Smart Traffic Lights

In-network Computing

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Introduction

- Traffic problems are a present and increasing reality particularly in big cities of the world.
- This problem could be attributed to:
  - Poorly planned urbanization
  - The increase in population
  - The increase in the number of vehicles
  - Lack of public transport, or poor public transport options.

Problem

- The impact of traffic congestion should not only be seen as a **time management problem** but also as an **environmental and public health threat.**

Example : Mexico City

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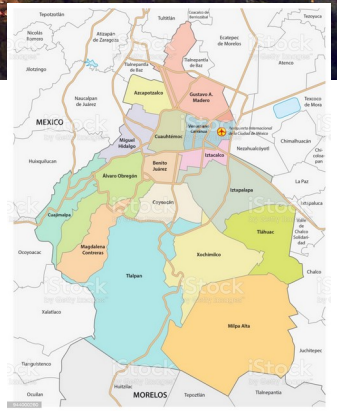


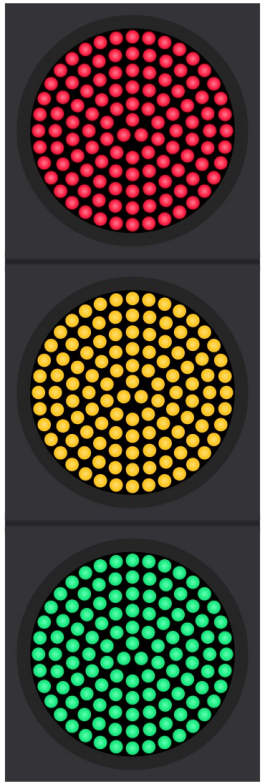
- Mexico city is the biggest city in North America and the 5th biggest city in the world with almost 22 million inhabitants.
- It has amongst the highest concentration of cars in the world. (5.5 M vehicles every day, and a further 5.1 M in the surroundings).
- The traffic is so congested that cars travel at an average speed of 32 km/h (20 mph)
- 65% of the goods transported in the city take on average **two and a half hours** to reach

Example : México City

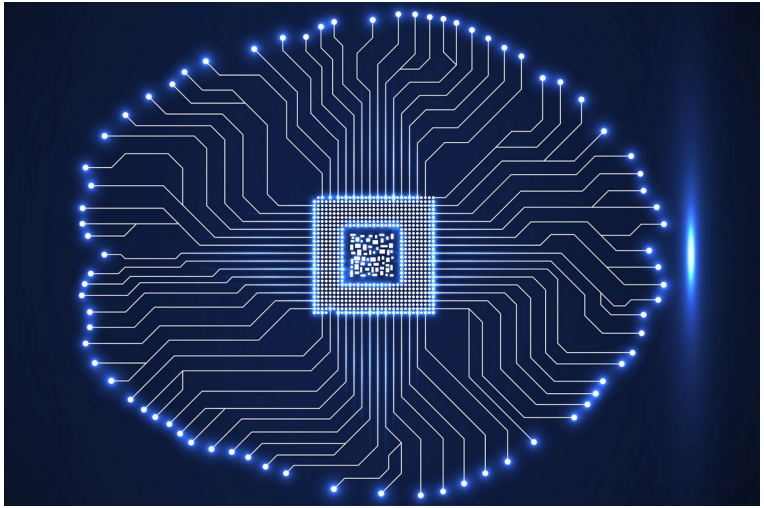
- The city's congestion creates an economic loss of **33 billion pesos ($1.7 billion)**, in addition to the terrible impact on air quality.
- In 1990, a report found that the pollution killed 100,000 children a year and created problems for the sight of 250,000 people, with a **life expectancy reduced by ten years**.
- Ever since then authorities have taken drastic measures to combat traffic congestion and pollution (Blocking of car traffic for two days a week and closing schools and factories).

Traffic lights today

- Simple timers: the traffic light will cycle through green, yellow, and red at regular intervals to ensure a consistent flow of traffic in all directions through the intersection.
- Sensor-based traffic signals: they rely upon a system of sensors to detect when vehicles are present.
- To our knowledge most of these methods **do not take into account the flow into/from other intersections or the overall traffic flow in a city.**



