Computational Modeling of Nonadaptive Crowd Behaviors for Egress Analysis

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WHEN: 10/17/1996

WHERE: Guatemala City, Guatemala

WHAT HAPPENED: About 80 killed in Guatemalan soccer stampede , when fans trying to jam into a soccer stadium stampeded at a World Cup qualifying match.

Source: *http://angel.elte.hu/~panic/disasters/index.html*

WHEN: 04/09/1998

WHERE: Mecca, Saudi Arabia

WHAT HAPPENED:

107 killed in hajj stampede, when a panic erupted after several pilgrims fell off an overpass at Islam's holiest site.

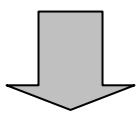
Source: *http://angel.elte.hu/~panic/disasters/index.html*

Outline

1. Motivation
2. Related work
3. Research approach
4. Demo
5. Potential applications

Motivation

- **1990 1,426 died** in stampede in overcrowded pedestrian tunnel. Mecca, Saudi Arabia.
- . . .
- **2004 (Feb 1st) 244 people** were killed by a stampede during “stone the devil”, Mecca, Saudi Arabia.
- **2004 (Feb 5th) 37 people** were killed at a lantern festival, Beijing, China.
- **2004 (Aug 2nd) 283 people** were killed during a supermarket fire, Paraguay.
- **2004 (Dec 31th) 169 people** were killed Buenos Aires Club fire, Argentina.
- **2005 (Jan 25th)** over **200 people** were killed in a stampede, Western India.
- **2005 (Feb 9th)** IKEA London stampede injured 20, store closed, England.



Most victims were killed or injured by *nonadaptive crowd behaviors*, not by the emergencies (such as fire)

Research Questions

- How can we better understand crowd behavio and improve crowd safety in emergencies?
- How can we improve design of safe egress?

Related Work: Theories

- **Panic theories** (Le Bon; McDougall; La Piere; Smelser).
- **Decision-Making theories** (Mintz; Brown).
- **Distribution of urgency levels theory** (Kelly, Condry, Dahlke, and Hill).

No coherent and complete theory on the subject of crowd behaviors (Chertkoff & Kushigian, 1999).

- Many factors ignored (crowd density?).
- Contradictions (rational versus irrational decision process?)

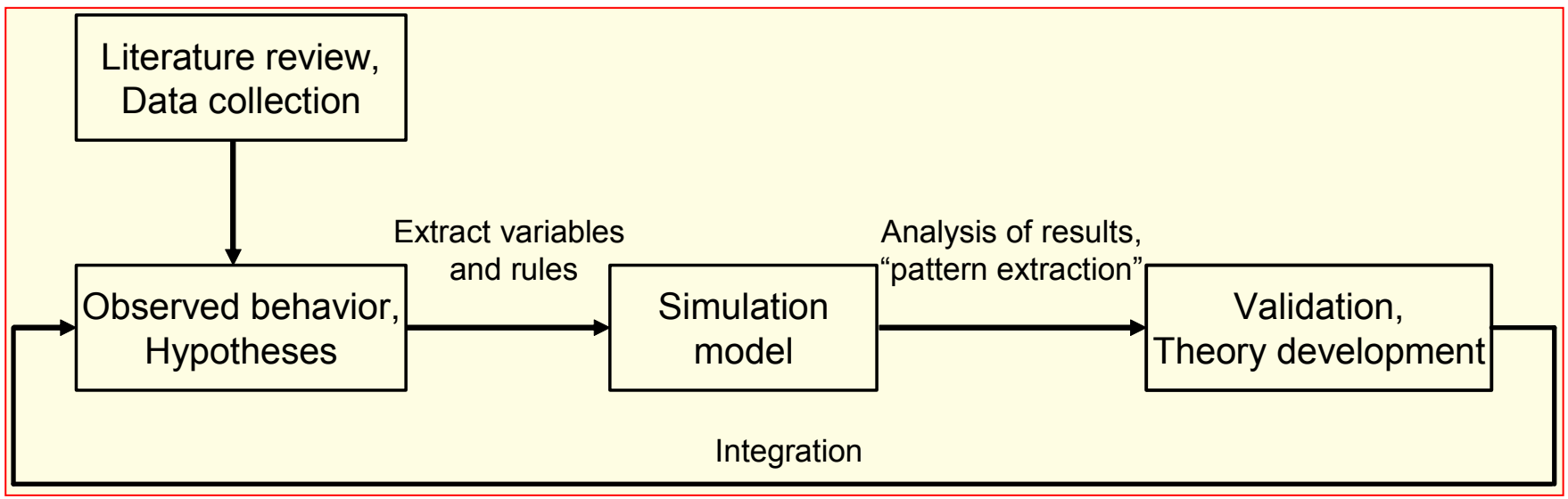
Related Work: Some Existing Computational Models

