Crowd Animation

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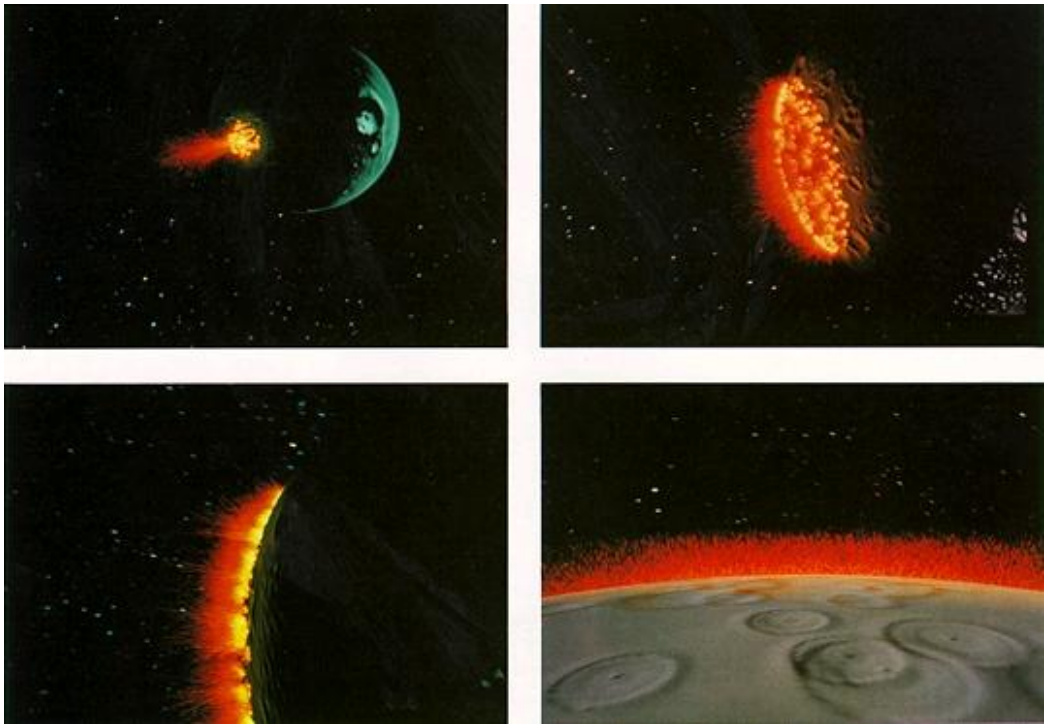
History

- Particle systems
- Flocking systems
- Behavioral systems

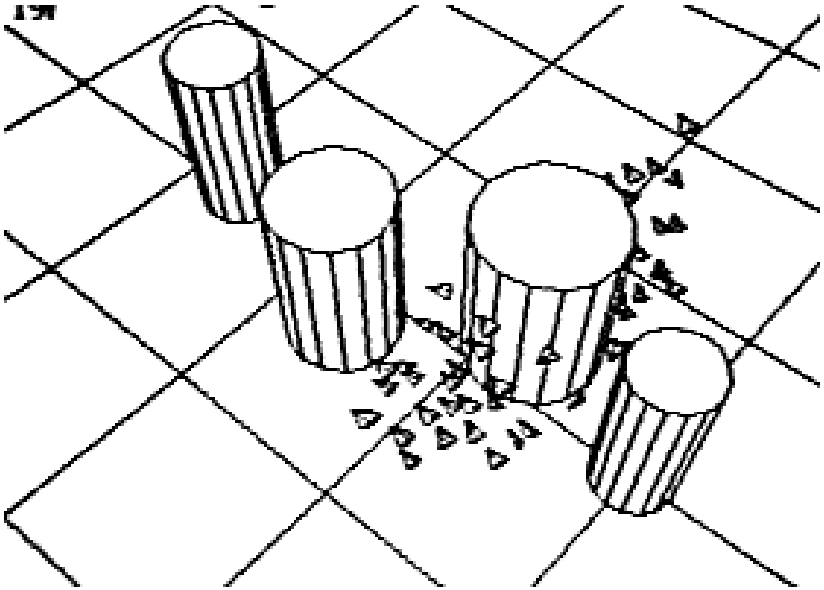
Particle Systems

- Tens of Thousands of members
- No intelligence
- Respond to global forces, including collision reaction

