Emotional Contagion

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Acknowledgement

Empirical evaluation of computational fear contagion models in crowd dispersions

Jason Tsai, Emma Bowring, Stacy Marsella, Milind Tambe

Jason Tsai, Emma Bowring, Stacy Marsella, and Milind Tambe (2013). Empirical Evaluation of Computational Fear Contagion Models in Crowd Dispersions, Autonomous Agents and Multiagent Systems, 27(2):200-217. (Tsaietal2014.pdf)

What is Emotional Contagion?

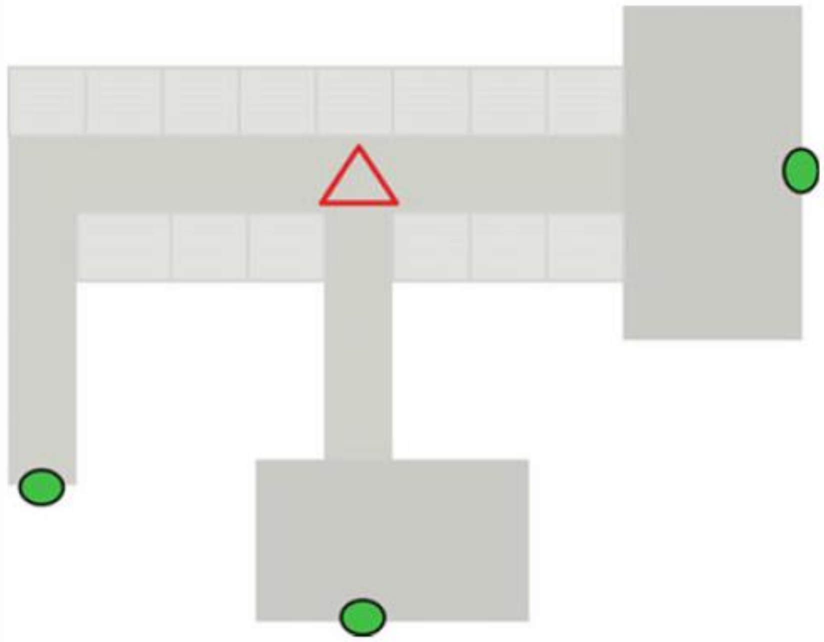
Models Studied

- ASCRIBE
- Durupinar

6 Differences

- Emotion level
- Fear level impacts contagion
- Emotional decay
- Interaction type
- Interaction determination
- Proximity

ESCAPES



Base ESCAPES Fear Model

- Agent inherits max fear level of neighbors
- Maintains level until exiting
- Seeing and hearing distance

The Durupinar Model

- Probability-based model
- Assumes that emotions spread in a manner similar to disease
- Includes only the susceptible and infected states (disregards immunity and recovery)

Model Characteristics

- Dose history of 0 = susceptible
- Dose history of 1.0 = infected
- Other non-zero dose histories imply recovering from infection
- Emotional status is binary
- Emotional thresholds assigned based on psychological studies

Steps of the Model

1. Each agent is assigned an emotional threshold
2. Agents are randomly selected and given doses, which have probabilistic sizes
3. Once magnitude of doses exceeds threshold, agent is infected
4. Infection decays over time back to zero

Pros and Cons

Pros:

- Easy to update dose histories
- Conceptually simple to grasp

Cons:

- Emotional contagion isn’t the same as an epidemic
- Binary emotional state is illogical
- Interactions between agents are not purely random

The ASCRIBE Model

- Developed by VU University researchers
- Emotional level is based on several attribute and agent interactions
- Iterates through agents and updates emotional levels

Model Attributes

Table 2 Phenomena modeled in ESCAPES

Phenomenon	Reference
People forget their entrance	[7]
First-time visitors	[8]
Heightened emotions lead to chaos	[28]
Herding behavior	[14]
Pre-evacuation delay	[15,22]
Families gather before exiting	[24]
Authorities calm people	[28]

Table 3 Aspects related to a sender S, receiver R, or both

Level of the sender's emotion	q_S
Level of the receiver's emotion	q_R
Sender's emotion expression	ϵ_S
Openness for received emotion	δ_R
Strength of the channel from sender to receiver	α_{SR}

Other Characteristics

- Deterministic
- Compare to thermodynamics
  - Heat capacity = emotional stability
  - Heat dissipation = homogenization of emotions
  - Over time, emotional composition of crowd is same

