WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Emergency Evacuation Simulation Using ABMS

Dr. N. Swapna Goud, Ms. C. Hithisha, Ms. Deepshika Thakur

[a] *Assistant Professor, Ghatkesar, Hyderabad, India*
[bcd] *B -Tech Student , Ghatkesar, Hyderabad, India*

A B S T R A C T

This study utilizes Agent Based Modeling (ABM) to explore crowd behavior during emergencies in stadium settings. Traditional emergency drills face limitations due to safety concerns and actor engagement. By employing ABM, this research investigates the impact of various actor characteristics on crowd behavior when faced with sudden environmental changes, such as a fire alarm in a stadium. Through simulations in NetLogo, the study aims to uncover behavioral patterns relevant to real-life emergency scenarios, enhancing understanding for future decision-making and design considerations.

Keywords: **agent based model, behavior, complex systems, pattern.**

1. Introduction

This paper delves into the dynamics of crowd behavior during critical situations, transitioning from normality to emergencies, using Agent-Based Modeling (ABM). It aims to capture essential features of scenario displacement and actor characteristics, exploring the consequences of changes in people's behavior under critical conditions. The study models large crowded environments to highlight interaction patterns and evaluates various simulation parameters. While panic behavior is commonly triggered in life-threatening situations like fires or stampedes, systematic studies and predictive theories in crowd dynamics remain scarce. Normal pedestrian behavior often transforms during emergencies, with individuals prioritizing swift exit routes, potentially leading to herding or flocking behavior and increasing the risk of stampedes. This paper explores such phenomena, contrasting traditional fluid-particle dynamics approaches with the emerging ABM paradigm in crowd dynamics research.

2. Literature Survey

"Agent-Based Modeling of Human Behavior during Building Evacuations: A Review" by Nilsson, D., Johansson, A., Frantzich, H., & Helbing, D. (2018)

This review article provides a comprehensive overview of agent-based modeling (ABM) applications in simulating human behavior during building evacuations. It discusses various ABM methodologies, including agent characteristics, decision-making processes, and interaction dynamics. The article compares different approaches and identifies challenges and opportunities for future research in this field.

"Simulation of Human Evacuation in Built Environments: A Review of Current Approaches and Research Needs" by Chowdhury, D., Alam, M., & Zhang, Y. (2017)

This review paper examines existing simulation techniques for modeling human evacuation behavior in built environments. It compares different modeling approaches, including agent-based, cellular automata, and continuum models, highlighting their strengths and limitations. The article also discusses key research gaps and suggests directions for future studies to enhance the accuracy and reliability of evacuation simulations.

"A Review of Crowd Evacuation Models" by Hu, X., & Liao, L. (2017)

* *Corresponding author.* Tel.: +0-000-000-0000 ; fax: +0-000-000-0000.
E-mail address: author@institute.xxx

This review provides an overview of crowd evacuation models, focusing on computational methods for simulating large-scale evacuations in various settings. The paper compares different modeling techniques, including agent-based, macroscopic, and microscopic models, and discusses their applications in studying crowd dynamics, evacuation strategies, and safety considerations. It also identifies emerging trends and challenges in crowd evacuation modeling.

"Pedestrian and Evacuation Dynamics" by Helbing, D., Farkas, I., & Vicsek, T. (2002)

This review offers a comprehensive examination of pedestrian and evacuation dynamics, covering theoretical principles, empirical findings, and computational modeling approaches. It compares different modeling paradigms, including agent-based, cellular automata, and fluid-dynamic models, and discusses their applications in understanding pedestrian behavior and optimizing evacuation strategies. The book also discusses practical implications for building design, urban planning, and emergency management.

3. Methodology

EXISTING SYSTEM

In traditional fire evacuation procedures, occupants in a high-rise building or large commercial complex rely on established protocols and guidelines to evacuate safely during emergencies. These procedures typically involve predetermined evacuation routes, designated assembly points, and trained personnel to coordinate the evacuation process. Occupants are instructed to calmly exit the building via stairwells or designated fire exits, following the guidance of evacuation signs and emergency personnel. Fire drills and training sessions are conducted periodically to familiarize occupants with evacuation procedures and ensure a swift and orderly evacuation in case of a real emergency. While traditional fire evacuation procedures are effective, they may lack the dynamic and scenario-specific analysis provided by simulation software, which can help identify potential weaknesses, optimize evacuation routes, and improve overall preparedness for emergencies.

