Towards Participatory Development of Agent Based Models

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Abstract. Recent research in ontologies for e-Social Science has emphasised the inherent pluralism in social science as well as the emergent and evolving nature of many concepts. Pluralism may be taken into account by using multiple ontologies, each representing its own view of reality and its corresponding data classification. Ontologies may also be combined with "folksonomies" in order to capture the emergent and imprecise nature of many concepts. In this paper, we argue that pluralism of viewpoints and participatory determination of semantics is also important for *social simulation*s. Using an example case study, we present a methodology for participatory determination of concepts to be included in agent-based simulations.

Introduction

Social science concepts are difficult to represent formally in a common ontology because they are "imprecise, contested and mutable" (Edwards et al, 2006). Examples include "poverty" and "wellbeing". However, recent research in e-Social Science is now addressing these issues. The contested nature of such concepts may be represented by using multiple ontologies, each representing a particular view of reality with its corresponding data classification. Conceptual imprecision and the continual evolution of meaning may be addressed by combining ontologies with participatory methods such as Web 2.0 and "folksonomies" (e.g. Gruber, 2006, Edwards, 2007).

In this paper, we argue that pluralism of viewpoints and participatory determination of semantics is also important for *social simulations*. We will propose a methodology to achieve this by capturing stakeholder concepts and giving them meaning using multiple simulations. Finally we argue that such simulations have the potential to enhance existing simulation-based social science research and encourage uptake of the technology by researchers who would normally be skeptical.

We will focus on "cognitively rich" agent-based models with beliefs and goals, where conceptual imprecision is a particularly challenging problem. However, the same arguments and solutions may be applied to other kinds of simulation such as numerical models and microsimulation.

Why ontological pluralism?

Agent-based simulations have potential benefits for social science and particularly for policy decision support, since they can help to predict the evolution of a complex system and to explain current observations (Epstein, 2006). However, simulations need to be descriptive, transparent and "owned" by the users (Gilbert and Terno, 2000).

A descriptive simulation requires a definition of the entities that are in it: what kind of things are agents, what entities are in the environment and how they are related. We have called this an *ontology* in earlier work (Kennedy et al, 2007), since the aim is eventually to integrate simulation content into the Semantic Web. In addition to the static entities in the simulation and their properties, the ontology may also determine aspects of the dynamic behaviour of agents in the simulation (e.g. using preference rules). Both the static and the dynamic specification together make up the simulation *model*. (An ontology may include all or part of this).

In previous work on AIMSS (Kennedy et al, 2007), we developed an architecture to support online adaptation of simulations in response to data content. To detect inconsistencies between model predictions and data, a considerable degree of interpretation of the data and simulation states is necessary. The interpretation is determined by a common ontology which specifies the concepts used in the simulation and in the real-world data. The ontology also determines the nature of the data that is generated from the simulation (the trace) and the interpretation of emergent properties within it. Similarly it influences the selection of additional data for comparison. Even if there is a model refinement process which is iterative and evidence-driven, the nature of the final model may depend considerably on the initial model and the initial set of concept definitions. For example, there may be a focus on one kind of agent behaviour (such as buying and selling) with less consideration of other issues. This means that one view of the world is arbitrarily favoured over alternatives. These problems may be avoided by allowing multiple conceptual systems to co-exist.

Why participation?

Conventionally, the semantic content of simulations is determined by "experts" (e.g. public policy researchers). Although experts have an important role to play in developing simulations, a fully "top-down" approach can mean that important stakeholder concerns are not taken into account in the model, which can lead to unexpected consequences in the policy implementation. We define "stakeholders" as social groups affected by Public Policy (e.g. residents). In the next section, we consider an example case study involving conflicting stakeholders.

Example Case Study

Airport expansion[1] is a highly contested policy issue which cuts across multiple systems of governance, riven as it is by the incompatible outcomes of enhanced economic growth and environmental well being. The building of new terminals and runways, or the raising of existing limits on take-offs and landings at airports, mobilises contradictory and incompatible demands and grievances by competing coalitions of stakeholders across local, national and international policy arenas (Griggs and Howarth, 2006).

