Candidate Papers:

Search and Rescue Robotics (SAR)

ISAR Publications. (2018). Bomb Detection Robotics using Embedded Controller. Annauniv. https://www.academia.edu/35869232/Bomb_Detection_Robotics_using_Embedded_Controller

Walker, J. (2019, November 21). Search and Rescue Robots – current applications on land, sea, and air. Emerj Artificial Intelligence Research. https://emerj.com/ai-sector-overviews/search-and-rescue-robots-current-applications/

Drew, D. S. (2021). Multi-Agent systems for search and rescue applications. In S. Ferrari & P. Zhu (Eds.), Current Robotics Reports (Vols. 2–189, pp. 189–200) [Journal-article]. https://drl.ece.utah.edu/wp-content/uploads/sites/155/2021/07/drew-reports2021.pdf

Healthcare and Assistive Robotics

Johansson-Pajala, R. M., Gustafsson, C., & Meding, J. (2022). SAR-Connect: A socially assistive robotic system to support activity and social engagement of older adults. International Journal of Environmental Research and Public Health, 19(20), 13409. https://doi.org/10.3390/ijerph192013409

Marmaglio, P., Consolati, D., Amici, C., & Tiboni, M. (2023). Autonomous Vehicles for Healthcare Applications: A review on mobile robotic systems and drones in hospital and clinical environments. Electronics, 12(23), 4791. https://doi.org/10.3390/electronics12234791

Applied Ethics

Wullenkord, R., & Eyssel, F. (2020). Societal and ethical issues in HRI. Current Robotics Reports, 1(3), 85–96. https://doi.org/10.1007/s43154-020-00010-9

Hammond, L., & Belle, V. (2021). Learning tractable probabilistic models for moral responsibility and blame. Data Mining and Knowledge Discovery, 35(2), 621–659. https://doi.org/10.1007/s10618-020-00726-4

Zacharaki, A., Kostavelis, I., Gasteratos, A., & Dokas, I. (2020). Safety bounds in human robot interaction: A survey. Safety Science, 127, 104667. https://doi.org/10.1016/j.ssci.2020.104667

Probabilistic Modeling

Hu, X. (2018). SLAM with the Sphero robot [Thesis, Universitat Politècnica de Catalunya]. In Automatic Control and Robotics. http://www.iri.upc.edu/files/academic/master_thesis/117-Thesis.pdf

Hasani, R., Tanno, R., Davies, T., & Daniel, L. (2024). NavFormer: A transformer architecture for robot target-driven navigation in unknown and dynamic environments. arXiv. https://arxiv.org/pdf/2402.06838

Knox, W. B., Whitaker, B. W., & Thomas, J. (2024). Using exploratory search to learn representations for human preferences. Proceedings of the 32nd ACM Conference on User Modeling, Adaptation and Personalization (UMAP '24). https://doi.org/10.1145/3610978.3640745

Multimodal Probabilistic Model-Based Planning for Human-Robot Interaction. (2018). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/8460766

Wang, Z., Mülling, K., Deisenroth, M. P., Amor, H. B., Vogt, D., Schölkopf, B., & Peters, J. (2013). Probabilistic movement modeling for intention inference in human–robot interaction. The International Journal of Robotics Research, 32(7), 841–858. https://doi.org/10.1177/0278364913478447

Understanding human interaction for probabilistic autonomous navigation using Risk-RRT approach. (2011, September 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/6094496

Oleinikov, A., Soltan, S., Balgabekova, Z., Bemporad, A., & Rubagotti, M. (2024). Scenario-based model predictive control with probabilistic human predictions for human–robot coexistence. Control Engineering Practice, 142, 105769. https://doi.org/10.1016/j.conengprac.2023.105769

Gui, H., Li, M., & Yuan, Z. (2024). A behavioral conditional diffusion probabilistic model for human motion modeling in multi-action mixed human-robot collaboration. Advanced Engineering Informatics, 62(Part B), 102742. https://doi.org/10.1016/j.aei.2024.102742

P. Yu, S. Dong, S. Sheng, L. Feng and M. Kwiatkowska, "Trust-Aware Motion Planning for Human-Robot Collaboration under Distribution Temporal Logic Specifications," 2024 IEEE International Conference on Robotics and Automation (ICRA), Yokohama, Japan, 2024, pp. 12949-12955, doi: 10.1109/ICRA57147.2024.10610874. keywords: {Markov decision processes;Heuristic algorithms;Decision making;Collaboration;Automata;Probabilistic logic;Planning},

State of the Field - Probabilistic Modeling in HRI Applications

SLAM with the Sphero robot

This paper investigated different approaches in Simultaneous Location and Mapping via a single Sphero robot utilizing implementations of a Kalman Filter or Set Theory. They utilized a strategy of wall following, which was successful but limited by the technology on the Sphero. The paper postulated that a more efficient implementation could be derived with better sensor technology and, possibly, more Sphero's working in conjunction, something that our project will investigate.

NavFormer: A transformer architecture for robot target-driven navigation in unknown and dynamic environments.

