Exploring Ragdoll Physics in Crowd Disaster Simulation

Alexander H. Chang[1], Aedan Ting, Edbert B. Hsu MD, MPH[2]

1 Lewis Katz School of Medicine, Philadelphia, PA, USA

2 Department of Emergency Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Introduction

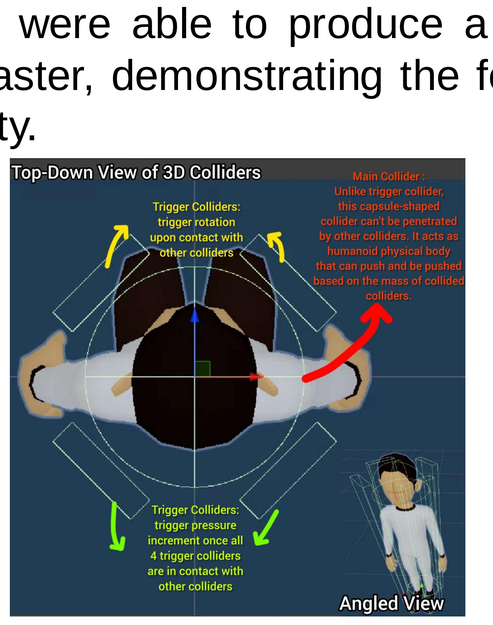
Crowd disasters pose a recurring challenge for societies worldwide, with events like human stampedes and crowd crushes resulting in significant human casualties.[1] Limited studies in the literature address the mechanisms of crowd dynamics and fewer still explore its mechanisms and patterns of injury.[1] A more robust understanding of crowd behavior dynamics and injury patterns are needed to improve effectiveness of response. Real-world exercises or experiments present insurmountable practical challenges. However, an innovative simulation approach using ragdoll physics derived from gaming graphics engines shows promise in shedding light on the complexities of crowd disasters. This project aims to showcase applications of ragdoll physics in enhancing our understanding of these complex recurring disasters.

Methods

We harnessed the power of the Unity Game Engine to develop real-time simulation for the dynamics of a crowd disaster with rendering of scene objects and user interface (UI) elements. Humanoid agents with trigger colliders were linked to color schemes representing impact forces sustained with lethal thresholds ranging from 500 to 550 pounds force for males and 450 to 500 pounds force for females.[2] The simulation enables users to manipulate parameters such as population, crowd density, directional movement and forces applied.

Results

We were able to produce a rudimentary simulation of a crowd disaster, demonstrating the feasibility of game engines and their utility.



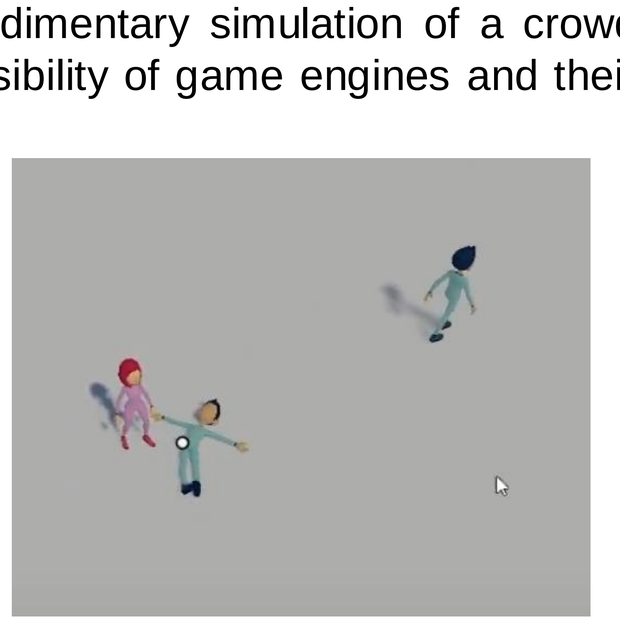


Figure 1a: (Left) The physics component of colliders within the Unity Game Engine allows for simulations of object interactions.
Figure 1b: (Right) A first iteration of populating a space with humanoid figures was created.

