A Framework Towards Visualising Poverty and Immigration Multi-agent Simulations

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Visualisation has always played an important part in understanding simulation. When studying social phenomena, Social Scientists need to have a useful output from methods run by simulation experts. A visual way of presenting simulations is a useful and interesting way for social scientists to explore simulations. However, simulation is a relatively new field; advancements in simulation might result in challenges for visualisation.

In this paper we will explore state-of-the-art work on simulating poverty—and incidentally consequent immigration—, and discuss challenges in visualising such simulations. In particular, firstly we will briefly describe advances in simulating poverty. Then, we will examine various visualisation techniques, such as density maps and flow charts, and check their suitability for our purpose.

Our goal is not to find specific guidelines about implementing a particular kind of visualisation, but rather to provide a framework—a set of principles—that future research should take under consideration in order to visualise simulations on poverty and immigration.

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1 Introduction

A social phenomenon is anything that influences or is influenced by organisms sufficiently alive to interact with others. Social phenomena are studied by Social Sciences. In general, these are the phenomena one encounters when one studies social behaviour; that is, when one studies the behaviour of social entities, but also the relationship between these entities. Poverty is a social phenomenon and is studied with the same methods used for such other phenomena.

A broad sense of poverty is the lack of some basic resources in comparison to the general standard. What a basic resource is varies depending on the society that sets them. Thus, in one society basic needs to cover may be health, hunger, etc., but in another society it may be a car purchase. For this reason we can define relative and absolute poverty. In our work we use relative poverty, which we define as: "a human condition that does not allow an individual to cover, for themselves and their family, whatever needs their society defines as basic in a particular socio-historical context." We assume that the conditions which affect poverty depend on specific attributes of a local setting, such as social norms, economic structures, the natural environment, public organisations and institutions. Thus, these attributes form the context in and prism through which we study poverty. To calculate poverty we use the methodological approach of objective-unidimensional poverty (see, for example, [1]), which fits our aforementioned definition.

2 Agent-based Simulation of Social Phenomena

The agent-based computational model is a new tool for empirical research [2]. It offers a natural environment for the study of connectionist phenomena in social science. Agent-based modelling provides a powerful way to address certain enduring questions. It allows one to subject certain core theories (such as neoclassical microeconomics) to important types of stress [3]. Agent-based modelling offers powerful new forms of hybrid theoretical computational work. These are particularly relevant to the study of non-equilibrium systems. The agent-based approach invites the interpretation of society as a distributed computational device, and in turn the interpretation of social dynamics as a type of computation. This interpretation raises important foundational issues in social science [2].

Social simulation has progressed from simple toy models to increasingly realistic models of complex social systems, such as agent-based models where heterogeneous agents interact with changing natural or artificial environments. These larger, multidisciplinary projects require a scientific research methodology distinct from, say, simpler social simulations with more limited scope, intentionally minimal complexity, and typically under a single investigator. In summary, our methodology starts with questioning what should be answered, then we build a simple model with basic attributes and we iteratively increase complexity until we have a model that answers our initial questions [2].

3 The Case for Poverty

For the purpose of this paper, we will present state-of-the-art work on simulating poverty [4]. The questions in the interpretation of this simulation are as follows: *Is there something that can be done so that poverty is reduced*; *do contemporary policies address the issue*; *are individuals alone capable of addressing poverty.*

The structure of the final model in [4] consists of:

a) the environment, which includes local attributes,

b) the agents who act in this environment and, finally,

c) the way agents interact with each other and with their environment, which is defined by a Social Network. The agents are autonomous, heterogeneous, self-directed and based on BDI (belief, desire, intention) architecture.

The novelty in this work is that the agents interact through a social network, that is, point c) in the above list.

The model was built with MASON, a tool—developed at George Mason University (GMU)—that simulates social phenomena [5], and is based on the *Tropos* methodology [6]. Finally, experiments run with five cases and concluded that the initial questions are answerable. The cases differed in the level of income of agents, and on the level of application of a policy against poverty. Each simulation loop represented 3 months, and all five cases run for 80 loops, i.e. 20 years.

Moreover, the percentage of agents below the relative poverty threshold, unemployment and immigration with regards to time were examined. Also, the distribution of income was studied as an indication of poverty.

