Agent-Based Modeling of Crowd Behaviors

Pedestrian crowds assembling at a concert arena

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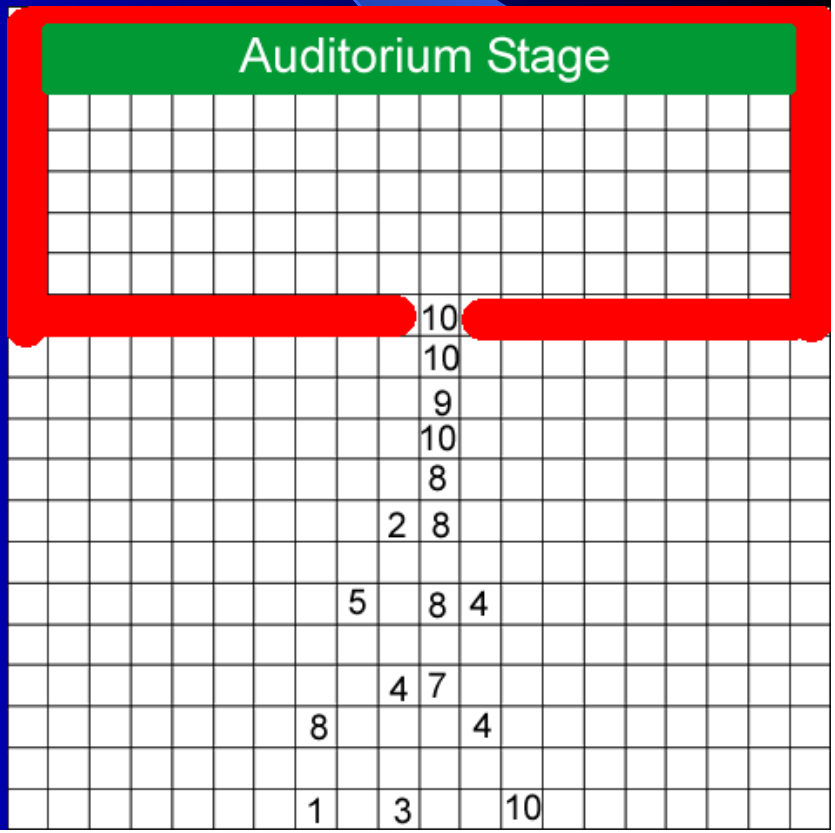
Pedestrian Model Objectives

- Model pedestrians arriving and flowing into a concert auditorium.
- Utilize vector-based pedestrian movement.
- Analyze congestion at entrance gate.
- Analyze time required to fill auditorium.
- Predicting macro-state pedestrian problems.

Problems with the CA Model

- CA models density diffusion and is not suited for individual behaviors.
- Difficult to model the mosh-pit (ignored privacy rules).
- Difficult to model groups traveling together.
- Difficult to model changing pedestrian velocities, necessary to represent hard-core spectators.

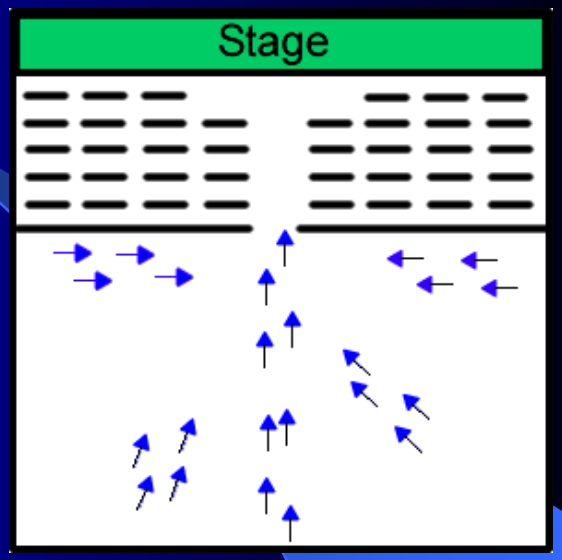


Reason for Using Agents (Advantages)

- Able to assign different characteristics and behaviors to individual pedestrians. (bottom-up)
- Able to model groups of agents traveling and sitting together.
- Able to model aggressive individuals, who have more motivation or different perceptions of space-time (adjusted rules).
- Able to send pedestrians to specific locations (targeted seating or mosh-pit).