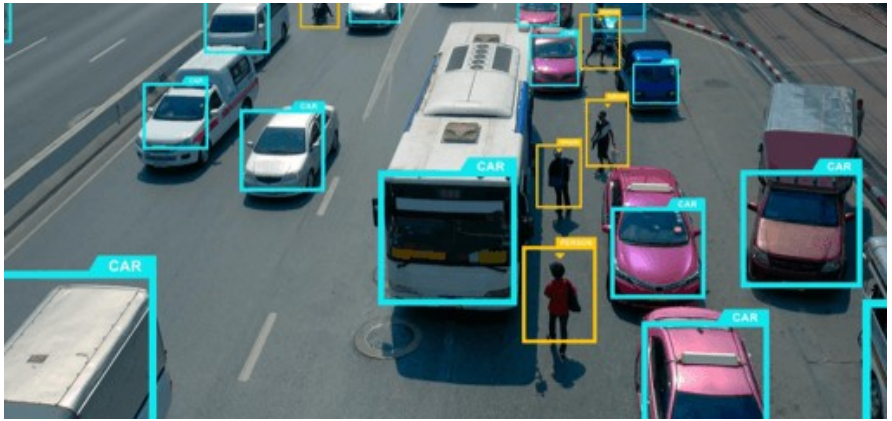
Proposal

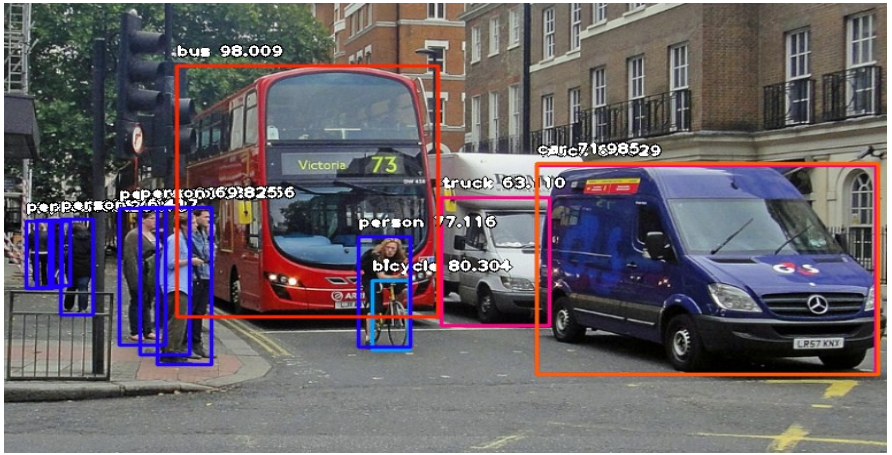


- Artificial intelligence and machine learning present a new approach to managing and possibly solving this issue in a more efficient and intelligent manner.
- We propose designing and implementing a smart AI-powered traffic management system with the goal of optimizing traffic times, avoiding congestion.

Initial study

- The initial study will consist of collecting information for the machine learning algorithm to train with.
- We will get the required legal permits to mount cameras in all intersections and points of interest of each part of a city in order to gather the necessary data during a year; this will give us an insight as to how seasons, weather, holidays and other important dates affect the traffic flow of a city





- An AI object detection program will obtain different variables that will have to be subsequently parsed and accepted by a human referee.
- The program will also train with infrastructural information (corporate buildings, commercial zones, hospitals, etc…) and their relation to the traffic flow as well to the previous variables.
- We will additionally collect and add he protocols already in place for that particular street/intersection to our database in order to be analyzed and taken into account

Initial study

The information gathered will include amongst other variables the following:

- Length and width of the street.
- Number of lanes.
- Number of pedestrians.
- Number of cars waiting at a light.
- Number of cars that can safely pass through a green light.
- Number of cars that run a red or yellow light.
- Type of cars and vehicles.
- Most congested intersections.
- Least congested intersections.
- Waiting time for each of the three lights.
- Waiting time for an intersection to decongest.
- Time of the day with the most traffic.
- Time of the day with the least traffic.
- Season/Time of the year with the most traffic.
- Season/Time of the year with the least traffic.