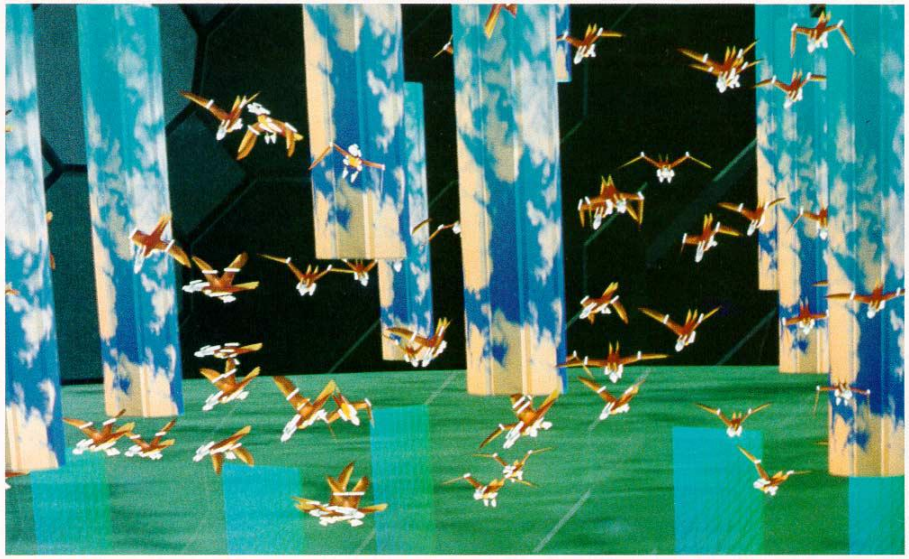


Flocking Systems

- Thousands of members
- Limited intelligence
- Some physical basis
- Collision avoidance
- Local control system



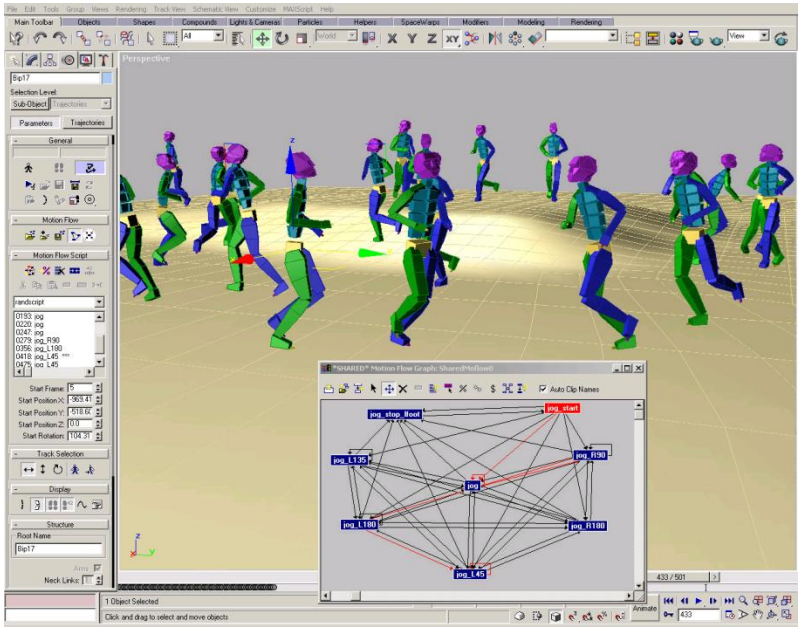
Flocks, Herds, and Schools: A Distributed Behavioral Model



- "Boids" given simple behavioral constraints:
  - Separation
  - Alignment
  - Cohesion
- Often cited as one of the first examples of flocking and emergent behavior
- <video>
- Craig Reynolds 1987

Behavioral Systems

- Tens to thousands of members
- Each member is highly intelligent
- Collision avoidance
- Behavior based on rules



Applications of Crowd Models

- Computer animation
- Games, interactive graphics, and virtual reality
- Robotics
- Aerospace
- Education
- Artificial life
- Art
- Biology
- Physics
- Other areas

Hierarchical Model for Real Time Simulation of Virtual Human Crowds

- Crowds are modeled at varying hierarchical levels:
  - Crowd
  - Groups
  - Agents
- Behavior is controlled by external control, scripted control, and at a low level, the innate behavior
- <videos>
- Soraia Raupp Musse and Daniel Thalmann, 2001