4 Results and Visualisation

The results in [4] show that applying policies against poverty is effective indeed, and that also helpful is a, more or less, equal distribution of wealth (see figure 1 for the results of

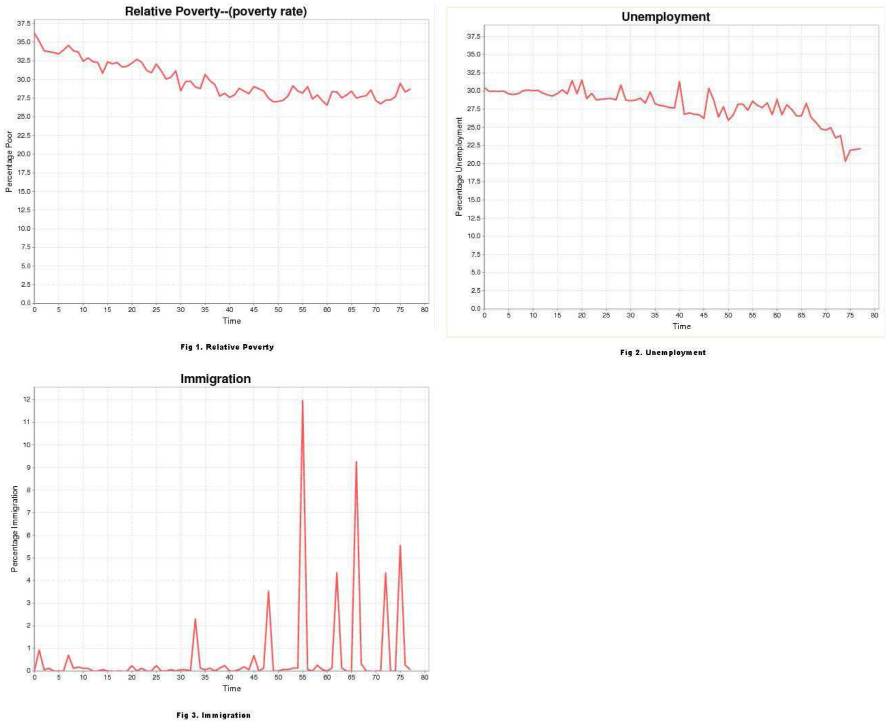

Figure 1: Relative Poverty, Unemployment, and Immigration [4]

the one case, the other four cases being similar). To the best of our knowledge, this is the first simulation that correlates poverty, unemployment, and immigration.

The results are visualised as line charts. This is in accordance with the principles of [7]; that is, results of a simulation should be useful to others than the simulation experts themselves. However, the usefulness of such charts is questioned; other ways are sought to visualise such qualities.

Poverty is usually visualised as a bubble chart (see, for example, figure 2 from [8]). However, other techniques have been proposed to visualise poor performance in an economy in [9] (see figure 3). Unemployment is usually visualised in a similar fashion. When local attributes are of interest, it is possible that the same qualities can be visualised as density maps.

Immigration is of a different nature: it shows a process rather than a momentary situation. For this reason, it is usually visualised in a different way, that is, using flow maps [10].

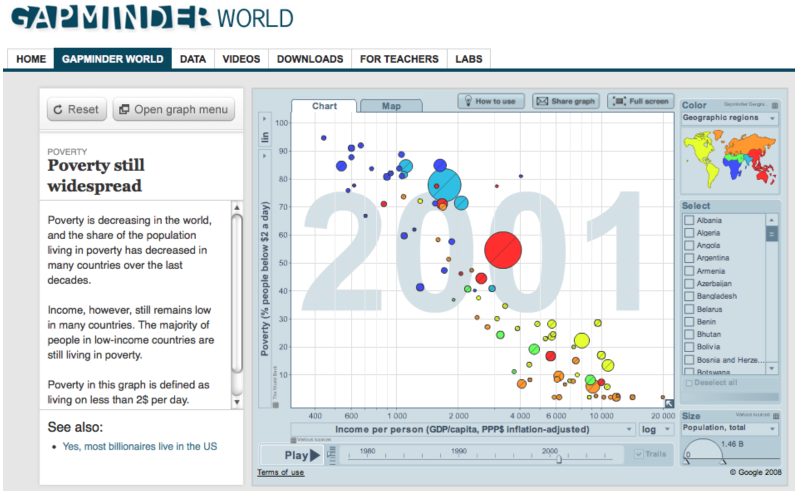

Figure 2: Poverty as a Bubble Chart [8]