- Matrix systems
  - Egress (1991 – present, AEA technology)
  - Pedroute (2000, London Underground Limited)
  - Simulex (1995 – present, IES Ltd, Scotland)
- Emergent systems (multi-agents) – bottom up approach
  - VEgAS
  - Legion (l999 to present, Crowd Dynamics Limited).
- Fluid or particle systems
  - Exodus (1997 to present, University of Greenwich)
  - Helbing's panic model (2000)

*Typical output: Overall and individual egress times, escape routes.

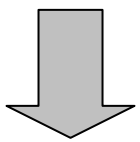
Research Objective and Method

1. Establishing a framework to study human and social behavior under emergency situations.
2. Developing a multi - agent based computational model as the basis to simulate crowd behavior for egress analysis and to capture emergent phenomenon.



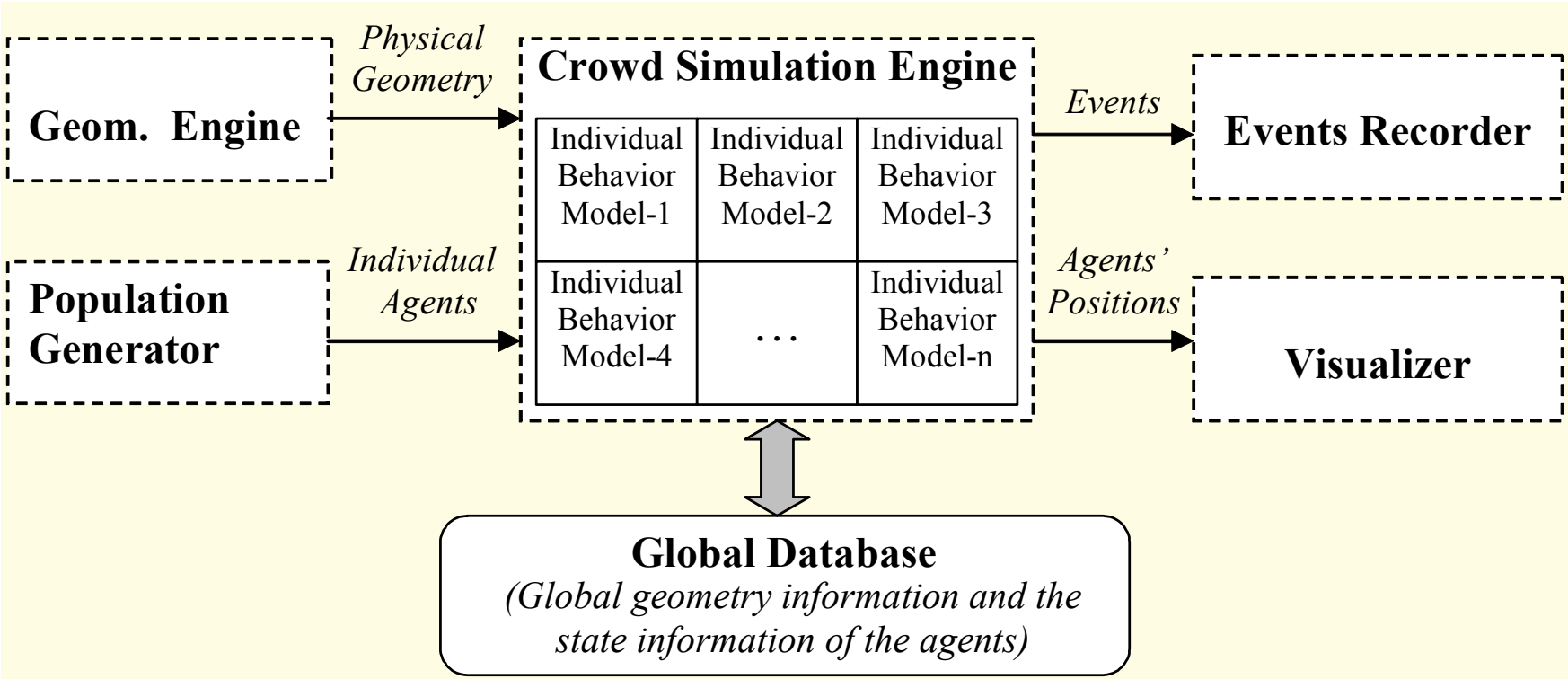
Basic Framework

- Crowd behaviors are human social behaviors, which can be described at three interdependent levels:
  - Individual (decision-making)
  - Interaction among individuals (social interaction)
  - Group (crowd and environment)



