Directable Multi-Agent Navigation and Simulation

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Project Proposal

• Authoring very large crowds is challenging
  – Simulating emergent behaviors using agent-based methods is non-trivial
  – Setting up simulations to get desired output is tedious

• Need to develop *real-time* tools for authoring multi-agent simulations
  – Degree of control can vary from scripting individual behaviors to controlling crowd *flows* (macroscopic)
Problem Definition

- User-guided navigation is a step towards directable crowds
  - Top-down approach
  - Provide macroscopic control over navigation of groups of agents using vector fields (flow fields)
  - Specification of emergent behaviors such as formation of lanes and vortices
  - Intuitive UI for editing multi-agent simulations
Previous Work

• Authoring crowd simulations
  – Steering Behaviors for Autonomous Characters [Reynolds 99]
  – CrowdBrush: Interactive Authoring of Real-Time Crowd Scenes [Ulciny 04]
  – Scalable Behaviors for Crowd Simulation [Sung 04]
  – Flow Tiles [Chenney 05]
  – Interactive Control of Large Crowd Navigation in Virtual Environments using Vector Fields [Jin 08]
  – High-Level Path Specification and Group Control [Silveira 08]
  – Group Motion Editing [Kwon 08]

* Massive [MassiveSoftware] has utilities to paint flow fields on terrain to direct crowd flow (http://www.youtube.com/watch?v=e0SlezN-0UU)
Approach

• Design vector fields for user-guided navigation
  – Construct local navigation field for every group of agents (goal-driven)
  – Global vector field specification for the entire scene (lanes, vortices and other movement patterns)

• Use a grid-based approach
  – Solve the Eikonal equation $\| \nabla u(x) \| = C(x)$ on a regular grid using FMM
  – Modify cost function based on user input
  – Parallelization over many cores/GPU
    • A Fast Eikonal Equation Solver for Parallel Systems, Jeong and Whitaker, SIAM-SC 2007

• Flow fields for global navigation + RVO for local collision avoidance!
  – Overall motions not smooth enough (modify RVO penalty criteria)
Novel Aspects

• Designing arbitrary vector fields for authoring multi-agent simulations
• Novel cost function for the Eikonal equation
• Eikonal equation needs to be solved per user-edit and **not** per simulation step
• Intuitive interface for authoring simulations (user mouse gestures, paint-brush like interface etc.)
Project Roadmap

- Incorporate new cost function in FMM based solver
- Develop intuitive UI for editing simulations
- Possibly port to many-cores/GPU based on [Jeong 07] for interactive editing

- Extensions:
  - Tool for higher-level behavior specification (queuing, following, shepherding etc.)
  - Dynamic flow fields
  - Data-driven crowds
Questions?