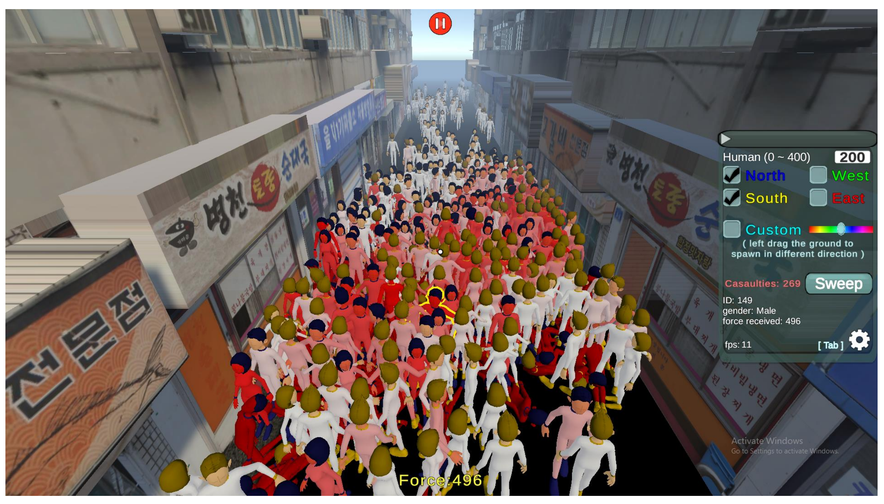


Figure 4: The simulation exhibits casualties and has the capability to highlight individuals as well as display the magnitude of force experienced by each person. (The intensity of red shading corresponds to the level of force sustained.)

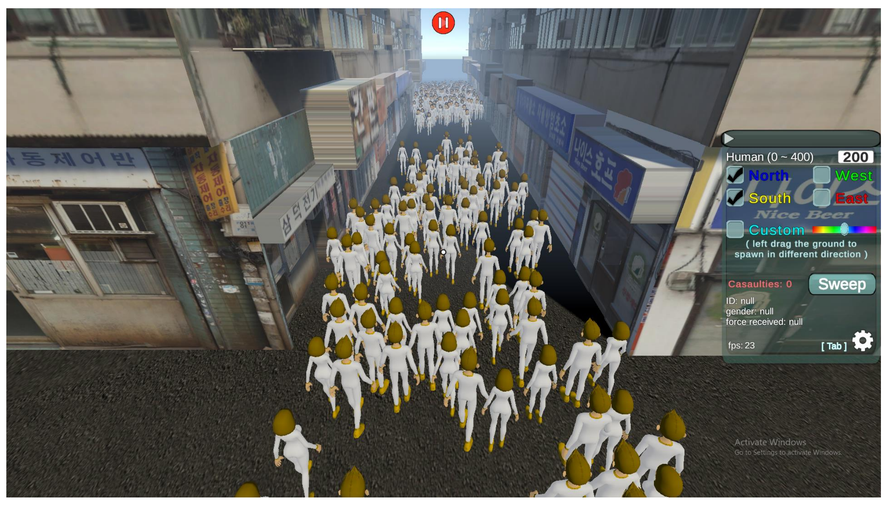


Figure 2: A simulation of a crowd going into an alley.

Figure 3: The simulation captures the dynamics of a crowd disaster.

Conclusions

Ragdoll physics stands as an indispensable asset for video game developers, empowering them to craft lifelike simulations and elevate gameplay experiences to unprecedented levels of realism and immersion. Beyond its gaming applications, this technology also holds the potential to deepen our understanding of crowd disasters, offering new insights into crowd dynamics and injury patterns.

References

1. Hsieh YH, Ngai KM, Burkle FM, Hsu EB. Epidemiological Characteristics of Human Stampedes. *Disaster Med Public Health Prep*. 2009;3(04):217-223. doi:10.1097/DMP.0b013e3181c5b4ba
2. Kroll MW, Still GK, Neuman TS, Graham MA, Griffin LV. Acute forces required for fatal compression asphyxia: A biomechanical model and historical comparisons. *Med Sci Law*. 2017;57(2):61-68. doi:10.1177/0025802417695711