Multi-agent based framework

System Architecture

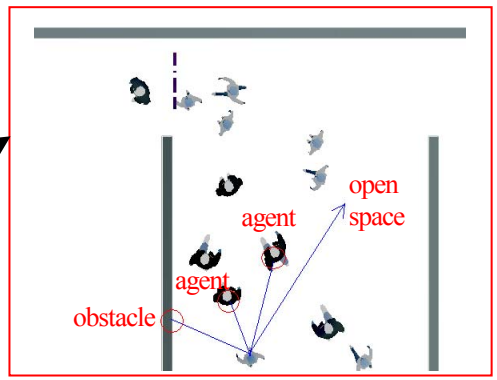


Prototype

- Autonomous agents

Body dimension, mobility, behavior style

Population type



Sensors

Emergent social behavior

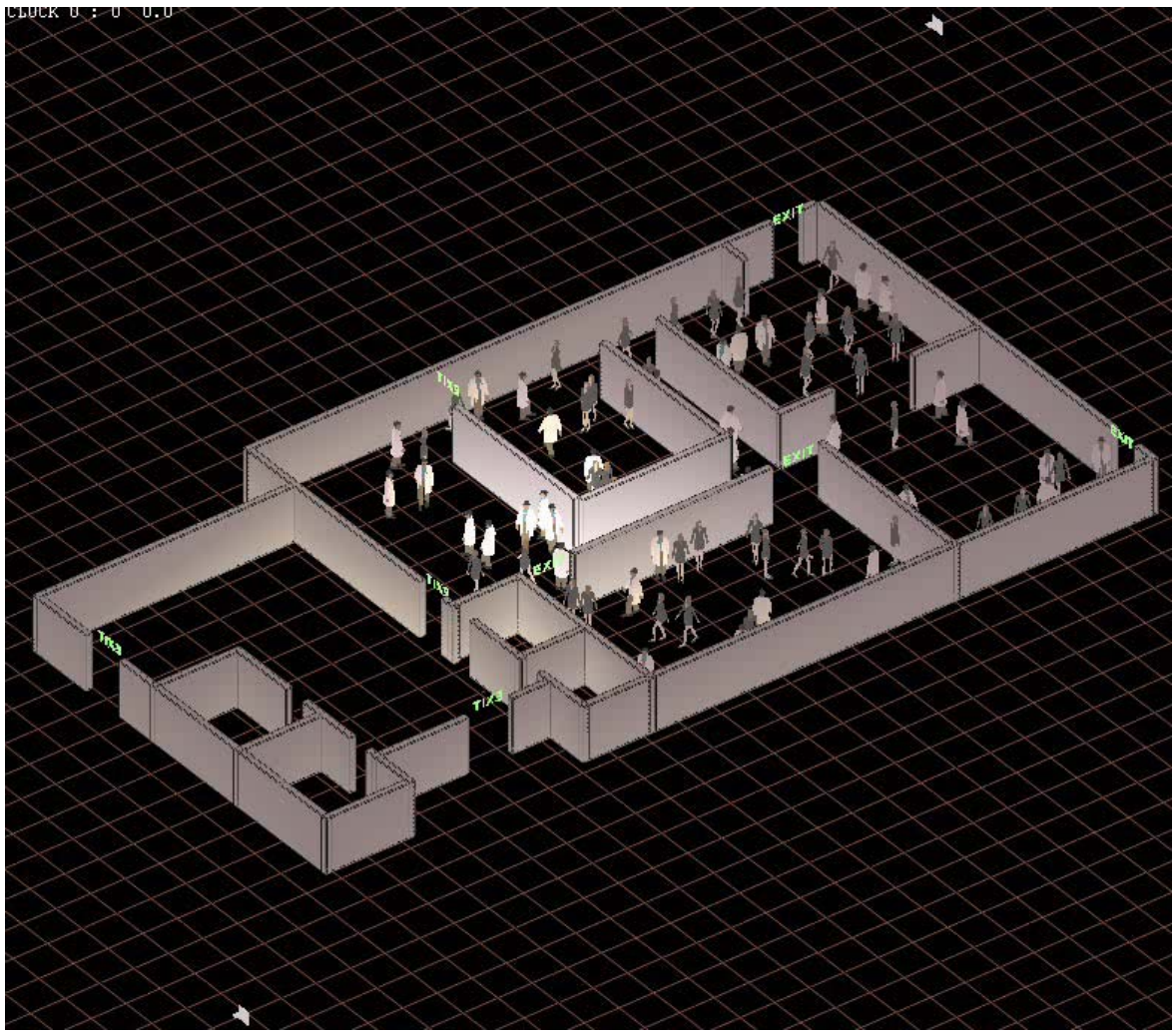
Individual behavior + interaction

Agent behavior

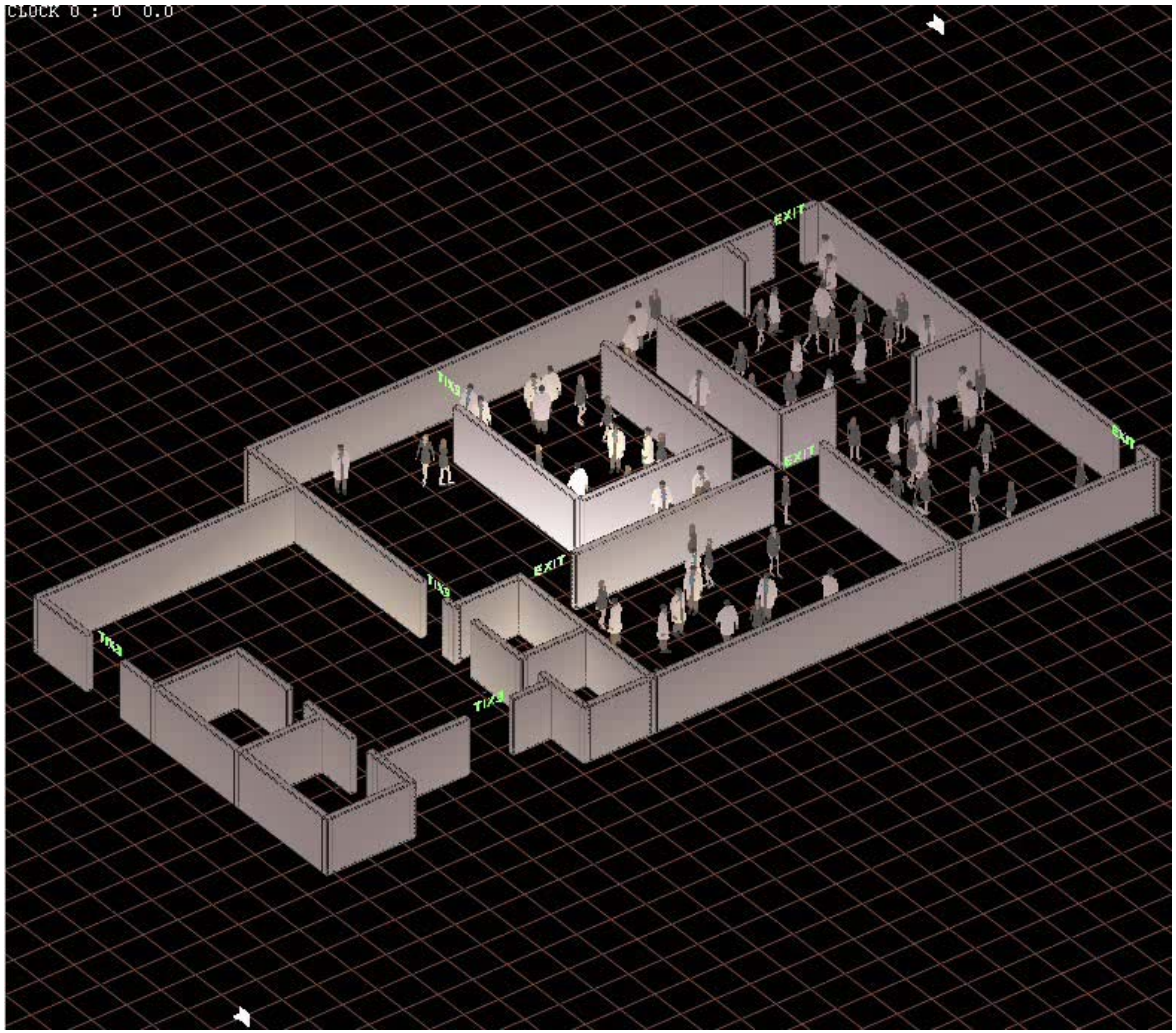
Individual;
Interactions among agents

Decision-making rules

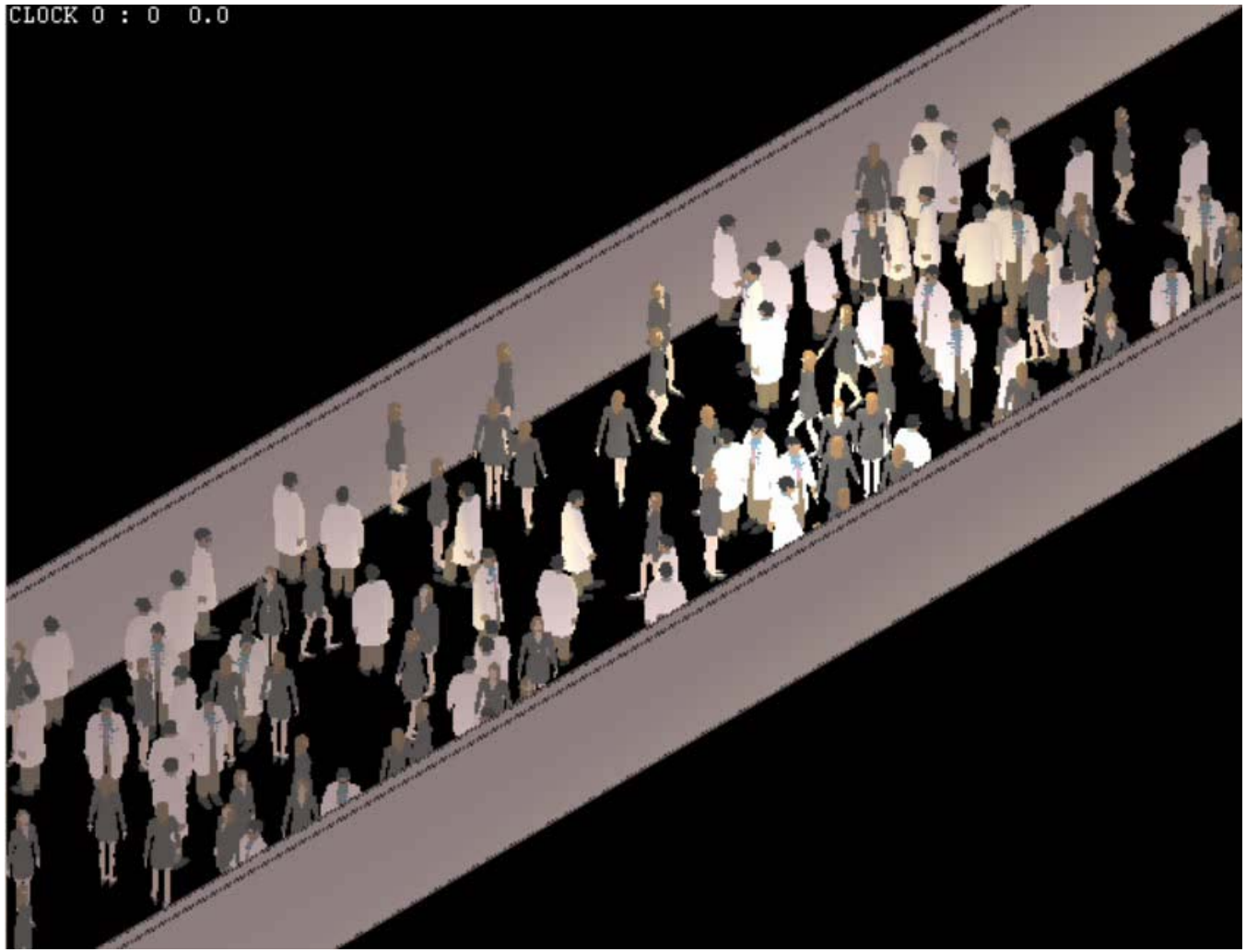
