A Data-Driven Simulation of Social Values Evolution (Extended Abstract)

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ABSTRACT

Modelling the evolution of moral values in a society is a complex problem that involves many interwined aspects. The approach presented in this paper takes information from a common tool of sociologists, public surveys, as input to build the model by following a data-driven approach, to analyse and interpret the impact of each factor separately, and their mutual influence. The system handles thousands of heterogeneous agents, with their own life cycle, reproduction patterns and complex social relationship dynamics including friendship. The emergence of a robust social network was a consequence of the system set up. Its output is consistent with respect to the ideological, religious and demographic parameters observed in real world surveys.

Categories and Subject Descriptors

I.6.5 [**Simulation and modeling**]: Model Development—*Agent based simulation and modeling*; J.4 [**Social and Behavioral Sciences**]: Sociology

Keywords

agent-based model, data-driven modelling, demography, social values, multi-agent based social simulation

1. INTRODUCTION

As agent-based social simulation [1] gets mature, new approaches are needed for bringing it closer to the real world, and therefore with an increased potential of being useful for social sciences researchers. With this purpose, an agent-based model (ABM) was developed for the analysis of the evolution of moral values in Spanish society during 20 years. The particularity of this model, coined Mentat and based on previous work [4], is that it tries to cope with several issues that are commonly neglected by a big part of the community of this field. In particular, most ABM in literature tend to be simple, following the Keep It Simple, Stupid (KISS) principle. However, recently other works [2] claim for a substantial increase on the complexity of the models, taking real data more into consideration.

Mentat applies a data-driven approach for injecting empirical data into Multi-Agent-Based Simulations. Specifically, Mentat has been intensively fed with data form sociologic surveys. Mentat handles complex friendship dynamics, which lead to the emerging of a robust social network. The links of this network evolve over time, both topologically and in strength. This process has been implemented with fuzzy logic techniques to obtain the smooth and continuous behaviour characteristic of friendship.

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2. THE SOCIOLOGICAL PROBLEM

The sociological problem has to cope with intra-generational changes (horizontal influence) and inter-generational changes (demographic dynamics). To better analyse the weight of each one in the global evolution, it has been decided to isolate the controlled simulation of each subprocess. Since changes in values have been chiefly generational changes, individuals moral values are kept constant, as they are not interfered by external influences. However, there are social dynamics (emerging and strengthening of friendships, couples), together with demographical changes (aging, deaths, reproduction). As a result, the moral values aggregation in the whole society evolved over time. This clearly reflects the mentioned inter-generational changes, but not the intra-generational ones.

The source for modelling and initialization of agents attributes has been the European Values Survey (EVS), which is performed every ten years in all European countries [3]. Moreover, the EVS is used for validation of the simulation model: initialising with EVS-1980, simulating 20 years, and comparing with EVS-2000.

The individual attributes that will be taken into account have been selected according to their high influence in the studied subject. In concrete: a general characterisation of the agents, like gender, age, education and economical level; moral values related attributes like ideology, religiosity, or tolerances to sensitive subjects like divorce, abortion or homosexuality; social relationships like their acquaintances, close friends, parents, couple or children.

3. BUILDING THE MODEL

The methodological approach, coined "Deepening KISS", starts from a simple model, following Sloman's prescription of a 'broad but shallow' design, to develop a series of models designed to progressively tackle different aspects of the phenomena to be studied. Then, through the use of evidence and especially data, a collection of progressively more descriptive models can be developed and explored. This exploration of design space allows to pick the best features of

each model in the collection to design a stronger model, and the process iterated. Deepening KISS with intensive use of data can be placed middle way in terms of simplicity versus descriptiveness, whilst it acknowledges the role of the experimenter as guide the search for the adequate models to face the stakeholders purposes.

Agents have a wide collection of attributes derived from the EVS: age, gender and their relationships (together with the position and the neighbourhood, but those are completely random). Individuals inherit the characteristics of their parents; they relate to other people that may become their close friends; they can find a couple, reproduce and die, going through several stages where they follow some intentional and behavioural patterns. Every agent can be child, adult or elder, and some restrictions apply, for instance, a child cannot have a spouse, only adults can reproduce, and only the elder have chances to die at some point.

