Solving the traffic issue

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Abstract

Inside a city, the traffic is one of the greatest CO_2 generator. The pollution is created by the increasing number of cars rushing from one part of the city to another. The traffic pollution is a real threat for all the large cities. Understanding how traffic works is the key element for the proposed solution. With each technology breakthrough, new challenges will undoubtedly appear. This is the case of the "engine" as we know it today. In order to create energy, the engine has to burn dinosaur pee (i.e. diesel; petrol; gas or a derivate of fossil fuel). As much energy is required, as much fuel the engine has to burn, this is a directly proportionate relationship between the two. When we are talking about the engine in a car, the biggest energy waste is happening while the car is building momentum (accelerating). Because inside a city the car has to build momentum for every traffic light, the efficiency of the engine drops; a large amount of fuel is burned and the pollution is accordingly. The proposed solution is trying to limit the number of times that the car has to build momentum (accelerate) through artificial intelligence and driver awareness.

Keywords: Smart **t**raffic, green city, social awareness, artificial intelligence, traffic lights, traffic jam, CO2

Introduction

Inside the large cities, the CO_2 emissions represents a big threat to general health of the population. The pollution is created by the increasing number of cars rushing from one part of the city to another. According to European Green City Index report, Bucharest occupied the 27^{th} position out of 30 for the Air Quality Index (AQI) with a score of 4.54 out of 10. The CO_2 emission per capita had a value of 5.32 tones in Bucharest while Oslo had a value of just 2.31 tons of CO_2 per capita. No matter how we put the issue, the traffic pollution is a real threat for all the large cities. Just to give you an idea, in the table below is presented the maximum value of Air Quality Index (AQI) as CO_2 micrograms per cubic meter for eleven cities. A value above 100 is considered to be unhealthy and a value above 250 is considered to be hazardous. The Nordic cities lead the ranking with Oslo and Copenhagen reaching around 50 to 60 maximum AQI, while Paris, London and Bucharest have values that exceed the 140 AQI mark. At the bottom of the ranking we can find Beijing with the most hazardous value that exceeds 500 micrograms of CO_2/m^3.

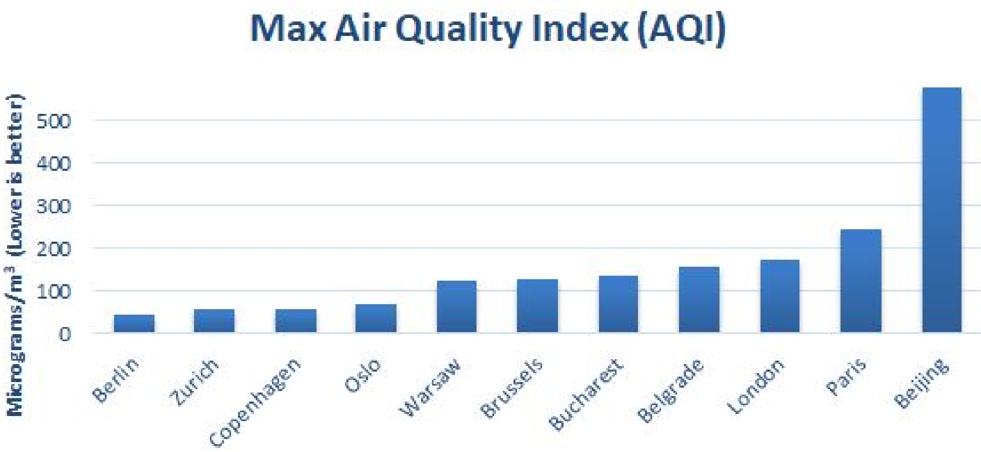

Table 1. Air Quality Index - CO_2 Micrograms/Cubic meter (maximum value) - Values available at http://aqicn.org/map/

How traffic works?

Being a car enthusiast since an early age and also a driver since 2010, I got to understand how traffic works inside a city beyond the average consumer. Because the number of cars is great, you need to use a traffic light for each road that cross each-other (intersection). The traffic light does his job extremely well, allowing cars from different direction to cross the same paths without hitting each other, but in the same time when you have a straight road that is full of traffic lights, you will need to stop for most of them. This is not very efficient when you think of moving a 1.6-tons vehicle with 50 km/h and then stopping for each traffic light. Putting the issue in other words, it is a waste of energy every time you hit the brake pedal. Of course, you need to stop because the traffic light is red and you might crush. When you accelerate again (build momentum) the car is the least fuel efficient.

