Experiments with Emotion Contagion in Emergency Evacuation Simulation

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  - Fear, escalating to panic, may lead to non-rational behaviour, disorientation etc.
- Emotions levels, expressions and their effect on behaviour differ among individuals, depending on their **personality**
- For more realistic MAS simulations of emergency evacuations, it is important to incorporate emotions and their **effects** on the agents

Emotional Contagion

"A process in which a person or group influences the emotions or behaviour of another person or group through the conscious or unconscious induction of emotion states and behavioural attitudes"[1]

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- One way of incorporating EC in MAS simulations is by using Formal Modelling

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- Formal state based modelling can rigorously define complex agent behaviour **influenced by emotions**
- **Emotional Contagion** can be incorporated in the formal models
- The produced models can be refined to **executable code**
- **Realistic simulations** of evacuation scenarios are produced

Emotional X-Machines

An *emotional X-machine* is defined[2] as:

$$^{e}\mathcal{X} = (\Sigma,\ \Gamma,\ Q,\ M,\ \Phi,\ F,\ q_0,\ m_0,\ E)$$

where:

- Σ and Γ are the input and output alphabets, respectively.
- Q is the finite set of states.
- M is the (possibly) infinite set called memory.
- Φ is a set of partial functions, $\varphi : \Sigma \times M \times E \rightarrow \Gamma \times M$.
- F is the next state partial function, $F : Q \times \Phi \rightarrow Q$
- q_0 and m_0 are the initial state and initial memory respectively.
- E is an emotional structure formalisation.

[2] Petros Kefalas, Ioanna Stamatopoulou, and Dionysios Basakos. "Formal Modelling of Agents Acting Under Artificial Emotions". In: *Proceedings of the Fifth Balkan Conference in Informatics*. BCI '12. Novi Sad, Serbia: ACM, 2012, pp. 40–45.

Emotional X-Machines cont'd

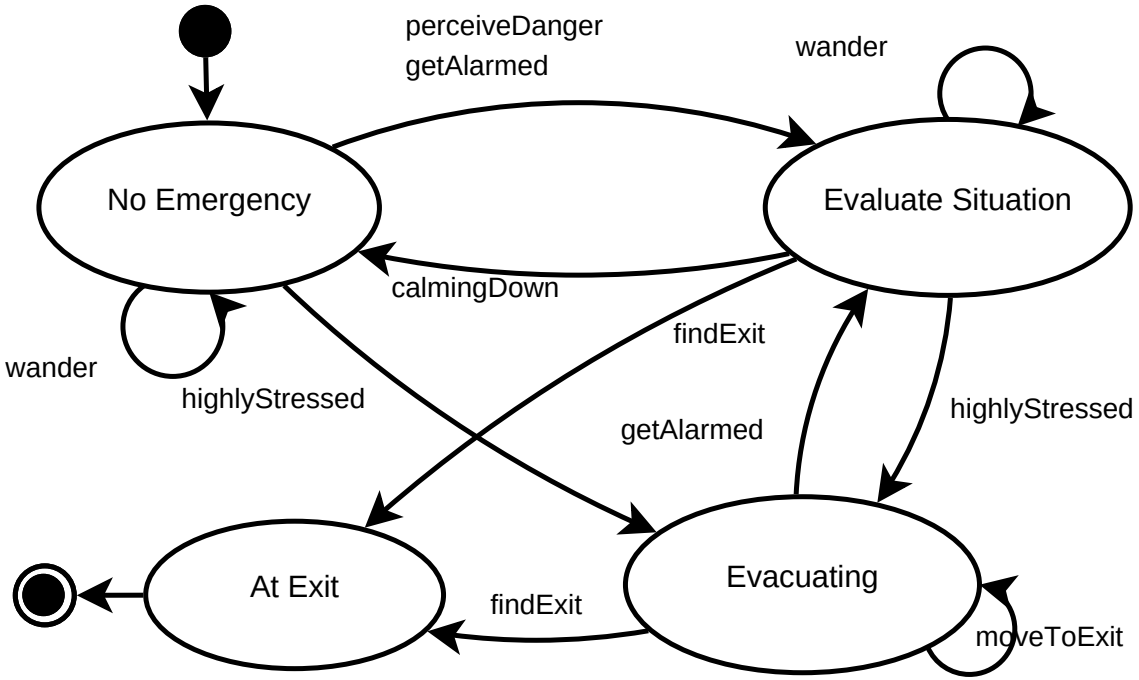
E is defined as:

$$E = (E_v,\ P,\ C,\ {}^{e}\Phi,\ e_0)$$

where:

- $E_v = (\epsilon_1, \ldots, \epsilon_n)$ is a vector containing emotion identifiers.
- P is a personality trait type.
- C is a contagion model type.
- ${}^{e}\Phi : E \times P \times C \times M \times \Sigma \rightarrow E_v$ is the set of emotions revision functions ${}^{e}\varphi$.
- e_0 is the initial vector of emotion identifiers representing the initial emotional state.