Densely Populated Urban Environments

- Focus is on rendering large crowds with robust collision detection, realistic shading, culling, and pedestrian movement
- Yiorgos Chrysanthou and Franco Tecchia, 2001

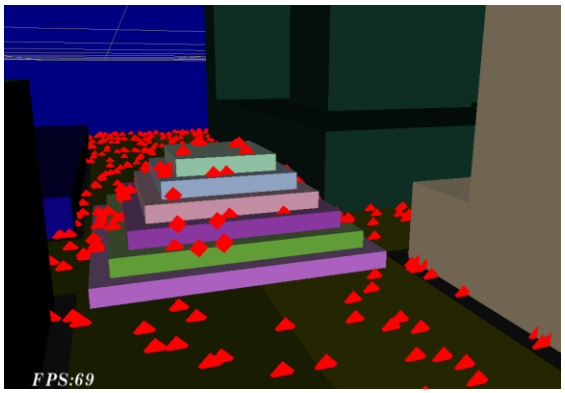
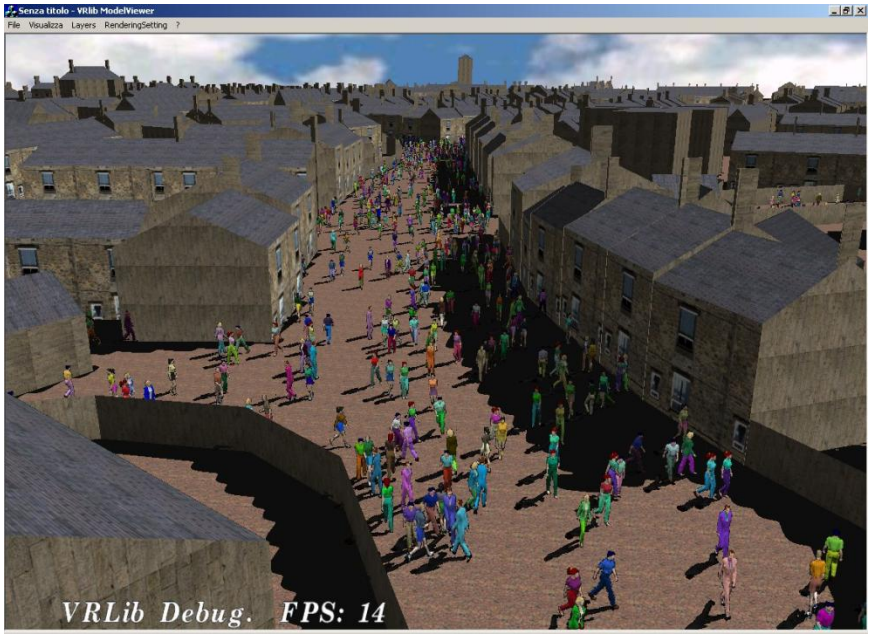


Figure 2. Particles avoid walls but climb over the smaller steps



Scalable Behaviors for Crowd Simulation

- Allows increase in crowd behavioral complexity without a corresponding increase in agent complexity
- Users can dynamically specify crowd behaviors
- Agents have a situation-based control structure
- Mankyu Sung, Michael Gleicher, Stephen Chenney, 2004

