Autonomous Human-aware Navigation in Dense Crowds

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Introduction

Motivation: Navigate Like Human
70% of humans tend to form interactive groups in social environments[1]. Can robots learn to follow certain pedestrian etiquette to navigate based on its understanding of social interactions among pedestrians?

Problem Definition
Given trajectories of observed pedestrians \( X = \{ X_1, X_2, ..., X_n \} \), and the target agent’s goal \( y_i \), predict the future trajectory \( Y_i \) of the target agent. The input trajectory of an agent \( j \) is defined as \( X_j = (x_j, y_j) \) from time steps \( t = 1, 2, ..., t_{max} \) and the future trajectory (ground truth) as \( Y_j = (x_j', y_j') \) from time steps \( t = t_{max} + 1, 2, ..., t_{max} + t_{prediction} \).

Definition of Socially Compliant Behaviors[2]
- **Comfort** is the absence of annoyance and stress for humans in interaction with robots.
- **Naturalness** is the similarity between robots and humans in low level behavior patterns.
- **Sociability** is the adherence to explicit social conventions.

Our Contribution
- A socially-aware path planning model based on Social-GAN[3], leveraging public trajectory-prediction dataset.
- A physical robot platform covers both the comfort and naturalness aspects.

Method

Understand pedestrians by extended SFM[1]

\[
\frac{d \hat{f}_t}{dt} = \hat{f}_t + \hat{f}_t' + \hat{f}_t'' + \hat{f}_t'''.
\]

Infer social relationship through coherent motion indicators

Jointly optimize naturalness and comfort from trajectory prediction

- Intention-force generator: Driving force towards the goal
- Group-aware generator: Aggregate interaction force from other agents
- Social discriminator: classification on social acceptability

System Overview

**Social Navigation Planning**

1. pedestrians: tracking, grouping
2. Social Navigation subsystem
3. Way-point
4. State
5. Registred scans
6. Local Planning
7. Navigation path

Segment pedestrians from the prior map in point cloud

**References**


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