Evacuating Agents



State Transition Diagram for Evacuating Agents

Our Contribution

- Formal Definition of Emotional Contagion models

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- Formal Definition of Emotional Contagion models
- Integration of EC models in a state-based Agent Model Specification
- EC models' implementation in NetLogo
- Conduction of experiments based on the different EC models

Model C1

- An agent's personality is defined by *openness* and *expressiveness*

[3] Mark Hoogendoorn et al. "Modelling the Interplay of Emotions, Beliefs and Intentions within Collective Decision Making Based on Insights from Social Neuroscience". In: *Neural Information Processing. Theory and Algorithms*. Vol. 6443. Lecture Notes in Computer Science. 2010, pp. 196–206.

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Emotion revision function:

$$\delta E_i = s_i * \left(\sum_{j \in AG} ((w_{ij}/w_i) * E_j) - E_i \right)$$

- emotion strength s_i depends on *openness* of agent i
- w_{ij} depends on *expressiveness* of agent j and distance

Inspired by ASCRIBE[3]

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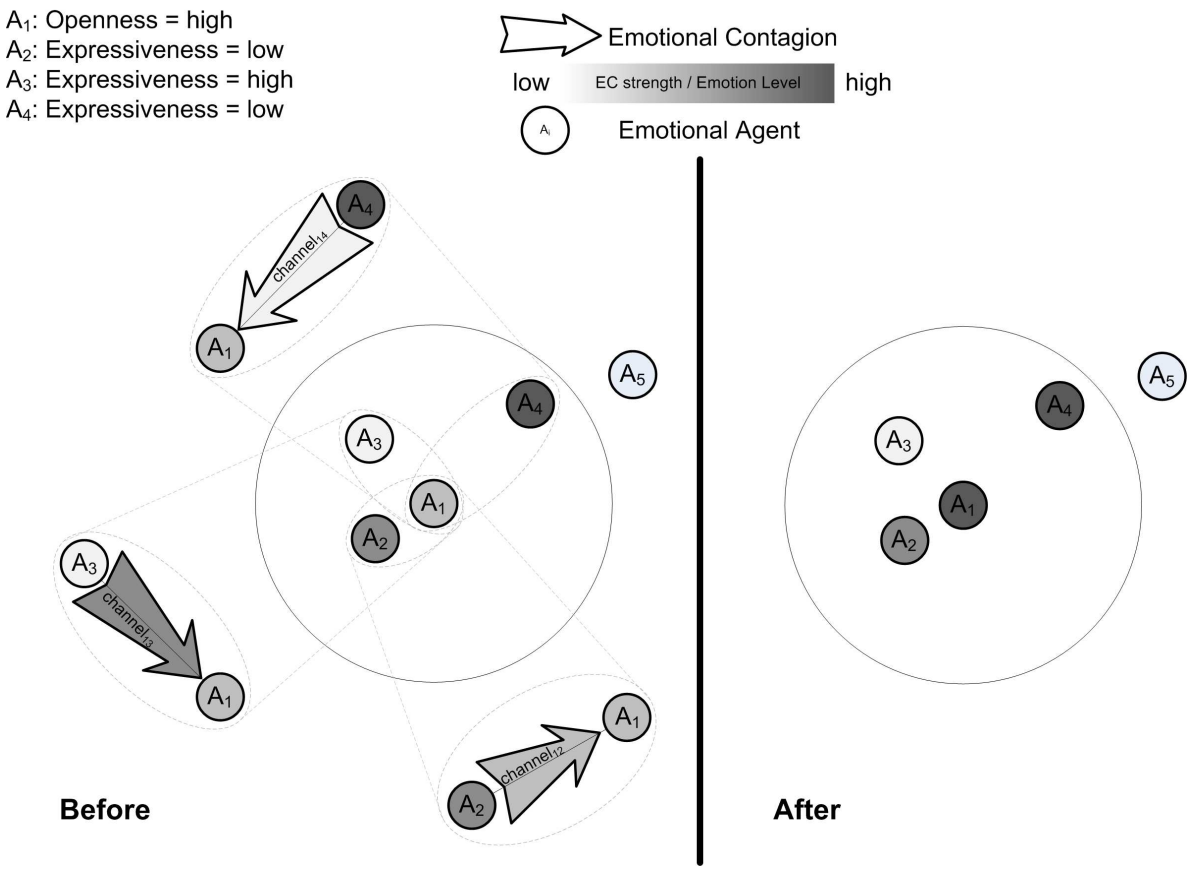
Model C1 cont'd



Model C2

- An agent can be either *susceptible* or *infected*

[4] Jr. Costa P.T. and R.R. McCrae. *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) manual*. Odessa, FL: Psychological Assessment Resources, 1992.

[5] Funda Durupinar. "From Audiences to Mobs: Crowd Simulation with Psychological Factors". PhD thesis. Ankara: Bilkent University, Department of Computer Engineering, 2010.

