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Potential of Social Modelling in Socio-Technical Systems

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Abstract

While modelling (and simulating) a socio-technical system, the primary focus has been on the technological side almost ignoring the social dimension of it. However, with recent advancements in Ambient Intelligence (AmI) and emotions sensing technologies, it is now possible to fill this gap. To this end, we have integrated cognitive decision making model abstracted from psychological, neurological and social theories of human behaviour in evacuation situations into a simulated environment, assisted by AmI technology. Initial simulation findings are reported in this paper, keeping focus on a scenario in which a small population of agents is technologically assisted. The results are: (i) the technologically assisted agents emerge as leaders during evacuation changing the intentions of most of the agents, and (ii) even a small population of such leaders is sufficient to guarantee an efficient evacuation due to leader following behaviour emerging as a social phenomenon.

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1. Challenges in Socio-Technical System Modelling

With advancements in the ambient technologies and the pervasiveness of digital contents, it is evident that pervasive applications are set to enter into complex social systems providing at least *assistance* (if not reliance) in situations such as evacuation from a public place. In addition to technical feasibility, which includes sensing capabilities, interaction mode, and communication range of the environment and supporting devices, more important are social dimensions where sensing the required attributes of a population of individuals influencing an individual would act as a basis of social behaviour determination and prediction.

Modelling a socio-technical system starts with modelling representative individual entities which are essentially heterogeneous, appearing at a real large scale and requiring numerous individual level interactions. Therefore, it is difficult to model such a system at variable (using structural equations) or system (using differential equations) level. As an analytical method for social systems, the agent-based modelling is rapidly gaining popularity, due to its capability of directly representing individual entities and their interactions [1]. As a specialized case of agent based social systems, the evacuation simulation is one of the more interesting topics in recent times because of its unique importance (impossibility of trial studies [2] and emerging nature of the phenomena [3]). Previously we have modeled space/environment, mobility, and technological aspects of such a system where each of the technology assisted agent simply follows the recommendations provided based on an exit choice strategy [4]. With this paper, we have reported

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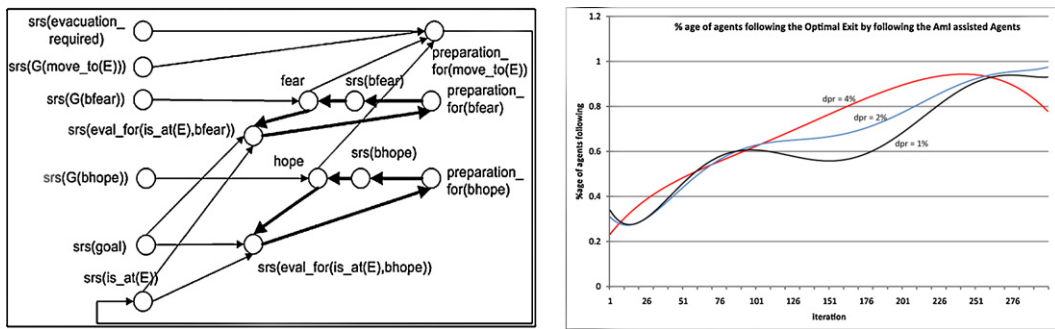


Figure 1. The emotional decision making model for the option to move to exit E (left); %age of *normal* agents following the optimal exit (instead of initial random exit) vs. time, for increasing device penetration rate (dpr) (right).

the results of incorporating social dimension of an agent, particularly focusing on cognitive models of decision making based on intentions and emotions.

2. Cognitive Agent Model

Our model is a general affective decision making model of cognitive processes of an agent related with cognitive attributes affected and influencing in an evacuation situation. These attributes are: (i) Intentions: **Trust** towards neighbouring agents and **Belief** for options (exits), (ii) Emotions: Fear for options, Hope for options and resulting attraction for options, and (iii) Individualism: Expressiveness, openness and contagion of agents.

Trust is an attitude of an agent towards an information source that determines the extent to which information received by the agent from the source influences agent's belief(s). Hence a more trustworthy agent would influence the beliefs of an agent more. In an emergency situation, a *normal* agent or simply an "agent" (without technological assistance) can presumably be affected by nearby *AmI assisted* agents (provided with assistance), given that there is high level of trust embodied into the AmI assisted agents. However, this is not a simple relation because it is affected by emotional situation of agent and its surrounding, individual behavioural features, and previous experience of agent. The model developed, based on the neurological theory by Hesslow [5] is shown in Figure 1 (see [6] for details).

3. Model Simulation and Results

The model is implemented in NetLogo, simulating agents evacuation from a real space (Linz main railway station). Given that a central evacuation control unit is aware of exit area dynamics and agents' position, a recommendation of exit choice can be provided to AmI assisted agents. The rest of the agents has an initial belief corresponding to a random exit. According to the model, an AmI assisted agent - due to high trust embodied into it - may act as a "leader", possibly diverting agents away from their initial beliefs. Considering a single floor of station, a population of 2,500 agents is simulated required to evacuate through one of four available exits. All of the AmI assisted agents are represented by "device penetration rate" (*dpr*) which is varied for several simulation runs.

The focus of the simulation is to study the effect of change in beliefs of (normal) agents from potentially a less efficient (random) exit towards a more efficient (recommended) exit. Following more trustworthy AmI assisted agents helps the cause. A representative sample of the simulation result is shown in Figure 1. It is evident that with increase in device penetration rate (*dpr*), the %age of (normal) agents deviating away from a random choice and falling into a position based (situational) optimum increases. This happens due to influence of AmI assisted agents in the surrounding which can be equated with leader following social behaviour. The leader following improves the evacuation efficiency in linear fashion, i.e. 66% (*dpr* = 1%), 81% (*dpr* = 2%) and 88% (*dpr* = 4%).

4. Conclusions

In addition to technological pursuit, it is important to model a socio-technical system at representative social (human) level. This paper marks a first step in this direction. This is an ongoing research with potential of bridging the gap between social and technological systems.

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