Let's suppose you are on a bicycle and you are pedaling toward a red traffic light. What would you do? Continue to pedal so you can stop sooner, or just coast toward the intersection hoping that the traffic light turns green and there is no need for you to stop? Why waste your energy pedaling toward a red traffic light? When you are driving a car, the same principles can be applied, only instead of your energy the engine uses fuel to produce energy.

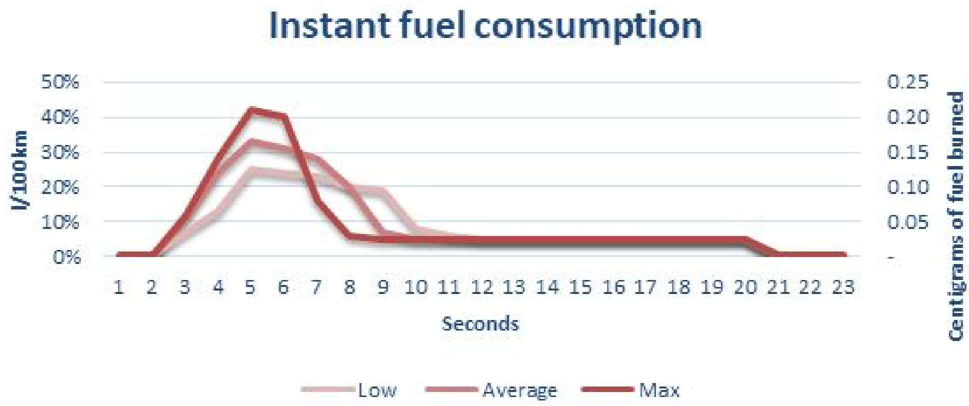

Figure 1. Analysis of fuel consumption between two traffic lights under different acceleration

In the Figure 1 you can see how the fuel consumption and grams of fuel burned is influenced under three types of acceleration between two traffic lights. Within the first 7 to 10 seconds the vehicle is building momentum (accelerating) and this is responsible for burning the greatest amount of fuel. When the car is keeping momentum (coasting) the fuel consumption drops drastically. This is the normal way an engine works. While accelerating, the engine is the least efficient because it needs a great amount of energy to build momentum. After the momentum is built the engine is used to keep the speed constant, a process that is very fuel-efficient. The biggest issue is when you need to lose the momentum by braking because in front of you is a red traffic light.

The figure 2 below is representing what is happening from efficiency point of view during six consecutive traffic lights that are red. For each traffic, light the three-step process: building momentum (acceleration); keeping momentum (coasting) and losing momentum (braking), is happening in the same way. It is a repetitive process that all the drivers have adopted without any further questions. There are very few people that try to anticipate what is happening in front of them while driving. This is the main reason why we are so inefficient while driving inside a large city.

The mass of one molecule of CO_2 is the equivalent of 44 grams. On average, the European[1] citizen creates approximately 9.1 t of CO_2 every year. More than half of this amount is made by driving the car inside the city. This means that every European is responsible for around 5 t of CO_2 inside the city.

[1] https://co2.myclimate.org/en/offset_further_emissions

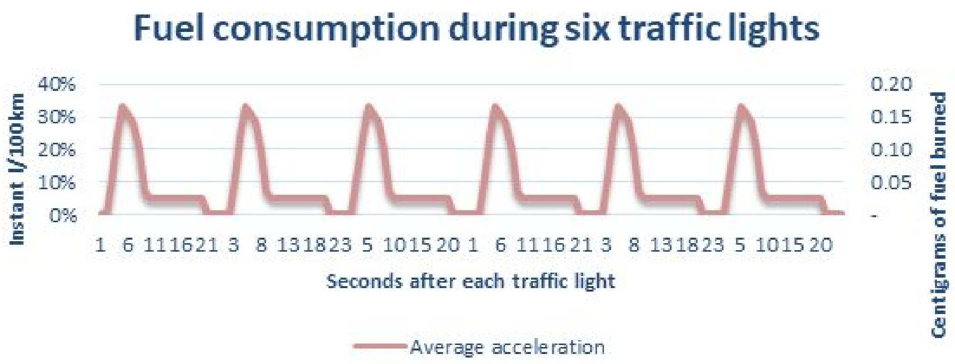

Figure 2. Analysis of fuel consumption during multiple traffic lights under average acceleration

What most of the drivers don't realize is that the top speed doesn't matter, it's the average speed that will do the job. When you are depending on the traffic light ahead of you, no matter what is the top speed you can get, the average speed of yours will always be similar with the cars surrounding you. The reality is that we are behaving like programmable robots that know only how to accelerate and break between the traffic lights; people never try to anticipate how the outside world is behaving. The reason is that no one ever told us to do so while driving, but also it can be tricky to anticipate others movements.

