NRI: FND: Efficient algorithms for safety guiding mobile robots through spaces populated by humans and mobile intelligent machines and robots

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https://www.nsf.gov/awardsearch/showAward?AWD_ID=1924790&HistoricalAwards=false

Goal: Solve the “unfreezing the robot” problem in path / motion planning when multiple agents (e.g., humans, robots, and intelligent machines) share a common space

Impact: Promote integration of intelligent machines in different aspects of our everyday life (e.g., fulfillment centers, busy crossroads on campus)

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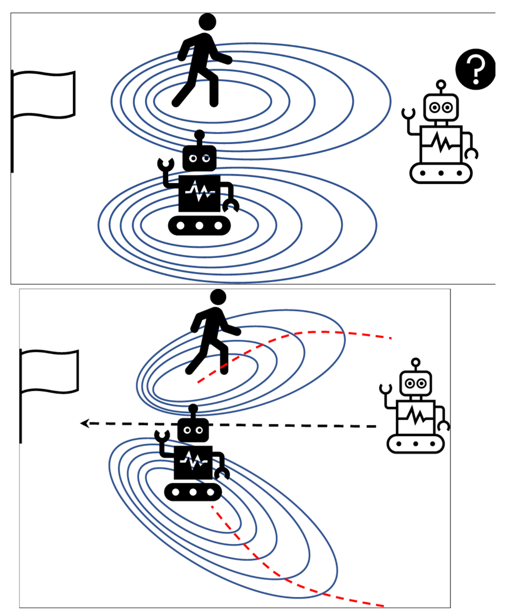
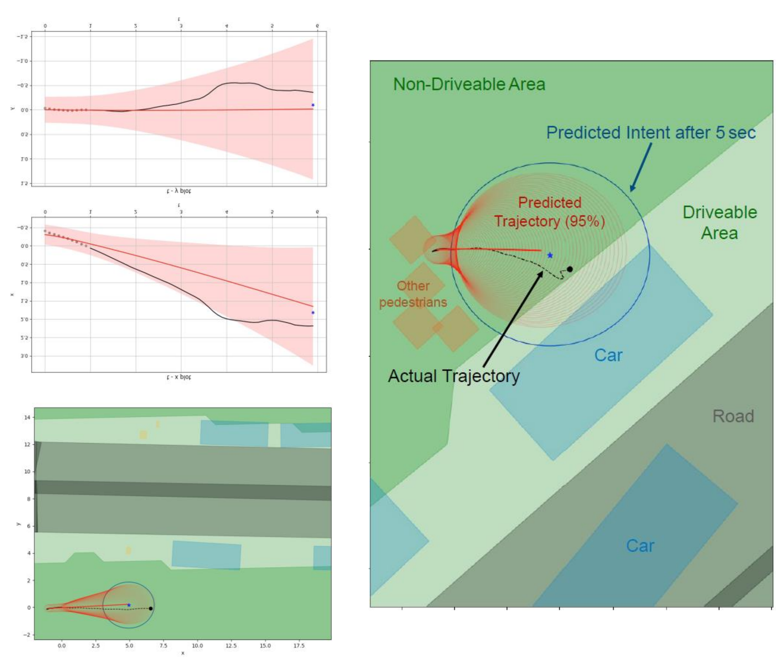
Motivation: Local motion planners that account for the intentions and future trajectories of nearby agents can find solutions to problems where worst-case / robust path planners may fail