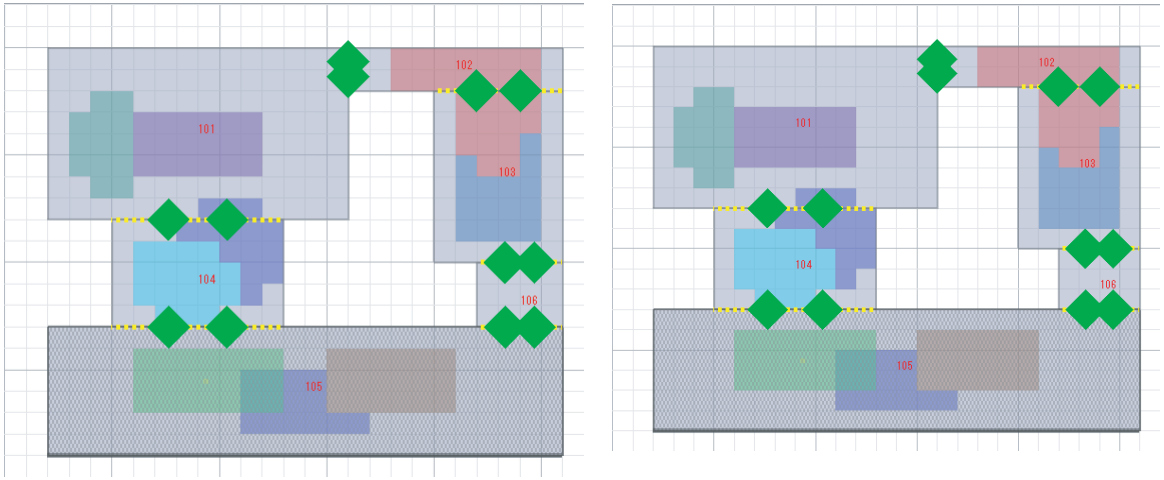
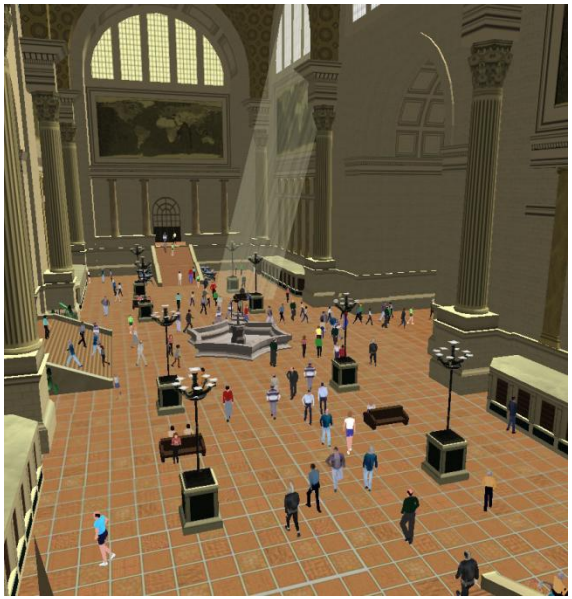


Figure 5: ***Left: Spatial situations can be easily set by drawing*** *directly on the environment. Situation composition can be specied by overlaying regions.* ***Right: Non-spatial situation*** *can be set on the crowd by grouping participants.*

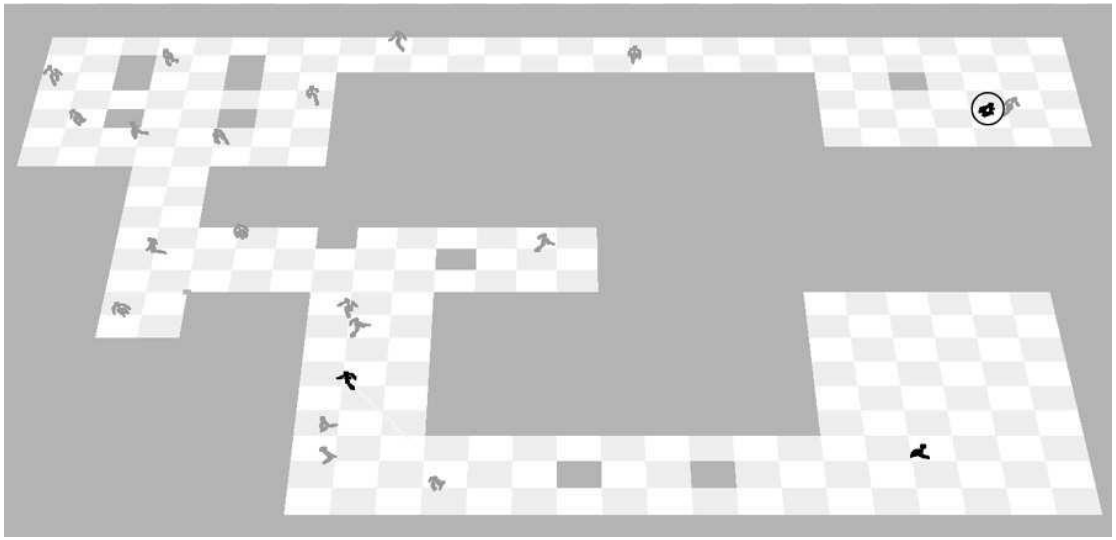
Autonomous Pedestrians

- Tackles the open problem of emulating real pedestrians in urban environments
- Motions controlled at different levels
  - Reactive behaviors
  - Navigational and motivational behaviors
  - Other interesting behaviors
- Information stored in mental states
- Wei Shao and Demetri Terzopoulos, 2005