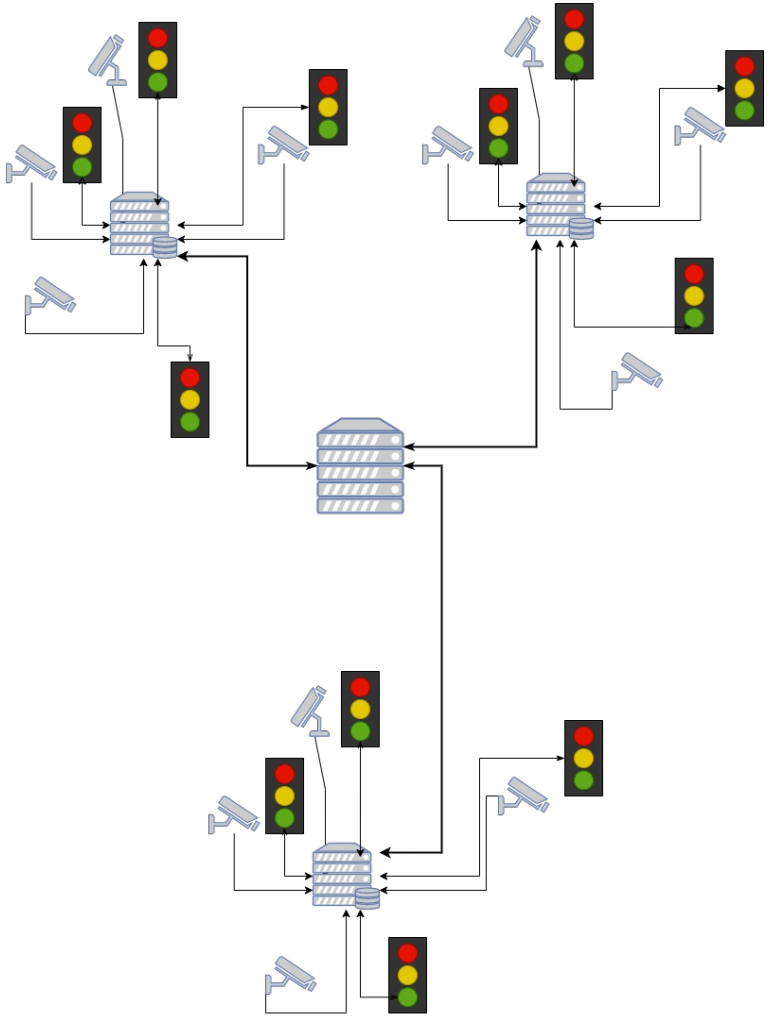
Computational Program

- We will use the information collected to design, train and test a machine-learning algorithm that is expected to find the different patterns amongst the variables and identify the relationships between them in order to produce a program that will optimize the flow of traffic through the waiting time of each signal.
- We will also train our program to identify accidents or any other exceptional/unexpectedl cases to plan and create alternative paths in order to keep the traffic flow mostly uninterrupted and most importantly clear the needed stree

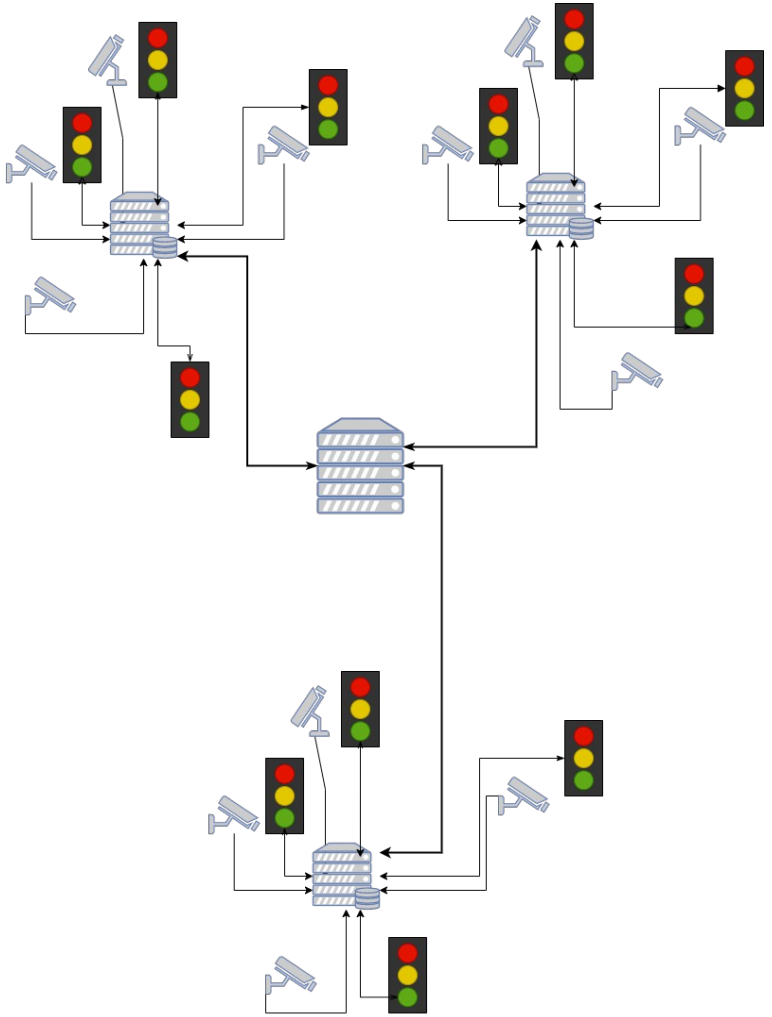
Computational Program

- We will train and test this program with different case scenarios for each municipality of the city and then for the city as a whole until obtaining acceptable metrics (accuracy, precision, sensibility, etc…)
- During this period of testing, the program is expected to optimize itself and return constantly improving custom made results for each part of the city and the city as a whole.

