Extending NormLab to Spur Research on Norm Synthesis (Demonstration)

Javier Morales[1,2], David Sánchez-Pinsach, Maite López-Sánchez
[1]Universitat de Barcelona,Spain
jmorales@iiia.csic.es
sdividis@gmail.com
maite@maia.ub.es

Iosu Mendizabal, Juan A. Rodriguez-Aguilar
[2]Artificial Intelligence Research Institute (IIIA-CSIC)
Campus UAB. Bellaterra, Spain
iosu@iiia.csic.es
jar@iiia.csic.es

Michael Wooldridge
Dept. of Computer Science
University of Oxford
Oxford, UK
mjw@cs.ox.ac.uk

Wamberto Vasconcelos
Dept. of Computing Science
University of Aberdeen
Aberdeen, UK
wvasconcelos@acm.org

ABSTRACT

On-line norm synthesis is a widely used approach to facilitate coordination in MASs. In [2] we introduced NormLab, a computational framework to support research on on-line norm synthesis. That framework provides functionalities to model, simulate and analyse norm synthesis algorithms in an agent-based simulation environment. Here we present several extensions to that work, providing a benchmark for research on norm synthesis in MAS.

Categories and Subject Descriptors

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

1. INTRODUCTION

Multi-agent systems (MAS) research has investigated two approaches 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 [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 development 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 relatively small. To analyse norm synthesis performance, NormLab provides tools to monitor simulations along with synthesis metrics.

This demo (available at [3]) explores the extended functionalities of NormLab. First, we incorporate a realistic multi-agent simulator of an on-line community to support the study of scalability and norm synthesis on domains with large spaces of norms. The introduction of this simulator opens the possibility of studying the domain independence of norms synthesis strategies, since 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 [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.

Appears in: *Proceedings of the 14th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2015), Bordini, Elkind, Weiss, Yolum (eds.), May 4–8, 2015, Istanbul, Turkey.*

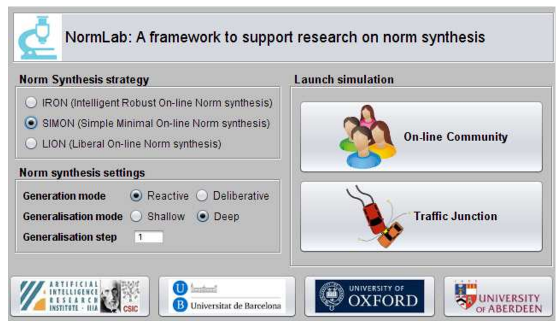

Figure 1: NormLab's initial menu.

2. NORMLAB EXTENSION

A realistic on-line community simulator. We endowed NormLab with a novel simulator for an on-line community of users exchanging 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 inappropriate contents. Figure 1 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)[1]. This simulator supports the study of new norm synthesis problems that are inherent to on-line community scenarios. While the traffic simulator 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.

[1]Additional simulators can be included by applying minor changes.

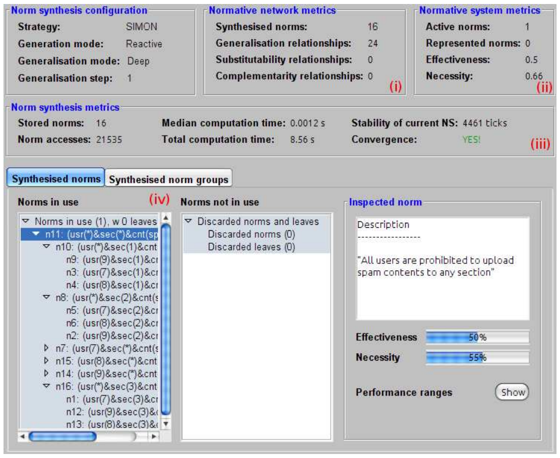

Figure 2: The norms inspector.

Richer portfolio of strategies. We extended NORMLAB's norm synthesis strategies portfolio with LION [1] (*LI*beral *O*n-line *N*orm 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 $n_1 1$, 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 (n_2, n_3, n_{11}, n_{12}), which are the ones that are available to the agents, are coloured in green, inactive

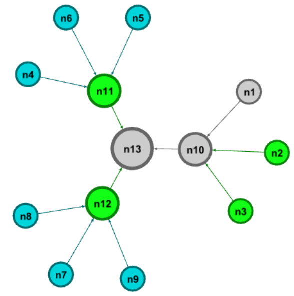

Figure 3: Snapshot of a normative network. Nodes stand for norms and edges stand for generalisation relationships between norms.

norms (n_1, n_{10}, n_{13}) are coloured in gray and generalised norms (from n_4 to n_9) in blue. Therefore, Figure 3 represents normative system $\{n_2, n_3, n_{11}, n_{12}\}$, 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. Thus, while specific norms (from n_1 to n_9) are represented as small circles, general norms are represented as larger circles. Since norm n_{13} 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.

Acknowledgements

Work funded by projects AT (CSD2007-0022), COR (TIN2012-38876-C02-01/02), and 2009-SGR-1434. Mike Wooldridge was supported by the ERC under Advanced Grant 291528 ("RACE").

REFERENCES

[1] J. Morales, M. Lopez-Sanchez, J. A. Rodriguez-Aguilar, M. Wooldridge, and W. Vasconcelos. Synthesising liberal normative systems. In *AAMAS 2015*. IFAAMAS, 2015.

[2] J. Morales, I. Mendizabal, D. Sanchez-Pinsach, M. Lopez-Sanchez, M. Wooldridge, and W. Vasconcelos. Normlab: A framework to support research on norm synthesis. In *AAMAS'14*, pages 1697–1698, 2014.

[3] J. Morales, I. Mendizabal, D. Sanchez-Pinsach, J. A. Rodriguez-Aguilar, M. Lopez-Sanchez, M. Wooldridge, and W. Vasconcelos. Enriching normlab to spur research on norm synthesis (demo). http://youtu.be/7XUT4MOXbVs.