Work In Progress: Collaborative AI Based Traffic Control System

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Abstract. This article presents a traffic control system based on connected traffic lights controlled by machine learning algorithms. Each traffic light has a vehicle detection computer program as well as a connection module allowing it to transmit its information to other traffic lights in order to boost the passage from one color to another depending on traffic volume. The information exchanged between the traffic lights is collected in a remote server embedding another computer program estimating the number of vehicles that must arrive on the main road in order to decide to slow down or to maintain the traffic on the way leading to this road. The aim is to keep traffic as smooth as possible in order to limit the loss of time on the road which can have consequences at various levels for society. The implementation of such a system consists of collecting data on the traffic of a few target areas in order to model it in simulation software and to conduct experiments by deploying the aforementioned computer programs. The results can then be presented to the state authorities responsible for road transport for deployment on-site.

Keywords: Traffic management · Urban mobility · Computer vision · Reinforcement learning · Edge computing · Internet of things.

1 Introduction

Traffic jams are a problem in almost every suburb or major city in the world. Millions of hours lost, late and stressed workers, pervasive noise and chemical pollution, and disproportionate economic losses for all businesses whose business is partly or entirely on the road. Traffic jams have many economic, social, health and ecological consequences.

The time spent in traffic jams is mainly considered as "lost", being used neither for work nor for leisure. This loss has a very significant economic cost. However, this waste of time could become a thing of the past with the use of certain artificial intelligence. Several mathematical models have shown that the behavior of motorists greatly increases the size and duration of a traffic jam and can even create it in certain places. American researchers at the University of California at Berkeley [1] believe that the solution lies in artificial intelligence. Their simulations have shown that increased use of the latter, whether in the management of traffic lights or the arrival of smart vehicles, could significantly reduce the time lost on the road [2].

1.1 Physics of Traffic Jams

Traffic jams are complex creatures. Researchers at the Mobile Sensing Lab at UC Berkeley (PI, Professor Bayen) compared the movement of cars on the road to the flow of particles in a river [3]. If all the particles go at the same speed, the flow will always be constant. However, if the speed of certain particles suddenly decreases, it will slow down all those behinds. These speed changes occur all the time in traffic, especially during rush hour. Accelerating and braking repeatedly causes a chain reaction: the greater the number of vehicles affected by this combination of movements, the greater the deceleration, going as far as stopping cars far behind and thus triggering a traffic jam.

1.2 Exemplary Conduct

Traffic jams could be significantly reduced if drivers respected a certain minimum distance between each vehicle. This buffer reduces the amount of deceleration transmitted along the chain of cars and allows each driver to maintain a constant speed. However, this minimum distance is not often respected. This is where artificial intelligence comes in. The researchers wanted to know if this could have a positive influence on road traffic, and this, in two distinct contexts: when vehicles are controlled by artificial intelligence, as would be autonomous cars, and when the traffic lights traffic are controlled by these algorithms. These two scenarios were evaluated in computer simulations where artificial intelligence had to find the best way to manage traffic by itself. This type of machine learning is called reinforcement learning. After thousands of simulations, the researchers noticed that, when the algorithm had to regulate traffic lights in a city divided into quadrilaterals, the average speed increased by 7% [1].

2 Research Problem

According to CETUD (Conseil Exécutif des Transports Urbains de Dakar), the land transport department has registered nearly 450,000 cars registered in Senegal, including 300,000 in Dakar. In addition to this, the rural exodus and population growth are other factors contributing to the fact that traffic in Dakar, the Senegalese capital, is particularly difficult especially during rush hour. Motorists lose on average more than 300 hours each year in traffic jams and this figure is multiplied by four for carriers who make several trips back and forth while they are paid according to the number of round trips made. It goes without saying that an improvement in the flow of traffic would bring enormous economic benefits as well as a considerable improvement in the living conditions of people. The State of Senegal has taken many steps to resolve traffic problems in the capital, but most of its efforts remain concentrated in increasing the number of existing roads or lanes of roads. Despite all these initiatives, the problem of traffic jams still remains. This is why it is very likely that good traffic depends more on good traffic regulation than on increasing lanes. To offer good traffic regulation, placing manually orchestrated traffic lights (by defined periods of passage from one color to another) is not enough. It would be necessary to collect a set of information on traffic at different levels such as the average daily number of vehicles circulating there, the rate of congestion, the places of bottlenecks, etc and to recreate these conditions in an appropriate test environment in order to conduct experiments there. The results on the decongestion of certain zones, the reduction of the travel time between two places as well as the release of bottlenecks among others can be presented in the form of graphs such as curves, histograms ... in order to identify the best ways to deploy.

