Crowd Simulation based on Self-consciousness Theory

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1. Background

Crowd Simulation

- Films
- Robotics
- Virtual Environment
- Sociology
1. Background

Crowd Simulation

- The process of simulating the movement of a large number of characters

1. Particle Motion
   - Characters are attached to point particles

2. Agent based model
   - Agents are given artificial intelligence
     - Functions, sight, basic motion, energy level, etc.
1. Background

Agent based model

- Simulating the actions and interactions of autonomous agents
- Simple behavioral rules generate complex behavior
- Used in biology, ecology, and social science
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   2.1 Planning
   2.2 Psychology

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2. Related work

Planning

- Existing crowd simulation
  - Find a way to reach a global planning destination (global planning)
  - Avoid obstacles and other agents (local planning)
2. Related work

Planning

- The standard crowd simulation loop is as follows:

  - **Find a path to the goal.**
    - Set the preferred velocity along the direction of the initial segment of the path.
2. Related work

Global + Local Planning

- The standard crowd simulation loop is as follows:

  - **Global Planning**
    - Find a path to the goal. Set the preferred velocity along the direction of the initial segment of the path.

  - **Local collision avoidance**
    - Steer the preferred velocity away from collision with other agents, yielding the actual velocity that the agent moves with.
2. Related work

Planning + Psychology

1. Simulating Heterogeneous Crowd Behaviors Using Personality Trait Theory [Stephen at el., SCA 2011]

2. How the Ocean Personality Model Affects the Perception of Crowds [Duruponar at el., CG&A 2011]

3. Interactive Simulation of Dynamic Crowd Behaviors using General Adaptation Syndrome Theory [Kim at el., I3D 2012]
2. Related work

Planning + Psychology

1. Simulating Heterogeneous Crowd Behaviors Using Personality Trait Theory [Stephen at el., SCA 2011]

- Mapping **Personality trait theory** with RVO
  - Psychoticism, Extraversion, Neuroticism
  - Mapping among adjectives and **PEN** factors

<table>
<thead>
<tr>
<th>Trait</th>
<th>Adjectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychoticism</td>
<td>Aggressive, Impulsive</td>
</tr>
<tr>
<td>Extraversion</td>
<td>Assertive, Active</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>Shy, Tense</td>
</tr>
</tbody>
</table>
2. Related work

Planning + Psychology

2. How the Ocean Personality Model Affects the Perception of Crowds [Funda Duruponar at el., IEEE 2011]

- Mapping the Ocean Personality with HiDAC
  - Openness
  - Conscientiousness
  - Extroversion
  - Agreeableness
  - Neuroticism
2. Related work

Planning + Psychology

3. Interactive Simulation of Dynamic Crowd Behaviors using General Adaptation Syndrome Theory [Kim at el., I3D 2012]

- Mapping General Adaptation Syndrome with RVO
  - Stressor Prototypes
    - Time pressure
    - Area stressors
    - Positional stressors
    - Interpersonal stressors
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   3.2 Self-consciousness Theory
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3. Overview

Observation

- In case of emergency, people don’t do anything to escape when neighbors don’t take an action
- A role of neighbors is important to others
- *Ex*) Subway accident
3. Overview

**Limitation**

- Other researches focus on personality of each agent.
- In the evacuation scene, every agent starts to escape at the same time.
3. Overview

Our goal

- Simulate agent affected by behavior of other neighbors (whether other agents escape or not)
- Agent start to escape at different time
- Agent moves differently when it moves alone or has neighbors nearby it
3. Overview

Overview of our approach

- Integrate planning algorithm with psychological factor
3. Overview

**RVO library**

- [Reciprocal Velocity Obstacles for Real-Time Multi-Agent Navigation, Jur V D Berg at el., ICRA 2008]
- Interactive navigation and planning of large numbers of agents
- Collision-free, Oscillation-free behavior
3. Overview

Parameter of RVO library

- Preferred speed
3. Overview

Parameter of RVO library

- Preferred speed
- Effective radius
3. Overview

Parameter of RVO library

- Preferred speed
- Effective radius
- **Maximum number of neighbors** affecting the local behavior of an agent
3. Overview

Parameter of RVO library

- Preferred speed
- Effective radius
- Maximum number of neighbors affecting the local behavior of an agent
- Maximum distance of neighbors affecting the local behavior of an agent
3. Overview

Parameter of RVO library

- Preferred speed
- Effective radius
- Maximum number of neighbors affecting the local behavior of an agent
- Maximum distance of neighbors affecting the local behavior of an agent
- Planning horizon
3. Overview

Parameter of RVO library

- Preferred speed
- Effective radius
- Maximum number of neighbors affecting the local behavior of an agent
- Maximum distance of neighbors affecting the local behavior of an agent
- Planning horizon
3. Overview

Self-consciousness Theory

- Public Self-consciousness
  - Tendency to focus on external environment or other people nearby

- Private Self-consciousness
  - Tendency to concentrate on one’s inner self and feeling

- Social Anxiety
  - Discomfort or fear when a person is in a social interaction
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   4.1 User study & Mapping
   4.2 Escape Algorithm
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4. Mapping

User study + Mapping

- Intuitive mapping
  - Participants choose tendency for each parameter compared to default value (bigger, similar, or smaller)

- Hand tuning mapping
  - Participants assign parameter values iteratively with observation.
  - Choose the scene when the scene is similar with they are expected.
4. Mapping

