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Review of Agent Based Modelling of Social Attachment in Crisis Situations

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ABSTRACT

Human behaviour during crisis evacuations is social in nature. In particular, social attachment theory posits that proximity of familiar people, places, objects, etc., promotes calm and a feeling of safety, while their absence triggers panic or flight. In closely bonded groups such as families, members seek each other and evacuate as one. This makes attachment bonds necessary in the development of realistic models of mobility during crises. This article presents a review of evacuation behaviour, theories on social attachment, crisis mobility, and agent-based models. It was found that social attachment influences mobility in the different stages of evacuation (pre, during and post). Based on these findings, a multi-agent model of mobility during seismic crises (SOLACE) is being developed, and it is implemented using the belief, desire and intention (BDI) agent architecture.

KEYWORDS

Affiliation, Attachment Bonds, Belief-Desire-Intention (BDI), Disasters, Earthquake, Evacuation, GAMA, Human Behaviour, Mobility, Multi-Agent Modelling, Pedestrian, Social Simulation, SOLACE

INTRODUCTION

The *mobility* of individuals during evacuations is of paramount concern during disasters. Quick thinking and decision making to move immediately towards a safe area saves individuals from danger. Mobility is influenced by: physical factors such as age, gender, body type; human factors such as emotions (calmness, level of fear, contagion) and cognitive aspects (knowledge and experience); environmental factors (presence of obstacles, obstruction, facilities promoting mobility); and social interactions and attachment, such as to family members or to specific places.

This paper focuses on the influence of social attachment and how it affects mobility in crisis situations. Social attachment, as used in this paper, means, the strong and weak bonds produced by relationships and interactions of individuals with others, namely family members, close kin, friends, colleagues, authority figures (leaders), and even strangers. This also includes the influence and affiliation to familiar objects, places and tasks (such as, personal belongings, the home and continuing

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to work, respectively) which are closely associated with these bond-related social interactions. The future goal of this work is to develop a multi-agent model simulating human behaviour during crises situations, integrating social attachment. The simulator will be used to investigate the effects of attachment bonds on the mobility of individuals and emergent groups during evacuations in crisis scenarios. In particular it will look at the nuances where attachment is beneficial or detrimental in the evacuation of large populations during crises.

A computational *agent* is a discrete entity defined in terms of its attributes and behaviours. Wooldridge and Jennings describe agents as being autonomous, operating without direct human intervention, having social ability (i.e. interacts with other agents), able to perceive and respond to their environment, and exhibiting goal directed behaviour (Wooldridge & Jennings, 1995). Gilbert and Troitzsch add that agents can be constructed to simulate some simplified aspects of human intentions which can include beliefs, desires, motives and emotions (Gilbert & Troitzsch, 2005). Multi-agent systems (MAS) allow heterogeneous agents to cooperate according to complex modes of interaction (Ferber, 2007). MAS have been used to investigate several phenomena and have proven to be a powerful tool for modelling in the social sciences and other related fields (Kravari & Bassiliades, 2015). Among the MAS architectures, a belief, desire, and intention (BDI) approach is ideal for modelling people (Adam & Gaudou, 2016). From Adam and Gaudou, BDI attempts to capture the common understanding of how humans reason with: beliefs which represent knowledge of the environment and the agent's self or internal state, desires or the goals the individual decides to achieve, and the intentions which describe a set or sequence of steps needed to achieve the determined goals (Adam & Gaudou, 2016). Still from the same authors, BDI architecture allows an agent to *err*, by having subjective representations of the environment in terms of beliefs that can be incomplete, flawed or different from other agents, can communicate and reason with other agents, have the ability to explain behaviours, exhibit emotion, able to internalize norms, and capable of making independent decisions.

The agent-based model (ABM) that is being developed involves representing human behaviour in a geographic space, where the agents participate in social interactions. In the model agents represent humans; they are autonomous and mobile, and have physical, cognitive, emotional and social attributes in the simulated space. Non-human objects such as pathways (doors, hallways, alleys and roads) and obstacles (walls, barriers, debris, natural features like rivers), define spatial geometry, delimit the agents' behaviour, and can either facilitate or restrict movement and social interaction. Agent interactions can produce groups, or large crowds with characteristic behaviours emerging from particular situations such as evacuations during crises.

As the process of modelling a seismic crisis taking into account social attachment (SOLACE) is still an on-going work, the present paper consists mainly of a review. The structure of this paper is as follows. The next section presents the state of the art in behaviour modelling in crisis situations and is further divided into subsections: trends in human behavioural modelling during crises, reactions to crisis, the stages of evacuation, mobility, and human behaviours observed during evacuations. The next section then presents the relevant social theories on attachment that explains these behaviours. Agent based models of social attachment are discussed in a further section. The paper closes with a discussion, conclusion and some ideas for future work.

STATE OF THE ART IN BEHAVIOUR MODELLING FOR CRISES

Trends in Behaviour Modelling for Crises

Human behaviours in evacuations are social in nature (Aguirre, 1983; Chu et al., 2011). Understanding the social and group processes during evacuations, such as how existing bonds are activated during a threat, the formation of new ties leading to group creation, and the interactions between individuals and groups, can lead to the development of more realistic behavioural models.