The Robot-Pedestrian Influence Dataset for Learning Distinct Social Navigation Forces

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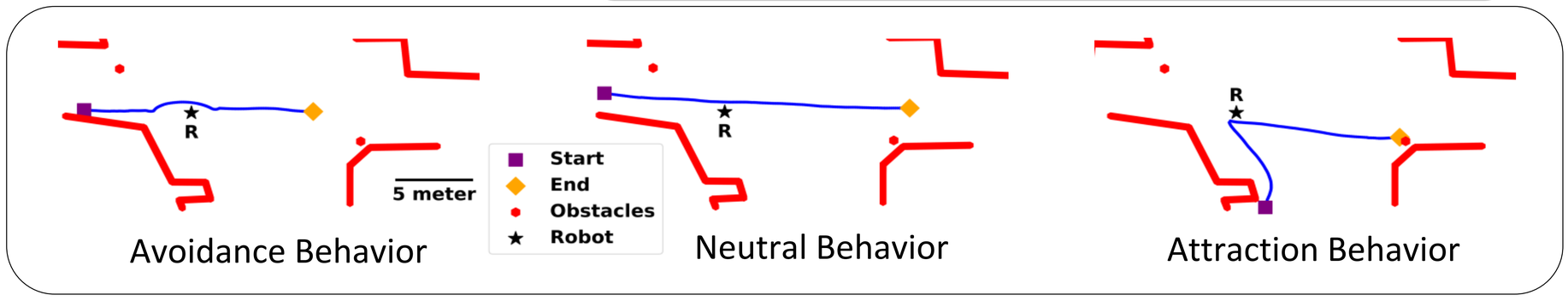
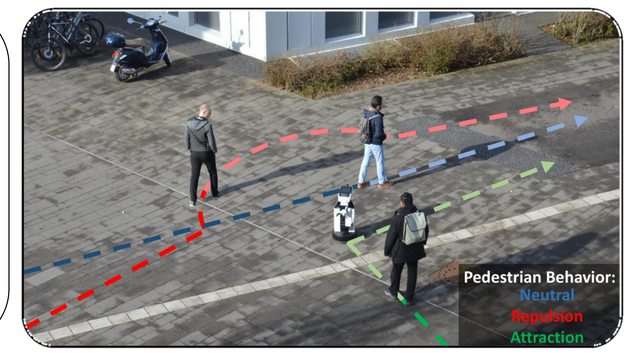
Overview





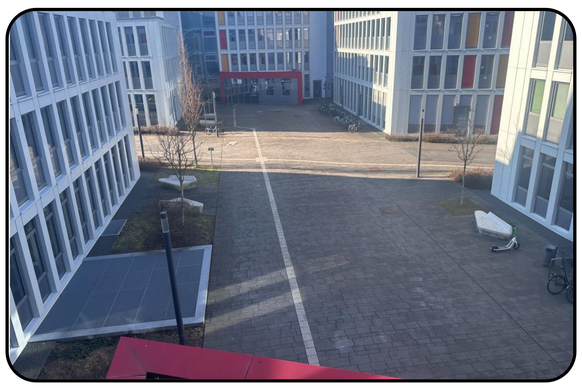
Motivation:

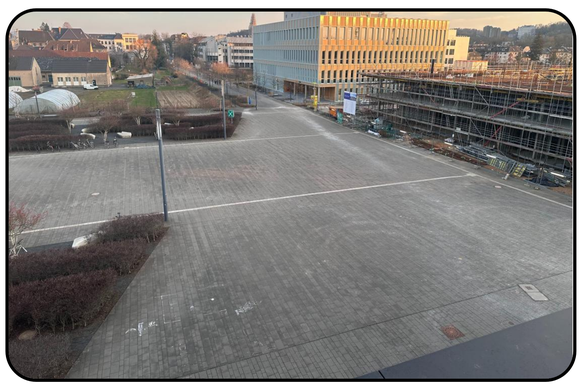
- Pedestrians do **not always avoid** robots during navigation but also show **neutrality** towards the robot and even **attraction behavior**
- Existing datasets do not that clearly capture or annotate these various reactions of pedestrians to robots
- We need to learn these pedestrian behaviors to enable robots to reason about them

Our Approach:

- Collection of the **Robot Pedestrian Influence (RPI)** dataset that captures pedestrian reactions to robots (avoidance, neutrality, and attraction) under various situations
- Novel **Neural Social Robot Force Model (NSRFM)** model that enhances traditional social force model for improved pedestrian trajectory prediction
- A pedestrian simulation system for learning and benchmarking robot navigation policies based on the NSRFM

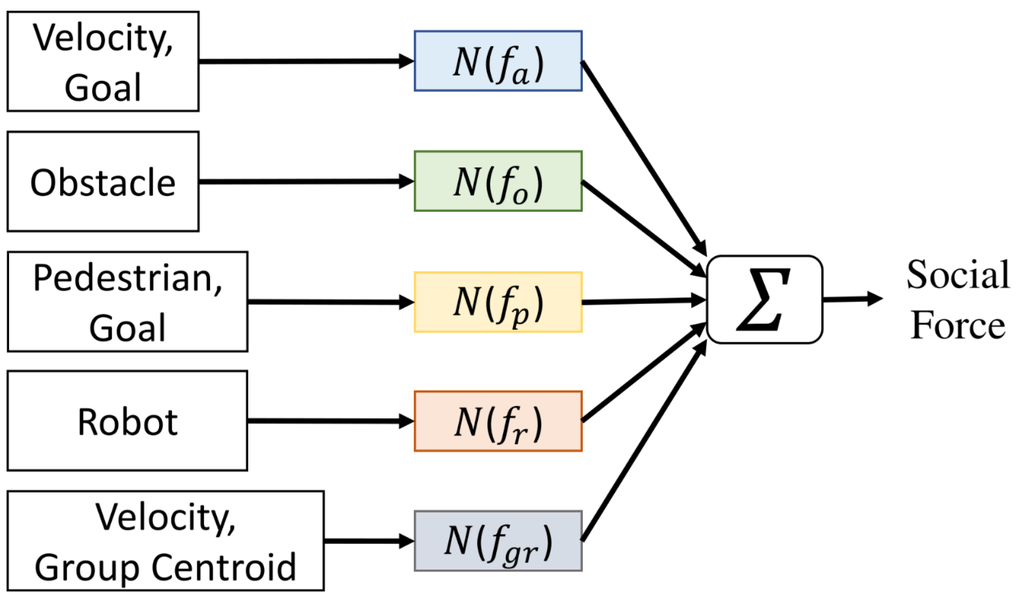
Dataset





- Data collected from 2 outdoor environments
- **Yolov11** model for tracking pedestrians while following **anonymization** protocol
- **18,699 trajectories** recorded in over two weeks
- 3 scenarios:
  - **Pedestrians only (PD)**
  - **Pedestrians with Stationary Robot (PD-SR)**
  - **Pedestrians with a Moving Robot (PD-MR)**

NSRFM



- Five separate neural networks learn and compute the individual force factors of the NSRFM
- Output of all the models is summed to compute the final pedestrian force and subsequent velocity

Results

- Breakdown of pedestrian behavior in our dataset

Robot Type	Attraction (%)	Avoidance (%)	Avg. Distance (m)
HSR (Stationary)	4.39	27.17	3.05
MPO700 (Stationary)	1.6	33.95	3.26
Go1 (Stationary)	7.82	26.39	3.24
Go1 (Moving)	7.96	26.1	3.41

- Comparison of our dataset with state-of-the-art

Dataset	Trajectories	HRI Trajectories	Percentage
ETH	750	0	0 %
JRDB	1,786	28	1.57 %
RPI (Ours)	**18,669**	**3,071**	**16.45 %**

- Comparison of our NSRFM model against state of the art

Model	Average Displacement Error (ADE) ↓		
	ETH	JRDB	RPI (Ours)
NSRFM (with group force)	**0.474**	**0.217**	**0.744**
NSRFM (without group force)	0.506	**0.217**	**0.744**
NSRFM (without robot force)	0.506	0.38	0.753
SRFM [13]	0.616	0.336	1.117
SFM [10]	0.616	0.412	1.118

Summary

- **Large dataset** collected with 3 stationary and moving robots – **Toyota HSR**, **Neobotix MPO700**, and **Unitree Go1**
- **Significantly more trajectories** and **human interactions** in the introduced dataset compared to **ETH** and **JRDB** datasets
- The **NSRFM** model demonstrates **lower ADE** compared to **SFM** and **SRFM** baselines on all the datasets, demonstrating success in learning pedestrian behavior towards robots

Contact

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