UPPSALA UNIVERSITET

The two-population 'MASHer' social force model creates interesting emergent results when applied to an evacuation scenario. Panicked people generally cause evacuation times to increase, and we can observe 'laning' within the crowd..

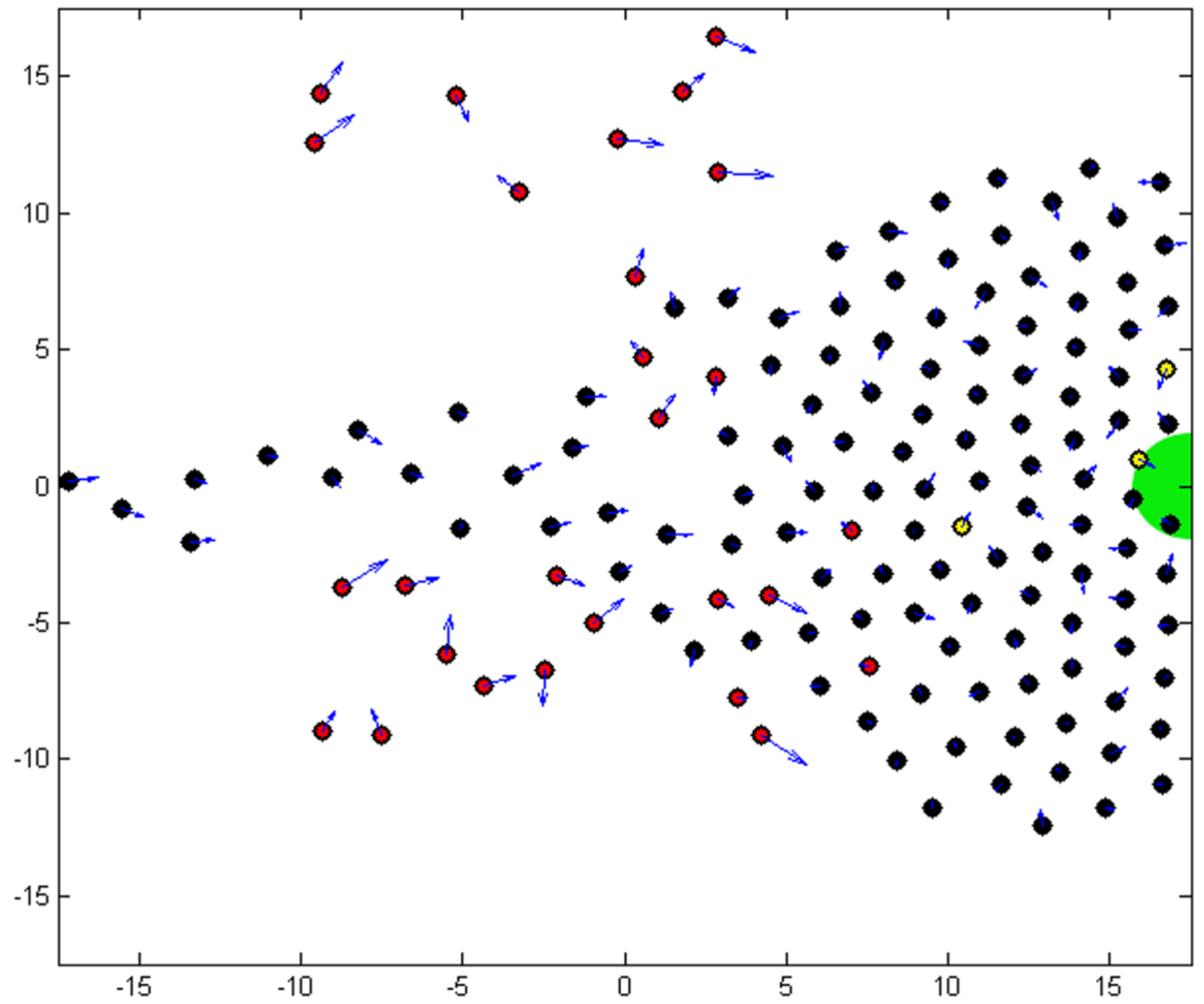
Crowd Crush in a Dual Population Evacuation Scenario

Crowd crush is a term for when the density and movements of a crowd becomes dangerous. Oscillating movements can leading to trampling, and pressure from extreme crowd density can lead to chest compression and lack of breath. This is common during human stampedes - such as one during the Hajj pilgrimage in Mecca, 2006, where crowd crush resulted in the death of over 300 pilgrims. Due to the dangers involved, experiments are not really viable, so researchers rely on numerical models as well as empirical data from real incidents.

