AGV control optimization with machine learning

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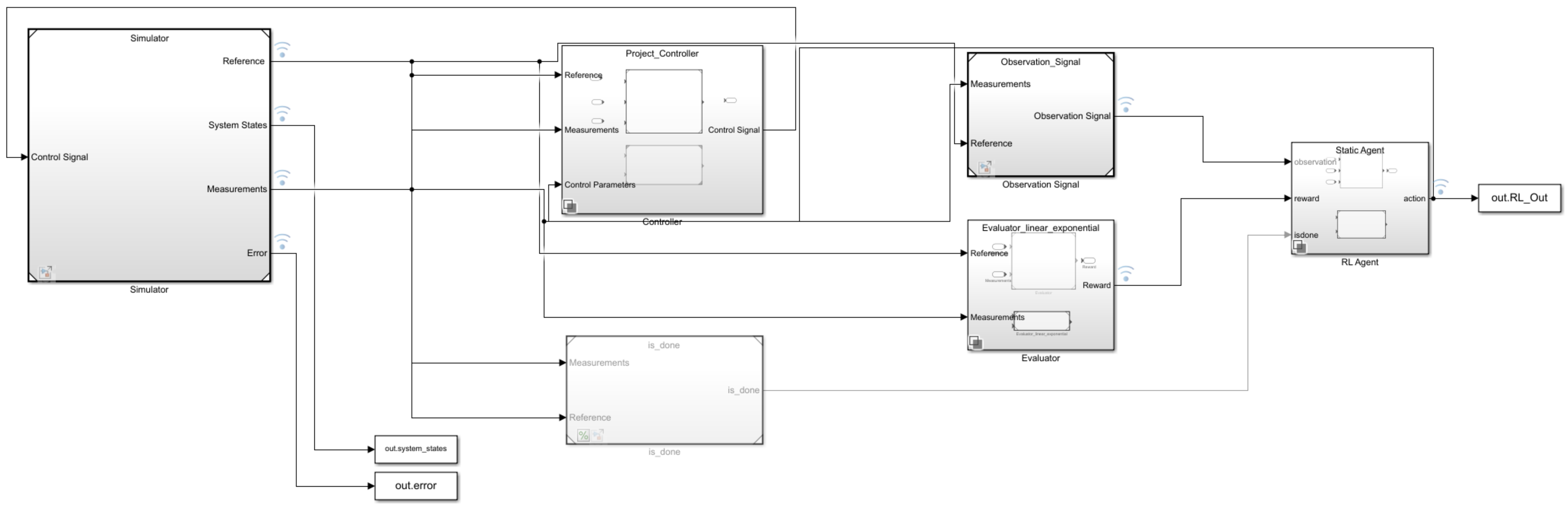


Introduction

- Goal: Machine learning based auto tuner for controlling PID parameters
- Problem: Tuning PID parameters manually is time consuming
- Objective: Minimize track deviation with ML-based controller

Simulator

An advanced Simulink model was constructed in order to enable realistic simulations of the AGV. The model was validated with real data from a real AGV and features a multitude of variable disturbances in order to increase the stability of trained agents.

Machine Learning

Two different machine learning methods were evaluated for the auto-tuner. Deep deterministic policy gradient (DDPG)

$$Q^*(s,a) = \mathop{E}_{s' \sim P}\left[r(s,a) + \gamma \max_{a'} Q^*(s',a')\right]$$

and proximal policy optimization (PPO)

$$L_t^{CLIP}(\theta) = min\left(R_t(\theta)A_t^{\pi_{\theta_k}},\ clip(R_t(\theta),\ 1-\epsilon, 1+\epsilon)A_t^{\pi_{\theta_k}}\right)$$

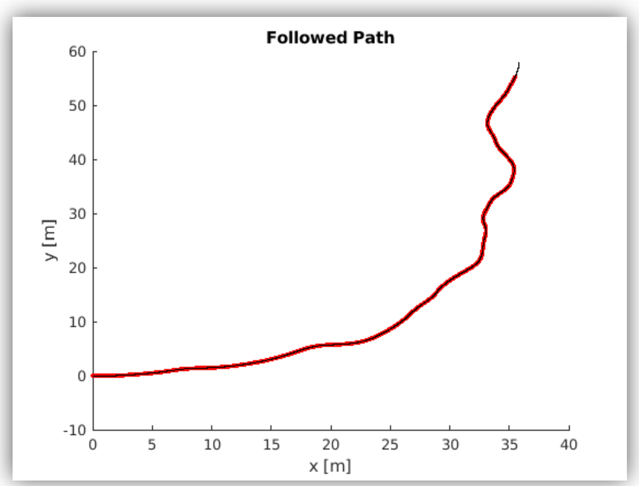
Two different reward functions have been investigated

- Simple linear based on velocity and heading error.
- Conditional error with an exponential error scale when error was larger than requirement.