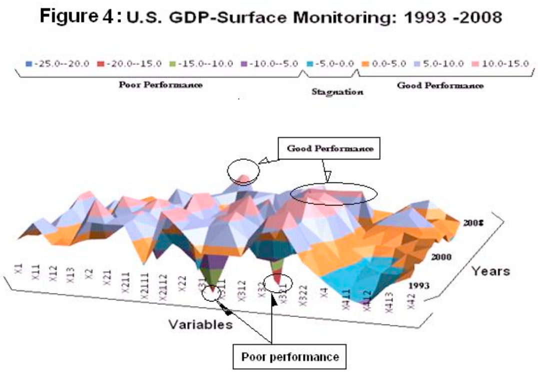

Figure 3: Surface Monitoring of Economic Performance [9]

Figure 4: Flow Maps from [10]: "(a) Minard's 1864 flow map of wine exports from France (b) Tobler's computer generated flow map of migration from California from 1995 - 2000. (c) A flow map produced by our system that shows the same migration data."

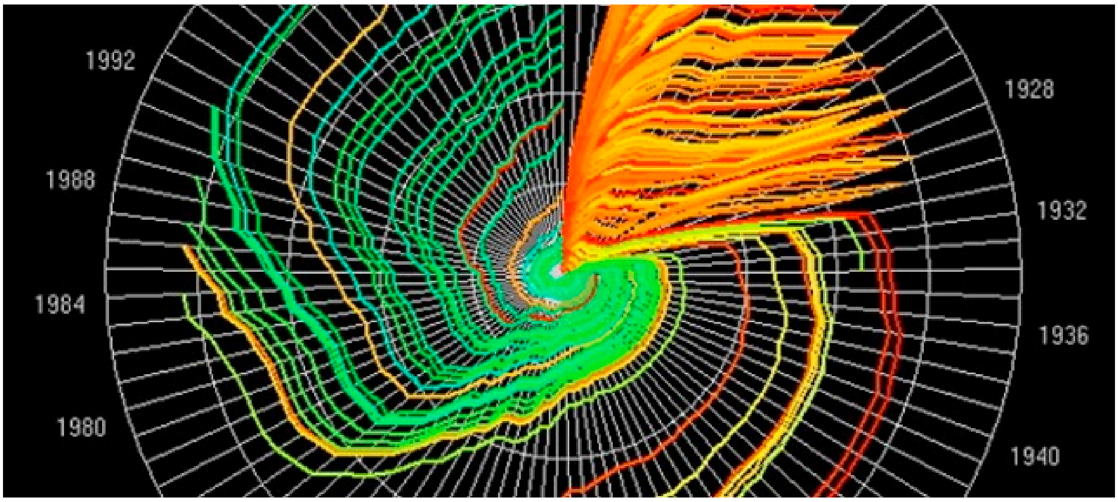

Figure 5: Spacio-temporal visualisation: Rank Clock [12]

5 A Framework Towards Visualising Poverty Simulation

The aforementioned techniques are incapable of covering in full the needs described in [7]. There is a mismatch in the qualities that each technique visualises; in particular, immigration being a process, versus poverty and unemployment being situations. That mismatch leads to difficulty in combining visualisations in a meaningful way. What social scientists would need to see from these diagrams, is the evolution in time of three variables: poverty, unemployment, and immigration. One could consider enough to use the ratio poverty/unemployment or poverty/immigration. Indeed, these are useful numbers to have; however, if one added an unemployment/immigration indication, the social scientist would still have three parameters to watch. This is not trivial to visualise.

Recent work in spatio-temporal visualisation [11, 12, 13] (see figures 5 and 6) has shown other tools which can be useful, such as *cellular automata, plume graphs* and *rank clocks*. While these might or might not be the tools to visualise poverty, they can provide a new insight. More specifically, they provide intuition in visualising attributes of different kind over a common period of time.

Drawing from the work on simulation and the intuition that spacio-temporal visualisation offers, we propose a framework of visualising poverty and its outcomes as a spacio-temporal system. The framework would take under consideration the following conditions:

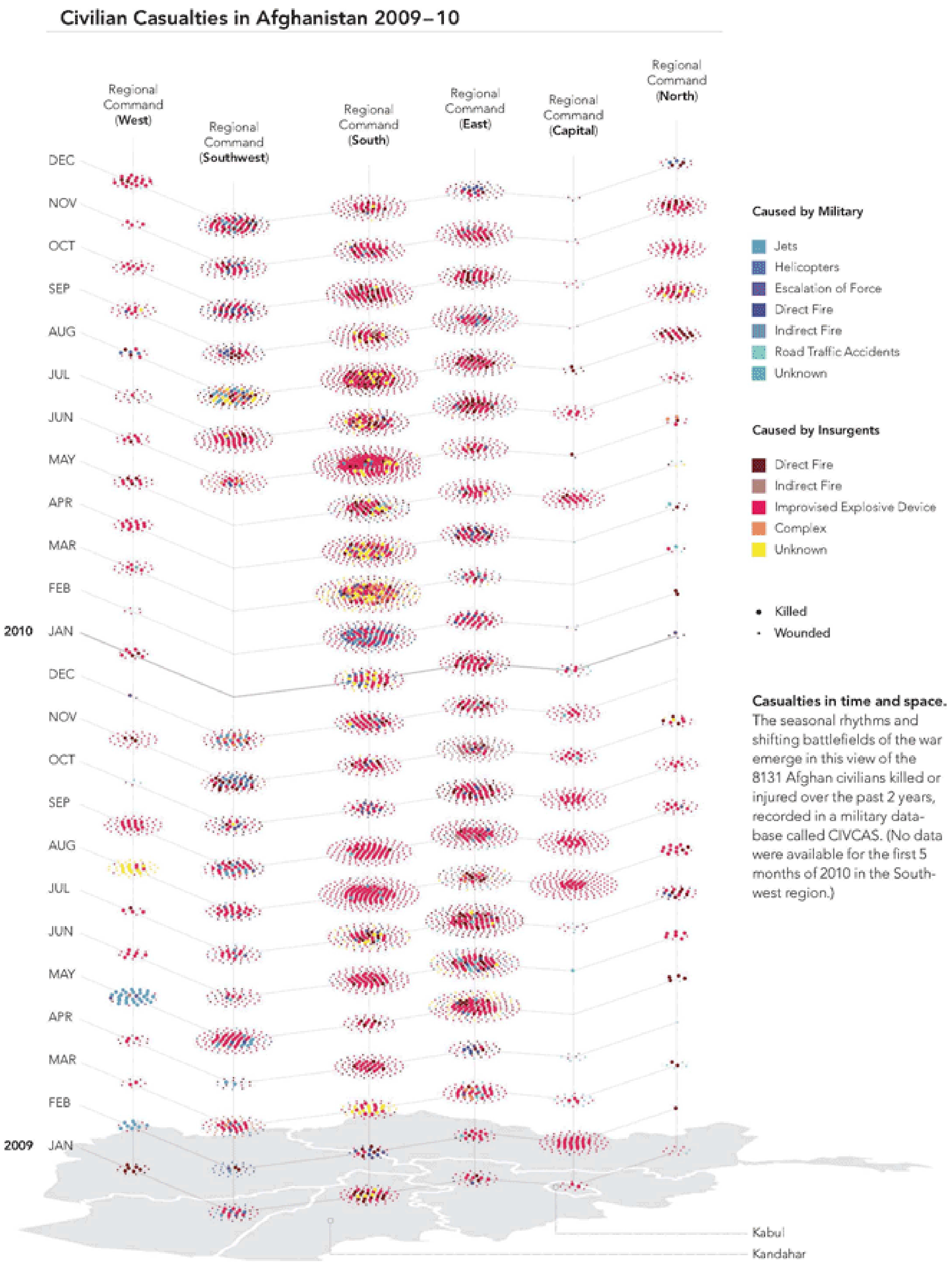

Figure 6: Spacio-temporal visualisation: Plume Graph [13]

- Our space has three parameters, i.e. poverty, unemployment, immigration.
- Our space evolves over time.
- Poverty drives the other two parameters.
- However, poverty is not *per se* "the cause" of immigration and/or unemployment.
- The correlation between *all three* parameters should be visible at any given time.
- Despite any correlation, there is no visible repetition pattern in the three parameters.
- Visualisation of the agents' social network might result in interesting results.
- Each agent behaviour should be individualy visualised.

Considering all of the above we can see that, not only there are three spacial parameters of different nature, but also that a possible visualisation of the agents' social network should simultaneously consider all other conditions. The rank clock, plume graph and cellular automata show respective interest in visualising temporal and spacial systems and could be a starting point in the search of a suitable visualisation.

6 Conclusion and Future Work

In conclusion, the results of poverty simulation are of different natures. Thus, it is difficult to visualise the relations between these results. We proposed a framework of considerations towards visualing multi-agent simulations in order to provide useful and meaningful material to social scientists. Moreover, we proposed techniques which could be a starting point for such visualisations.

Future research should focus on evaluating the suitability of the proposed methods or similar for the purposes described in this paper. These techniques could be compbined to provide useful visualisation techniques, or, if discarded, the reason why they were discarded should further improve our framework for simulation visualisation.

Acknowledgements

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