Our project is about extending an existing model of two populations to fit an evacuation scenario. We investigate how the balance of populations and their behaviours affect the evacuation.

The MASHer model, put forth by Jesse Silverberg et al. in 2013, was originally used to investigate emergent phenomena from collective motions in crowds at heavy metal concerts. It is a force-particle model with two different populations whose behaviour is simulated with a number of forces that emulate physical collisions, will to move or stand still, and a social 'flocking' force describing the will to move along with people in the immediate vicinity.

In order to apply the MASHer model to our decided scenario (a smoke-filled room), we made extensions to almost all parts of the model. We kept the two populations, but reworked their behaviour. We added proper wall collisions, exit detection and geometry, as well as a way for panicked people to discover the exit detection based on proximity. To look at the effects produced, we also elected a number of relevant metrics to analyze our data with, such as crowd density and local speed, movement, and body compression.



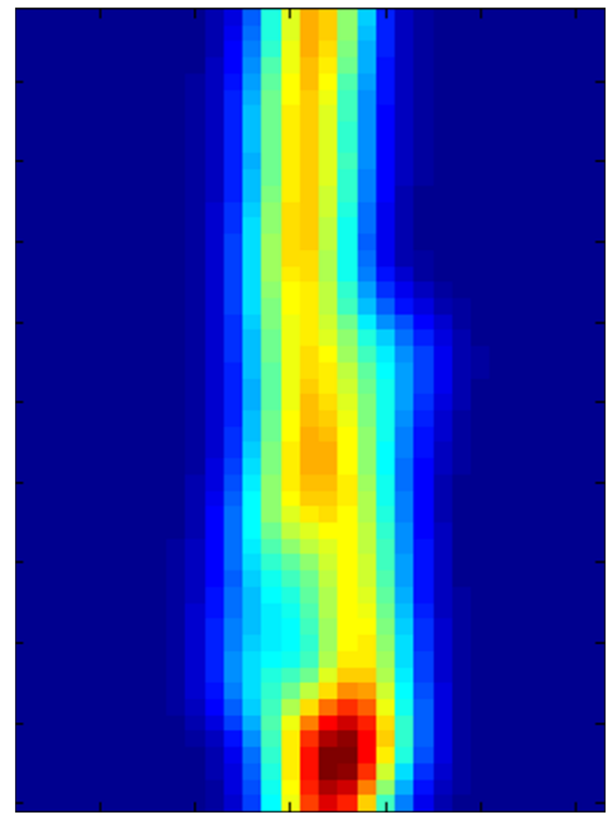
Stable state simulation of 150 MASHers where red are panicked, yellow are panicked that have found the exit and black are calm. When MASHers exit they are reseeded at the left side of the room. We observe a large crowd trying to reach the exit marked with green. Also observe the panicked MASHers running around in other parts of the room.

The altered MASHer model simulates an evacuation scenario and measures how evacuation time and body compression for the MASHers varies with several parameters, such as the amount of panicked people or the strength of their flocking.

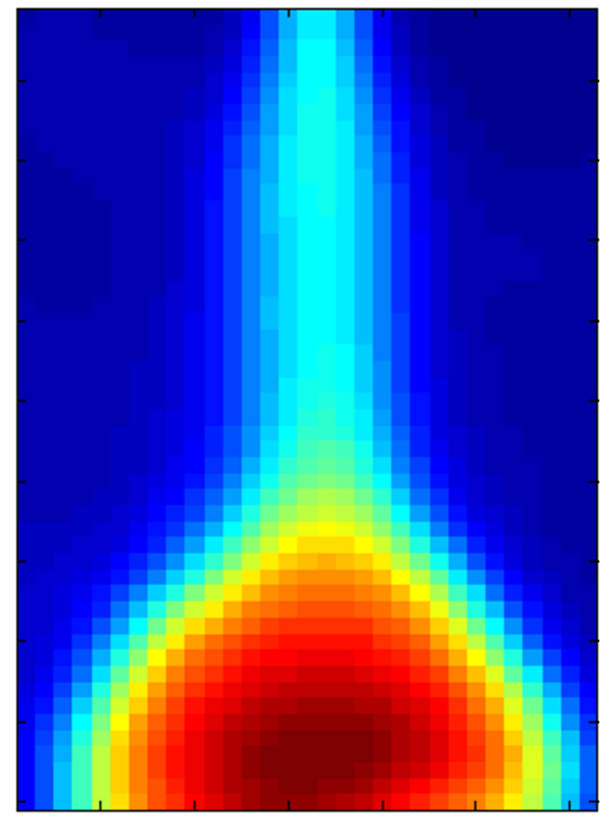
It is assumed that people unaware of the way out will be in a panicked state (red), and will try to move along with others to discover an exit, which is implemented using the original flocking force. Calm (yellow) MASHers ignore others and walk directly towards the exit.

