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Comment on nhess-2021-79

Anonymous Referee #1

Referee comment on "Flood–pedestrian simulator for modelling human response dynamics during flood-induced evacuation: Hillsborough stadium case study" by Mohammad Shirvani and Georges Kesserwani, Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-79-RC1, 2021

General comments

The value of Agent-Based Modelling as a technique to understand the role of individual decision making in response to hazards, such as flooding, has increased in recent years, since the initial publication of ABM evacuation behaviour was published in 2011. This study is an interesting example of further development of this application of ABM and demonstrates a good synthesis of empirical research to formulate agent behaviour. Through introducing agent characteristics such as age, gender, weight, variable movement speeds and stability patterns, the model introduces an enhanced level of heterogeneity amongst the agent population from previous iterations of the model.

Major comments

However, there lies two fundamental concerns related to the outputs of the model:

- It would appear that uncertainty inherent within modelling stochastic agent behaviour is not acknowledged. The impression given is that model simulations were ran only once for each scenario (lines 331 – 333) and outputs were then analysed. There should be evidence of multiple simulations for each test scenario to account for variance in behaviour of agents. For example, confidence intervals and averaging over an appropriate number of simulations would provide a more representative set of outputs that account for stochasticity.
- The number of agents included in the Hillsborough case study is 4,080. The lowest recorded attendance for Sheffield Wednesday in 2019 was counted at 21,485, meaning that the agent population is only 18% of what is considered ‘real’. Given that the start of the paper states that the FLAMEGPU platform can handle “as large population size as

needed (line 79)" and that throughout the paper congestion is frequently stated as a factor that influences flow dynamics and evacuation time, a question emerges as to why such a significantly low agent population has been adopted. The paper states that "using a bigger population size would lead to extreme pedestrian congestion that impacts the movements of individual pedestrians (lines 489 – 490)". Surely, in the context of a football match, this is an important factor that must be represented as accurately as possible. There is no justification for the chosen figure of 4,080 and it seems arbitrary. I am not wholly convinced that subsequent outputs reflect evacuation times that would be representative of a football match. Either a more realistic agent population in line with actual attendance rates is necessary, or justification that the emergent behaviour is not dramatically impacted by the chosen number of spectators.

Technical/Minor Comments:

- In section 2.3.2, it states "…the more crowding of pedestrians the more energy loss in the floodwater dynamics for low risk floodwaters, which in turn enables the pedestrians located behind to take a faster moving speed (lines 346 – 348)". Whilst it is well noted that crowding would disperse the floodwater, making pedestrian movement easier, I can't help but wonder if collective moving speed would in turn be slowed down by the congestion itself, therefore this could be acknowledged.
- In section 2.3.2, it also states "enabling it with the two-way condition (Mode 2) increases slightly the evacuation time as crowding is more likely under the walking condition (lines 435 – 436)". It would be reasonable to assume that the 'running condition' would be more likely to cause crowding as it represents a more 'excited' response, causing further bottlenecking in the evacuation process compared to more organised walking agents. Some consideration of this would be insightful.
- The model demonstrates well a fundamental concept inherent within complexity sciences and Agent-Based Modelling; emergence. The adoption of risk perception thresholds seem to have influenced the favouring of destination selection by agents with varying levels of risk perception. As is the case for risk perception and adaptive behaviour in response to flooding (i.e. risk perceptions thresholds increase after an individual's property is flooded, which increases the likelihood of adopting protective measures in future) as an active area of interest within flood risk management. Some further comments on the overlap between risk perception and evacuation behaviour may be insightful to lay foundations for future research.
- Some more clarity on what solvers are used to dictate the flow of water in the hydrodynamic model should be provided in Section 3.2.1.
- Calibration/validation evidence of the hydrodynamic model should be provided in more detail to highlight the robustness of hydrodynamic outputs. Two separate figures are provided of flood extents; an Environment Agency figure (Figure 8) and your own (Figure 10). These could be combined into one figure, by overlaying and analysing to provide an FSTAT value to indicate accurate representation of simulated outputs versus simulated. Similarly (at a minimum), a figure showing simulated and observed hydrographs should be provided to demonstrate that flood depths are within an acceptable tolerance.
- A supplementary table providing a summary of all agent variables and values upon initialisation (flooding, navigation and pedestrian agents) would be useful. This would promote replicability and reproducibility.