This changing pattern of competing demands in aviation policy places increasing pressures upon policy-makers to give meaning and policy content to 'sustainable aviation'. A cursory examination of events over the summer of 2007 at Heathrow Airport vividly demonstrates the complexity of the decision-making process facing policy-makers. At the end of July and August 2007, the Camp for Climate Action brought together environmental movements and

[1] This case study of airport expansion draws heavily upon the research undertaken by Steven Griggs in collaboration with David Howarth from the University of Essex. We thank David Howarth for permission to use this research.

local resident groups who accused Heathrow of being ‘a bigger source of CO_2 emissions than most countries’, and challenged the expansion of air travel and the airport as ‘sheer lunacy in this time of ecological crisis’ (www.climatecamp.org.uk). Yet, at the same time, Heathrow Airport came under attack by government ministers for its congestion and the excessive delays experienced by travelers.

In fact, there will be no single ‘problem’ or demand that emerges to be analysed across a sector, but a range of ongoing competing problematisations by various actors. Each problematisation will itself inform rival and often irreducible demands that privilege different ‘scientific’ facts and evidence (Verweij et al, 2006: 16-19). Thus the ‘problem’ of aviation is different for the UK government, the airport operators, the airlines, environmental protestors, the local communities affected or threatened by airport expansions, passengers, and so on. These constituencies are themselves in turn complex and differentiated entities.

Against such a policy background, different simulations might be generated to support decision-making processes for a number of airport management proposals. The following are two examples:

Simulation A: the effects of changing flight paths on local neighbourhoods’ quality of life.

The changing of flight paths poses a particular challenge for policy-makers as it destabilises existing patterns of noise pollution with the consequence that any change to mediate the impact of noise on one community may well blight the quality of life of a community previously unaffected by airport noise. Stakeholders would include for example local residents, noise pollution groups, local schools, local businesses, and local authorities. However, although one might posit a narrow spatial delineation on particular local airport communities, the simulation may well engage more national stakeholders concerned with the protection of the countryside and the environment.

Simulation B: the expansion of runway capacity at an international airport and its impact on the economy, the environment and quality of life of local residents.

The building of an additional runway at an international airport such as Heathrow or Stansted mobilises complex coalitions of stakeholders both locally and nationally. It often brings together novel alliances of local residents and environmental activists opposed to pro-growth regional coalitions engaging the airport and national carriers, local businesses and trade unions and indeed local residents (see for example the campaign against the second runway at Manchester Airport (Griggs and Howarth, 2002)). Yet, at the same time, it also mobilises national and indeed international actors because of its impact upon economic and environmental issues beyond the region (Griggs and Howarth, 2004). Thus the decision-making processes will inevitably take on a much wider spatial dimension as the likes of national lobbies such as Friends of the Earth, Confederation of British Industry and the Council for the Protection of Rural England enter the policy arena.

The Proposed Method

We propose to introduce participation by involving stakeholders in the determination of *concepts and ontologies* which are used to specify the simulations. The behaviour of entities in the simulations should be based on expert scientific evidence (e.g. cognitive science or physics). However, the focus of the simulations - in the sense of *what kind of things are simulated* - should be determined by stakeholder concerns. This is related to the participatory *software design* of agent-based simulations (Ramanath and Gilbert, 2004) except that we are focusing on the semantic content of the simulation, not its design or interfaces.

We define "concept capture" as a translation process whose input is an informal characterisation of stakeholder concerns and whose output is a simulation specification. Such a specification is composed of an ontology and a dynamic behaviour model, along with an initial state. Stakeholder concerns can include: (a) concepts and issues that are *important* (e.g. length of queues in airports, experience of pupils at a local school) and (b) entities and options that are evaluated as *desirable* or *undesirable* (e.g. excessive CO2 emissions, efficient airports).