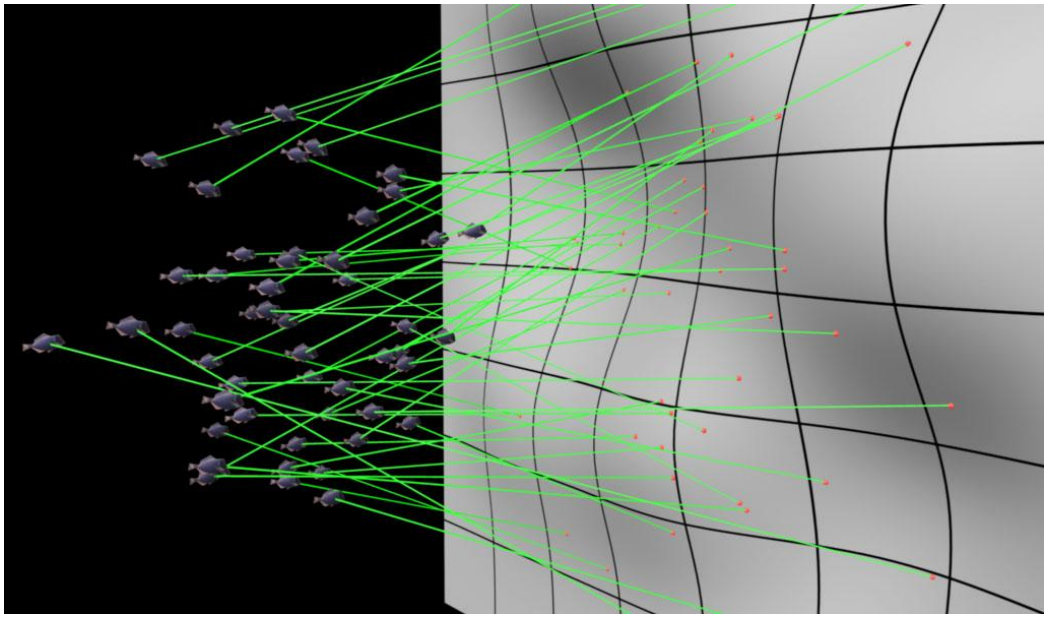
Fast and Accurate Goal-Directed Motion Synthesis for Crowds

- Limit characters to specific postitions
- Generate a space of possible actions with a motion graph which is searched to find the appropriate action
- Mankyu Sung, Lucas Kovar and Michael Gleicher, 2005



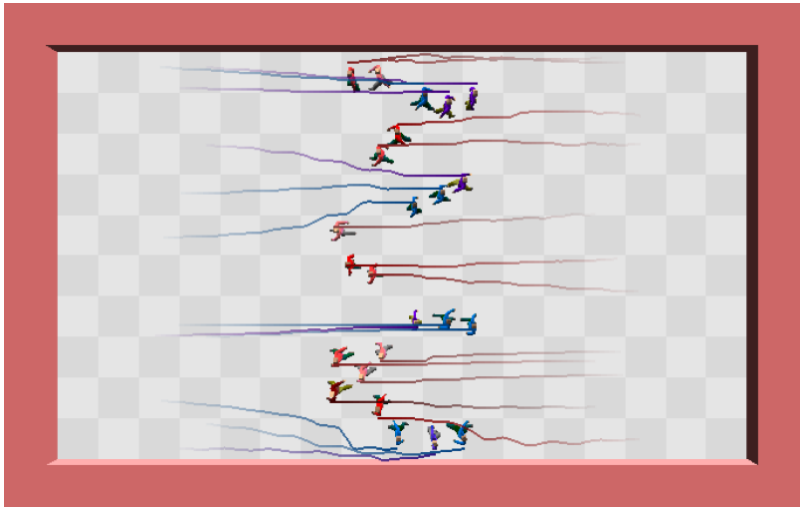
Modeling Behavior in a School of Fish by Fast Synthetic Distributed Vision

- Uses distributed vision rays to lower the cost of computing the fish's perception at each step.
- Adriano Rinaldi, Alessio Malizia, Rick Parent, 2006