Proposed solution

How would it be if you can find all traffic lights on green and you wouldn't need to brake to a full stop ever again? Quite good I think. Let's suppose that you know when the next traffic light ahead of you will turn green or red. Will you still behave the same or would you try to synchronize the speed so there's no need to stop? What if someone can tell you the speed that you need to have in order to find the next traffic light green? Well, it is possible!

Technology today allows us to use precise Global Positioning System (GPS) in our pockets. What if for each road intersection coordinated by traffic lights, a mobile application can learn the timing of that specific traffic lights based on every individual GPS? An integrated feature would monitor each traffic light inside a city based on the behavior of traffic participants and can indicate the speed that you should be driving for getting to the next traffic light perfectly synchronized.

Instead of you accelerating up to 57 km/h and reaching the next traffic light on red, the mobile application would indicate the speed that you need to adopt in order to perfectly synchronize with the following traffic light. And the process can continue after each traffic light that you meet. We know that Speed = Distance/Time. The distance is known, and the traffic-light time can be learned from drivers' behavior. This way we could find the speed that you should be driving for getting to the next traffic light perfectly synchronized. Of course, there can be a threshold speed regarding the minimum and maximum so the chances of tangling up the traffic are minimum.

By altering your speed with just 15km/h for a distance of 500m the time you reach the finish point can be modified by 15 seconds. The value can be influenced by the speed that you are having in the first place as well, but 15 seconds can make the difference between perfectly synchronized green light and a full stop to red.

Looking at the graph bellow we can see that the process of building momentum (acceleration) happened only once, while for the rest of the journey small adjustments were made. This means that you need to accelerate to a moderate speed that an integrated feature of a mobile application is indicating (e.g. Maps, Waze etc.) and then just keep that speed constant or make slight adjustments. Using such a feature (Figure 3) you would need to accelerate once to the indicated speed for synchronizing yourself with the next traffic light.

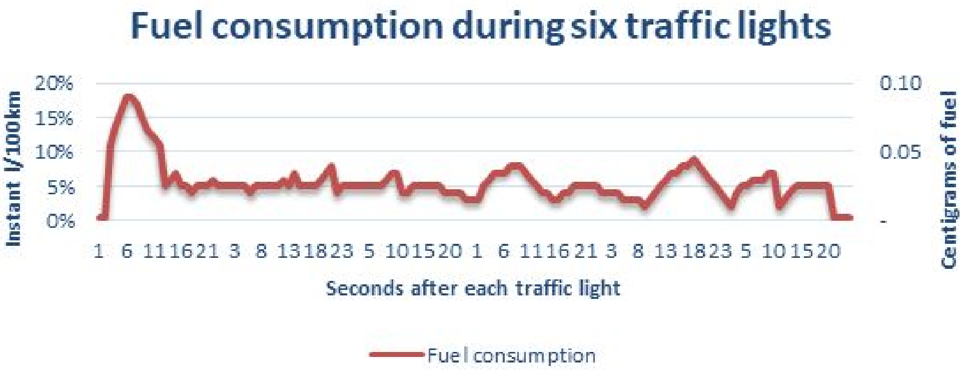

Figure 3. Analysis of fuel consumption during multiple traffic lights under synchronized conditions

After crossing the next traffic light, the application would recalculate the speed you need to adopt for catching the following traffic light on green, then the following and the process would just continue over and over. By using this process, the time spent on the road will be similar and the average speed will be similar. The only difference is that you will behave in a much more efficient way. How efficient? Well, by adding up the numbers and comparing them with Figure 2, would give us an increase in efficiency of more than 60% (see Table 2).

	The smart way	**The monkey way**	**Difference**	**Smart/Monkey**
Average Fuel consumption	5.6%	9.1%	+3.5%	+62.5%
Fuel burned	39 g	63 g	+27 g	+61.5%
Top speed	46 km/h	73 km/h	-27 km/h	-27 km/h
Average speed	35 km/h	35 km/h	0	0
Lowest speed	30 km/h	0 km/h	+30 km/h	+30 km/h

Time reaching destination	138 seconds	138 seconds	0	0

Table 2. Comparison between proposed solution and actual conditions

By adjusting your speed for synchronizing with the next traffic light, the fuel efficiency increases from 9.1% to 5.6% (lower is more efficient) and the amount of fuel consumed drops from 63 grams to 39 grams. All this while having the same average speed and the same time travel. It is a win-win situation. Of course, these are some raw figures and the probability of you to stop for pedestrians or the impossibility to perfectly synchronize with the next traffic light may appear, so we need to apply a correction factor to the numbers. The correction factor is mostly variable and uncertain based on location, hour and day measured. Or… is it really? Well, if the application is learning from drivers' behavior, and there is a pattern for a certain pedestrian crossing at a certain hour in a certain day that shows the probability of you needing to stop there is around 90% (9 out of 10 cars are stopping) and the average stopping time of a vehicle is 13 seconds, then you can predict the unpredictable.