Intuitive modeling

- Participants asked which parameter values are suitable for self-conscious agent compared to default agent (level 1 to 5)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>neighborDist</td>
<td>15.0 m</td>
<td>3 – 30 m</td>
</tr>
<tr>
<td>maxNeighors</td>
<td>10</td>
<td>1 – 50</td>
</tr>
<tr>
<td>timeHorizon</td>
<td>10.0 s</td>
<td>1 – 30 s</td>
</tr>
<tr>
<td>radius</td>
<td>2.0 m</td>
<td>0.3 - 2.5 m</td>
</tr>
<tr>
<td>maxSpeed</td>
<td>2.0 m/s</td>
<td>1.2 - 2.2 m/s</td>
</tr>
<tr>
<td>affectNeighbor</td>
<td>3</td>
<td>0 – 10</td>
</tr>
<tr>
<td>escapeProbability</td>
<td>0.4</td>
<td>0 – 1</td>
</tr>
</tbody>
</table>
4. Mapping

Intuitive mapping

- Calculate mean from user study
- Mapping mean to parameter value

Range of parameter

<table>
<thead>
<tr>
<th>Start</th>
<th>Default</th>
<th>?</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
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</tbody>
</table>

Mean

31
4. Mapping

**Escape Algorithm**

- We add escape algorithm for escape scene.

\[
\text{Danger } d \rightarrow \text{Type of agent } f(P_e, N_a) \rightarrow \text{State} \rightarrow \text{Multi-agent Simulation Planning}
\]

\[P_e: \text{ Escape Probability}
\]

\[N_a: \text{ Num of Affected Neighbor}\]
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5. Result

**Escape scene**

- Private S.C. agents start move first then default agents follow them (private: purple, white: default)
5. Result

**Escape scene**

- Default agents start move first then public S.C. agents follow them (public: green, white: default)
5. Result

- Escape time is depends on existence of other agents.

![Escape time for agent type](image)

- **alone**
  - private agents: 56.6
  - public agents: 60.6
- **multiple agents**
  - private agents: 92.2
  - public agents: 110.6

- private agents
- public agents
5. Result

Bystander scene

- Compare ours and PEN modeling [Stephen at el., SCA 2011]
  - Psychoticism, Extraversion, Neuroticism
5. Result

Bystander scene (Ours)

public: green
private: purple
S.A.: red
5. Result

**Bystander scene (PEN model)**

P: yellow
E: sky blue
N: blue
5. Result

- In our model, radius of agents are similar with default
- Some radius of agents are too small in PEN model
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6. Conclusion

**Contribution**

- Simulate agents following Self-consciousness theory
- Behavior of agents depends on existence of other agents nearby
6. Conclusion

Limitation & Future work

- Hard to divide people into three categories
- Considered most representative element in current work

- More detailed simulations that can consider agent with all three elements
Thank you
Sources

Images

- **World war z**: https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcSab3wsFzFsjFyiQ9gvG4_bMwebirbLC3eZKtnvnMq9CDM9-u8X
- **Agent based modeling**: http://www.anylogic.com/upload/medialibrary/b34/b348de15a0a5c94f9c35b60b5040256f.jpg
- **Eye**: http://aldinsjourneytolife.files.wordpress.com/2012/07/self_conscious-1.jpg
- **Modeling**: http://vision.eecs.ucf.edu/ICCVWorkshop/images/im3.jpg
- **Escape**: https://www.openabm.org/files/books/1928/6k-RoomExit4.png

Object retrieval and localization with spatially-constrained similarity measure and k-NN re-ranking [X. Shen et al., CVPR 2012]
Appendix

HiDAC

Object retrieval and localization with spatially-constrained similarity measure and k-NN re-ranking
[X. Shen et al., CVPR 2012]
7. Future work

Mapping Function

Psychology Paper

Public and Private Self-consciousness: Assessment and Theory.
(A Fenigstein et al., CCP 1975)

Real Data (using R)

<table>
<thead>
<tr>
<th>Private</th>
<th>Public</th>
<th>SA</th>
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7. Future work

## Mapping Function

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<th>Classification</th>
<th>Low</th>
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<th>High</th>
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</table>
## 7. Future work

### Mapping Function

<table>
<thead>
<tr>
<th>Level</th>
<th>Neighbor Distance</th>
<th>Max Neighbors</th>
<th>Radius</th>
<th>Prefer Speed</th>
<th>Time Horizon</th>
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<tbody>
<tr>
<td>Private SC</td>
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<tr>
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<td>-40%</td>
<td>+30%</td>
<td>+30%</td>
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<tr>
<td>M</td>
<td>default (15m)</td>
<td>default (10)</td>
<td>default (1m)</td>
<td>default (1.45m/s)</td>
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<tr>
<td>L</td>
<td>+30%</td>
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<td>+40%</td>
<td>-30%</td>
<td>-30%</td>
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<tr>
<td>Public SC</td>
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</tr>
<tr>
<td>H</td>
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<td>-30%</td>
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</tr>
<tr>
<td>M</td>
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<td>default</td>
<td>default</td>
<td>default</td>
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<tr>
<td>L</td>
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<td>+30%</td>
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<td>+40%</td>
</tr>
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<td>Social Anxiety</td>
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</tr>
<tr>
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</table>
Appendix

RVO library

- Reciprocal Velocity Obstacle