This paper explored a novel approach to transformer based target driven navigation using a simple RGB camera, as compared to a more typical approach. The approach is split into two aspects, exploration and obstacle (debris, human, robot) avoidance, with training across both used to outperform standard methods in dynamic and unknown environments. While this paper does not directly relate to human-robot-interaction, it sets the stage for the current frontier of what our robot is trying to accomplish and provides insights into reasonable stretch goals and possible future work.

Using exploratory search to learn representations for human preferences.

This paper tackled the issue of choosing how a robot should communicate ideas to a human via symbols/signals by training the robot on data gathered during the process of preferences configuration. The authors trained the robot not only in the robot's signals but also its behavior patterns based on this process and it was shown to be an effective way of ensuring the human understood the robot and even enjoyed it. This paper lays out a possible avenue for better human robot interaction in our project that I would love to investigate further.

Multimodal Probabilistic Model-Based Planning for Human-Robot Interaction.

This paper investigates model-based planning for human robot interaction in a dangerous situation utilizing just a dataset of human behavior to generate the model and produce an appropriate robot policy. The paper concludes that this kind of modeling is potentially viable in conjunction with standard emergency responses/subroutines in order to better respond with uncertainty in human behavior. This paper utilizes probabilistic models to highlight the importance of flexibility in human-robot interaction especially in scenarios with lots of factors and levels of interaction that require quick responses.

Probabilistic movement modeling for intention inference in human–robot interaction.

This paper investigates utilizing probabilistic modeling of human intention as a more effective way to anticipate human behavior. Human behavior is recognized to be typically goal-driven and is then mathematically reduced to a Gaussian model. This paper allows us a view into how to achieve utilizing a swarm of Spheros for mapping and guidance via probabilistic modeling of multi-agent systems involving an unpredictable and mobile human.

Understanding human interaction for probabilistic autonomous navigation using Risk-RRT approach.

This paper investigates how to properly integrate robots utilizing probabilistic autonomous navigation by integrating perceptions of "social disturbance" risk into their probabilistic calculations. Modeling humanity's variety of conscious and unconscious social norms is a problem akin to modeling an environment with multiple unpredictable agents and is thus a sensible addition.

Scenario-based model predictive control with probabilistic human predictions for human–robot coexistence.

This paper explored an enhancement to real-time robot navigation by utilizing scenario based planning via a model predictive control in order to maintain a safe distance with humans. This paper demonstrated how probabilistic human behavior predictions could be effectively integrated into the control strategy, which is integral to our project of swarm robots.

A behavioral conditional diffusion probabilistic model for human motion modeling in multi-action mixed human-robot collaboration.

This paper describes a novel way to manage human robot coexistence in the same space by leveraging a diffusion probabilistic model that predicts motion by conditioning the diffusion process on behavioral states. This paper, among others, builds a foundation for human-conscious robot artificial intelligence which is integral for robots working in human spaces.

Trust-Aware Motion Planning for Human-Robot Collaboration under Distribution Temporal Logic Specifications

This paper investigates an implementation of human trust in a robot, which can be probabilistically modeled and used to better facilitate human-robot interaction. As robots increasingly coexist with humans, effective collaboration requires a certain level of mutual trust and understanding, which facilitates efficient teamwork.

Synthesis

Overall, the current-state of probabilistic modeling in robotics is strongly cemented for navigation tasks (with such effective techniques like simultaneous localization and mapping (SLAM) and algorithms like the Kalman filter). However, the addition of humans into the environment has only begun to be explored. A variety of papers investigate the idea of probabilistic modeling of human behaviors to facilitate safer and more effective coexistence. By predicting human intention and motion using Gaussian processes, robots can adapt to the unpredictable nature of human existence. Our proposed project builds on this research, with a focus on human-robot interaction with multiple moving agents.

As we aim to develop a safe and effective human-robot interaction system in the form of a SLAM-based Sphero swarm guidance system, we must investigate how it relates to probabilistic modeling. The technical aspects of our project, such as SLAM, have been successfully demonstrated in prior work, like Hu (2018). Our goal is to examine the effectiveness of using a swarm of robots to guide humans through tasks more efficiently. By incorporating probabilistic movement modeling, we can ensure that the robots operate safely and adapt to dynamic environments. Additionally, basic behavior modeling can be used to influence how the robots communicate instructions, ensuring that these messages are clearly understood across different cultural contexts. This is particularly important in scenarios where miscommunication could have serious consequences, such as in life-or-death situations, which are a theoretical application for our human-robot interaction system project. Research such as Gui et al. (2024) applies probabilistic modeling to better predict and respond to human behavior, which informs our approach. Building on Knox et al. (2024), who explored how gathering user preferences can improve robot communication, we plan to collect baseline data on user behavior. This data would help us model human complexity more effectively, providing a strong foundation for probabilistic calculations in human-robot interactions. Ultimately, our project aims to integrate these ideas to design swarm behavior that efficiently maps an area and communicates guidance effectively, regardless of the context.