Anyhow, a correction factor of around 50% (61/1.5=40) needs to be applied and the real increase in efficiency will drop to around 40%. Now, what really means 40% increase in efficiency?

Implications

1. Fuel consumption drops

What will you gain if you are using such a feature while driving? From financial perspective if you drive around 22.000km yearly and 12.500km are inside the city, we are looking at savings of €42 monthly. Maybe it's not a deal breaker, but if you add up the ware of the car (lower expense for set of new breaks, tiers, braking fluid, etc.) the yearly savings add up to more than €700. That is an extra salary at the end of each year. Over 100.000km we are looking at around €3.500 in savings.

	The smart way	The monkey way	Difference
Average yearly distance	22,000 km		
Inside city (60%)	12,500 km		
Fuel consumption	6.0%	9.1%	3.1%
Average price/liter	€ 1.29		
Liters consumed	750 Liters	1,138 Liters	€ 388
Yearly expense	€ 968	€ 1,467	€ 500
Monthly expense	€ 81	€ 122	€ 42

Table 3. Efficiency from your wallet

2. CO_2 emissions drops

If the financial perspective is not motivating enough, maybe your kids' future health is. If one individual is reducing the fuel consumption by 40%, the yearly car footprint will drop from 5 t of CO_2 to just 3.5 t of CO_2. Putting this into perspective, if there are 300.000 cars inside a city and all individuals will use the feature, there will be saved approximately 450.000 t of CO_2 every year. The results are truly spectacular and the effect is immediate.

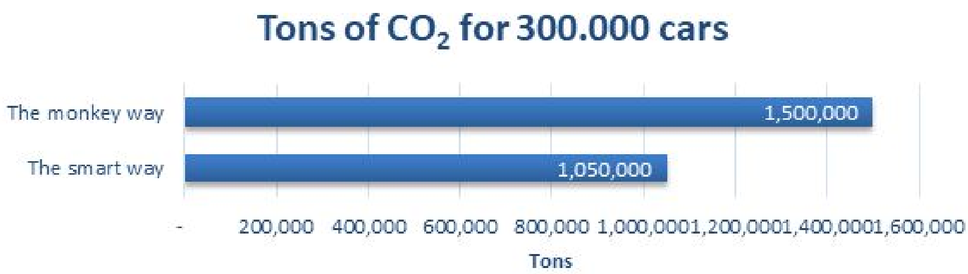

Figure 4. Footprint difference over one year period for 300.000 cars

3. Traffic flow increases

A short analysis on how traffic works will reveal how inefficient people are working as a group while driving. Supposing that you are waiting at a traffic light and you are in the 5th car in a raw, after the traffic light turns green, you would have to wait around 7 seconds before you start to accelerate and another 3 to reach the traffic light. After 10 seconds on green, only 5 cars have passed. Why is this happening? Because we are not racing drivers and every car waits for the car in front to start moving. This is creating a snake effect that is expanding slowly. We should ask ourselves what would happen if all of the drivers reached the traffic light perfectly synchronized?

In 10 seconds, if all the drivers would be synchronized and driving with a speed lower than 50km/h the traffic flow would be of around 12 vehicles. This means that 12 vehicles that have around 50km/h can pass through an intersection in 10 seconds if they are synchronized. The efficiency of traffic flow increases by more than 140% (Figure 5).

Figure 5. Flow of cars through an intersection over 10 seconds

4. Risk of accidents drops

By using the feature, although the average speed will be the same, the indicated speed will be most of the times smaller than your usual speed. This means that you can prevent the risk of an accident a lot faster and you can stop a lot sooner. It is hard to approximate the risk difference but if you take a look at Table 2 we can see that the top speed difference is about 27 km/h.

Summing-up

Pollution is a real threat to large cities due to substantial number of cars. Because drivers act independently and cannot anticipate the traffic lights, the efficiency of a car inside the city is decreased substantially.

By using technology in our favor, we can anticipate the traffic lights and act accordingly. Technology can learn from drivers' behavior and can help us all to adjust the speed in such a manner that we can catch all traffic lights perfectly synchronized on green. This feature could give us an increase in efficiency of more than 40%, higher traffic flow, lower emissions and lower risk of accidents.

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