State-of-the-art framework of impacting factors on pedestrian behavior

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Crowd management gained in importance over the last decades for various reasons. The number of mass events for religious, sportive and festive gatherings is increasing, just like the population of the world. As a consequence, the urban spaces become more crowded over time, however, these spaces are not always able to manage the increase in crowd flow sufficiently. These insufficient environments lead to severe disasters like the ones observed at the Hajj, an annual religious gathering of five days with two million Muslims in Saudi Arabia. More than once, the normally peaceful gathering transformed in a stampede with many fatalities. Witnessing more than 3000 casualties in the last 35 years with the all-time low of 1426 deaths in the stamped of 1990. More recent examples are the stampedes at the Astroworld Festival on 5 November 2021 and at the Olembe Stadium on 24 January 2022. The first one led to 10 casualties and 300 injured and the later on to 8 casualties and 38 injured.

In order to manage the large number of crowds while maintaining the efficiency of the environment and the comfort levels of the pedestrians, both long-term and short-term solutions can be deployed. The long-term solution is adjusting the design of the infrastructure, whereas the short-term solutions are crowd management measures (CMMs) that can be implemented in already existing environments without too many adaptations. The literature already provides improved infrastructure designs and various CMMs that are able to guide, stir and influence the pedestrians' behavior in such a manner that the crowded environment is elevated to an environment with higher level of safety and comfort for the pedestrians. For example, the implementation of lighting and signage increases the pedestrian wayfinding performance during evacuations – leading to a higher probability of a successful evacuation. However, state-of-the-art literature is missing out on a clear overview of all these different relations.

For that reason, the present study proposes a framework of various impacting factors on both pedestrian behavior based on the currently existing literature. The considered impacting factors are limited to personal characteristics (e.g., age), architectural features (e.g., stairs), crowd management measures (e.g., illumination settings) and dynamics (e.g., crowd density), whereas the pedestrian walking speed, route choice and wayfinding performance are from interest for the pedestrian behavior. The main purpose of the framework is to visualize the state-of-the-art knowledge about the relations between these impacting factors and the pedestrian behavior, but especially to find the research gaps for further research.

The literature study corresponding to this framework is based on the following keywords: 'pedestrian dynamics', 'pedestrian behavior', 'pedestrian walking speed', 'pedestrian route choice', 'pedestrian wayfinding performance', 'pedestrian characteristics', 'crowd dynamics', 'crowd behavior', 'crowd management measures' and other keyword close to these. Moreover, the snowballing technique is used frequently to enhance the search method.

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