Steps of the Model

1. Interactions with other agents occur
2. Emotional impact of each interaction is calculated using: $\gamma_{SR} = \epsilon_S \cdot \alpha_{SR} \cdot \delta_R$
3. Collective emotional impact is determined
4. Agent emotional level is updated

Pros and Cons

Pros:

- Based on interactions with other agents
- Emergent behavior makes sense

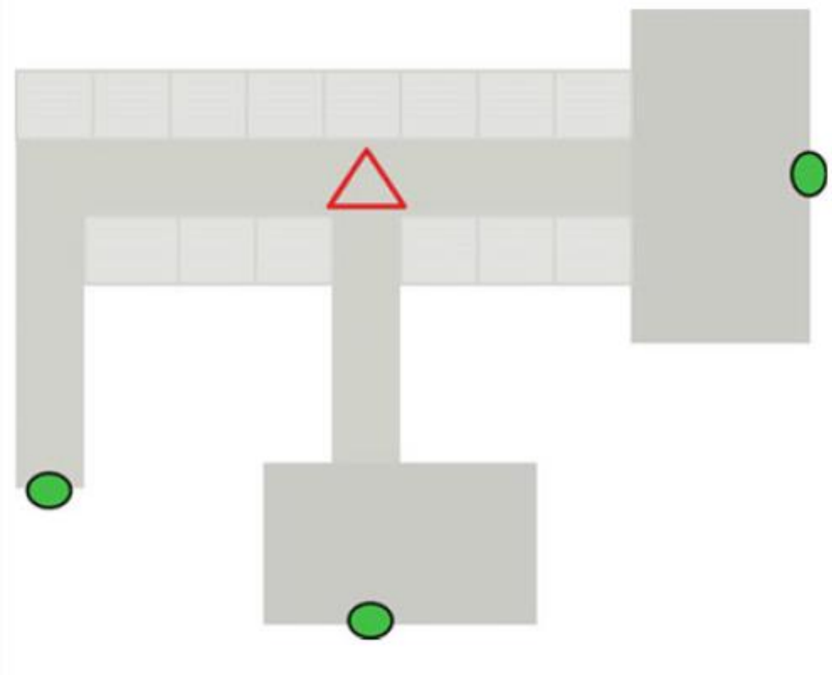
Cons:

- Modeling agent interactions is more complex
- Deterministic nature may not describe erratic emotional behaviors

Simulation Experiments

- ASCRIBE and Durupinar use different mechanisms of contagion
  - To evaluate impact studied the differences running the ESCAPES Simulation
- Perform a sensitivity analysis and look for any trends