PROPOSED SYSTEM

In our proposed method, we present a simulation framework to study emergency evacuation scenarios in a stadium environment. The framework incorporates various aspects such as agent characteristics, environment modeling, strategies for evacuation, and detailed modeling of crowd behavior.

Agent Characteristics:

Agents in the simulation exhibit diverse characteristics, including group age, sex, weight, and peripheral vision. These characteristics are sampled from distributions collected from Pordata, ensuring realism in the simulation. Additionally, agent panic level, speed, health, and muscular force are calculated based on these characteristics, enabling nuanced modeling of individual agent behavior.

Environment Modeling:

The simulation environment represents a stadium bench, which is part of a larger interconnected space. The focus is on the interactions and behaviors of individuals seated in the stadium during an emergency event. The stadium is divided into six distinct areas, with agents uniformly assigned to each area.

Trigger Event:

A random fire serves as the trigger event for the emergency scenario. The fire can occur in any location within the stadium and spreads uniformly with a speed adjustable by the user during simulation time.

Evacuation Strategies:

Three distinct evacuation strategies are modeled for agents to safely exit the stadium field during the emergency:

“Smart”

The “smart” strategy assumes that all survivors are equipped with the knowledge of the nearest exit location from where they are, and will try to proceed to the nearest possible exit with the use of the best-first search algorithm. In the event that the designated exit has been blocked by the fire, they will locate the next nearest exit.

“Follow”

The “follow” strategy is used to model the ‘herding behaviour’ of survivors, as similar in the flocking library. In this strategy, survivors only have limited vision with no knowledge of the nearest exits, and they will follow the exact action of the other survivors 1 patch in front of them. If the fire is within their vision, they would run in the opposite direction from the fire. If they see an available exit, they will run straight for the exit.

Panic Behavior:

Agents start with a panic level of 1, which increases to level 3 as the fire approaches. Higher panic levels correspond to increased agent speed as they perceive the imminent threat.

This comprehensive framework provides a robust platform for studying emergency evacuation strategies and crowd behavior in stadium environments, facilitating insights into optimizing safety measures and response protocols.

ADVANTAGES

Enhanced Safety Preparedness: By accurately modeling crowd behavior and evacuation strategies, the proposed method significantly enhances safety preparedness in stadiums during emergencies. This ensures that stadium operators and emergency responders are better equipped to handle various crisis scenarios effectively.

Risk Mitigation and Prevention: The simulation tool allows for the identification and mitigation of potential risks and hazards within stadium environments, enabling proactive measures to prevent emergencies or minimize their impact.

Optimized Emergency Response Plans: Through the simulation of different evacuation strategies and scenarios, stadium operators can develop and optimize emergency response plans tailored to specific stadium layouts and capacities. This leads to more efficient and effective evacuation procedures in real-life situations.

Improved Training and Preparedness: The simulation tool serves as a valuable training resource for stadium staff, security personnel, and emergency responders, enhancing their preparedness to manage emergencies such as fires, stampedes, or other critical incidents.

Enhanced Design and Layout: Insights gained from the simulations can inform the design and layout of stadiums to minimize congestion, improve crowd flow dynamics, and enhance overall safety during both normal operations and emergencies. This ensures that stadiums are built or renovated with safety considerations in mind, ultimately benefiting spectators and event organizers.