Conclusion

Compared to conventional tuning, the ML-based tuning methods can yield:

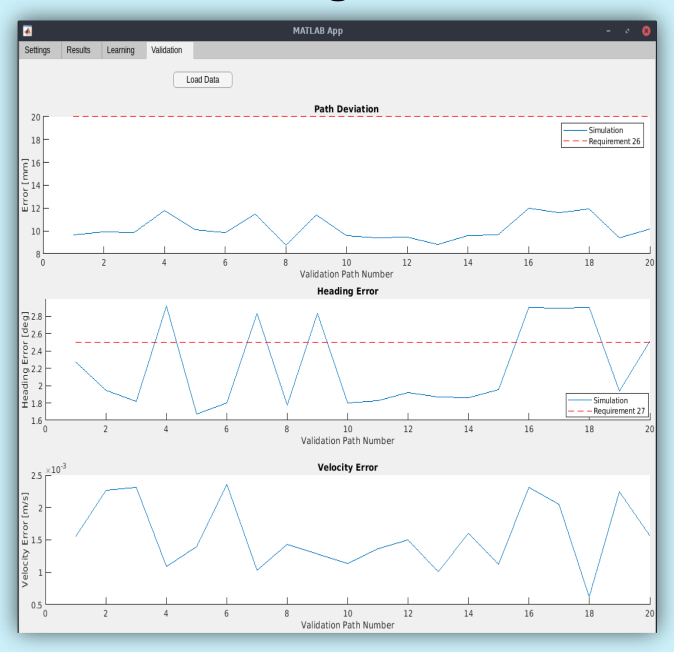
- Improved performance
- Increased robustness for various environments
- Decreased tuning time



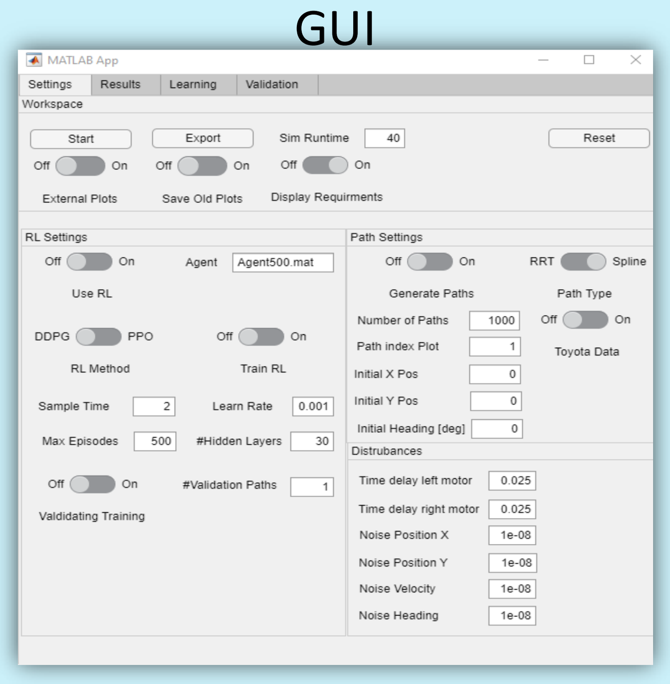
Experiments

The machine learning methods are evaluated with regards to their path-following performance compared to the manually tuned controller