Participatory development can take place in two stages outlined below:

Identifying viewpoints: social scientists. A systematic study of people's viewpoints, beliefs and attitudes can be obtained using a q methodological study. Stakeholders engage in subjective rank-ordering of sample statements to establish subjective viewpoints across a range of issues; correlations between personal profiles will be used to indicate similar and different viewpoints(van Excel, 2005). This process, and the subsequent analysis, can then be deployed, in collaboration with textual analysis of policy documents and organisational literature as well as semi-structured interviews, to inform the identification of competing discourse coalitions across the policy space under examination and the positioning of "representative" individuals across a population of viewpoints in the local community.

Once the main divisions between stakeholders have been determined, their concepts and values are used to determine simulation content. For example, if we consider simulation A above, the precise details of the neighbourhood model may be determined by stakeholders in residential areas. In particular, we may ask the following questions:

- who are the affected "agents"? These may include households, services (e.g. schools) and businesses (e.g. cafes). They are the different agent types to be included in the simulation along with their goals. In some cases, the agent types may represent the stakeholders directly.
- what kind of activities are most affected by noise (e.g. conversations)?
- what are the negative impacts (e.g. lack of sleep)? These define what it means for a simulation result to be "good" or "bad" (the "evaluation" aspect of concept capture).

The *importance* of these issues is determined by stakeholders, meaning that they will be represented richly in the simulation (with a focus on their detail). However, the precise behaviour of entities requires scientific expertise as well as stakeholder input. For example, if a resident believes that noise causes health problems, this would need to be backed by evidence.

Construction of models: computer scientists. In the next stage, computer scientists construct models whose entities and properties correspond to the issues raised by stakeholders. For stakeholder groups who agree about fundamental concepts (e.g. "sustainable aviation" has an agreed meaning), a common ontology may be derived from the results of the concept capture process, which can be used to generate a single simulation such as **A** above. Depending on the particular concerns of each group, different visualisations (perspectives) of the same simulation may be constructed, providing a "window" with which they can interact further if appropriate.

In the case of conflicting stakeholder groups, contested concepts may be represented differently using different ontologies, each corresponding to a stakeholder viewpoint. The multiple ontologies can then specify different simulations, in which the same concept plays different roles. The "meaning" of the concept is instantiated by the simulation in each case.

For example, in simulation A, the concept of “airport expansion” is represented negatively in terms of the “cost” of noise pollution which needs to be spread more evenly by alternating runways. In simulation B, the same concept can be represented positively in terms of less congestion and shorter queues. Simulation B could be divided further into two different versions, one focusing on the experience of passengers while the other gives more representation to the local neighbourhoods.

Simulations may be composed of simpler models. Some may be “off-the-shelf ” (e.g. climate and economic models), while others may be “purpose-built”. Advances in large scale distributed simulation techniques and interoperability frameworks such as HLA (Kuhl et al, 2000) can support such a component-based approach to simulation construction. Each component can be represented by a visualisation giving the perspective of a particular stakeholder group (e.g. a spatial model of a residential neighbourhood).

In some cases, stakeholders may interact directly with simulations and try out various “what-if” scenarios. Clearly, this will require significant effort and resources to develop usable software and interfaces.

Potential Benefits for Social Science

A participatory approach can help clarify important stakeholder concerns that may not be appreciated by experts designing a simulation in a top-down approach. Therefore, it can enhance the value of simulation in social science research.

Furthermore, the methodology should help stakeholders understand the simulations, making it easier for them to provide feedback and interact with the simulations directly. Assuming that the challenges of usable interface design can be solved (itself a participatory task), stakeholders may interact with a simulation in different visualisation modes which represent other perspectives. Enabling stakeholders to experience different perspectives may enhance their understanding of each others' concerns, thus promoting cooperation. (This needs to be tested in practice, though).

Finally, the introduction of semantic pluralism and participation has the potential to increase uptake of simulation technology by social scientists who are skeptical about the use of computer models because of their perceived inability to represent imprecise and contested concepts. The use of multiple perspectives and simulation interoperability can allow social scientists to compare different ways of describing the same social phenomenon (e.g. Mason, 2006). In this case the participating stakeholders may themselves be social scientists who take different views of the system in question (e.g. “macro vs. micro” but also others that cross-cut this distinction).

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