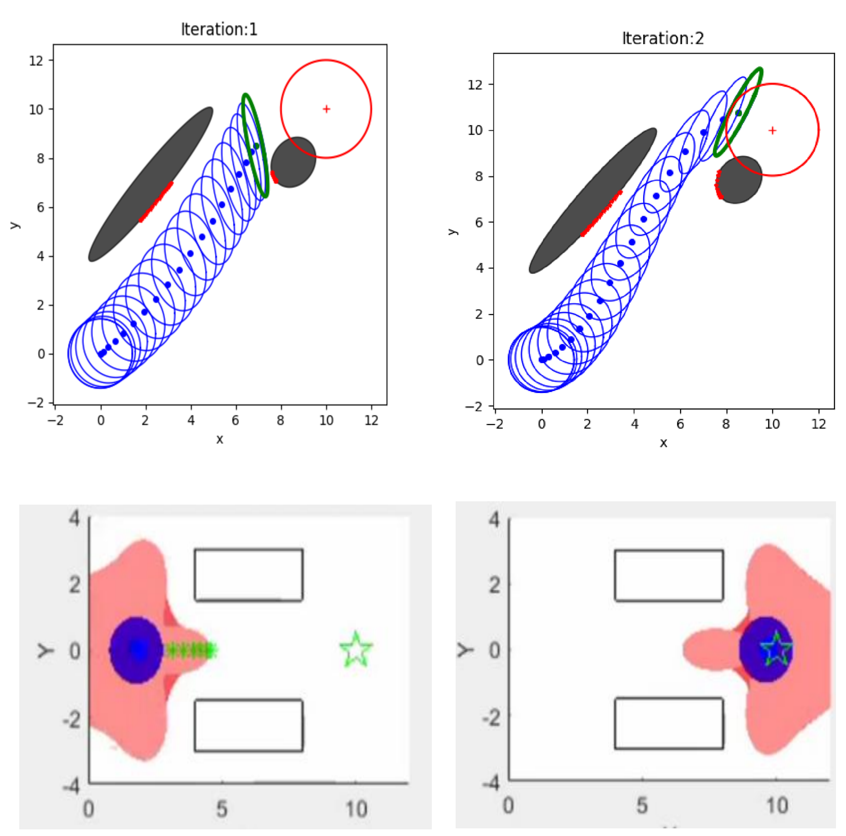
- **Prediction problem:** Use non-parametric regression/estimation to predict the intent and future trajectories of nearby mobile agents/obstacles based on real-time data and construct “probabilistic” obstacles
- **Local motion planning problem:** Compute safe trajectories that keep mobile robots away from probabilistic obstacles (abstractions of nearby mobile agents) using stochastic optimal control methods



- **Prediction Problem:**
- **Given:** Observed trajectories of nearby mobile agents/obstacles and information about environment (roads, obstacles, etc.)
- **Predict Intent**, that is, where the mobile agents / obstacles are expected to be in the imminent future (e.g., goal destinations) using Stochastic Variational Gaussian Processes while incorporating environment information
- **Predict Trajectory** using Multi-Output GP with cubic spline kernel based on real-time data about history of trajectories

Impact to research community in robotics:

- Contributions to robust motion planning for uncertain robotic systems based on prediction of future trajectories of nearby interacting robotic systems and moving obstacles (e.g., manipulation problems in the outer space)
- Contributions to estimation and prediction of intent and trajectories of robotic systems operating in dynamic environments
- Contributions to control of probability distributions of uncertain systems which can find applications in deployment problems for large-scale robotic networks (e.g., swarms of drones)



- Covariance / distribution control algorithms to steer the uncertain state of the ego-robot “close” to its goal destination while remaining far away from probabilistic obstacles (abstractions of nearby agents)
- Distance between probabilistic obstacles and ego-robot is measured in terms of squared Wasserstein distance (or other similar metrics for the distance between probability distributions)
- Compute (probabilistically) safe paths in crowded workspaces based on more accurate descriptions of probabilistic obstacles by using spherical harmonics

Broader impact (society): Ensuring safety and harmonious co-existence of humans and robots is necessary for the smooth integration of robots and intelligent machines into our everyday lives and the workplace of the future.

Broader impact (education & outreach): Several undergraduate and under-represented students will participate in the validation of this research via computer simulations as well as experiments using low-cost platforms in the facilities for robotic research in the PI’s department

Broader impact (economy): The proposed research can have a significant positive impact on national economy by promoting the safe operation of robots working in the same space with humans by preventing collisions that can cause damages and injuries, economic losses or even loss of life.