Abstract

Traffic congestion has caused trouble for people for many years. With the level of traffic increasing in previous years, local, state and national governments, along with researchers, are looking for a way to manage this problem. Ramp Metering is a method developed to reduce highway traffic by controlling the flow of vehicles. What started as a manual process has now technically advanced, with the rise of AI creating adaptive solutions. However, traditional AI methods require a lot of data and communication power to carry out this. With data protection rules and regulations on the rise, this data might be difficult to source. Therefore, adaptive models are complicated to train and, as a result, create.

The proposal of Federated Reinforcement Learning (FRL) seems to be a solution to this problem in recent years. Combining reinforcement learning with federated learning, FRL can create an adaptive solution by communicating with many different client nodes while protecting the privacy of the data.

This thesis aims to create an FRL design for the problem of adaptive/intelligent ramp metering control. Through research into the background and related works of FRL, a design is proposed. This design is implemented by using SUMO, a simulation environment, and TraCI, an interface built to interact with SUMO. The design consists of a Q-Learning method integrated into an FL model. The design is then evaluated in three different scenarios; low traffic load, high traffic load and mixed traffic load. It is compared to industry-popular methods of ramp metering such as fixed-timing and Q-Learning. From the results, it can be concluded that there are no improvements in the network by using FRL. This could be due to a configuration error which will be detailed in Chapter 5. However, FRL still poses an excellent research opportunity, and further work in this area is detailed in the final chapter.