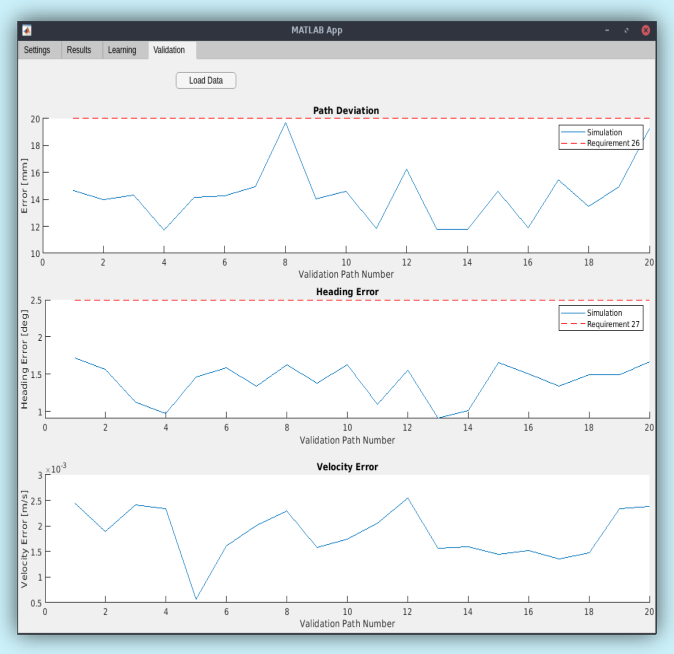
Manual Tuning Performance



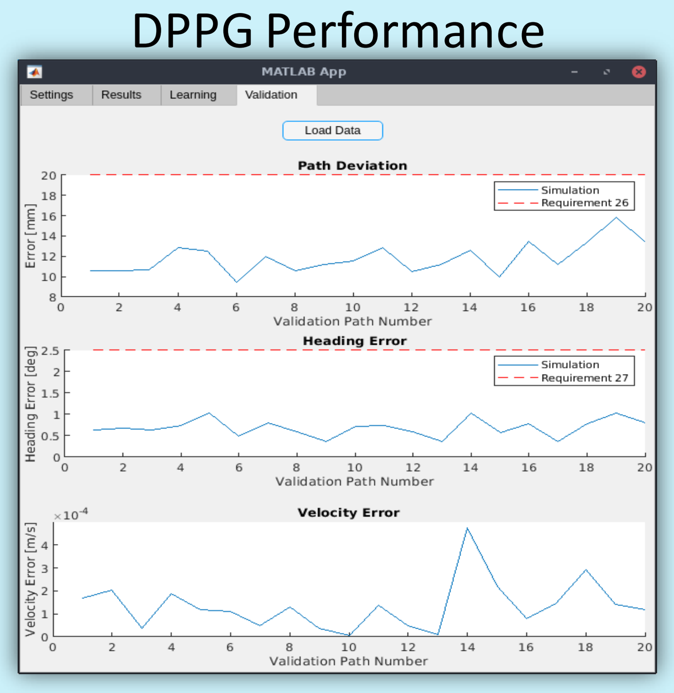
GUI



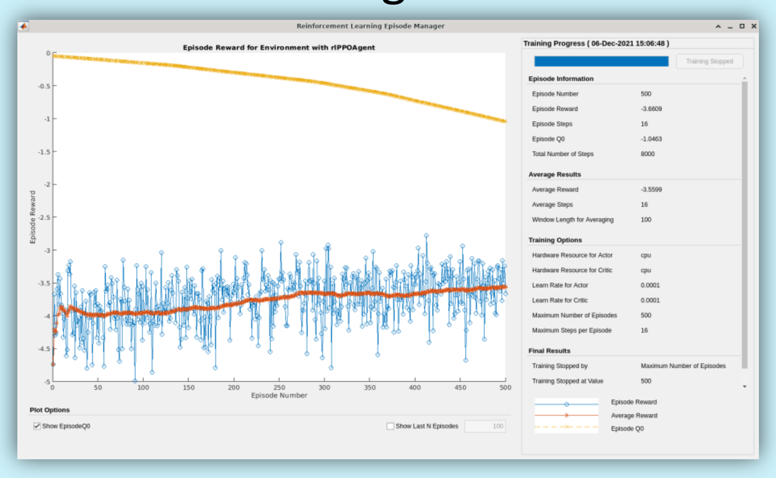
PPO Performance



DPPG Performance



Training PPO



Training DDPG

Future Work

Some interesting questions that need to be researched is:

- Implement into a real vehicle
- Test more reward functions based on other variables
- Extend simulation environment with a more detailed model for electric motors

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