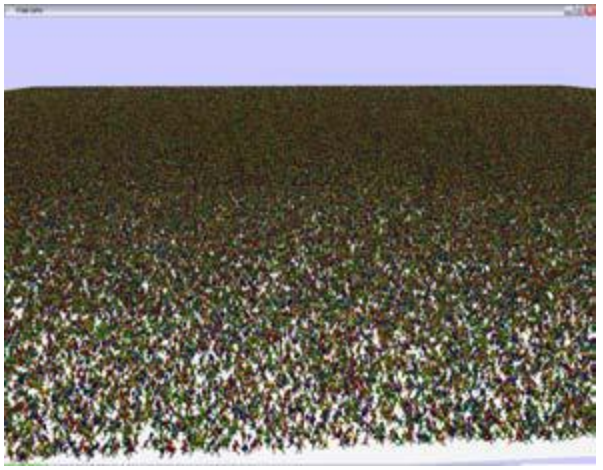
Continuum Crowds

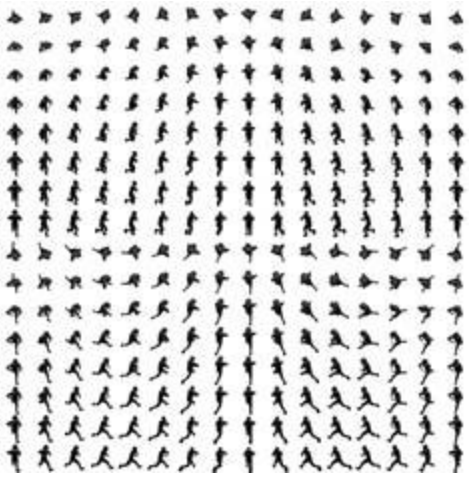
- Environment creates a potential field based on density and topographical speed
- Individual direction based on goals, speed, and discomfort
- New characters can be added at low cost
- <video>
- Adrien Treuille, Seth Cooper, Zoran Popovic in SIGGRAPH 2006



Imposters and pseudo-instancing for the GPU

- Goal: to use the GPU to render as many characters as possible at interactive speed
- Imposters and pseudo-instancing are used to simplify rendering where applicable
- 2^20 characters at 5 fps
- <video>
- Erik Millan and Isaac Rudomin, ACM 2006

