Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 108C (2017) 215–224

Procedia Computer Science

International Conference on Computational Science, ICCS 2017, 12-14 June 2017, Zurich, Switzerland

The study of the influence of obstacles on crowd dynamics

Oksana Severiukhina[1], Daniil Voloshin[1], M.H. Lees[1,2,3], Vladislav Karbovskii[1]

[1] *ITMO University, Saint Petersburg, Russia*
[2] *University of Amsterdam, the Netherlands*
[3] *Nanyang Technological University, Singapore*
oseveryukhina@gmail.com, achoched@gmail.com, M.H.Lees@uva.nl, vladislav.k.work@gmail.com

Abstract

This paper presents the research on the influence of obstacles on crowd dynamics. We have performed experiments for four base scenarios of interaction in crowd: unidirectional flow, bidirectional flow, merging flows and intersection. Movement of pedestrians has been studied in simple shape areas: straight corridor, T-junction and intersection. The volumes and basic directions of pedestrian flows were determined for each of the areas. Layout of physical obstacles has been built from different combinations of columns and barriers. In order to acquire characteristics of the crowd dynamics a set of simulations was conducted using PULSE simulation environment. In the result, we have managed to obtain several dependences between layout of obstacles and crowd dynamics were obtained.

Peer-review under responsibility of the scientific committee of the International Conference on Computational Science

Keywords: pedestrian crowd dynamics; obstacles layout; agent-based modeling

1 Introduction

Mass gatherings are an essential part of our lives. Public events are held more often, moreover, the scope of events and the number of participants increase. There are several types of activities that may bring large numbers of people together: sports (Olympic Games, world championships), religious (Kumbh Mela, The Hajj), cultural (concerts and festivals) and political events (mass meetings and strikes). Each type has its own characteristics: behavior and purposes of the participants, place and time.

Crowd managers should consider a lot of details to organize a safe and secure event. Soomaroo and Murray [1] have analyzed previous cases of disasters for the period between 1971 and 2011. Overcrowding and crowd control were defined as one of the key areas for preparation of mass events. There are several potential hazards related to crowd movement: suffocation, crushing, trampling.

1877-0509
Peer-review under responsibility of the scientific committee of the International Conference on Computational Science
10.1016/j.procs.2017.05.162

These can lead to a large number of casualties. In recent years, there have been several dangerous accidents during mass gatherings. One of the biggest stampede occurred during the annual Hajj pilgrimage in Mina (Mecca, Saudi Arabia) in 2015: more than 2000 pilgrims died and more than 900 pilgrims were injured. The stampede occurred when two large groups of pilgrims with different directions of motion collided faced at the crossroad. Another deadly stampede occurred in Cambodia in 2010 during the Khmer Water Festival. 347 people were killed and 755 people were injured. The crush occurred on a narrow passage of the bridge: some people were trampled, some people drowned in river. In stampede people lose their balance, fall down and may turn into obstacles for others pedestrian because pushing crowd is not controllable.

Installment of physical obstacles to navigate pedestrian flows is a common crowd control and management tool. Such obstacles include crowd control barricades, barriers, line management systems, temporary fencing, and entry control systems [2]. It is widely accepted that temporary obstacles coupled with permanent architectural design solutions and can increase the safety of mass events. The aim of this paper is to identify dependences between various types of obstacles and the main characteristics of the crowd's movement in various types of interaction between flows. It can provide considerations when planning for future events in terms of security and crowd control.

In this work, we describe the method and first results of the study of obstacles influence on the crowd dynamics. Some background information and related works are presented in section 2. Section 3 contains description of selected scenarios and scheme of our approach. In section 4, we present the data obtained from the simulation. Section 5 presents conclusions and a discussion of further research.

2 Related works

The study of dynamics of the crowd movement and influence of different layouts and forms of obstacles have an interdisciplinary nature. On the one hand, one should take into account the experience of crowd managers of mass gatherings, on the other, relevant developments (methods and tools) from the field of crowd movement modeling.

Scientific and practice-oriented organizations worldwide study features of mass gatherings and investigate the causes of dangerous incidents [3]. This becomes the basis for the publication of standards and regulations of safety during mass events. For instance, the British "Health and Safety Executive" organization [4] identifies two types of hazard factors: crowd and venue-related. In the first group hazards may be caused by crushing, aggressive and dangerous behavior, such as climbing on barricades or buildings. Hazards associated with a venue are the following: collapse of structures, such as a fences or barriers, which may crush people, moving vehicles sharing the same route as pedestrians, failure of equipment, such as turnstiles and so on. Therefore, pedestrians face a variety of permanent and temporary obstacles, which can interfere with their movement. From another perspective, temporary structures like barriers are one of the ways to control pedestrians' behavior. According to the guide [5], there are several main purposes of barriers: pedestrian flow control, flow direction management, blocking, and area delineation (separation of groups, boundaries marking etc.).

Crowd consists of separate groups of pedestrians or flows gathered together by a common interest or activity. These groups or flows have different characteristics of movement. Duives describes the taxonomy of base cases of crowd movement and distinguishes two types of flows [6]: unidirectional and multidirectional. Unidirectional flows can be straight, rounding corners or entering, exiting. Multi-directional flows can be parallel or crossing with focal point or random. This taxonomy helps to define base scenario of flow's interaction for investigating crowd motion.

There are two main methods to study the dynamics of the crowd: the experiment with people and crowd simulation. Lots of experiments have been devoted on objects of various shapes with the help of volunteers. For example, Helbing [7] conducted experiments for corridors with single or two opposite flows passing a short or long bottleneck. Authors [8] study various forms of ordering in