Using neural networks to model a multi-robot lane driving scenario

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In the field of robotics and autonomous systems, achieving accurate predictions of robot trajectories is crucial for safe and efficient navigation. The high-fidelity robotics simulator Webots guarantees accuracy in trajectory but is limited in terms of scalability and efficiency. This project's goal was to implement a scalable neural network capable of generating trajectories efficiently, while maintaining an acceptable level of precision. In Figure 1, we present a representation of the navigation environment that our robot encounters. The environment is composed of a cyclic path that can encompass varying numbers of lanes, adding an additional layer of complexity to the robot's task.

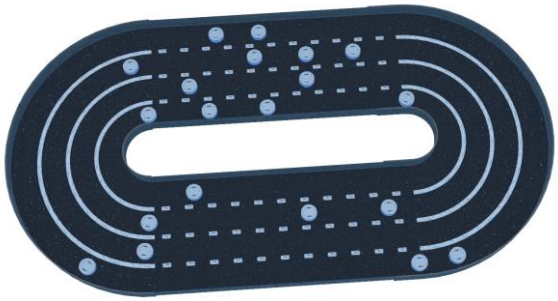

Figure 1 : Robot simulation environment

In this scenario, our neural network is tasked with simulating the robot's positions from a given initial position. The network's output, summed with the input, yields the next position x (t + 1). This calculated position then becomes the subsequent input for the neural network, and consequently forecasts the position at the subsequent time step x (t + 1) as described in the figure 2.

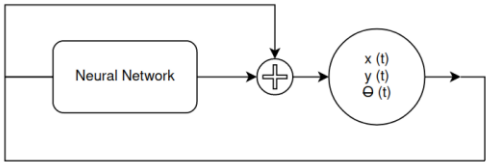

Figure 2 : Simulation mechanism using neural network

We have investigated a variety of machine learning algorithms for predicting robot trajectories in this project. Conventional neural networks (MLP, RNN, GNN) had trouble reconstructing, but PPO using reinforcement learning (RL) as well as imitation learning produced reliable results. We further found that combining RL and imitation learning results in superior performance with respect to either one used alone, producing reasonably accurate, scalable and computational efficient trajectories. However, it is important to mention that the training time is significant and specific to a given environment.

The Figure 3 illustrates the resulting simulation of one robot using the best trained neural network (imitation learning using reinforcement learning agent). The green trajectory represents the desired path generated by the Webots which the robot should ideally follow, while the red trajectory depicts the output from the neural network.

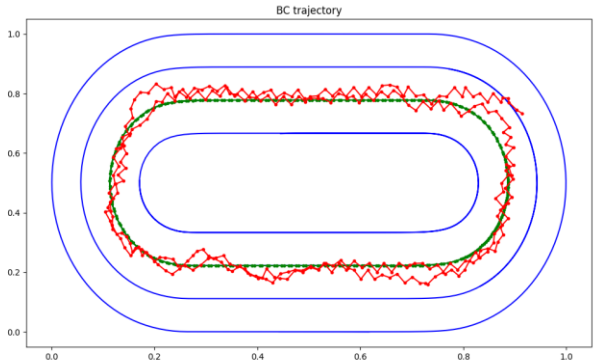

Figure 3 : 1 robot trajectory simulation