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Emotion strength update:

$$E_i' = E_i + f(\theta, D + \sum_j^N d_j)$$

- d, D: emotion dosage and cumulative emotion dosage received
- θ: *empathy* value, depends on personality

Inspired by Durupinar[5]

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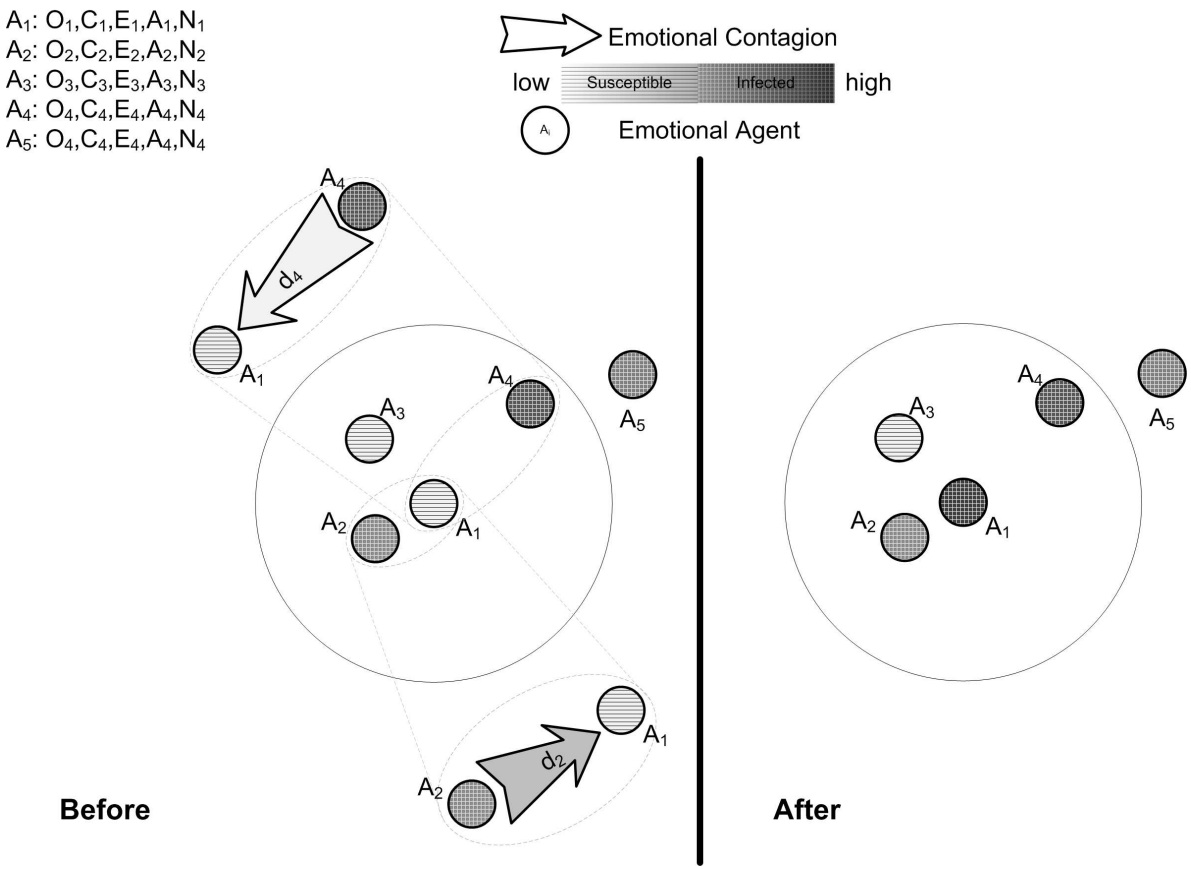
Model C2 cont'd



Model C3

- Agent with lower emotion strength inherits the highest emotion strength value of neighbors that are not authority figures

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Emotion strength update:

$$E_i' = \begin{cases} E_j, & \text{if agent } j \text{ is an authority figure,} \\ E_j, & \text{if } E_i < E_j \text{ and } j \text{ not an authority figure.} \end{cases}$$

Inspired by ESCAPES[6]

