Adding Sociality to Virtual Pedestrian Groups

Speaker: Norman Jaklin

Social Groups and Navigation (SGN)

November 14, 2015
Work of our Group: Navigation of Autonomous Virtual Agents

Research involves
- Crowd simulation
- Motion planning
- Navigation meshes
- Computational geometry
- Animation
- ...

Application areas are
- Crowd management for real-life mass events
- Safety-training software
- Simulation of evacuation scenarios
- Urban city planning
- Entertainment games
- ...

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Context:
Five-level Agent-navigation Planning Hierarchy

- High-level planning
- Global route planning
- Simulation loop
- Route following
- Local movement
- Animation

- start/goal positions
- indicative route
- preferred velocity
- velocity

- Environment
  - Navigation mesh
  - Weighted regions

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An Example Video of our Work
Related Work on Social Groups

Musse and Thalmann 1997
Qui and Hu 2010
Kamphuis and Overmars 2004
Kimmel 2012
Park et al 2012
Huang et al. 2014
Moussaïd et al. 2010
Karamouzas and Overmars 2012
Wu et al. 2013

Existing methods

- either omit social formations
- or model them explicitly
- affect only local navigation planning
Research Question

How can we generate emergent coherence and socially-friendly behavior on both global and local levels without explicitly modeling fixed formations?
The Social Groups and Navigation (SGN) Method

1. Animation
   - Velocity
   - Preferred velocity

2. Local movement
   - Indicative route

3. Route following
   - Start/goal positions

4. Global route planning
   - Simulation loop

5. High-level planning

Environment
- Navigation mesh
- Weighted regions

Visual cues, events

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Basic Settings and Initialization

Input: An environment with obstacles...
Basic Settings and Initialization

...and groups of agents...
Basic Settings and Initialization

...with goal areas.
Assign a leader for each group randomly.
Basic Settings and Initialization

Compute shared global paths for leaders.
Group initialization

- Coordination Mode
  - Group members approach their group leader along individual paths until the group is coherent.

- Group-Walking Mode
  - Members walk as a group based on social forces and visual perception, thus maintaining sociality.

Method terminates

- if there is a new goal area
- if all members reached their goal area

if group is coherent

if group lost its coherence
Leader and Last Member

Based on the curve-length distance along the global path.

Goal
Leader
Last member
Visibility distance $d_{ij}$ for agent $A_{ij}$ (the $j$th member of the $i$th group).
Two Quantitative Metrics

**Coherence**

A group is *coherent* ⇔ leader is in visible distance of the last member.

**Sociality**

A group is *partially social* ⇔ each member has at least one mutually visible other member within a *social threshold distance* $d_{social}$.

A group is *totally social* ⇔ it is partially social and all members are mutually visible.
Example Configurations

Not coherent
Example Configurations

- Leader
- Shared global path
- Last member

Coherent
Example Configurations

\[ d_{social} \leq d_{ij} \]

Not social
Example Configurations

$d_{social} \leq d_{ij}$

Partially social
Example Configurations

$$d_{social} \leq d_{ij}$$

Totally social
Social Forces

- Compute an agent’s acceleration in each simulation step
- Social-force model based on Moussaïd et al. 2010\(^1\), with modifications:
  - Physical-contact forces with other agents
  - Physical-contact forces with obstacles
  - Group force: \( f_{vis} + f_{att} \)
    - \( f_{vis} \): each agent rotates so that its fellow members are visible
    - \( f_{att} \): each agent is attracted towards the centroid of the group

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Experimental Results

Partial Sociality

Bidirectional Corridor

Groups of 2: 80%
Groups of 3: 60%
Groups of 4: 40%

Bottleneck

Groups of 2: 90%
Groups of 3: 70%
Groups of 4: 50%

Corners

Groups of 2: 100%
Groups of 3: 80%
Groups of 4: 60%

Building Evacuation

Groups of 2: 90%
Groups of 3: 70%
Groups of 4: 50%

SGN: Moussaïd et al.

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Experimental Results

Real-Time Performance

- **Average Time Per Step (ms)**
  - Individuals: Serial 230, Parallel 50
  - Groups of 2: Serial 220, Parallel 50
  - Groups of 3: Serial 210, Parallel 50
  - Groups of 4: Serial 200, Parallel 50
  - Mixed: Serial 210, Parallel 50

- **Frame Rate (#steps/sec)**
  - Individuals: Serial 12, Parallel 15
  - Groups of 2: Serial 12, Parallel 15
  - Groups of 3: Serial 12, Parallel 15
  - Groups of 4: Serial 12, Parallel 15
  - Mixed: Serial 12, Parallel 15
Results: Video
Conclusion

- SGN is based on the social-force model by Moussaïd et al 2010.
- SGN introduces social-group behavior on global and local levels.
- SGN yields emergent coherence and socially-friendly formations without explicitly modeling fixed formations.
- SGN can simulate several thousands of agents in real-time when run in parallel.
- SGN can be used in any crowd-simulation framework that handles global path planning and local path following separately.
Future Work

- Extended validation:
  - Comparison with more existing work
  - Comparison with more real-life data
- Long-range visual perception rather than short-range field of view
- Combination with other existing work such as our *Stream* model for coordinating dense crowds
Thank you for your attention!

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