Representing Community Concerns in Agent-Based Models:

a Web 2.0 Approach

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Abstract Decision-makers in an online deliberative forum require access to tools to help them understand the potential impact of proposed policies. Agent-based models can help to predict such impacts. However, the questions being asked by many existing models are not always relevant to the concerns of communities affected by proposed policies. In this exploratory paper, we outline a methodology for exploiting Web 2.0 to capture the concerns of diverse communities and translating these concerns into formalisms that can generate agent-based simulations. We argue that this has the potential to support collaboration and consensus formation in addition to improving the relevance of the models. However, it is important that such a participatory approach can be reconciled with scientific development of models, based on empirical evidence.

1 Introduction

Agent-based simulations are used in the social sciences to simulate the behaviour of individuals, groups and organisations (Smith and Conrey, 2007; Gilbert and Terna, 2000). These simulations can help online decision-making processes because they can show the unfolding of a sequence of events in time. They may also be useful as a source of evidence to support policy arguments when combined with other online research tools (e.g. Chorley et al, 2007). However, the issues which are addressed in many existing simulations and related data analyses are not always relevant to the concerns of communities affected by proposed policies. For example, arguments in support of airport expansion may be backed by models showing a positive effect on the economy, where "positive" is defined only in terms of numerical growth. Therefore, a need exists for participatory development of models.

Participation can also help decision-makers to be aware of the diverse concerns and different conceptualisations held by other groups who may be affected by the policies under discussion. This is important, for example, if consensus is sought between diverse members of a coalition.

In this exploratory paper, we present a conceptual framework for participatory determination of semantic content of simulations and discuss possible methods of implementation. The work is a preliminary study[1] resulting from a previous project[2] detailed in (Kennedy et al, 2007).

2 Related Work

Our proposed concept is related to participatory design of software. In particular, (Ramanath and Gilbert, 2004) uses a software engineering approach for design of agent-based simulations. However, our main focus in this paper is how to determine what *policy-related issues* the modelling and data analysis should

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focus on. It is not about the software design or the details of the user interface, which is the main focus of projects such as (Sjogreen, 2006).

The use of role-playing games (RPG) in agent-based simulations (Guyot and Honiden, 2006) is also relevant and could be integrated with the work being proposed here, although the RPGs would need to be part of a controlled scientific experiment if they are to determine the actual behaviour of agents in the model.

3 Participation: Example Domains and Methods

Simulations can help to visualise the unfolding of a sequence of events which might occur as a result of implementing a particular policy (a "what-if" scenario). This can help decision-makers understand the consequences of implementing a policy, or the outcomes of non-intervention. Of-course, a simulation on its own it is not sufficient to guide policy-making, since it is a very simplified version of reality (even with participation). However, simulations can make people think about policy options and consequences. Even if their results are questioned, they may give rise to important questions which were not previously addressed.

To show how participation can work, it is useful to consider several examples of policies which affect local communities and which might become case studies. These include the following:

- closure of local health services to be replaced by more centralised ones.
- a new house building programme in a green space.
- airport expansion

We assume that each participant in an online deliberative forum belongs to a social group with its specific concerns about the proposed policy. For example, in the health services scenario, such groups may include those with disabilities, the elderly, those with low income or unemployed, mothers with young children etc. In the housing scenario, the groups may include ethnic minorities, the unemployed, low income groups who require social housing and environmental and conservation groups. The goal is that all participants should reach a consensus on an acceptable policy, along with arguments in support of it. In addition, they should understand the potential policy consequences for groups other than their own. (For example, this may be about the understanding of cultural sensitivities or the pressures of living in a deprived neighbourhood).

The process of participatory determination of semantics may take place in two stages:

- Initial "capturing" of concepts and values that are important to communities and translating them into formalisms that can be represented in simulations.

- Participatory evaluation and modification of simulations.

These stages apply to each group participating in the forum. We discuss these stages below.

3.1 Concept capture

In the first stage, each group gives the following kind of information:

- what are their concerns? what matters to them the most? (e.g, the health of their children, affordable housing).
- what are their positive and negative experiences and how do they expect the policy to affect this?
- what are the concepts and issues that need attention? (e.g. noise levels around an airport.)

This information can then be used to answer the following questions, which are required to specify a simulation:

- *Who are the affected agents and what are their goals?* These may include residents and services (e.g. schools) and businesses. In some cases, the agent types may represent the community groups who are determining the content.

- *What environment do the agents live in?* (from (c) above). For example, this can be a spatial map of a residential area, where the main entities are homes and streets along with buildings associated with services and businesses etc. Alternatively it may focus on population and available jobs and homes, where the spatial element is more summarised. Parts of the environment may be dynamically changing (e.g. noise levels and air pollution). These may be more appropriately modelled using physics-based numerical simulations which can be combined with agent-based models.

- *What are the negative and positive impacts on the agents?* (from (b) above). These define what it means for a simulation result to be good or bad.

- *What kind of agent activities should the simulation focus on**?*** This is based on those activities that are most affected by the negative or positive impacts (e.g. looking after children or elderly people, conversations with neighbours, job-seeking, house-seeking etc).

Answers to these questions determine the concept ontology which is used to specify and describe the simulation content.