Each agent can communicate with their wide Moore neighbourhood, and depending on their rate of one-to-one similarity, build a friendship relationship. Agents can search for a couple among their friends, and if they succeed, they could have children. Principles of meeting and "mating" by which strangers are converted to acquaintances, acquaintances to friends, and friends into a partner, follow the same rules. Meeting depends on opportunities alone; instead, mating depends on both opportunities and attraction. Features like social status, attitudes, beliefs and demographic characteristics (that is, degree of "mutual similarity") channel individual preferences and they tend to show more bias toward homogeneous friendship choices.

Similarity, proximity or friendship are vague or blurry categories, modelled as continuous variables that evolve dynamically through a logistic function, $\frac{dF}{dt} = F(t) \times K(t) \times r$. At each time point, *F(t)* defines the minimum degree of friendship that is given as an initial condition ($0 < F(t) < K$); K is the maximum degree of friendship that agents can reach (K can be understood as the level of "close friends"), and finally r value defines the growth rate of friendship. The "proximity principle" described is modelled by modifying the growth rate r and stating it as follows: the more similar in social characteristics two individuals are, the higher the growth rate of their friendship is. Fuzzy sets over each agent attribute have been defined, and a fuzzy similarity operator that influences friendship emergence and partner choice.

Mentat handles 3000 agents in a grid of 100x100 cells. The agents are spread randomly (uniform distribution) around the space. Thus, with a resulting density of one agent per 3.3 cells, and a Moore distance of 6, each agent can communicate with around 35 agents. This number is consistent with the sociological conceptions of the average personal network sizes (with strong and medium-strength ties). The time scale is *one year = 50 steps*, so the total simulation time is 1000 steps (20 years). The program has 8 configurable free parameters (like thresholds, Moore distance or probabilities), together with 10 parameters that enable/disable model stages (like fuzzy friendship or empirical initialisation). The rest of the choices have been empirically grounded (like the probability equation for knowing how many children a Spanish middle-age woman may have). The model has been implemented in Java using the Repast framework, importing the EVS spreadsheets and generating a collection of graphs and aggregated statistics. Note that as the system is non-deterministic, the graphical results have some variations at each execution: the outcome should not be taken as a static output. In every execution the trends were very similar, even though the exact data have some small comparison errors. Therefore, the system executions have structural similarity.

During the simulation a robust social network can be observed, emerging from the micro-interactions. Nearly every agent has a lot of links, but not a lot of close friends. However, some "hubs" exist: agents with lots of friends, because they are close to the "average of their surroundings". Big concentrations of families and the previously mentioned "hubs" are deeply interrelated, as the more friends an agent has, he bigger probabilities it has a family. And the more families a sector have, the more populated it will be and more friends the neighbours will have.

4. DISCUSSION

The output was compared with the EVS of 1990 and 2000. The high stability of Mentat has simplified the analysis, so it can be assessed that these values have a minimum error between executions. After the warming-up stage, Mentat yields stable results, with a good match to results observed in reality. In some situations (children birth, or political ideology) the side effect of additional iteration steps yields a bigger error. This can be caused by not having modelled the intra-generational changes, so the agents main attributes remain static over time. The values predicted for religious typology also show good accuracy, despite the different curves that each type follows (rapid fall, hill, smooth rising and smooth growing). This is due to the fact that religious evolution is deeply related with intra-generational evolution, and not with the horizontal influence along life.

A thorough sociological analysis showed that Mentat highlighted the importance of demography in the twist in social values that happened in the Spanish society in the studied period. The high correlation of the output with observable data is counter-intuitive, as it does not take into account the horizontal influence in values among people (intergenerational evolution). Even if other statistical techniques on this issue can be used for sociological explanatory purposes, ABM can deal with the social networks of individuals and their emergence dynamics. It could be interesting to extend Mentat with new stages that handle some sort of horizontal influence.

5. REFERENCES

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