3 Goals

The main objective of this research is to come up with a system capable of efficiently regulating traffic while benefiting from high availability by means of increased resistance to breakdowns of the overall system (acquisition modules + regulator system of the traffic). In addition, the solution should be easily replicable because the problem of traffic jams is not only attributable to the city of Dakar but also to many other cities in the sub-region and the world. Thus, it would be wise to produce our own data acquisition modules capable of providing continuous and anonymous data flows (images will have no other objective than that of fluidizing traffic in cities) on all forms of urban mobility - from pedestrians to cyclists, from cars to trucks, and everything in order to cope with possible future large-scale deployments. This data could help public sector organizations better plan and manage the urban environment in the face of perpetual change.

4 Methodology

For the development of the traffic control system, two (2) key steps have been identified:

4.1 Data Acquisition

We will start by developing a prototype of a data acquisition module composed of a raspberry pie, a pie camera and a GSM sensor allowing to transmit the information to a remote server hosted in the cloud (Fig 1).

The choice of this range of electronic components is mainly based on the fact that they are accessible, have rich documentation and a large and active community that we could consult in case of problems. This module will be progressively improved by integrating new sensors according to the type of data that we would like to collect in the future. This module will then be placed at the level of a few target areas in the capital where traffic jams are more frequent in order to collect continuous data on the different forms of urban mobility.

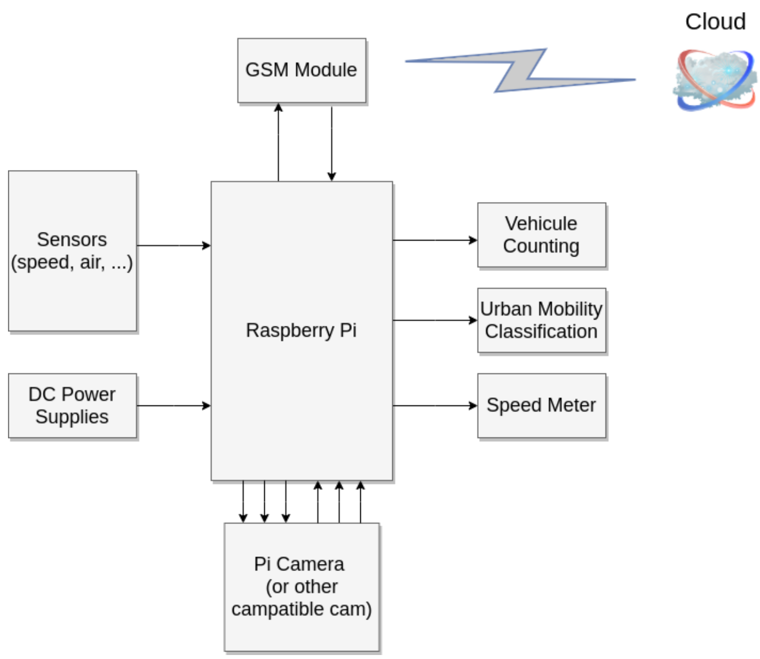

Fig. 1. Data acquisition module architecture

4.2 Design and Deployment of Machine Learning Algorithms in the Simulation Environment

Once the data has been recovered, it will be integrated into SUMO (Simulation of Urban MObility) [4] which is an open-source traffic simulation software, designed to manage large road networks. In addition, SUMO is compatible with Flow [5], a traffic control benchmarking framework that provides a suite of traffic control scenarios (benchmarks), tools for designing custom traffic scenarios and integration with libraries. learning through in-depth reinforcement and microsimulation of traffic. Deep reinforcement learning (deep-RL) offers the possibility of studying complex traffic control problems involving interactions between humans, automated vehicles and detection infrastructure. This is how we will explore both gradient-based algorithms such as Trust Region Policy Optimization (TRPO) [6] and Proximal Policy Optimization (PPO) [7] but also gradient-free methods such as Evolutionary Strategies (ES) [8]. All these algorithms have been tested and proven in the context of road traffic [1].

5 Perspectives

For the moment we are in the study phase both in the design of the prototype of the acquisition module as well as the handling of the SUMO solution for the simulation. We will later in the design of the machine learning algorithm after a comparative analysis of existing algorithms. A significant starting point would be the research paper on Benchmarks for reinforcement learning in mixed-autonomy traffic [1] doing a comparative analysis of reinforcement learning algorithms applied to traffic. We hope to obtain tangible results proving how beneficial a traffic regulation by our system can be for the city in order to obtain the approval of the authorities for large-scale deployment. We also hope to spend the acquisition module prototype presented previously at a more advanced unit that we design ourselves and we could market. The final system will provide an online platform for accessing the capital traffic data to enable decision-makers to consider proactively advanced use of models based on the past and present urban behavior, as well as traffic flows projected on the basis of advanced predictive analytics.

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