Multi Agent System Includes:

- Release Poisson distribution of automata equivalent to the number of tickets sold.
- Pedestrian sized 2-D lattice, regular-grid tessellation (75cm^2).
- Attraction components are early arrival (temporal) and closer seats (spatial).
- Walls, the mosh-pit & collision-tolerances are repulsion components.



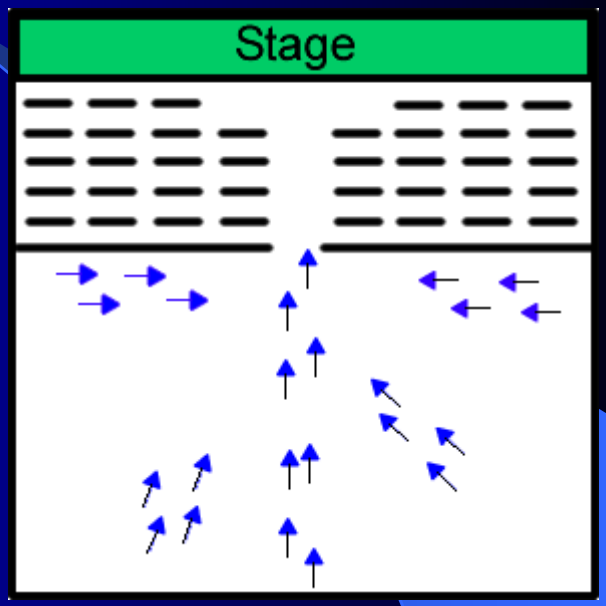
Pedestrian Rules

- A pedestrian prefers to go straight ahead as long as possible, provided the alternative route isn't more attractive.
- A pedestrian will change directions as late as possible.
- A pedestrian will move at a comfortable speed.
- A pedestrian prefers to maintain a buffer distance from other pedestrians and obstacles.

From Helbing & Molnar (1998)

Scales within the Model

Representing the system with multiple scales



Environment Scales & characteristics

1. Seating –Empty, Taken & Reserved
2. Rows – Empty, Partial & Taken
3. Hall Capacity – Percent filled (0-100%)
4. Facility Grounds – Open or Closed

Pedestrian Scales & characteristics

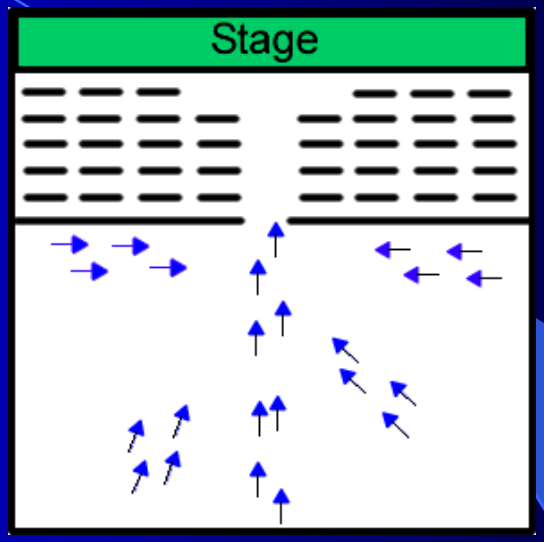
1. Individuals – velocity, motivation, general or seat#
2. Groups – velocity, motivation, general or seat#, groupID
3. Audience – audience type (rock, country, blues, etc.)

The Tipping Points

(facilitate changes in characteristics / states)

Tipping Point changes states

1. What's the unit scale?
2. What's the current state?
3. Apply tipping criteria
4. Observe resulting state



Spatial Example:

1. Seating scale
2. Empty
3. Empty & directly ahead
4. Taken

Temporal Example:

1. Facility scale
2. Closed
3. Tipping @ time 18:00
4. Open

Incorporating GIS / GI-Science

- Nearest-Neighbor Analysis – interaction with neighbors determines how individual automata react. Automata can use gaps for changing lanes or to avoid congestion.
- Shortest Path Analysis
- Buffering Personal Space
- Pedestrian navigation requires the model to represent a real spatial environment (Schelhorn et. al, 1999, pp. 4-5).

