A framework to monitor, model, and actively manage crowd behaviour

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Abstract

In this poster we outline our framework for the analysis of crowds in different settings (city centres, sports events, etc.) and situations (regular or extreme). The framework has a monitor, a model and an intervene component to evaluate a number of strategies for risk and damage mitigation measures. This is illustrated with an example of a crowd at a football stadium.

Keywords: Crowd behaviour, crowd monitoring, agent-based model, intervention, scenario analyses.

1 Introduction

Understanding the behaviour of crowds of people in different settings and situations is essential to ensure peoples' safety. Settings with large crowds are, for example, festivals, city centres, sports events, fairs, and traffic hubs. These settings differ in terms of crowd size and diversity, temporal extent, and spatial character (indoor/outdoor, open/closed space). Management strategies to mitigate risks and damage in regular as well as in extreme situations should take these differences into account. Our aim is to evaluate a number of management strategies based on monitoring data to actively manage crowds in order to mitigate risk and damage.

Broadly speaking, two approaches are in use in research to gain understanding of crowd behaviour: empirical crowd research, and crowd simulation (Wijermans *et al.*, 2013). *Empirical crowd research* is an active field in the social sciences, in which behavioural theories are developed in the form of descriptions with an empirical base (Helbing, Johansson and Al-Abideen, 2007). Yet, due to the large number of interconnected factors that play a role in crowd behaviour, such theories are difficult to test in experimental settings. A key issue here is that not all factors are controllable. *Crowd simulation* uses computer models of individuals in a crowd and of their surroundings. This approach thus allows for the evaluation of all interconnected factors that are included in the model. Yet, the agent behaviour in simulation models is often too simplistic, or too focused on a single, extreme event, such as a disaster.

Weijermans *et al.* (2013) have brought the two approaches together: they have built an agent-based simulation framework, CROSS, in which the agent model includes cognitive levels as described in empirical theories. There are however two problems with this framework:

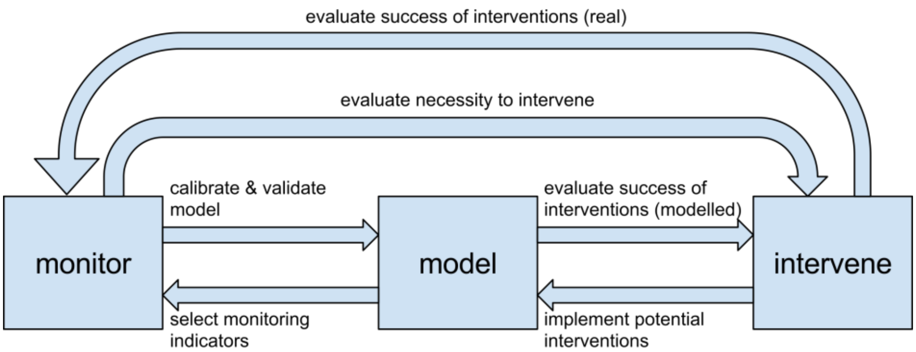
- Empirical data are not directly involved in it, only indirectly via the theories; and
- There are no means to intervene during the simulations, i.e. to activate a measure in case of an extreme situation.

Our goal is therefore to build a framework with a monitoring component, a modelling component, and an intervention component. The components will be detailed in the following section.

2 Framework

The crowd analysis framework we are working on, consists of three components: monitor, model, and intervene (Figure 1). A case study of the simulation of the movement of supporters in and around a football stadium is used here to elaborate on the framework. The model component of the framework

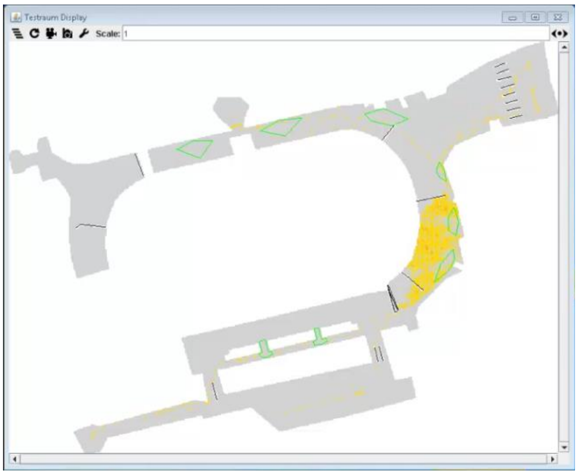
Figure 1: Conceptual model of the crowd analysis framework.



consists of an agent-based model of the supporters and their physical surroundings (see Figure 2 for a screenshot of an example model). In the monitor component, the supporters are monitored, for example via airborne remote sensing (Figure 3), video cameras on the ground, or voluntarily by using a mobile phone app. The data from these different sources are analysed to derive indicators (Hillen *et al.*, 2014). Those indicators are not related to individual behaviour, but to the emerging patterns of the model, such as crowd density, movement direction, or speed, such that they can be used for model calibration (e.g. Verstegen *et al.*, 2014).

In the intervene component, management strategies are implemented that can either be applied before or during a football match. Examples of measures taken in advance involve some form of adaptation of the physical environment such as opening/closing doors or changing lighting.

Figure 2: Screenshot of the interface of an agent based model simulating a crowd (each yellow point is an individual) trying to exit a football stadium.



Source: Norman Langner, used with permission.

Measures taken during the event mainly involve communication with the supporters, such as messages via an app or dynamic signage (Langner and Kray, 2014). The poster will show example scenarios and how the proposed framework could be applied to realize them. During the poster session we hope to obtain feedback on the proposed framework, on further interesting crowd scenarios, on additional monitoring sources and on alternative management strategies.

References

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Figure 3: Airborne remote sensing image of a crowd around Borussia-Park, the football stadium of Borussia Mönchengladbach.

Source: Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)