Detection of Primitive Collective Behaviours in a Crowd Panic Simulation Based on Multi-Agent Approach

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ABSTRACT

In case of emergency and evacuation, it is often impossible to interpret manually the complex behaviour of a crowd, essentially due to the lack of staff and time needed to understand a situation. In the literature, a monitored system using data fusion methods makes it possible to perform automatic situation awareness. Using Swarm Intelligence domain, the authors propose an approach based on multi-agent system to simulate and detect primitive collective behaviours emerging from a crowd panic. It enables anticipating collective behaviours in real-time as well as their anomalies according to specific scenarios. Detection is the possibility to learn, recognize and anticipate different behaviours by a probabilistic model. The collective behaviour detection of a crowd panic in real-time is based on a learning method on an extended model of Hidden Markov Model. This paper presents experiments of simulation and detection using an implementation of a virtual environment.

Keywords: Collective Behaviour Detection, Crowd Panic, Hidden Markov Model, Multi-Agent System, Virtual Environment

INTRODUCTION

There are more and more events of social gatherings so increasing the risk of security issues. For instance, twenty-one persons perished in the Love Parade on July 24th, 2010 in Duisburg in Germany. This was due to a collective panic which happens during the passage through a tunnel, in spite of a trained security force which could only the importance of the phenomenon. Thus, collective behaviours detection would be an inestimable help in many situations to decrease the number of damages, wounded and deaths during collective panic.

Using a virtual environment to simulate social gatherings spares us the difficulty to obtain real measurements for our study. In order to limit the complexity of the work, we choose to simulate and detect only collective behaviour.
movements of a crowd panic because of their devastator effects. This simplification enables us to validate the effectiveness of our techniques. First we simulate movements of a crowd panic using different techniques of swarm intelligence present in literature. Secondly we present an innovating method to detect recurrent panic movements in a specified environment. The objective is to obtain an automatic situation awareness to prevent possible problems in the environment and to anticipate in real-time complex behaviours of movements during a collective panic. This kind of tool could be embedded in a smartphone or any monitoring system and help the security forces and people to act as well as possible.

The remainder of this paper is constructed as follow: We present our state of the art about simulation and detection of collective and social behaviours. We deal with our decision and detection model. We discuss the implementation of the software, experiments and obtained results.

BACKGROUND

To model a crowd panic behaviour, we present a study of crowd behaviours by a simulated multi-agent system. Agent, multi-agent system and swarm intelligence concepts lead in literature to several kind of behaviour modeling. We have used some of these methods which we will present in this part.

Crowd Behaviour Simulation

Some ways are available to model and generate collective movements. We were interested first of all in their origin, that is to say individual behaviours.

Individual Formal Models

According to the definitions of Ferber (1995), Wooldridge (2002), and Russel and Norvig (2003), agents are provided with environment’s perception capacities, means of action and rules of decision, allowing selecting some aspects of their current behaviour according to internal and external variables which are accessible for them.

For a set of no-cooperative agents as a crowd, each agent has an individual goal and can interact with other agents to reach this goal. But when people are in panic, their goals are the same one for all, to escape, but they only try to reach theirs before other people.

In the literature, three possible behavioural modeling approaches are distinguished (Zacharias, MacMillan, & Van Hamel, 2008): macro-level formal models (models of society behaviours), meso-level formal models (models of group behaviours) and micro-level formal models (models of individual behaviours). Considering a crowd simulator, our agents must function in stigmergy (Grasse, 1959; Beckers, Holland, & Deneubourg, 1994; Cao, Fukunaga, & Kahng, 1997), that is to say, “the production of a certain behaviour in agents as a consequence of the effects produced in the local environment by previous actions.” The choice of the modeling type depends on the nature of the problem to solve and, as far as our use case is concerned, on used micro-models to represent individual behaviours in case of panic.

In micro-models, an individual in a crowd panic will tend to trust a superior authority as a group and to follow it. We find this concept in Fiske (1993, 2000), it is defined the human conceptual model as being intercultural frameworks in all human cultures, coordinating their social interactions by using a mixture of fundamental relational models: communal sharing, authority ranking, equality matching and market pricing. These four models are organized in a set of associated concepts and rules which are used as a generative grammar for thinking and coordinating their relations.

To simulate a crowd behaviour by an individual formal model in the micro-level, the cognitive architecture of each agent must enable to compute itself its intentions according to its desires and its beliefs about its environment. This kind of agent model includes a BDI architecture (Belief, Desire & Intention) (Rao & Georgeff, 1997; Bratman et al., 1998) to generate hybrid behaviours:
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