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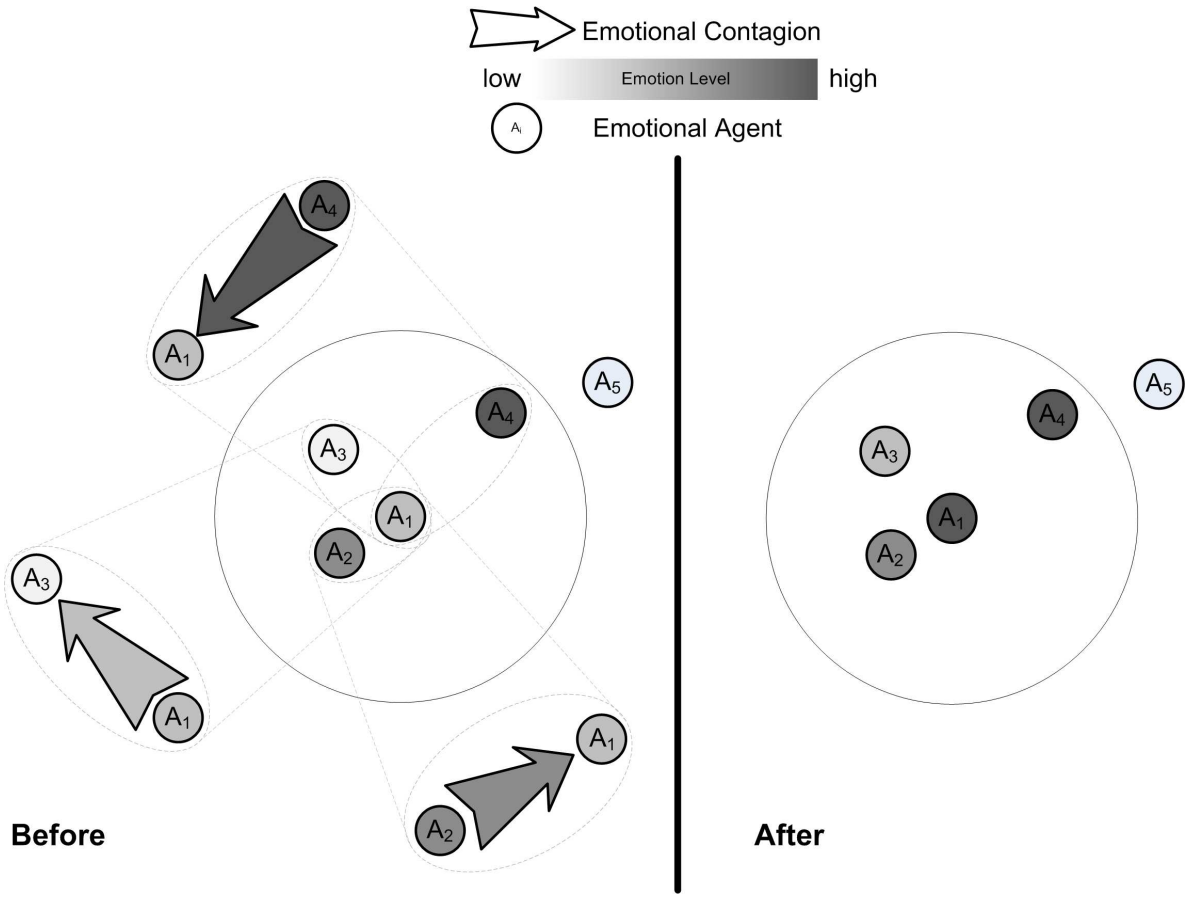
Model C3 cont'd



