Project 4: Sim-to-Real Implementation of Learned Behavior from Simulation to Real Robotic Platform

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***Abstract*—In this reflection, project 3's waffle bot simulation implementation is being compared to that of the real world implementation conducted in project 4. Changes made between both projects are observed as well as the overall differences and impacts of sim to real life implementations.**

I. Changes made between the Project 3 and Project 4 code

In the code implementation of project 3, certain sections of code were required to work with the Gazebo simulation software. In the project 3 code, in order to properly simulate the wafflebot, it was necessary to get and set the model state to and from Gazebo in order for the robot to move accurately in the simulated environment. In addition to the code used for any Gazebo simulation behavior, there was also code used for reinforcement learning in project 3. In the reinforcement learning code, certain information was needed, such as the epsilon value, the number of episodes, the learning rate, the sleep rate, and the discount factor. When training, the temporal and q values also needed to be calculated in the process of training in order for the waffle bot to correctly learn wall following behavior.

Unfortunately, when performing the real world simulation in project 4, the project 3 code could not be used as is. Because the waffle bot is no longer being simulated in the Gazebo simulation, this means that the project 4 code no longer needed any code from project 3 that was previously used for this purpose. The project 4 code also did not require any of the training code used in project 3, as project 4 is only demonstrating the q table learned from project 3 in a real world environment. The last change that needed to be made to the project 4 code was adjusting how the laser scanner data was used; in the real world environment, the laser scanner will sometimes include data that reads as a distance of 0. Because of this, the code needed to be adjusted to turn these 0s into infinity values so that it would not impede performance of the waffle bot.

II. Differences between sim and real

When observing the difference between the Gazebo simulation and the real world implementation, there were surprisingly not that many noticeable differences between the two in terms of performance. In the real world implementation, the waffle bot was noticeably moving closer to the walls than the Gazebo simulation implementation. Although the waffle bot never got stuck in the real world implementation, it did have moments of hitting the corners of the environment when conducting a few turns; this was likely due to the fact that the waffle bot was closer to the walls than demonstrated in the Gazebo simulation. Something that could also be observed in the real world simulation better than the Gazebo simulation was the manner in which the robot took actions. In the real world demonstration it was easier to observe that the robot was taking significant more forward actions and only moving left or right when needed for turns.

III. Challenges of real-world implementation

There were no major challenges when implementing from the simulation to the real world environment. The biggest challenge experienced was changing the code from project 3 to project 4 in order for the real world robot to properly perform; although no changes were made besides the ones mentioned that would be required for project 4 to function correctly. There were issues when trying to deploy to turtle bots 3,4,or 5; this was likely to improper implementation of the degree ranges, but there was not enough time to investigate this further.

IV. Impact of simulation on real-world application

In real world applications, simulation on real world implementations have a huge impact on the performance and outcome of the robots performance and learning success. From the Sim to real world papers provided as extra credit reading material, it was stated that there were a lot of challenges that required unique solutions to each implementing of sim to real world implementations; this is an issue because it makes finding more generalized conclusions difficult. Despite this, there is still benefits and information that can be learned when conducting sim to real world implementations, especially in the fact that it is significantly cheaper than learning strictly through real world environments.

V. Other observations and conclusions

Beyond what was stated, there were not many other observations to be observed. However, from what was observed, it can be concluded that the overall simulation to real world implementation was an overall success. In future implementations, more testing and training would be conducted to find the best and most efficient wall following behavior for better performance.