Interactive Navigation of Multiple Agents in Crowded Environments

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“Autonomous navigation and planning of multiple agents in crowded scenes with stationary and moving obstacles”

- Autonomous navigation
  - No master process that directs everything
- Multiple agents
  - Largest stadiums seat 250,000
- Crowded scenes
  - Complex requirements on navigation
- Dynamic obstacles
  - Anticipate future position of obstacles
“Fast two-level planning method for real-time navigation of many agents in a crowded virtual environment”

- **Preprocessing**
  - Roadmap (graph) of environment with only large static obstacles
  - Compute shortest path in roadmap from agent location to goal

- **Global path planning**
  - Pick a visible node in roadmap from current position of agent
  - Minimize the distance from agent position to goal position
  - Recompute if selected node disappears
Local collision avoidance with Reciprocal Velocity Obstacles

- Neighbor agents are treated as “dynamic obstacles whose future motions are predicted as linear extrapolations of their current velocities”

- Velocity Obstacles assume passive dynamic obstacles
  - Can exhibit oscillating movement when obstacles are active

- Reciprocal Velocity Obstacles assume active dynamic obstacles
  - “Agent $A_i$ does only half the work to avoid a collision with agent $A_j$”

- An agent selects a velocity outside the union of the Reciprocal Velocity Obstacles of the neighbor agents
“Nearly linear function of the number of agents”

- Neighbor selection
  - Only evaluate the Reciprocal Velocity Obstacle of nearby agents
  - Naive quadratic time algorithm that includes neighbors behind agent
- Parallelizable
  - “as long as each agent is able to observe the same environment and the positions and velocities of other agents in the environment”
- Performance
  - 20,000 agents over 16 cores runs in 2 frames per second
  - 5,000 agents over 16 cores runs in 14 frames per second
- Limitation: Can produce unrealistic motion
Oooh! Pictures!
Oooh! More pictures!