Case Study

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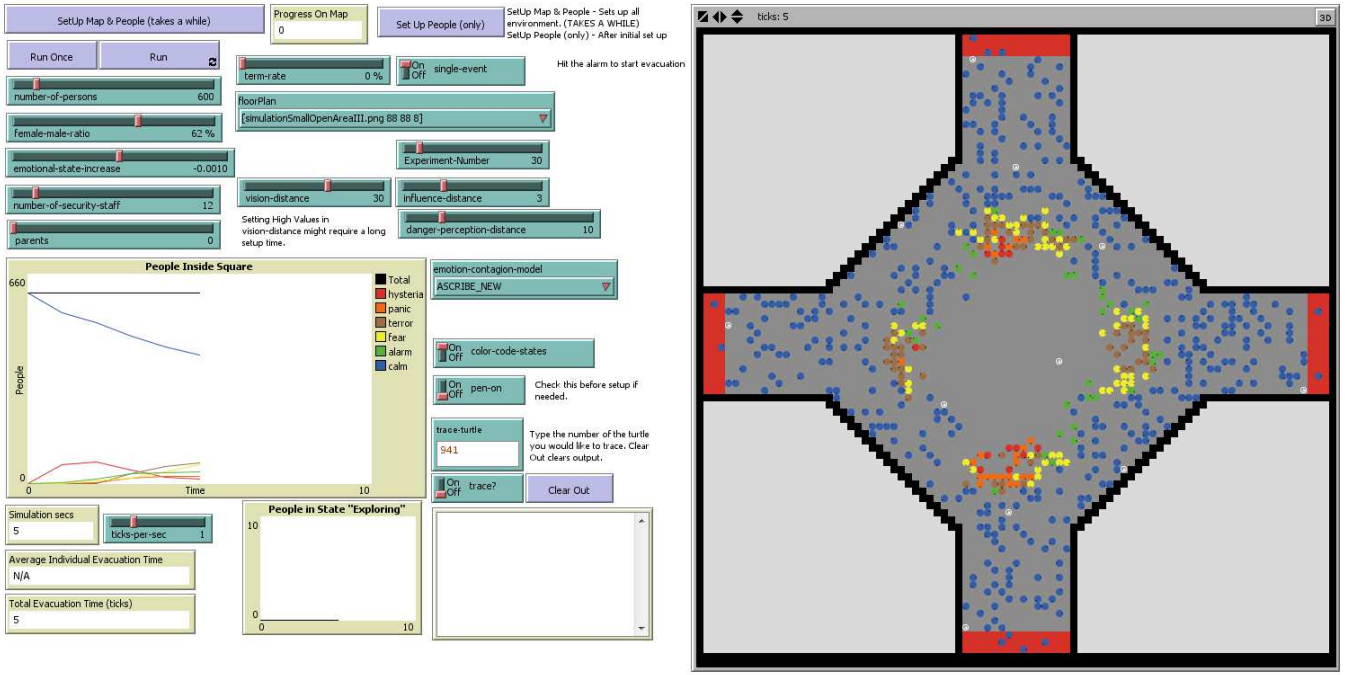
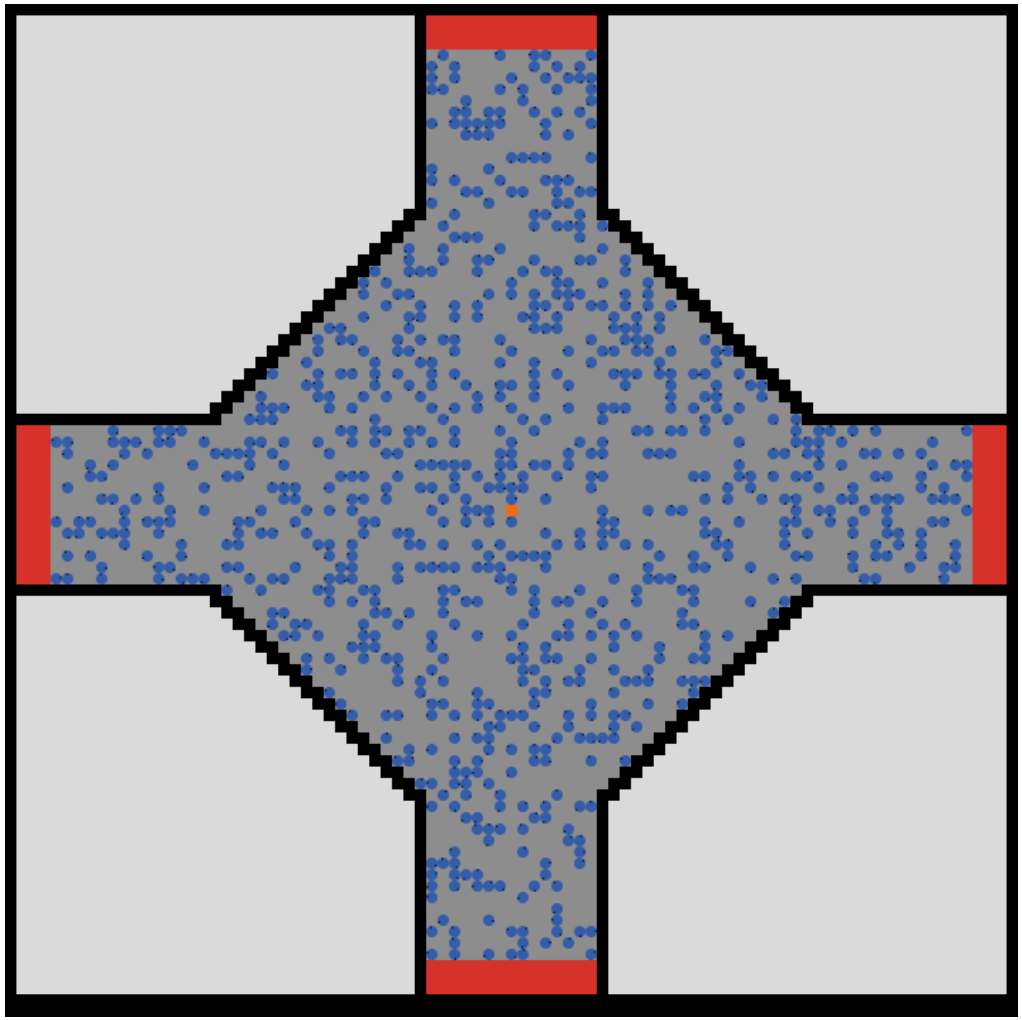
- Source of alarm might be instantaneous or continuous
- Families with children might be present
- Security personnel might be present
- Emotion strength decreases with time with a rate that depends on personality
- The levels of emotion: Calm $\rightarrow$ Alarm $\rightarrow$ Fear $\rightarrow$ Terror $\rightarrow$ Panic $\rightarrow$ Hysteria