SYSTEM ARCHITECTURE

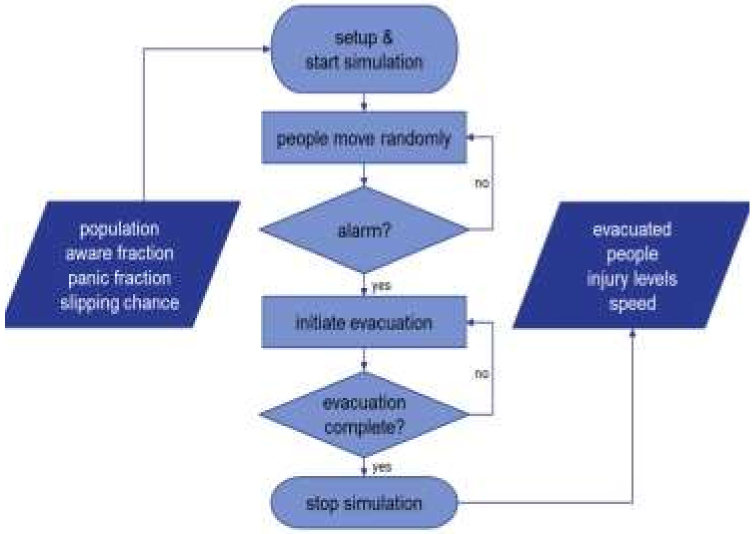

Fig. 1 – Project Execution Flow

4. Results

SetUp

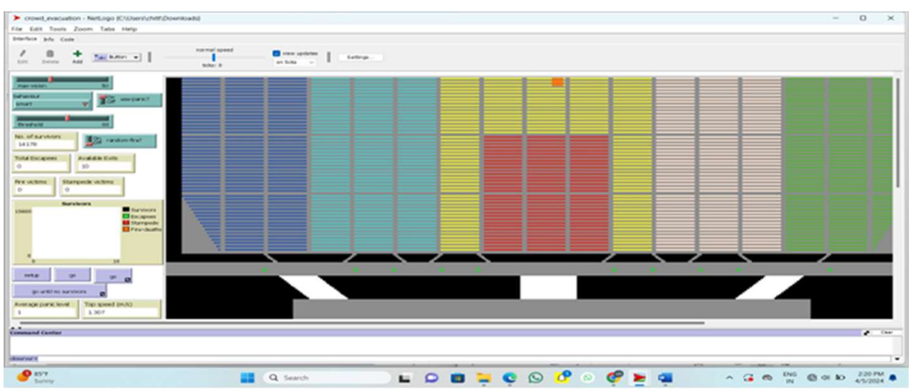

Figure 2 Setup

For a fairer comparison of results, we fix the origin location of the fire and we run a behaviour space for 100 times to confirm the results plotted.

“Smart” Strategy

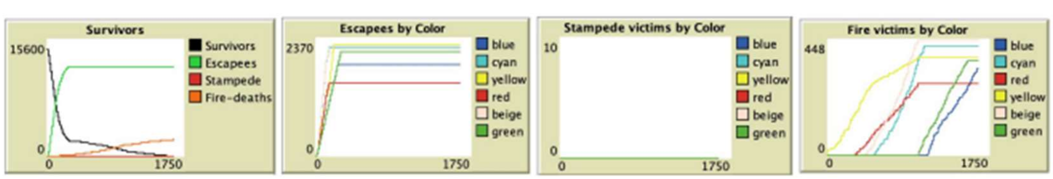

Figure 3 Without panic

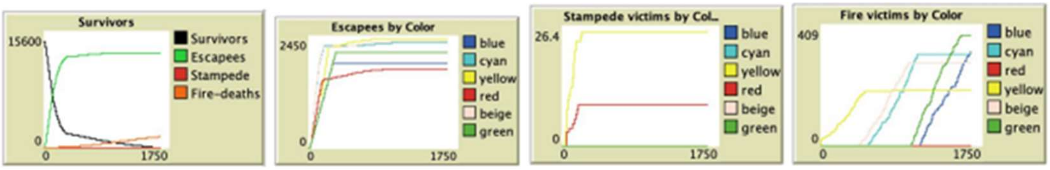

Figure 4 With panic

When there is no sense of panic, there are zero deaths resulting from stampedes - a clear contrast between Figure 6.1 and 6.2 Red agents (where the VIPs are seated) can escape scathe free with 100% survival rate (See Figure 6.2). Interestingly, less victims die in the fire in the scenario with panic due to the sense of urgency resulting in increased speed.

“Follow” Strategy

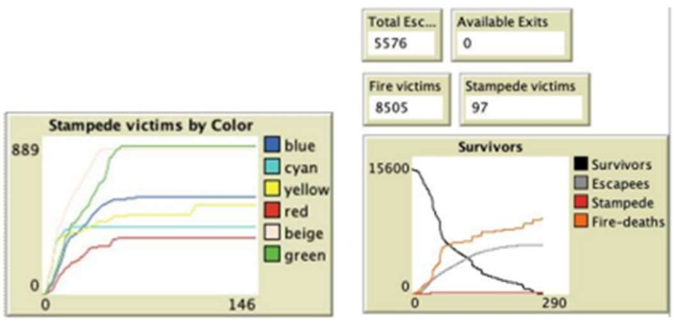

Figure 5 follow strategy

Cause 1: Lack of Knowledge as a Factor for Human Stampede Effect
A comparison between the “Smart” strategy and “Follow Strategy” reveals the effect of the lack of knowledge of the stadium layout and exit points on the human stampede effect. We can clearly see the much higher stampede casualty rate in the “follow” strategy.