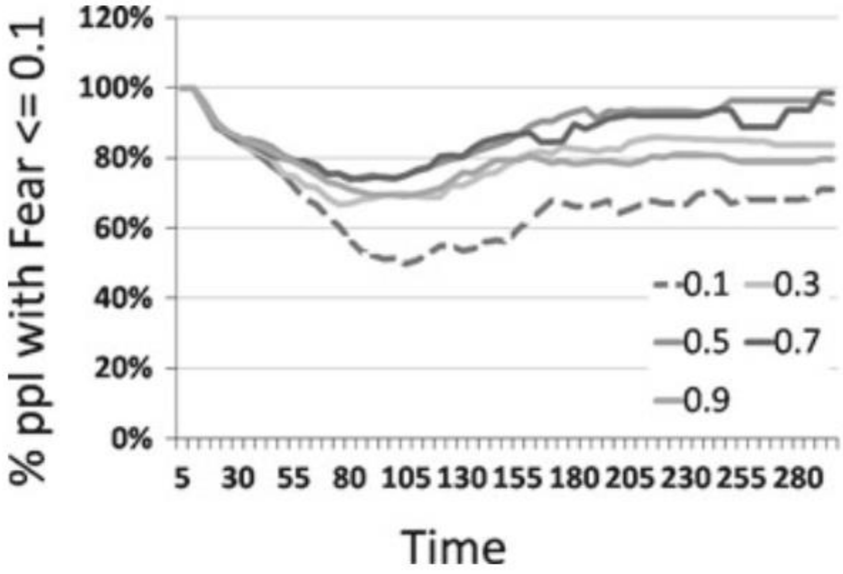
ESCAPES



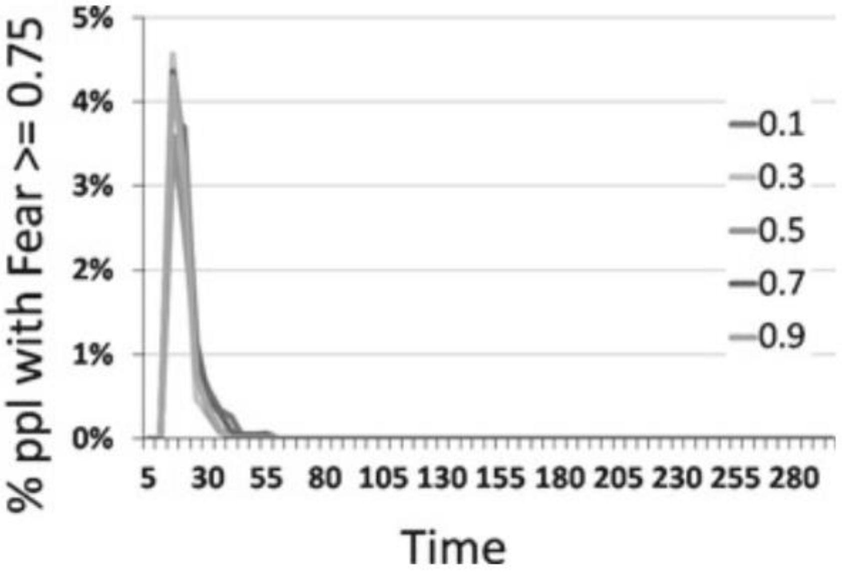
Simulation Experiments

- Same map was used for all experiments
  - 30 trials were run for each setting
  - Panic event at red triangle 15 seconds in
  - 100 normal pedestrians
    - 10 families of 4
  - 10 authority figures that patrol the scenario

ASCRIBE Experiment



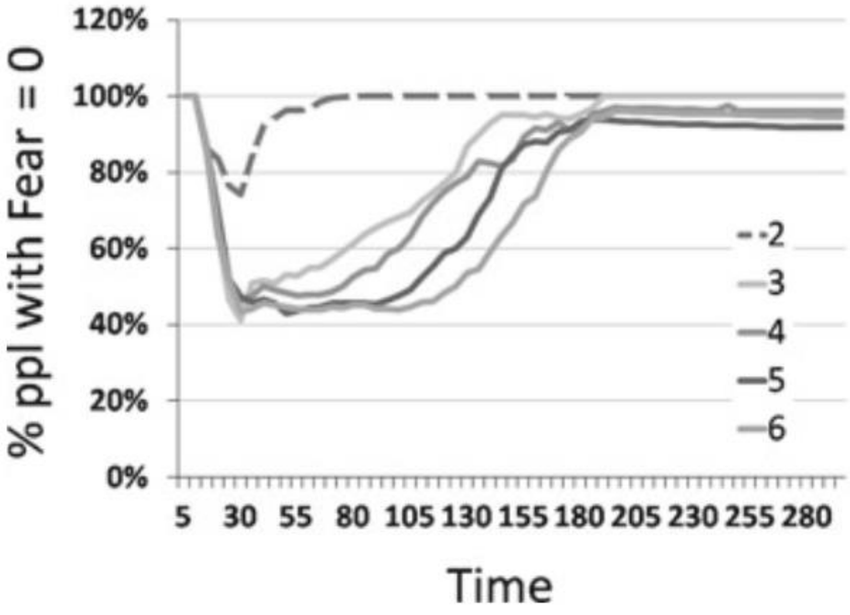
(a) Percent low-fear agents



(b) Percent high-fear agents

Durupinar Experiment

- Extremely low values for K (dose distribution less than 3) cause very little fear transfer



(a) Percent no-fear pedestrians

Simulation Results

- ASCRIBE model has a spike of newly fearful agents directly after the event
  - Given enough time average fear level will be 0
- Durupinar has spikes throughout the simulation
  - possibility of fear transferring indefinitely

Simulation Results

- Binary fear mechanic when set to speed
  - Agents either move very slowly or at max speed
  - Unrealistic
- Durupinar model does not include proximity
  - Agents can receive fear randomly throughout the environment
  - Unrealistic

Simulating Real Life

The Hypothesis (V U University)

Simulating crowd movement as a result of panic with emotional contagion will be more accurate than just a crow movement simulator

The Data

- Mapped the overhead movements of 35 individuals over 15 seconds
  - Picked as point estimates of subsets of the crowd
- Make an environment with similar exits as the video

The Goal

- Map agents movements to the video and find the error
  - Error is in pixel distance
- Find the best set of parameters without contagion.
- Find the best set of parameters with contagion and measure the difference

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Results

- Lower error was achieved with the addition of mental state contagion
  - 18% lower average error rate (.54 over .66)
- Emotional contagion plays an important role in crowd behavior under panic

