

Project Proposal: CampusResilience

Modeling Human Evacuation via POMDP in Extreme Weather Scenarios
at the University of Utah

January 29, 2026

1 Introduction

University of Utah's campus is characterized by its unique topography at the foothills of the Wasatch Range. During extreme events such as blizzards or seismic activities, standard navigation becomes a Partially Observable Markov Decision Process (POMDP). Agents (students and staff) must make sequential decisions based on incomplete environmental data, such as obscured pathways due to snow accumulation or structural failures from earthquakes.

2 Problem Formulation (POMDP)

We define the evacuation process as a 7-tuple $(S, A, T, R, \Omega, O, \gamma)$:

- **States (S):** The true configuration of the campus, including road blockages, slope friction coefficients, and snow depth.
- **Actions (A):** Movement vectors, seeking shelter, or waiting for information.
- **Transitions (T):** $P(s'|s, a)$, the probability of reaching state s' given action a in state s .
- **Observations (Ω):** Partially observed data (e.g., visibility limited to 5 meters).
- **Observation Function (O):** $P(o|s', a)$, the probability of perceiving observation o from the true state s' .
- **Reward (R):** A multi-objective function:

$$R = w_s \cdot \text{Survival} - w_t \cdot \text{Time} - w_e \cdot \text{Exposure} \quad (1)$$

3 Proposed Methodology

Inspired by the **AgentSociety** framework, this project focuses on the large-scale interaction of heterogeneous agents.

3.1 GIS and Environmental Modeling

Using `OSMnx`, we will generate a high-fidelity graph of the University of Utah campus. Each edge will incorporate *Slope Data* to simulate the metabolic cost and slip-risk associated with Utah's terrain.

3.2 RL Architecture

Since states are not fully observable, agents will utilize **Deep Recurrent Q-Networks (DRQN)**. The internal LSTM layer will allow agents to maintain a *Belief State* by integrating historical observations to overcome the lack of real-time global information.

4 References

1. **AgentSociety**: Tsinghua University FIB-Lab. *Large-scale Agent-based Society Simulation*. <https://github.com/tsinghua-fib-lab/AgentSociety>
2. Kaelbling, L. P., Littman, M. L., & Cassandra, A. R. (1998). *Planning and acting in partially observable stochastic domains*. Artificial Intelligence.
3. Hausknecht, M., & Stone, P. (2015). *Deep Recurrent Q-Learning for Partially Observable MDPs*. arXiv preprint arXiv:1507.06527.
4. Boeing, G. (2017). *OSMnx: New methods for acquiring, organizing, visualizing, and analyzing complex street networks*. Computers, Environment and Urban Systems.