Cause 2: Seat Location as a Factor for Human Stampede Effect
Given the unsafe layout of the stadium, the seat location is definitely one of the direct influencing factors on the Human Stampede Effect. In the “Smart” strategy, we see that the highest casualties from stampede came from the center block, even though it is not very significant. As for the one with the follow strategy we can see is the seating blocks from the sides that are seeing more stampede casualties.

Cause 3: Age as a Factor for Human Stampede Effect
We see from the results of both the “follow” and “smart” strategy that the children and elderly tend to be greater casualties of the stampede effect, possibly due to their slower movement and susceptibility to getting crushed in high density areas easily.

Parameter

FORMULA:

Force/Pressure:

$Fp = \sum mass_a * speed_a$

Health:

$Health_a = mass_a * speed_a * threshold$

Parameter table:

PARAMETERS	DESCRIPTION
Age Group	Normal Distribution: 3 Categories Child Adult Elderly
Gender	Male 48% Female 52%
Speed	Each agent has a base walking speed depending on their age category: Child: 038m/s Adult: Uniform distribution between 1.50m/s and 1.51m/s Elderly: Uniform distribution between 1.30m/s and 1.40m/s
Max vision	Uniform distribution 0 (vision can be extremely poor due to natural blindness or onset of smoke) and a maximum that can be set between 20 and 100
Panic level (1 to 3)	Level 1 – All agents base Level 2 – Fire in agent's vision. Agents speed increase fast pace (1.80m/s) Level 3 – Fire nearer (half the distance that the agent can see). Agent's speed increases to a running speed (2.50m/s)
Mass	Agent mass drawn from a normal distribution depending on their age category and gender Female child mean = 35kg Male child mean = 40kg Adult/Elderly mean = 57.7kg

Table 1 parameters

5. Conclusion

This project attempts to find out the significance of various factors on the human stampede effect using the unsafe layout of stadium as a simulation environment. Using the experiment results, it hopes to provide some form of insights into likely causes of human stampede effects and seeks to provide informed recommendations to increase survivability in crowd evacuations in such settings. We see that the results have testified to all the hypothesis causes of the human stampede effect, namely the lack of knowledge of the location layout, the seat location of the spectators and the demographics of the spectators. Amongst these factors, we see the largest impact on the human stampede effect being the lack of knowledge of the location layout. This is probably due to the direct effect of the lack of knowledge on creating the 'herding' behavior which often leads to frantic situations of "blind" leading the "blind". Furthermore, the "following" behavior causes the pressure in the same direction to increase by multiple times, resulting in much higher stampede casualties. The panic level in this situation is also seen to be much higher. Hence, while changing infrastructure to include more exit points may be the most ideal solution, in the event that this idea is not welcome by authorities, one can simply inform the spectators of the fastest way to exits in times of emergency situations and provides more visual aids such as exit signs along the way. These small alterations may simply lead to a much smaller stampede casualty rate as modelled in the "smart" strategy simulation.

6. References

[1] Dennis Parker and John Handmer, *Hazard management and emergency planning: perspectives in Britain*, Routledge, 2013.

[2] Alexander Mintz, "Non-adaptive group behavior.," *The Journal of abnormal and social psychology*, vol. 46, no. 2, pp. 150, 1951.

[3] Dirk Helbing, Illes J Farkas, Peter Molnar, and Tamas Vicsek, "Simulation of˝ pedestrian crowds in normal and evacuation situations," *Pedestrian and evacuation dynamics*, vol. 21, no. 2, pp. 21–58, 2002.

[4] Noor Akma Abu Bakar, Khalid Adam, Mazlina Abdul Majid, and Mario Allegra, "A simulation model for crowd evacuation of fire emergency scenario," in *2017 8th International Conference on Information Technology (ICIT)*. IEEE, 2017, pp. 361– 368.

[5] Yasser M Alginahi, Muhammad N Kabir, and Ali I Mohamed, "Optimization of high-crowd-density facilities based on discrete event simulation," *Malaysian Journal of Computer Science*, vol. 26, no. 4, pp. 312–329, 2013.