Neural Networks and Adaptive Models for Traffic Control

By

Andrei C. NAE [1], Ioan DUMITRACHE[2]

[1] Faculty of Automatic Control and Computer Science, University POLITEHNICA Bucharest, Romania, e-mail: naeandr@gmail.com
[2] Faculty of Automatic Control and Computer Science, University POLITEHNICA Bucharest, Romania, e-mail: ioan.dumitrache@acse.pub.ro

Abstract :

This work presents new developments for T-CPS (traffic cyber physical systems) using NN-neural networks and adaptive diving models. This work benefits from advanced capabilities from today programing environment and HPC resources, in an attempt to further develop this type of modelling towards realistic traffic configurations and large-scale applications, in the overall context of CPS – Cyber Physical Systems and future autonomous driving concepts.

Our work is structured in 3 main areas:

- At vehicle level: Autonomous vehicles are be based on an advanced driver model (ADM+ALC), able to face all challenges from the current traffic: urban traffic rules, lane changing needs, congestion, passenger comfort. We introduce such a model and characterize this with respect to current expectations. This is considered to be the kernel of the new generation autonomous car's computer system;

- At the infrastructure level: Traffic lights are still to be considered the main driver with respect to the overall traffic management. Smart concepts for traffic lights management and additional sensing capabilities (e.g. queue lengths) are to be integrated in a global concept to also benefit from new development in NN-neural networks control algorithms. There is also provision for communication network with respect to the sensing needs of the CPS car either with respect to other CPS cars, infrastructure sensors and controls or both.

- A (realistic) simulation environment: CPS concepts integration in a realistic T-CPS system is demonstrated in a powerful simulation environment developed for microscopic/detailed traffic analysis.

NN concept and a novel implementation is the major development in this work. We strongly emphasize the role of the Self-Adaptive Control Systems based on the following building blocks:

- Reinforcement Learning
- Adaptive Performance Optimization
- Connected Vehicles and Automated Vehicles Environment

From simulation results obtained for ADM + ALC model, we clearly demonstrates the importance and effectiveness of the four-stroke traffic light timing as compared to three-stroke traffic light

[1] Faculty of Automatic Control and Computer Science, University POLITEHNICA Bucharest, Romania, e-mail: naeandr@gmail.com
[2] Faculty of Automatic Control and Computer Science, University POLITEHNICA Bucharest, Romania, e-mail: ioan.dumitrache@acse.pub.ro

timing in a reference case (Bucharest/Lujerului junction). If we consider ADM and problems associated to the real traffic conditions and congestions in busy traffic case, we propose the four-stroke cycle scenario, with NN logic control for traffic lights, able to lower waiting time close to fixed pre-times cases, but with higher performance in terms of safety (no collision/accident) and potential resilience.

References

1. Babicheva, T.S., "The use of queuing theory at research and optimization of traffic on the signal-controlled road intersections", Information Technology and Quantitative Management, (ITQM 2015), Procedia Computer Science, 55, (2015).
2. Wang, Y., Guo, Y., Wei, Z., Huang, Y., Liu, X., "Traffic Flow Prediction Based on Deep Neural Networks," 2019 International Conference on Data Mining Workshops (ICDMW), Beijing, China, 2019, pp. 210-215, doi: 10.1109/ICDMW.2019.00040, (2019).
3. Nae, C. A., Dumitrache, I., "Neuro-Fuzzy Traffic Signal Control in Urban Traffic Junction", 22nd International Conference on Control Systems and Computer Science (CSCS22), Romania, (2019).

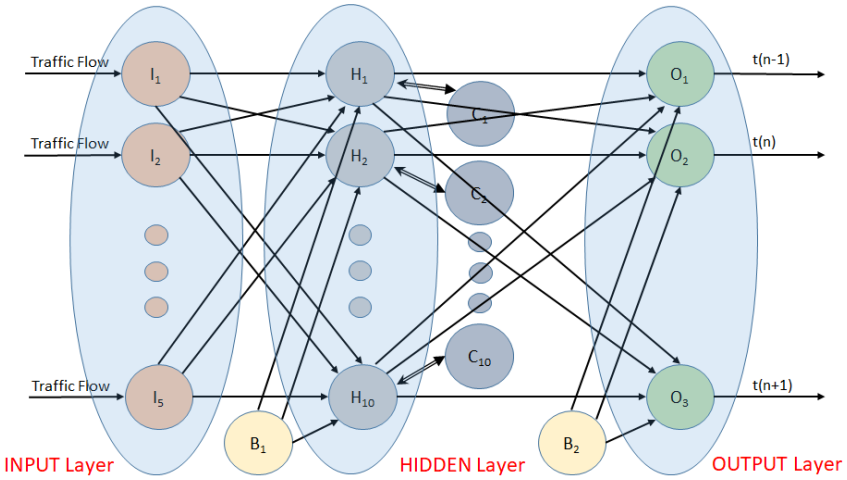

Figure 1 –Neural Network concept used for traffic system control

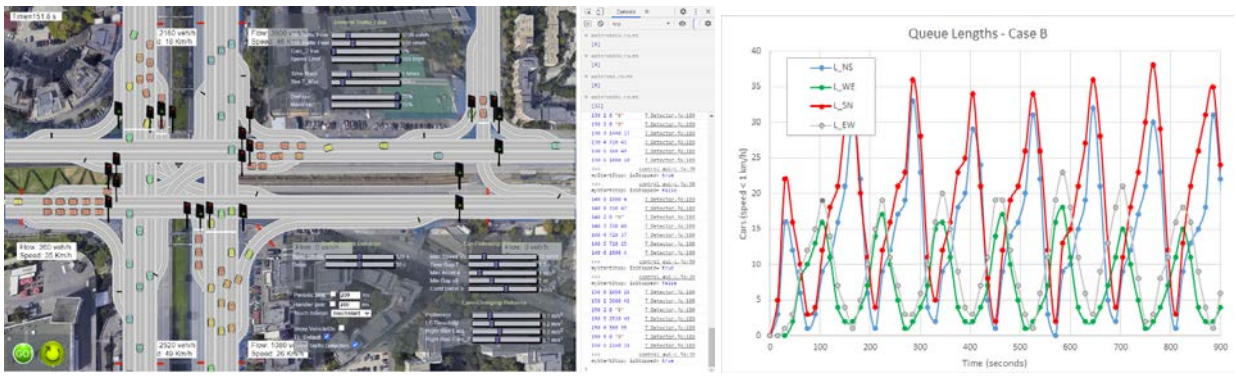

Figure 2 - Simulation Domain – with Traffic Detectors and NN for traffic lights