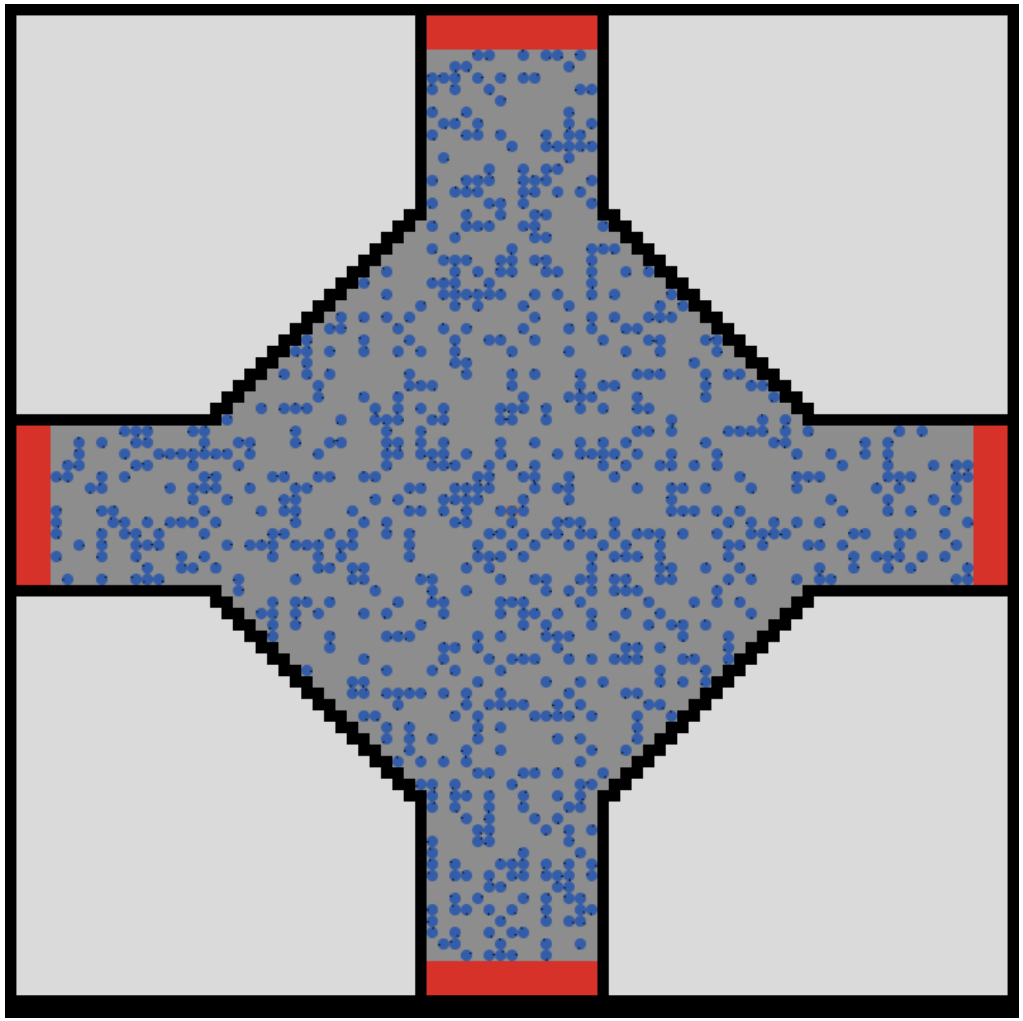
Simulation Interface



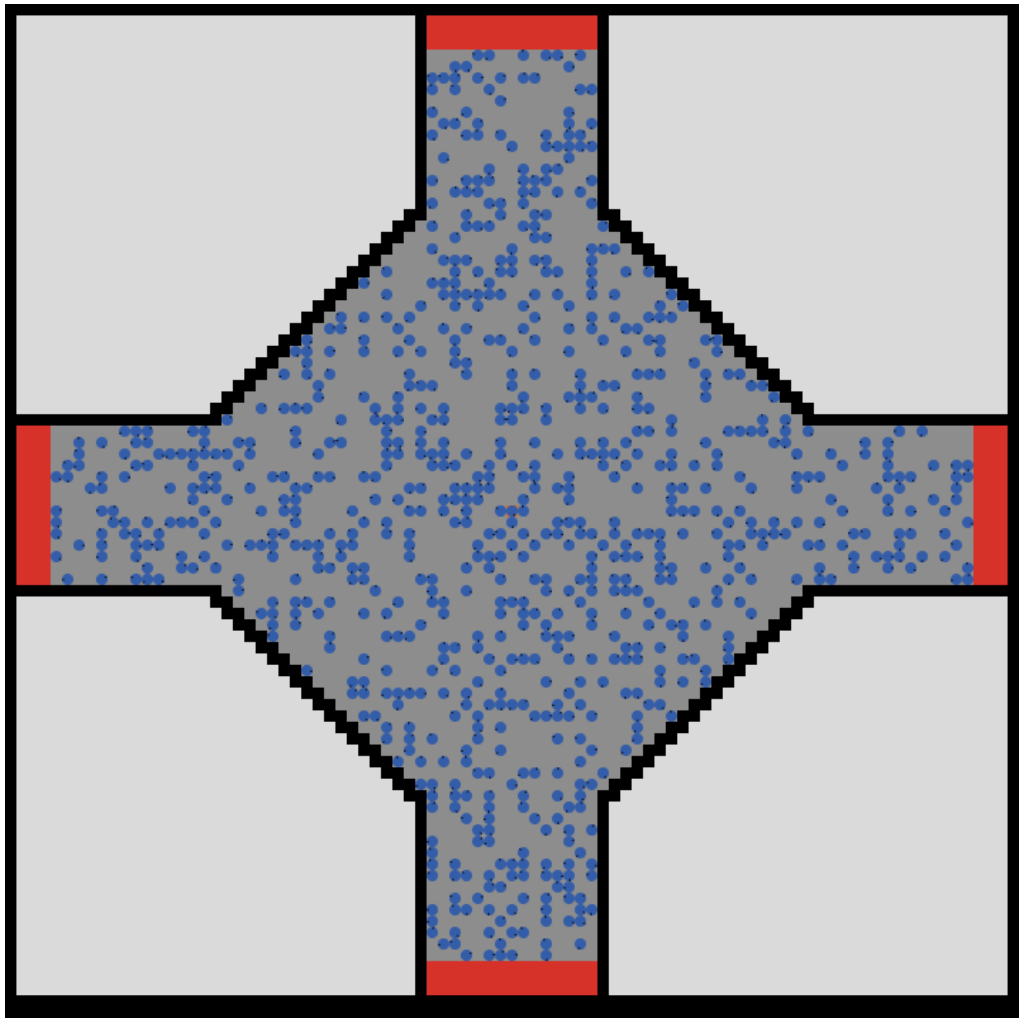
C1 Simulation



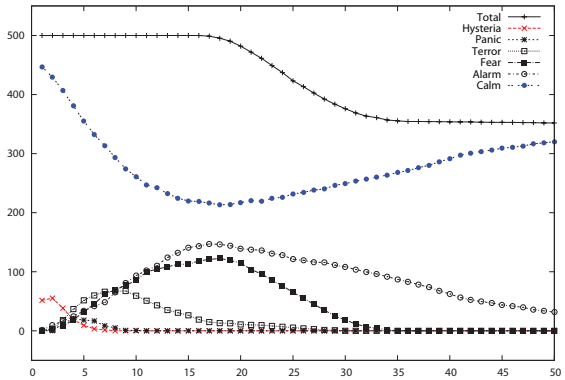
C2 Simulation



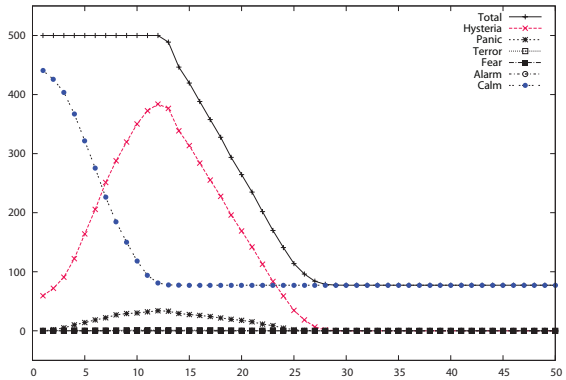
C3 Simulation



