Generating Needs, Goals and Plans for Virtual Agents in Social Simulations

Anton Bogdanovych and Tomas Trescak

Marcs Institute for Brain, Behaviour and Development
School of Computing, Engineering and Mathematics,
University of Western Sydney, NSW, Australia
A.Bogdanovych@westernsydney.edu.au, T.Trescak@westernsydney.edu.au

Abstract. Many modern virtual reality reconstructions of historical sites focus on buildings and artefacts, but often ignore the issue of portraying everyday life of the people who populated the reconstructed area. This is mainly due to high costs and complexity of populating such sites with virtual agents. Here we show how combining needs modelling and planning can help to automate the development of large agent societies.

1 Introduction

Virtual reality reconstructions of historical sites provide an opportunity to experience traditions, rituals, architectural style and significant events associated with some extraordinary places that may no longer exist at present. Many current works predominantly focus on the elements of architecture, ancient buildings, objects and even entire cities. Supplying virtual simulations with agents that are capable of convincing and historically authentic behaviour beyond simple crowd simulation algorithms is difficult and costly. Virtual agents must be able to play different social roles, actively use surrounding objects, interact with other agents and even engage into interactions with humans. Modern video games are a good illustration in regards to the potential of having such simulations, but the cost of developing video games is very high. We propose a way to make agent-based historical, cultural and other kinds of virtual simulations more affordable by automating the process of populating a virtual environment with virtual agents. In our previous work [1] we have shown how it is possible to generate an infinitely large crowd of agents of unique and yet ethnically acceptable appearance from a small sample of manually designed avatars. Here we show how this crowd can be brought to life by automatically supplying agents with goals in response to their simulated needs and then how to achieve these goals using planning [2].

2 Virtual Agents in Social Simulations

A high level overview of our approach is presented in Figure 1. Here each agent (in the crowd of a desired size) is generated using the genetic approach described in [1]. The agent would borrow some of the appearance features of those agents from the manually designed sample population, but would also introduce some acceptable variation through mutation mechanisms. Every agent assumes a certain role in the reconstructed society (e.g. Potter) and this role would be associated with a set of norms and protocols of acceptable behaviour that the agent must follow while pursuing its goals. Rather than explicitly prescribing how each agent should satisfy its goals we rely on AI planning [2], where the agent senses surrounding objects and other actors and includes the perceived information into its decision making. Given that the environment is correctly annotated with preconditions and post-conditions and also taking the institutional constraints into account each agent would be able to dynamically construct complex role-specific plans in response to general needs (like hunger, thirst, fatigue, curiosity, etc.). In the example shown in Figure 1 the agent playing the Potter role produces a clay pot, trades it for food and then consumes the food when hungry, while an agent with some other role (e.g. fisher) would satisfy hunger differently (e.g. will catch fish and then will cook it on an open fire before eating it). Further details of this architecture are presented in [3]. One of the key points we expand upon in this publication is the automatic generation of agent goals.

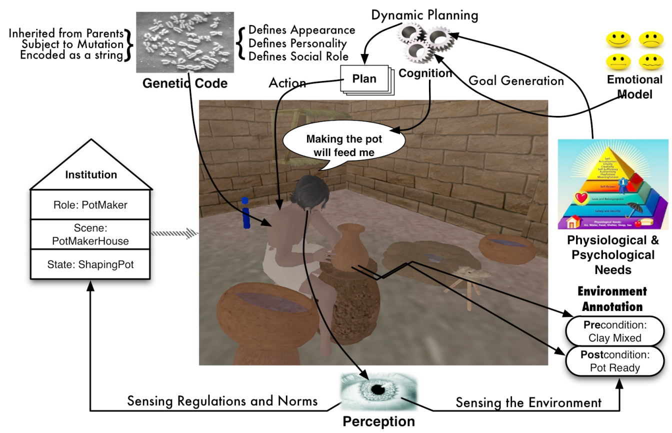

Fig. 1. The Overview of the Agent Architecture

The key aim of having virtual agents in social simulations is to closely portray everyday life of people inhabiting the simulated space. This realisation has inspired us to turn to social sciences with an attempt to understand the underlying principles that drive human behaviour. One of the first concepts one usually comes across in this respect is the Maslow's Pyramid [4]. It outlines, from a psychological perspective, categorisation and prioritisation of fundamental human needs and desires. The ERG theory [5] and the Reiss Motivation Profile [6] have further developed Maslow's ideas and partially validated them.