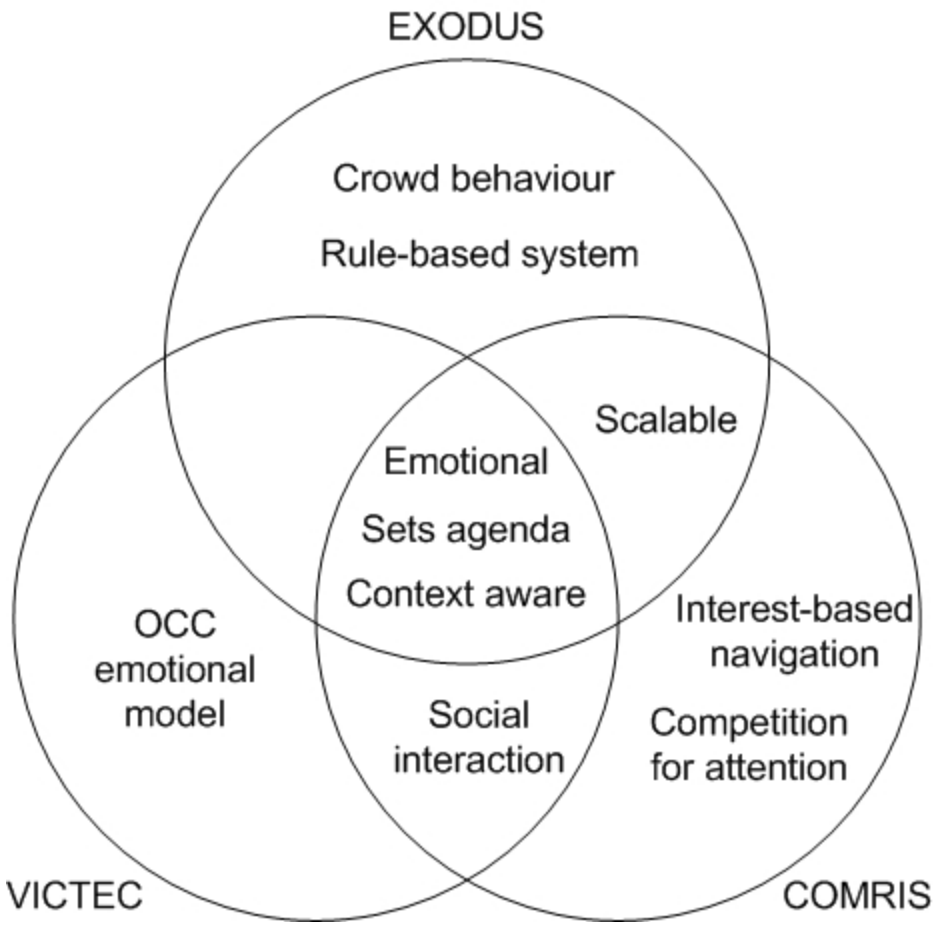




Crowd Creation Pipeline for Games

- Realistic crowds are still too expensive for realistic gaming
- Combine geometry and imposter approach for faster rendering
- Also include pre-simulated cloth sequences
- Model prepping
- Exporting the data
- Rendering
- R. McDonnell, S. Dobbyn and C. O'Sullivan, 2006

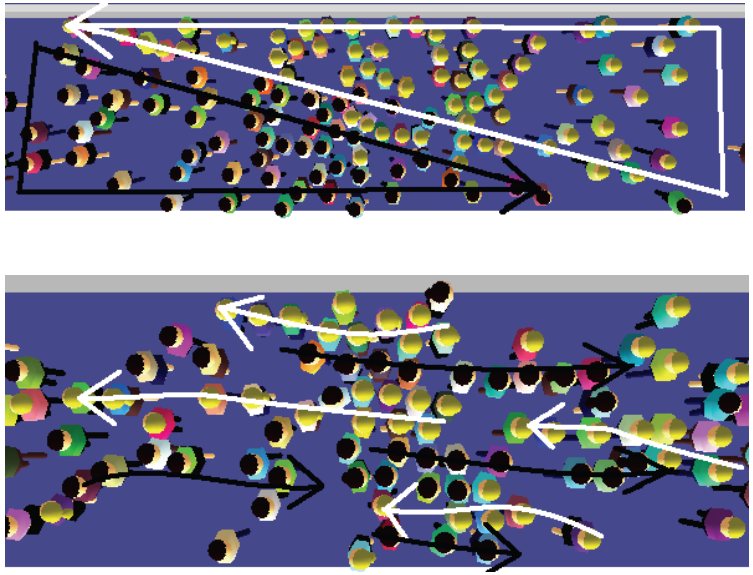
A Conceptual Framework for Modeling Crowd Behavior

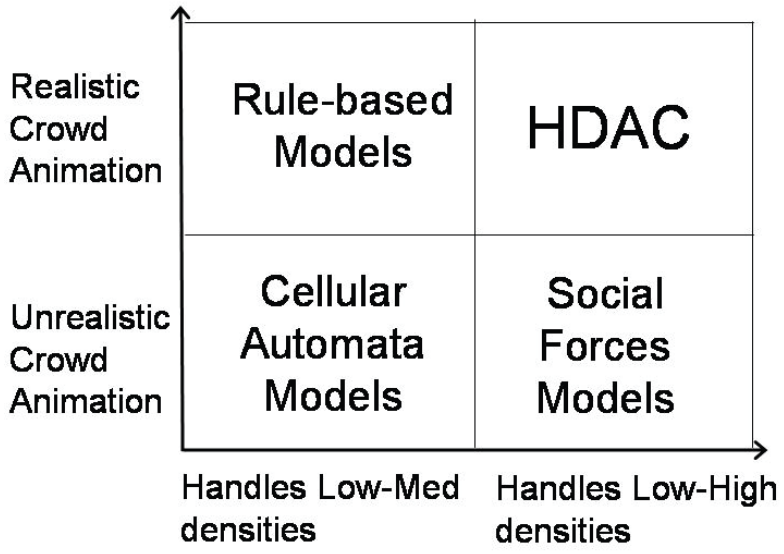


- Priya Dey and David Roberts in SIGSIM 2007
- <escalator video>
- A context-aware agent which is able to dynamically change its desires and needs

Controlling Individual Agents in High-Density Crowd Simulation

- Focus on global wayfinding and local motion
- Take into account agent personalities
- Line forming and character interaction, including pushing
- N. Pelechano, J.M. Allbeck and N.I. Badler, 2007





Massive Software

- The most widely used package for large-scale crowd simulations
- Used in The Lord of the Rings, The Chronicles of Narnia, I, Robot, Happy Feet and others
- Developed by Stephen Regelous <video>

Future Work

- Larger scale crowds at interactive speeds
- Add a wider variety of behaviors for the crowd
- Add more dynamic control
- Balance between agent autonomy and animator control