Getting the Data

Spatial Data

1. Auditorium & Grounds: Survey-grade GPS
2. Seating, corridors, mosh-pit: Linear measurements

Pedestrian Data

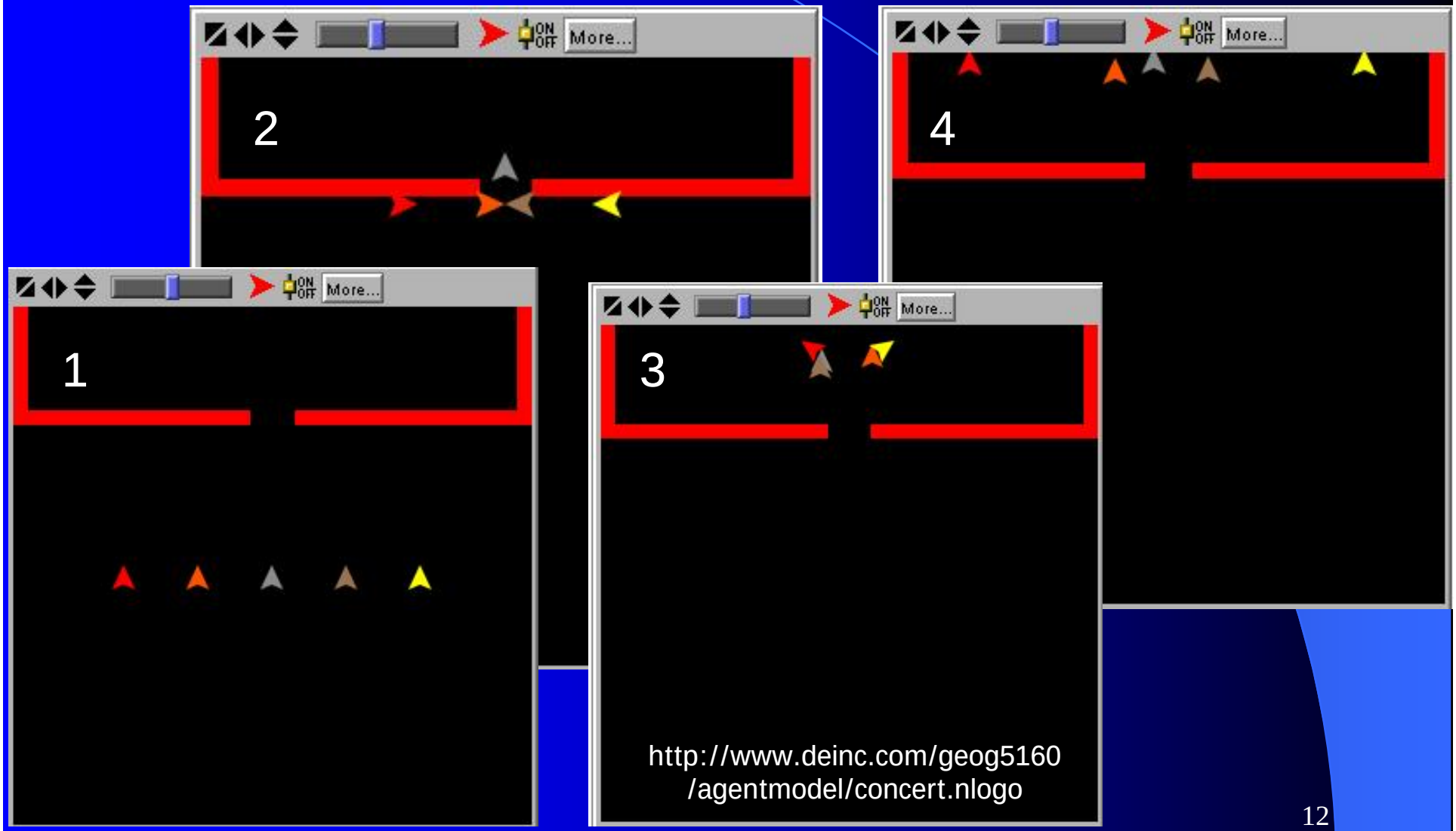
1. Statistical observation
2. Social-economic census (Age, Income)
3. Spectator Survey – incentive is free ticket

Using the Model to Test Theories

This model can be used to analyze real world problems with pedestrian traffic flows, like the expected bottleneck at the admittance gate. Results may be useful in finding alternatives for renovation and new construction or to minimize impediments that restrict pedestrian flows.

The simulations may provide additional support to theories by Helbing & Molnar, who suggest that a broader door doesn't necessarily increase the efficiency of pedestrian flow. Rather, two doors are much more efficient than a single door at double-width (1998, p.6).

My Turtles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http://www.deinc.com/geog5160
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References

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