In our work we have combined the findings of Maslow and those proposed in the ERG theory and Reiss Motivation Profile to produce the pyramid of motivation. This pyramid features 23 human needs that have been identified by [4] and later verified and extended by [5] and [6]. A computational simulation of this pyramid by each agent allows to automatically generate goals in response to some of the needs requiring satisfaction. We treat each of the needs as a reservoir that is replanished (satisfied) after performing the relevant action (e.g. sleeping to reduce fatigue) and depleted in response to other actions (e.g. walking will increase fatigue). So, we can track need depletion and when the corresponding reservoir reaches a critical mark we automatically generate a corresponding goal and use AI planning to produce a sequence of actions that lead to achieving this goal. With the help of an institution, which would enable having agents playing different roles and would specify acceptable interaction protocols resulting goal satisfaction for each of these roles, we can automatically simulate large diverse societies with complex perceived behaviour of individual virtual agents.

3 Case Study: Ancient Mesopotamia 5000 B.C.

To illustrate our approach we have developed a simulation[1] of everyday life in an ancient Mesopotamian settlement around 5000 B.C. shown in Figure 2.

Fig. 2. Ancient Mesopotamian settlement populated with virtual agents

Producing this simulation involved modelling the buildings and city layout based on the results of archaeological excavations and manually designing the appearance of the base population of 2 agents. Using the "genetic code" of the base population a desired number of city inhabitants could be automatically generated following the approach in [1]. Next, the institution (similar to the one in [3]) has been designed. The institution covers the role structure, possible scenes and acceptable interaction protocols different roles can use for pursuing their goals. In this institution the agents can play one of the four roles: Fisher, Baker, Shepherd or Potter. For each of these roles the institution specifies protocols for working, obtaining food and trading. In their planning agents can then map a general-purpose goal (e.g. satisfy hunger) to their role and obtain the possible actions that this role can perform. While executing their plans agents must use the existing resources represented by 3D objects in the virtual environment. These objects (e.g. wheat, fish, etc.) are annotated with actions that can be performed with them together with pre-conditions and post-conditions.

There are limited resources in the environment and some resources are removed after an interaction (e.g. catching a fish). Agents need to travel to the

[1] Accompanying video is available at: https://youtu.be/Z5HFQvx0u2c

destination of the resource, which increases their fatigue. When fatigue passes a threshold value agents rest until fatigue is lowered. Upon arrival, an agent can discover that the required resource is no longer available, so its plan fails and an alternative plan is used.

Plans are dynamically generated based on the current goal. Goals are triggered by agent needs. For example, when an agent reaches a threshold value for hunger, it tries to generate a plan, to reduce the hunger level. For this purpose, there are actions such as "eatFish", that the agent performs, once it acquires sufficient resources. Another need that has been simulated is comfort. In our simulation comfort is associated with storing enough food to survive three days without working. To store food agents with roles Fisher, Baker and Shepherd must trade their work products (fish, bread or milk) with a Potter for a storage pot. Potters do not directly produce food and can only receive it in exchange for pots. Figure 3 shows examples of agents satisfying their needs.

If all physiological needs are satisfied an agent starts to satisfy its curiosity need, which is to conduct a random walk and interact with novel objects.

Fig. 3. Acting Upon Physiological Needs: Sleeping, Drinking, Eating and Resting

We have conducted an experiment that involved generating 100 agents (25 agents per each role: Baker, Fisher, Potter and Shepherd). The resulting everyday life simulation looked very convincing. Sleeping, waking up, having breakfast by preparing the food from storage or obtaining food through work, working to satisfy immediate hunger or comfort and being curious are types of behaviour our agents demonstrated. These behaviours were not scripted, but resulted from acting upon frustrated needs and generating goals and plans for satisfying those.

References

1. Trescak, T., Bogdanovych, A., Simoff, S., Rodriguez, I.: Generating diverse ethnic groups with genetic algorithms. In: Proceedings of the ACM symposium on Virtual reality software and technology. VRST '12, New York, USA, ACM (2012) 1–8
2. Hendler, J.A., Tate, A., Drummond, M.: AI planning: Systems and techniques. AI magazine **11**(2) (1990) 61
3. Trescak, T., Bogdanovych, A., Simoff, S.: Populating virtual cities with diverse physiology driven crowds of intelligent agents. In: Proceedings of the Social Simulation Conference (SSC 2014). (2014)
4. Maslow, A.H.: A theory of human motivation. Psychological review **50**(4) (1943) 370–396
5. Alderfer, C.P.: An empirical test of a new theory of human needs. Organizational behavior and human performance **4**(2) (1969) 142–175
6. Reiss, S., Havercamp, S.M.: Motivation in developmental context: A new method for studying self-actualization. Humanistic Psychology **45**(1) (2005) 41–53