3.1.1 Components of an agent-based model

We define an agent-based model as having two components:

- ***Concept ontology*** (T): what kinds of entities are being simulated and what kinds of activities? Examples: different types of household, different types of road traffic, or crime etc. (In Semantic Web terminology, this is often called a "T-Box").

- ***Behaviour model*** (A): how do the entities in the concept ontology behave and what is known about their passive states? (In Semantic Web terminology the term "A-Box" is often used - for "assertion").

The concept ontology (T) is based on a taxonomy of entities, with a focus on issues that communities find most important. For example, if the proposed policy is airport expansion, one group may be mostly concerned about the increase in noise and road traffic. Therefore, different kinds of noise and pollution should be emphasised in the simulation.

By contrast, the behaviour model of a simulation should be based on scientific evidence. For example, the dynamics of noise and pollution models are based on physics equations. The behaviour rules of agents should be based on scientific theories in cognitive and social science. For static relationships that are not taxonomic, empirical observation and statistics can provide evidence. For example, population density in a region with moderate rainfall tends to be greater than in a desert region. However, the data to be collected and the focus of the statistical analysis (what to measure) should also be determined using participatory methods in the same way as for simulation.

There are some exceptions to the above because some scientific models may involve connections between entities not thought to be related by community participants and these should affect the conceptual (taxonomic) model (e.g. nutrition may be related to crime).

3.1.2 Web 2.0 technologies

Some developing technologies have potential to "capture" concepts and values. Two important ones are (a) folksonomies along with other aspects of Web 2.0; (b) machine learning, including data-mining and text-mining (see e.g. Han and Kamber, 2006). Folksonomies are classifications of online content which are determined by user-created tags (labels), e.g. Flickr. They can contribute to a "bottom-up" emergent classification instead of a top-down taxonomy. Folksonomies also have the advantage of being accessible to non-specialist users. However, they do not have the rigour and explicit formalisation of meaning used in an ontology which is necessary for exact sharing of knowledge for scientific purposes. A major challenge is how to translate informal concerns and values into formal ontologies to generate simulations.

Machine learning such as data-mining can be used to generate an ontology from a folksonomy. Research is ongoing in this area (e.g. van Damme et al, 2007). Text mining can also be used to automatically generate ontologies or to extend or populate existing ontologies (e.g. Cimiano et al, 2006). Text available in blogs and online forums may be mined, along with more traditional surveys in which free text is used.

3.1.3 Identifying differences and representing pluralism

Data mining methods or statistical methods such as Q-methodology (van Excel, 2005) can be used to determine the major divisions between sets of concerns. This could be applied to survey data. The result can be a mapping between individuals and groups to which they belong, where each group is labelled with a "principal concern". Separate ontologies (initially empty) may then be assigned to each group, on the expectation that the concerns determine largely what concepts should play a greater role in the taxonomies. According to participant preferences, the automatically generated classes may be overriden by their own concept of which group they belong to. The next step is to analyse text and other content produced by members of each derived group. This can include text that they have written in blogs and forums, which may be analysed using text-mining.

Participants may also be invited to add content (such as photos, text, movies, news reports etc.) and classify the different content using their own labelling. The resulting folksonomy used within each group can then be used, along with the results of text-mining, to generate an ontology that represents the perspective and concerns of that group. The whole process may be iterative. For example, major differences within a group may be discovered in the second stage that were overlooked in the first stage. Domain experts will then refine the ontologies and generate dynamic models, according to scientific knowledge and methods.

3.1 Participatory evaluation and modification of simulations

The result of the "concept capture" stage will be a collection of simulations, each emphasising different kinds of behaviour and entities in the environment and possibly different kinds of agents. The second stage is the iterative and participatory refinement of simulations. A procedure for this can involve the following steps:

- Invite participants from the different groups to interact with each simulation, and make comments or add tags.
- Participants should also have the opportunity to interact with simulations that represent concerns of other groups, and in turn add tags or comments to those.
- In conjunction with domain experts, the ontologies may be revised and new behaviour models added, according to participants' tags and comments.

For example, one simulation may represent the goal of affordable housing while another one represents the concerns of environmental groups. The first kind of simulation could include agents who build and demolish homes or buy and sell large blocks of apartments (such as local authorities, businesses and nonprofit organisations) as well as residents who move in and out of an area depending on their income. The second kind of simulation could focus on the dynamic process of building, with its effects on wildlife and green space.

A major challenge is the design of simulation interfaces that are usable by community members. However, relevant work on visualisation such as e.g. (Counsell et al, 2006; Al-Kodmany, 1999) may be combined with simulations.

4 Conclusion

Technologies are being developed which can enable participatory determination of semantics in agent-based models. These technologies also provide the potential for one community group to interact with a simulation that was generated from the concerns of a different group. This can enable members of the first group to gain an insight into the concerns and experiences of the second one, which they may have been misinformed about (e.g. from press reports). Such tools, therefore, have the potential to enhance cooperation and mutual understanding among participants in an online deliberative forum.

A precise methodology needs to be developed for integrating these technologies into a unified infrastructure, where a distinction is made between participatory semantics and the scientific basis of models. This requires interdisciplinary collaboration between computer scientists, sociologists, domain experts and community representatives.

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