

Crowd and Traffic Simulation

(and graphics research)

ACM SIGGRAPH

- Special Interest Group on GRAPHics and Interactive Techniques
- The top conference in computer graphics
- Covers five areas: **geometry, rendering, animation, image processing, and modeling.**
- Has several venues: **technical papers, posters, courses, emerging technologies, exhibitions, and even a job fair.**
- Technical papers at:
<http://kesen.realtimerendering.com/sig2013.html>
- Held in the United States and Canada
- Has a counterpart in Asia: SIGGRAPH Asia
- Demo

SCA – Symposium on Computer Animation

- The top symposium on animation
- Held one year in Europe and one year in the United States (together with SIGGRAPH)
- Covers a wide range of animation topics, from characters to physics

I3D – symposium on interactive 3D graphics and games

- Held in the United States
- Covers real-time graphics techniques: mostly rendering and animation
- Very useful for game applications

Game Developers Conference (**GDC**)

- The top conference on game development
- Covers the development topics of different games: **PC games, console games, mobile games, independent games...**
- Covers many areas: **graphics, AI, art, audio...**
- The counterpart in Europe: GDC Europe
- Also has tutorial sessions and job fair

Crowd modeling applications

Entertainment:

Games

Animation movies

Art

Evaluation:

Architecture

Disaster evacuation

Training:

Virtual reality simulation



Individuals and Crowds

- Individuals are agents
 - Reactive vs. planning
 - Goal vs. need driven
- Groups – set of similar agents
 - Spatially close
 - Like minded (likely to make the same decision)
- Crowds – many individuals, with or without groups
 - Emergent behavior – panic?
 - Non-uniformity – everyone is different
 - Quantity & density – average distance between members

Execution environment

- Real-time / Interactive
 - Simple computations
 - Given n agents, can avoid n^2 or higher algorithms
 - Limit size
- Off-line
 - Can use complex models for behavior
 - Can allow interaction between all agents (n^2)
 - Size limited only by hardware memory and storage

Example 1

Autonomous Pedestrians

Emulating real pedestrians in urban environments

Motions controlled at different levels

- Reactive behaviors
- Navigational and motivational behaviors
- Cognitive behaviors

Information stored in mental states

<http://www.youtube.com/watch?v=cqG7ADSvQ5o>

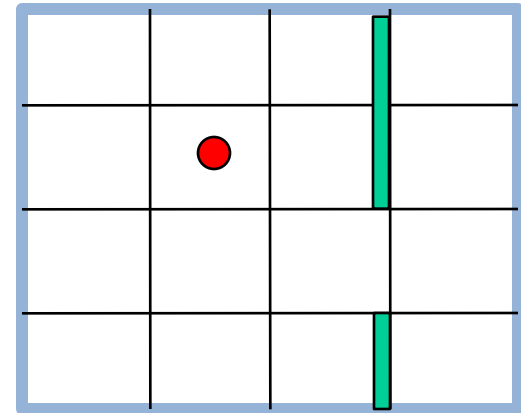
Example 2

- **Aggregate Dynamics for Dense Crowd Simulation**
- <https://www.youtube.com/watch?v=pqBSNAOsMDc>

Spatial Organization: How the space is defined?

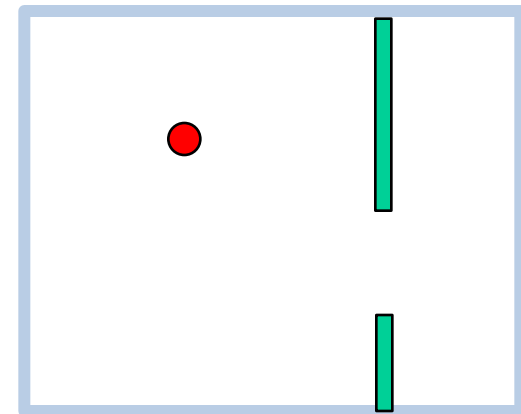
Cellular decomposition:

- Regular 2D grid
- Adjacency accessible
- Density limited
- Cells define obstructions



Continuous space:

- Step in any direction
- Need to decipher obstructions
- Perception needed



Navigation: How an agent moves?

- Fluid flow
 - Density fields, velocity fields
- Particle systems
 - Individual agents make decisions independently
- Flocks
 - Agents will be influenced by others
- Rule-Based
- Perception and cognitive model

Panic & Congestion handling

- Personal space
 - Distance to the neighbors
- Danger awareness
 - How close the danger is and how fast are they evacuated
- Exit awareness
 - Panic if there is no way out...

Motion & Navigation

Path planning

Roadmaps

Passing on pathways

Potential fields

Forming & maintaining subgroups

Recent papers on crowd simulation

- Simulating Heterogeneous Crowd Behaviors Using Personality Trait Theory
<http://gamma.cs.unc.edu/personality/>
- Environment-aware Real-time Crowd Control
<http://homepages.inf.ed.ac.uk/s0967017/crowdcontrol.html>
- A Synthetic-Vision-Based Steering Approach for Crowd Simulation
<http://www.irisa.fr/mimetic/GENS/jpettre/> (scroll down to find paper and video)

Commercial crowd simulation

MASSIVE <http://www.massivesoftware.com/>

What is Massive?

<http://www.youtube.com/watch?v=U2VaLD3GWAs&feature=related>

LQ1 <http://www.youtube.com/watch?v=W5pNPJAhsBI>

LQ2

<http://www.youtube.com/watch?v=WXqNO9Yi2ZU&feature=relmfu>

Traffic Simulation

- Traffic analysis
 - Predict traffic jams
 - Evaluate road constructions
 - Accidents
- Games
 - Need for speed
 - Simcity...



Traffic Simulation

- Similar to crowd simulation
 - Also has agents (vehicle, not human)
 - Navigation: how to move each vehicle?
- Difference
 - **Movable space:** can only move in lanes (or making lane changes)
 - **Vehicle types**
 - **Moving speed:** acceleration, deceleration
 - **Road conditions:** weather, road under construction...

Traffic Simulation

- Three typical navigation/simulation strategies
 - Macroscopic (fluid flow model)
 - Can handle many vehicles
 - Not accurate when predicting a single vehicle
 - Good for density/jam estimation
 - Microscopic (Particle model)
 - Can estimate the motion of every vehicle nicely
 - Efficiency
 - Good for travel time estimation
 - Mesoscopic
 - A hybrid approach

Microscopic Traffic Simulation Model

- Car Following model
 - Safety distance
 - Desired speed
 - Comfortable braking deceleration
 - Acceleration
 - http://en.wikipedia.org/wiki/Intelligent_driver_model
- Lane changing model
 - Safety distance
 - Emergency: Passing? Exiting?

Examples

- Continuum Traffic Simulation
 - [A macroscopic approach](#)
- Interactive Hybrid Simulation of Large-Scale Traffic
 - [A mesoscopic approach](#)

More Details

- http://en.wikipedia.org/wiki/Traffic_simulation