Neural Network-Based Approach to Adaptive Traffic Signal Controlling

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Abstract

Machine learning and neural networks have been the last decade's central topics in the tech world. Today we can observe many day-to-day used cases of machine learning and related technologies in our lives. Some of them have been part of our lives without even us realizing it. Machine learning and neural networks are good at solving problems that usually don't have straightforward solutions. The primary use case of machine learning within the realm of traffic control comes from visual-based vehicle identification. This is a subject field that has been thoroughly researched. This research aims to find the feasibility of having neural network-controlled traffic signals in isolated and coordinated arrangements in a road corridor. It is intended to give the decision power of a traffic signal to a machine learning algorithm that has been trained on that specific task. The method is also intended to address two drawbacks in signal timing calculation. The first one is the lack of a mechanistic-empirical approach to a traffic signal timing design, where the trained machine learning algorithm can act as the mechanistic component to check or verify the empirical design. The other downside of traffic signal timing design is it is essential to conduct a traffic survey for every specific junction. And every design should follow with calculation for phase design, amber time calculations, determination of cycle length, and other empirical tasks. This method could replace all that effort with the concept of "train once and deploy anywhere". The first neural network was created for a four-way junction with four input nodes for queue length in four directions, twelve hidden nodes, and four output nodes. The sigmoid activation function was used on the hidden nodes, and the softmax activation function was used on the output nodes. Softmax activation ultimately outputs which direction the traffic light should be set to green depending on the input queue length data. This method uses an unsupervised learning technique that selects the best outcome out of 25 simulations that run parallelly and advance it to the next generation. The algorithm creates 25 new parallel simulations with the selected best neural network from the previous generation by adding random changes to the neural network parameters. Each generation runs for a fixed time frame (10000 frames) before it gets reset, and the best neural network gets to advance to the next generation. This simulation is carried out until the number of cars that pass through the junction within the given time frame is levelled off, and the best-performed neural network can be saved. The predominant objective of this research is to introduce an all-in-one solution to automate signal controlling where traffic surveys and scenario-specific calculations for phase timing are not required. Rather than having a fixed set of rules for the given queue length, this neural network can be trained and deployed into inexpensive hardware like Arduino or Raspberry-pi to control a traffic signal adaptively. And with some improvements, this technology can be extended to carry out the signal control timing of a road corridor or a road network where a single neural network can control all the traffic signal timing in a road grid adaptively. This neural network will be able to adapt to different traffic scenarios and other external factors, such as different weather conditions and rush hour traffic.

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