Comparing Model-Based Methods to Predict Human Trajectory in Follow-Ahead Problem

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Introduction

- **What is Follow-Ahead?**
  - Following-ahead algorithms use machine learning to predict a humans trajectory to stay ahead of humans.
  - Follow-behind algorithms have had more recognition..
    - For example, self-driving luggage that follows behind.
    - **But,** it is best if the luggage is in-front, so we can feel secure and interact with luggage more conveniently.
- **Why Model-Based Methods:**
  - The field of reinforcement learning is primarily focused on model-free methods.
  - Model-based methods have been shown to be more efficient than model-free methods[2]
- **What our solution is:**
  - Extending the work of Nikdel et al ., (2021) we will be using model-based algorithms with the addition of obstacle avoidance [3].
  - We are using a simulation environment but our solution is going to be organized so that it could be easily setup to run with real robots in the world.

Figure 1. Illustration of the follow-ahead problem. Adapted from [3].

Methods

- Our approach is to use a popular model-based learning algorithm (i.e., World Model) in addition to executing our own Human Intent Neural Network (HINN).
- **World Model**:
  1. Convolutional Variational AutoEncoder.
  2. Long Short Term Memory Network.
  3. Controller.
- **HINN + Heuristic Search:**
  - The Human Intent Neural Network is a feed forward neural network, which outputs the prediction of the next human state.
  - The prediction is used to generate a goal for the robot.
    - Heuristic search algorithms: Monte Carlo Tree Search (MCTS) or Distance Heuristic.

Results

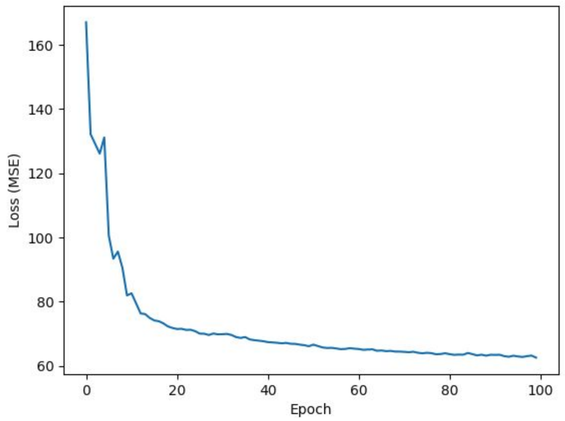

Figure 2.Training loss for the HINN over 100 epochs.

- **Current status:**
  - We have extended the given Gym environment to include obstacles, obstacle avoidance, and support for our pipeline.
  - We have also started training the HINN (figure 2), as well as implementing the heuristics and world-model algorithm.

- **ROS & Gazebo**
  - We used Gazebo to simulate the robot follow-ahead scenario. How this is instantiated can be seen in fig 3.
  - Using the ROS navigation stack with TEB Local Planner we implemented obstacle avoidance.
  - With a combination of ROS, Gazebo, and Gym, we setup the environment and generated training data

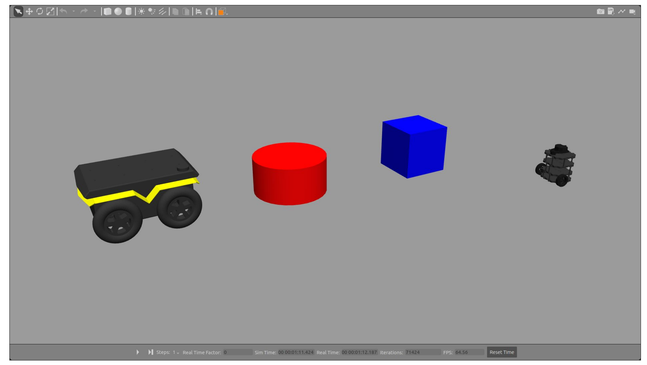

Figure 3. Illustrating in Gazebo how the robot's path to the person is obstructed

Conclusion

- We have seen promising preliminary results from the HINN.
  - Currently, we cannot state if model-based is better than model-free.
- In the next week, the model-based algorithms will be completed using obstacle avoidance.
- If time allows, we hope to utilize MCTS to choose the best action for the robot.
- We are changing our obstacle avoidance system in ROS to use a costmap to facilitate a transition to the real world.

References

[1] W. Mi, X. Wang, P. Ren, and C. Hou, "A system for an anticipative front human following robot," *Proceedings of the International Conference on Artificial Intelligence and Robotics and the International Conference on Automation, Control and Robotics Engineering - ICAIR-CACRE '16*, 2016.
[2] A. Brunnbauer *et al.*, "Model-based versus model-free deep reinforcement learning for autonomous racing cars," *arXiv [cs.LG]*, 2021.
[3] Payam Nikdel, Richard Vaughan, Mo Chen, *"LBGP: Learning Based Goal Planning for Autonomous Following in Front,"* Burnaby, British Columbia, Canada: IEEE International Conference on Robotics and Automation, 2021, submitted.