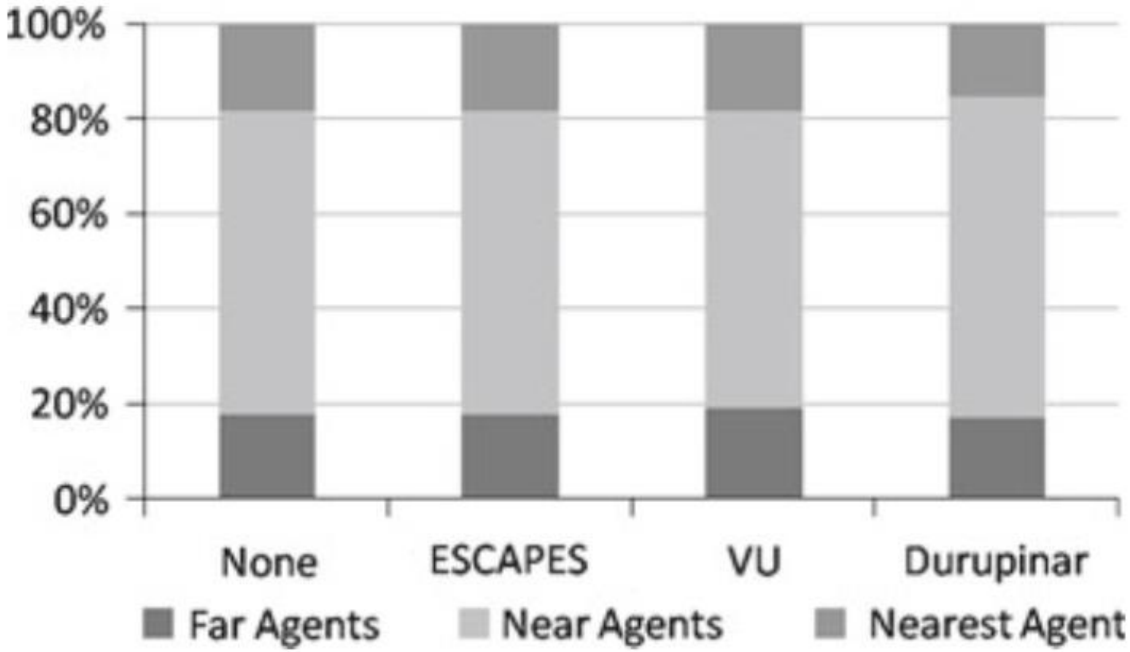
Extending V U Research

- Import the same data set
  - Use no contagion (base)
  - Escapes simulator
  - ASCRIBE model
  - Durupinar model
- Observe which model has the best performance
  - Ran 30 trials for each model

Extending V U Research

- People's directions did not vary based on emotion
    - Thus contagion only has impact on agent speed

Results



100%
80%
60%
40%
20%
0%
None
ESCAPES
VU
Durupinar
Far Agents
Near Agents
Nearest Agent

Results

Model	Overall	Near
(a) Base models		
None	0.375	0.699
ESCAPES	0.375	0.698
ASCRIBE	0.362	0.663
Durupinar	0.383	0.758

Results

Variation	Overall	Near
(c) ASCRIBE variations		
Base	0.362	0.663
Decay	0.363	0.687
No speed	0.387	0.767
No prox	0.414	0.797
Model	**Overall**	**Near**
(d) Durupinar variations		
Base	0.383	0.758
No decay	0.387	0.771
Speed	0.388	0.784
Prox	0.380	0.754

Results

- ASCRIBE model provides the closest match to real world crowd mechanics
  - 14% average difference between Durupinar
  - Error, especially in a longer simulation can have devastating results
    - over two meters of error in a single frame after five minutes

Greece

Greece

- Same setup as Amsterdam
  - 10 people followed for only 4 seconds
  - Results were similar
    - 12% more error in Durupinar

Conclusions

- Issue with the Durupinar model is the method of contagion
  - Is probabilistic with a binary representation of the effect (unrealistic)
- Heat dissipation mechanism is better suited in this situation

Conclusions

- Issues with both models include
  - Unable to repilicate human randomness
    - One person didn’t move
  - Fear could cause people to not move
  - Not enough data
    - Has to be in a natural setting
    - Unethical to replicate in a Lab

Conclusions

- For the future
  - Use virtual worlds to get more data
  - More cameras can capture more video
  - Studies like this will help us recreate more human like agents
    - Necessary for setting up simulations were human like behaviors are necessary

Questions?