1)

Automobiles have long became a part of our everyday life. A personal car has a lot of both merits and downsides. For a single person benefits clearly outweigh, but is it the same for the society as a whole? With the growth of population increases the number of cars bought annually and, therefore, the number of cars on the roads daily.

2)

Traffic jams influence cities in various ways. Commuters start wasting more time to drive to work or return home, the atmosphere is being polluted by the toxic fumes from gasoline and diesel cars, business suffers from traffic congestion: neither appointments nor negotiations cannot be properly planned and logistics becomes economically unstable and unprofitable.

3)

According to Traffic Index Ranking published by TomTom in January, 2019, Moscow could be found in the 6th place in the list of the most heavily congested cities in the world.

4)

A year later, in January, 2020, in the same ranking Moscow has a leading position among the most heavily congested cities and is one of three capital cities on the top-5 list.

5)

Due to the Yandex thorough appraisal of traffic jams in Moscow from 2013 to 2017, average congestion level has changed. In the area between the Third Transport Ring and Moscow Ring Road the situation had enhanced and the congestion level lowered up to 1.5 points during the rush hours. On the contrary, in the center of the city the congestion level rose up for 2 points. In other words, the road situation in Moscow has hardly improved. And this tendency continues up to 2021.

All these factors impact quality of life and overall rating of the city. So what can be done to fix this?

5)

The most obvious solution is to build more roads and road junctions. This will help to better maintain the traffic, but this will also take time, space and money to build and the more roads are built the less space remains for residential and/or industrial development.

Some governments such as one in China endeavor to reduce the number of cars on the roads by passing specific laws regulating traffic and automobile trade. In Suzhou, the researchers tried to differentiate parking prices and congestion charges throughout the day in the old town and succeeded to lower traffic level.

But the cheapest and the most effective way of handling the problem is the production of artificial intelligence software for controlling movement on the intersections and that way optimizing the traffic.

6)

As mentioned in CNN article published on 6 January 2021, some governments are already discussing the commissioning of new technology in cities struggling from traffic congestion.

The **ultimate goal** of this project is to produce a software for traffic lights intellectual control,

an algorithm that can switch the lights and control traffic on the roads, and an estimation of its

accuracy.

7)

Now lets get down to basic terms. A traffic signal control agent or TSCA is a program that controls overall traffic on the intersection and sends commands to specific traffic lights to optimize their performance and decrease values of metrics, the most common of them being 1) number of queued vehicles, 2) vehicle throughput of the intersection and 3) vehicle delay before passing the intersection.

In order to test such agents virtually first one can use simulators that resemble real life traffic on the roads such as the one on the slide. The model is integrated into the simulator environment and connected to traffic lights control system. Then a bunch of test suites are run to detect vulnerable or slow parts.

8)

There is a vast majority of traffic simulations from online microsimulators where user controls only given parameters to large offline simulators with helpful features and APIs. API - **application** **programming** **interface**, - is a set of instruction that makes interaction between external program and simulator possible.

9)

SUMO is a powerful tool for simulation and is also an open-source project which means that it does not stop being enhanced. Simulator of Urban Mobility provides an ability to generate traffic lights and set their control regime as well as make a python script to control traffic light at every given moment.

10)

Let’s compare built-in regimes. There are three basic modes: static, actuated and delay-based. Static regime fixes light phase duration and does not change its behavior over time. Actuated and delay-based modes can be called intellectual as they change traffic light logic depending on time gaps between vehicles or accumulated time loss of queue vehicles respectively.

We have evaluated the performance of built-in traffic lights switching behavior with the help of provided python script. One can see metrics values measured for a session of 120 seconds. The project takes this value as a baseline and seeks to enhance the traffic situation on a single intersection.

11)

In order to achieve this goal python script based on Paul L. Fackler algorithm described in his article Solving Optimal Switching Models was implemented in jupyter notebook. As proposed in the article, the optimal switching problem solution is based on matrix operations.

In order for the script to work, one should implement a reinforcement learning model that will choose family of approximation functions and set traffic lights transition values.

A research by Genders and Razavi reviewed various methods of reinforcement learning implementation for this problem. In the end, it comes down to deep Q-network traffic control agent.

13)

Reinforcement learning is one of the machine learning approaches that lets computer interact with given environment and remember and combine features that give the most value.

Let me present some concepts valuable for this project.

Deep neural networks or DNN are neural networks with many layers. The most famous of them are those achieving incredible results in ILSVRC, a competition where people try to create the most efficient classification for a set of images using machine learning. The greatest thing of DNN is extracting feature representations through backpropagation. Not going deep into deep learning, DNN extract the most essential features from data.

13)

The combination of the two concepts provides a basic understanding of what deep Q-network is. To clarify, we will provide an example. There is an article called [Playing Atari with Deep Reinforcement Learning](https://arxiv.org/pdf/1312.5602.pdf) that explains the concepts, algorithms and motivation behind machine learning playing Atari Breakout arcade and progressing in it. Another example is AlphaGo DQN, which in the last few years learned to outplay real people in real-time DOOM games and now learns to control cars and helicopters.

14)

To sum up, the work has not been finished yet but we are eager to give a go-ahead to the plan for further expansion and produce a software that consists of the simulation control script and computational script for optimizing regime switching problem solution using deep Q-network that surpasses baseline traffic light behavior model performance.

That is all, thank you for your attention.