Project Update: Pedestrian Simulation Using Behavioral Heuristics

Sanjay Jangir
Under the Guidance of Prof. Shankar Prawesh

July 2, 2025

1 Introduction

This report summarizes progress on my ongoing project to simulate pedestrian movement using behavioral heuristics. The core objective is to model how people navigate crowds and obstacles by making intuitive, human-like decisions—such as waiting, stepping sideways, or following others—rather than relying solely on force-based or optimization models. The project began with the Vadere simulator for rapid prototyping and later transitioned to the more flexible TaiCrowd framework for deeper customization and experimentation.

2 Project Goals

The primary aims of this project are:

- Simulate pedestrian movement using intuitive, rule-based heuristics.
- Reproduce the decision-making hierarchy described by Seitz et al. (2016): Step-or-Wait → Tangential → Sideways → Follower.
- Create realistic environments with walls, bottlenecks, and dynamic agent interactions.
- Compare heuristic-based models with traditional approaches, such as the Optimal Steps Model and Social Force Model.
- Identify limitations and potential improvements of behavioral heuristics in crowd simulation.

3 Progress and Methodology

3.1 Initial Prototyping with Vadere

- Utilized Vadere's built-in Behavioral Heuristics Model for rapid scenario creation.
- Designed simple environments (rooms, exits, obstacles) to observe agent movement.

- Configured pedestrian properties (radius, speed) to reflect real-world variability.
- Experimented with trigger-based behaviors, such as "step and wait" and "forward-only movement."
- **Limitation:** Vadere's heuristic logic proved difficult to customize for advanced behaviors.

3.2 Transition to TaiCrowd

- Switched to TaiCrowd (Python/Taichi) for full control over agent logic.
- Implemented the full decision flow from Seitz et al.:
    1. Attempt to step forward.
    2. If blocked, try a tangential step.
    3. If still blocked, step sideways.
    4. If all fail, follow the agent ahead.
- Developed and debugged the logic hierarchy, ensuring correct transitions between behaviors.
- Visualized agent trajectories and interactions using real-time animations to validate the model.

4 Key Learnings

- Behavioral heuristic models often yield more human-like, adaptive movement patterns than force-based models.
- The same environment can produce markedly different flows depending on the chosen behavioral model.
- Vadere is excellent for structured, repeatable experiments; TaiCrowd excels in custom logic and real-time visualization.
- Gained proficiency in Taichi for high-performance, real-time simulations and debugging.
- Visualization is essential for both validating agent decisions and communicating results.

5 Next Steps

- Expand scenario complexity: Model corridors, intersections, and high-density crowd situations.
- Introduce agent diversity: Vary patience, speed, and decision thresholds to reflect real-world heterogeneity.

- Systematic comparison: Quantitatively compare heuristic-based and traditional models using standardized benchmarks.
- Explore extensions: Integrate attention mechanisms or adaptive learning to enhance realism.
- Validate against real-world data: Compare simulation outputs to empirical pedestrian datasets for model calibration.

6 Tools and References

- **Vadere Simulator:** For initial prototyping and structured experiments.
- **TaiCrowd Framework:** For custom logic, decision hierarchies, and real-time simulation.
- **Languages & Libraries:** Python, Taichi, JSON, Matplotlib, Numpy.
- **References:**
  - Seitz, M.J., Köster, G., & others (2016). "Natural Decision Making in Pedestrian Evacuation." *Safety Science*, 86, 142-154.
  - Additional papers on pedestrian modeling and behavioral heuristics.

7 Broader Impact and Applications

This project's outcomes can have potential applications in:

- **Urban planning:** Designing safer, more efficient pedestrian infrastructure.
- **Event management:** Optimizing crowd control strategies for large gatherings.
- **Robotics:** Informing navigation algorithms for robots operating in human environments.
- **Emergency evacuation:** Improving models for safety analysis and evacuation planning.

8 Closing Thoughts

This project bridges the gap between theoretical models of pedestrian behavior and their real-time implementation. By starting with foundational decision flows and incrementally increasing complexity, I aim to contribute to the development of more human-aware, adaptive pedestrian simulation models. I look forward to further exploration, validation, and innovation in this area.

Prepared by:
Sanjay Jangir
Github: https://github.com/Sanjayj23/Pedestrian-Simulation-Using-Behavioral-Heuristics
B.Tech. Civil Enginnering, July 2025