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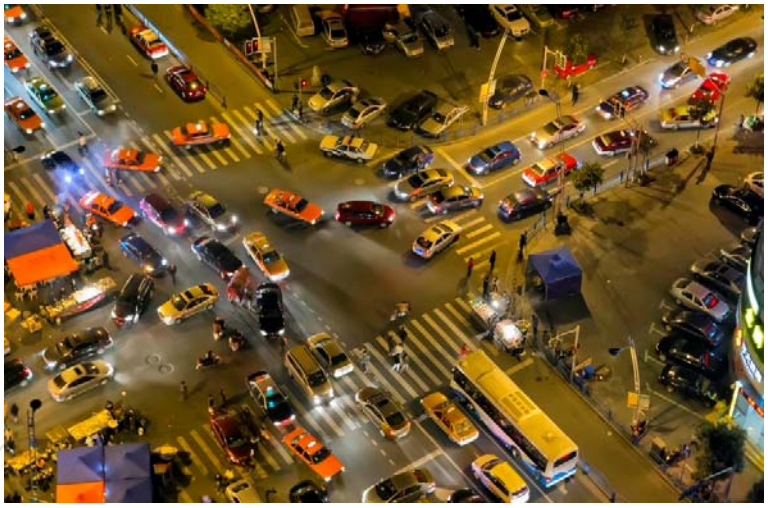
ABSTRACT PhD THESIS



CONTRIBUTIONS ON THE USE OF NEURAL NETWORKS IN TRAFFIC ENGINEERING

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Abstract

Transport strategies at European and global level pay greater attention to sustainable urban development, including by creating environmentally friendly transport systems and promoting sustainable urban mobility. The analyses carried out within the Urban Mobility plans prove that urban agglomerations lead to reaching the limits of current traffic capacities and negatively influence the provision of population mobility. The correlation of traffic capacities with road flow sizes implies the use of appropriate methods of acquiring traffic data, processing and interpreting them, as far as possible in real time. Therefore, from the planning stage of investments in transport infrastructures, it is recommended to monitor the impact that traffic management systems have on the efficiency of the solutions proposed for implementation.

The emergence in recent years of high computing power processors connected to high storage capacities, the disclosure of mobile communication networks, Wi-fi networks, etc., have laid the foundation for the widespread use of artificial intelligence, which nowadays allows sorting, classifying and analysing appreciable amounts of data, so as to obtain optimized solutions or even predictions with a high degree of accuracy. This results in the necessity of introducing artificial intelligence to solve complex traffic and mobility engineering problems.

One of the possibilities of using artificial intelligence in the field of transport is the use of artificial neural networks (ANNs), which have the ability to perform operations in parallel, simulating the human brain and saving data due to inter-neural connections.

General subject of the doctoral thesis it is the study and analysis of the possibilities of using artificial neural networks, in order to improve road traffic conditions. The main directions of research consisted in establishing a methodological approach for obtaining traffic models with a high degree of accuracy. Also, there were considered the establishment and optimization of training types and algorithms for neural networks, so as to develop predictions related to solving problems in traffic engineering.

It was proposed to make (through a program in Matlab language elaborated by the author) some ANNs, to be connected to a road traffic simulation program, and by training them, based on carefully selected data sets, predictions and optimizations of the control elements of traffic light intersections were made.

The doctoral thesis is structured in six chapters containing 107 figures and 80 tables, complemented by a bibliography consisting of 169 scientific papers and 8 references from the Internet.

Chapter 1 Introduction it contains a brief overview of the current problem of road traffic at international level, including from the perspective of the use of RNA, as well as a brief summary of the main chapters of the paper, presenting the main research directions.

Chapter 2 Traffic models it is dedicated in the first part to the bibliographic study in which a series of topics regarding the main parameters of road traffic were treated, and in the second part it details some theoretical elements underlying the simulation models at microscopic and macroscopic level. Emphasis was placed on defining the main factors underlying the calibration and validation of traffic models, but also analysed the recommendations from the literature on the

requirements fundamentals for obtaining traffic models that reflect as accurately as possible the reality in the field.

Chapter 3 Use of neural networks in traffic simulations it contains theoretical notions of neural network architecture and their main characteristics, as well as a brief overview of learning methods for RNAs, focusing on those with supervised and reinforcement learning.

Chapter 4 Case studies address two case studies representative for the topic of the thesis. The first refers to the realization of the calibration and validation of a microscopic traffic model, using a series of data collected from the field in Constanta municipality. The main performance indicators of the analysed intersections are described, both in the initial situation and after the implementation of the proposals for urban improvement of the analysed area. The second study presents a much more complex approach. Based on the data extracted from the macroscopic transport model of Bucharest, a microscopic analysis of the central area of this city was carried out. For this study, a neural network with supervision learning was developed in the Matlab language. To stimulate the learning process of this ANN, the parameters with the highest degree of independence were selected from all the input data that a traffic model has available The simulations resulted in a decrease in travel times and vehicle queues on Unirii Boulevard and the streets adjacent to it.

Chapter 5 Theoretical and applicative contributions regarding the implementation of traffic studies and the use of artificial intelligence presents theoretical and applicative contributions for the development of traffic studies and the use of ANNs. The detailed logical scheme of the stages of achieving a traffic model was described and the development of a working methodology was detailed, through which the specialists in the field can definitely identify the necessary steps in carrying out traffic analyses, which provide forecasts with high accuracy of the main critical variables (traffic). A methodology for assessing the multimodal service level for public transport was presented, by assigning a score and a formula for integrating this score into service level size classes (denoted by letters A to F), following the model of classic service levels. At the same time, the theoretical concepts related to the use of artificial neural networks to improve public transport using the multimodal service level were laid. Finally, through a case study, an example was presented of the use of artificial neural networks with in-depth reinforcement learning, to optimize the performance indicators of the traffic model, connecting a specific calculation program (developed in Matlab language) with a traffic simulation program (VISSIM), allowing a data exchange through a COM interface.

Chapter 6 Final conclusions, original contributions, dissemination of information and future research directions summarizes the theoretical and applicative contributions of the author on the use of RNA in the field of traffic modelling, as well as proposals on methodological approaches to the realization of traffic models. It is pointed out that the use of an ANN can lead, for signal control junctions, to the improvement of performance indicators with values between 12 – 20%. In addition, according to the results obtained from the case study in the previous chapter, it is shown that the implementation of an ANN at a group of two intersections generates annual economic benefits of over EUR 500 000.