UNIVERSITY OF BUCHAREST

FACULTY OF MATHEMATICS AND COMPUTER SCIENCE

MASTERS OF ARTIFICIAL INTELLIGENCE

**Dissertation Thesis**

**Spatial-Temporal Neural Networks for Traffic Prediction**

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Abstract

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# Introduction

# Theory

## Traffic Flow

Traffic Flow represents the study of interaction between travelers of different types, including vehicles and pedestrians with infrastructure having the goal to create an optimal transport network with efficient and optimal traffic movement such that traffic congestion is reduced to a minimum.

Traffic networks are complex and nonlinear, depending on external factors such as current time of day/year, weather, and also on internal factors such as infrastructure, number of vehicles and their types or unexpected vehicle crashes. Due to the fact that traffic is based on human interaction, or rather individual reactions to other pedestrians or vehicles, the system does not follow any rules and is rather chaotic.

The traffic system is composed of roads/pavement on which the participants in traffic travel at a certain speed to reach their individual goal. The size can vary and is objective, it can range from a neighborhood to a countries entire traveling system. There are traffic systems which are unique to a single type vehicle, for example the railway system in which just the train travels. Traffic flow is focused on city sized traffic systems for cars, which exhibit the biggest congestion.

Participants in traffic are pedestrians and vehicles (bikes, motorbikes, cars or public transportation). Different types of vehicles can be more effective than others. An example is the underground metro system which is supervised by an entity, thus the participants travel restrictively to preserve the entire system efficiency and can take thousands of passengers. Another example is a car which can take up to a maximum of 5 passengers legally. Although a car can travel to any point but a metro system has predetermined stations.

The main variables that are considered in traffic flow theory are density (k, number of vehicles per unit of space), speed (v) and flow (q, number of vehicles per unit of time).

Speed is defined as the distance traveled per unit of time. Due to the high number of vehicles in a traffic system it is impractical to measure the speed of every vehicle, and the average speed is measured. There are 2 main definitions of speed.

The first one is time mean speed, which is the average speed of a vehicle over a period of time, is computed by measuring the distance traveled by a car over a certain reference point. This method is not accurate because the average speed of a vehicle over a wide range does not take into account the difference between the speeds of different vehicles.

m = Number of vehicles passing through a fixed point; = speed of vehicle i

The second method is called space mean speed. This method is measured over the entire segment. Consecutive recordings of passing vehicles over the entire segment are considered to track individual vehicle speed, after which the speed is calculated. It is considered more accurate than the first method

m = Number of vehicles passing through the roadway segment; = speed of vehicle i

Density represents the total number of vehicles per road segment. There are two types of densities: critical density and jam density. Critical density is considered to be the maximum density under free flow, while jam density is considered the maximum density under congestion. Density is measured as:

K = density, L = length of a roadway, = time, m = number of vehicles

Flow is represented as the total number of vehicles passing through a point given a time period. Headway is the inverse flow, which is represented by the time elapsed between the n-th vehicle passing a point and the next (n+1-th) vehicle. Flow is measured as :

q = flow, T= time interval, = point in space, m = number of vehicles

The goal of traffic flow analysis is to develop a model that will allow vehicles to reach their destinations within the shortest possible time. This is achieved in a four stages process:

* Generation – Generate the paths
* Distribution – after generation it makes the different Origin-Destination (OD) pairs between the location found in step 1;
* Modal Split/Mode Choice – the system has to decide how much percentage of the population would be split between the difference modes of available transport, e.g. cars, buses, rails, etc.;
* Route Assignment – finally, routes are assigned to the vehicles based on minimum criterion rules.

## Machine Learning

## Convolutional Neural Networks

## Long Short-Term Memory

## Graph Convolutional Networks

# Related Work

# Methodology & Experiments

## Dataset

## Models

# Results & Conclusions

# Bibliography