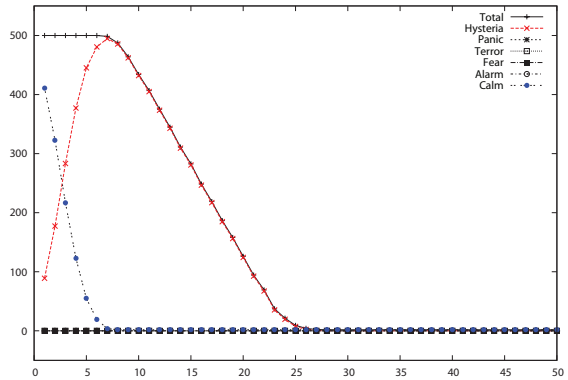
Results



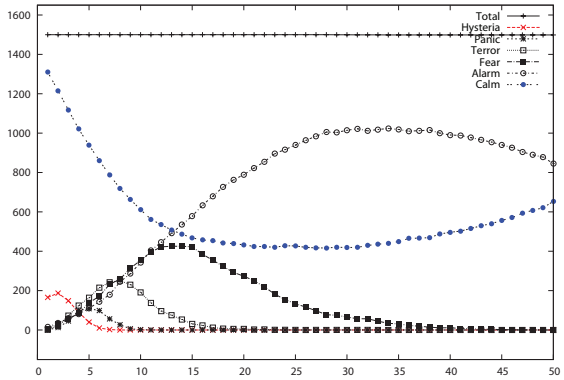
(a) Model C1 (500, 0)



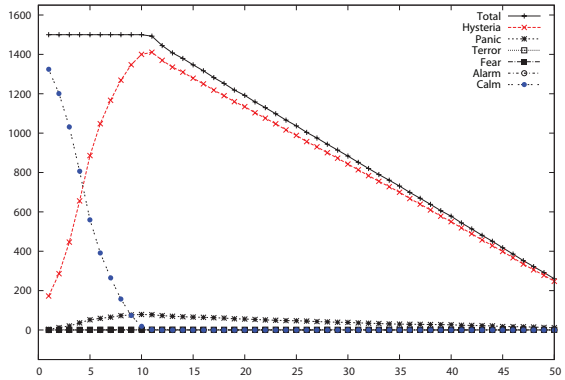
(b) Model C2 (500, 0)



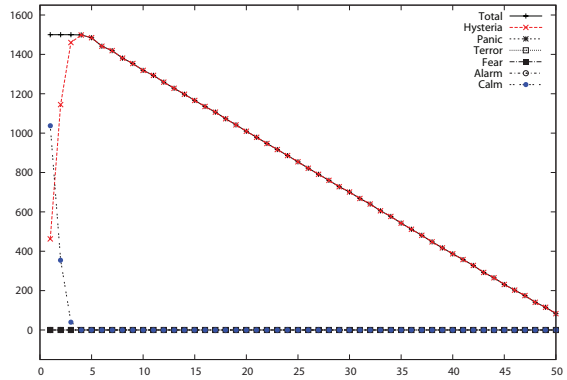
(c) Model C3 (500, 0)