The propulsion force has two roles. People aware of the exit are directed and moved towards it, while people unaware of the exit are propelled towards their current facing. Repulsive forces simulate physical collisions between MASHers and the room geometry. Lastly, the noise force adds some randomness to all movements.

The scenario is investigated in two different settings: First, to look at evacuation time, we have a limited amount of MASHers leaving a room. Secondly, we look at a situation where MASHers keep entering the room through a door opposite the exit and look at how density and speed average out over time in a 'stable' state.



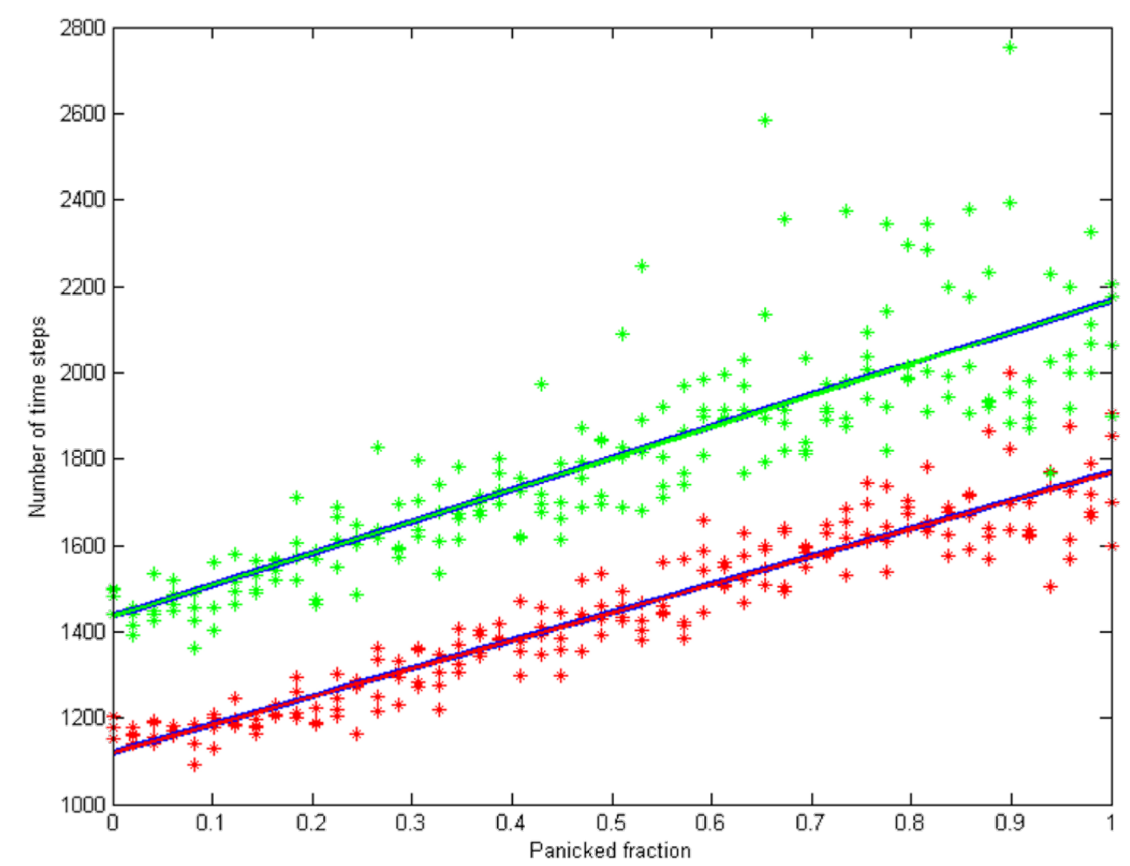
Average movement over a large number of time steps.



Average density a over large number of time steps.

Pathing is an interesting effect that sometimes appears in stable states, where most movement tends to occur along a specific route. This shows in the movement plot above (left), where we see that most movement in the crowd happened along a specific path. The density plot above (right) shows the shape of the crowd in question.

"Panic is almost always bad" is the conclusion from the plot below. For both limits , having a larger amount of panicked people increases evacuation time. Reversely, having a small number of calm MASHers in the mix guides panicked ones to the exit. Interestingly, even with small amounts of panicked MASHers, results are slightly worse, suggesting negative interactions between the two populations.



Green indicates for 90% evacuated and red indicates for 80% evacuated.

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