenarios (i.e., the traffic and on-line community scenarios), and hence can be independently executed and analysed on any of them. The left-hand side of Figure 1 shows the different norm synthesis strategies that can be chosen to execute in any of the two simulators that NORMLAB provides.

New norm synthesis metrics. The different strategies provided by NORMLAB keep track of norms by means of a graph-based data structure (the so called normative network) whose nodes stand for norms and whose edges stand for generalisation relationships between norms. Norms in a network can have different states (e.g., active, inactive). The performance of these strategies is therefore closely related to the size of the normative network and the number of times they require to retrieve information from it. We have extended NORMLAB by adding metrics to analyse the space and time complexity of the norm synthesis process, along with metrics to track the evolution of the normative network and the normative system. Figure 2 shows the norms inspector interface, which depicts on its top part (i) metrics of the normative network, such as its number of norms and relationships; (ii) metrics of the normative system, where a normative system represents the norms available to the agents, and is composed of those norms that are active in the normative network; and (iii) metrics of the spatial complexity (stored norms) and time complexity (computation time) of norm synthesis. On its bottom part, Figure 2 shows (iv) norms and their generalisation relationships. It depicts norm n1,1, that prohibits all users to upload spam to any section, generalising several norms that prohibit different users to upload spam to different sections.

New visual analysis tools. We incorporated a norm visualiser that shows the evolution of a normative network along time. It graphically represents synthesised norms as circles, and relationships between norms as edges between circles. Figure 3 shows a normative network at a given time. It depicts 13 norms, along with their generalisation relationships. Norm generalisation makes it possible to represent several specific norms by means of a general (abstract) norm that concisely represents them in a compact manner. In the Figure, the state of a norm is represented through its colour. Thus, while active norms (n1, n10, n13) are coloured in gray and generalised norms (from n4 to n9) in blue. Therefore, Figure 3 represents normative system {n2, n3, n11, n12}, namely the norms that active in the network. Finally, the size of a norm depicts its generalisation level, namely its height in the generalisation structure. While specific norms (from n1 to n9) are represented as small circles, general norms are represented as larger circles. Since norm n13 is the most general norm, it is represented as the largest circle.

Incorporation of rapid development support. We designed a new API and components for NORMLAB to support the development of new norm synthesis strategies. We also developed a tutorial and a collection of examples that show how to use NORMLAB basic components to create new norm synthesis strategies from scratch.

3. CONCLUSIONS

Norms have been used for regulating MASs, and on-line norm synthesis has been proven to be appropriate to synthesise norms in open systems. However, there is a lack of computational frameworks to support research on norm synthesis for MASs. NORMLAB provides state-of-the-art norm synthesis strategies that can be executed in a traffic simulation environment. We have presented an extension to NORMLAB that incorporates several components. First, a simulator to study norm synthesis in a realistic scenario. Second, a new portfolio of strategies that incorporates LION, a novel norm synthesis strategy. Third, new metrics to perform a precise analysis of the norm synthesis process. Fourth, novel visual tools to track the evolution of norm synthesis, and finally a tutorial and examples to ease the rapid development of new norm synthesis strategies.

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