- We will have a local server with the traffic optimizer related to that particular part of the city and then all the local servers will be connected to the central main server with the optimizer for the whole city.

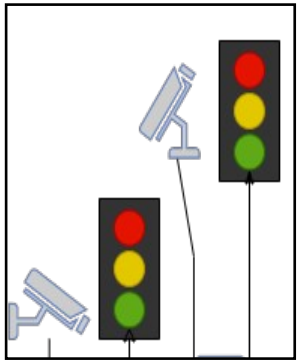


- Once we reach satisfactory results from the program, it can finally be put into real life operation.
- We will first activate our traffic optimizer on just an specific part of the city (in order to control to our best ability the beginning of the real life operation) before expanding and activating it in the whole city.

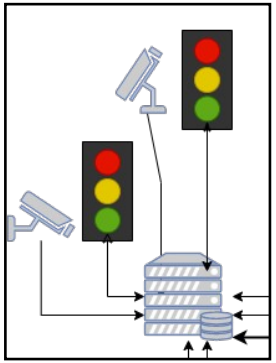


Real Life Operation : AI Cops

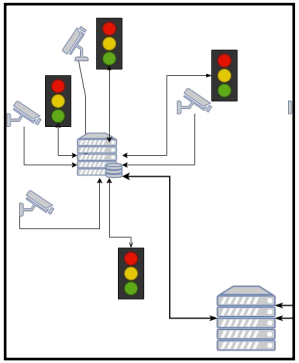
In order to have our program function reliably in real life we will keep using the smart cameras (AI “Cops”) previously used for gathering informational data in the initial study. These cameras will provide real time information (fog computing) that will be first sent and stored in the local server (edge computing) and then to the main server (cloud computing) of the city.



Fog Computing

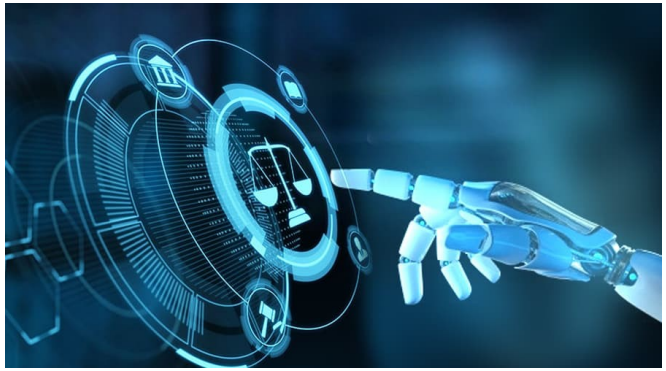


Edge Computing



Cloud Computing

Real Life Operation : AI Cops



Therefore the smart cameras used in the system have a double purpose:

1. The collected data sent to the local and main servers is used to make sure the program is working efficiently and to constantly improve and optimize it.
2. The cameras act as AI “cops” that will monitor and police the computer algorithm and therefore the traffic. In case of an accident, the program will activate the alternative traffic flow plans that will keep the traffic

The program’s operation must be overseen by humans in case the system ever produces an error or if the alternative plans put in motion in case of an accident are not

Challenges

- How will the information be transmitted and received between the traffic lights and the center main server?
- How can we break down the system to give a most precise optimization depending on each zone of the city (hyperlocalization) and then put it together again for the whole city?
- We found that using local servers (fog and edge computing) to custom the data according to the area and then connecting to a main server (cloud) worked to solve the problem.
- How we make sure the result of the computation is correct and safe to use?
- AI Cops will constantly monitor the traffic and human referees will monitor the program.

Plans for the future

- This project is a prototype strategy for solving traffic jams using ML powered smart traffic lights.
- We believe this could be a good solution for some of the main problems with traffic congestion.
- We are aware and in fact, we expect to find unforeseen issues once this new technology is applied in our simulations, therefore constant research and testing will be of essence to optimize this strategy.
- It will be important to keep in mind the following:
    - The accuracy of the results and the efficiency of the computational algorithm.
    - The propriety of the necessary physical equipment.
    - The laws that must be followed in order to carry out the project.
    - The administrational tasks.

Conclusions

- This system is meant to optimize traffic lights coordination and times in order to reduce traffic congestion and its subsequent problems.
- We hope to have a constantly improving program through AI.
- We hope to provide a secure strategy with correct outputs that will always be in check by computational methods and human experience.
- It will bring significant improvements into the everyday life and health of the citizens of a city.

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