(d) Model C1 (1500, 0)

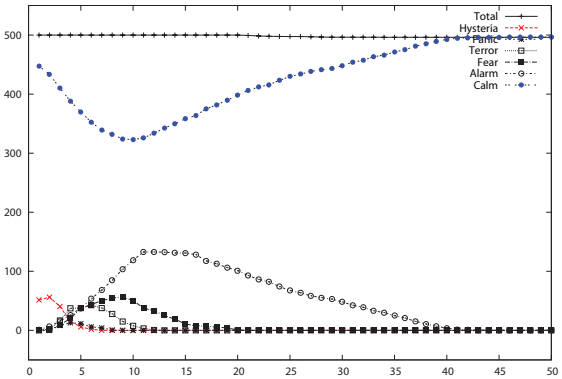


(e) Model C2 (1500, 0)

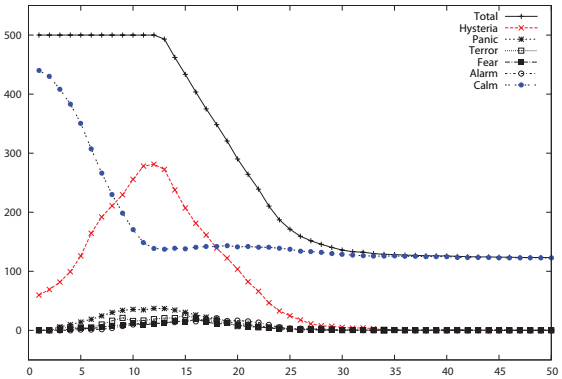


(f) Model C3 (1500, 0)

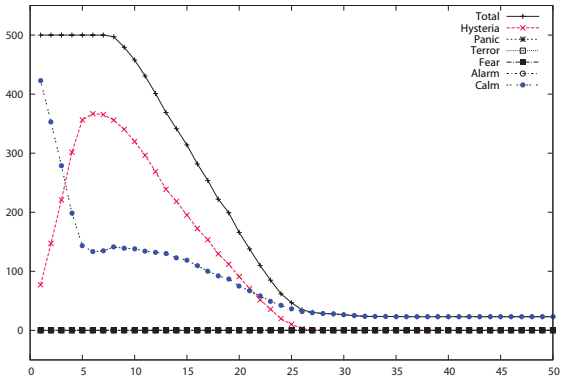
Results cont'd



(g) Model C1 (500, 20)



(h) Model C2 (500, 20)



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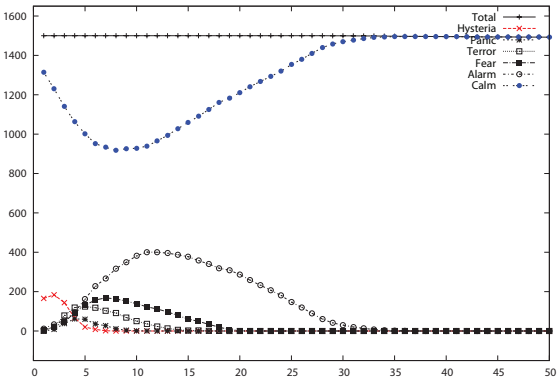
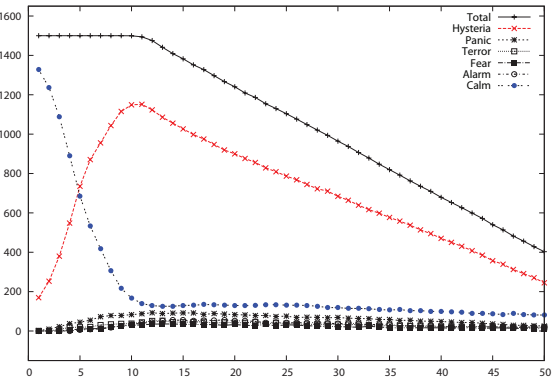
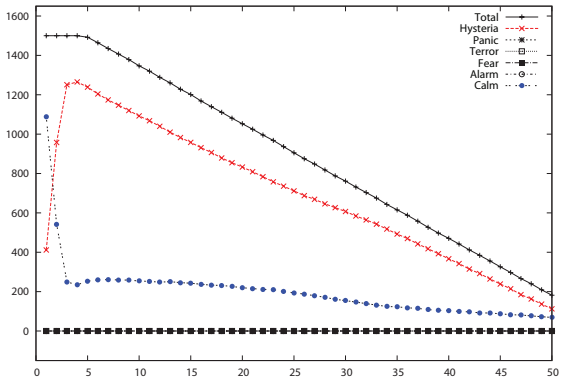


(j) Model C1 (1500, 20)



(k) Model C2 (1500, 20)



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- Validation of such models is extremely difficult due to lack of real data
- Comparison against video footage of real evacuations would offer insight into determining model usefulness and further refining

Thank you for your attention.
Any Questions?

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