Demo: Competitive Behavior



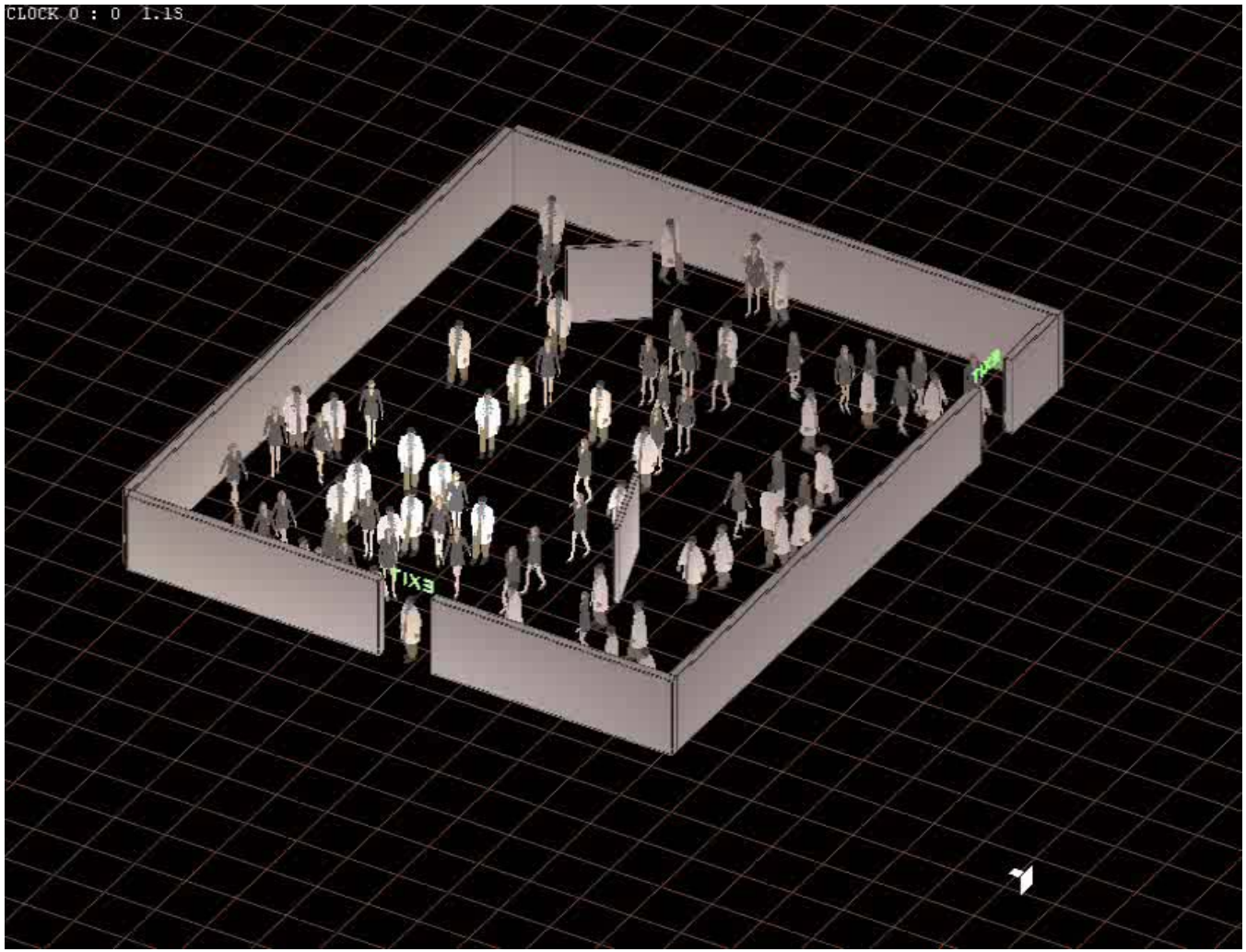
Demo: Queuing behavior



Demo: Bi-directional flow



Demo: Herding behavior



Demo: Subway

Potential Applications

- Assisting building design
- Developing performance-based building code
- Emergency planning
- Crowd planning & management

Acknowledgements:

– This project is partly supported by Center for Integrated Facility Engineering, Stanford University.
– Autodesk, Inc. provided CAD software support.