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Project Documentation

1. Modeled System
    a. Description

This model simulates drivers' behavior in EDSA upon opening and closing U-turn slots. The goal of this model is to prove that there is an optimal/suboptimal U-turn configuration to open and to close besides the current setting in EDSA. It also demonstrates how traffic jams can form.

This model is an extension of the two-lane version of the "Traffic Basic" model.

b. Things to Look at

Our initial idea for the U-turns is that when two close distance U-turns open together, it will create a traffic jam.

Also, according to Wilensky, U. & Payette, N., (1998) traffic has a wave phenomenon where the behavior of an agent is different in a group. This can be seen as the vehicles are moving forward, traffic jams are moving backwards. Additionally, they mentioned that drivers exhibit a "snaking" behavior as the road becomes congested. They will try to switch back and forth lanes therefore causing the phenomena.

For lane changing, drivers often choose the lane that seems to be the best or in accord with his/her destination. (S)he will then devise a plan to move to that lane. To move to the chosen lane, there must be available gaps that are acceptable. In a highly congested highway, acceptable gaps are limited. Traffic may slow down and jam without any centralized cause, just as it did in the two-lane version of the "Traffic Basic" model.

In these scenarios drivers react by changing lanes, but this usually does not help them solve their problem. So the things to look at are the combinations of U-turns and the specifications of vehicles per lane.

For this project, we are interested in U-turns thus we did not include an analysis for the specifications of vehicles per lane.

2. Agents
   a. Drivers of different vehicles

Agents are the drivers of different vehicles in EDSA. Some of the drivers except bus drivers will U-turn at some point according to their destination. In this setting, the destination assignment is randomized. Also, buses are 1.5 larger than other vehicles. In this case, it seems that cars are at the level of a bus, but it is only in a shape sense, not the actual size.

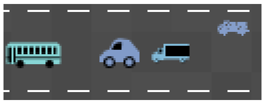


Fig 1. Different Vehicles in the Simulated EDSA

   b. Properties
      c. Bus Drivers

         i. Speed
            This is influenced by the acceleration and deceleration set for the bus.

         ii. Top Speed
            This is randomized from 40 KPH to 55 KPH. Randomized since some of the buses have deprecated top speed.

         iii. Acceleration
            Acceleration of bus; configurable through slider

         iv. Deceleration
            Deceleration of bus; configurable through slider

d. Car/Logistics/Motorcycle Drivers

i. Speed

This is influenced by the acceleration and deceleration set for the vehicle.

ii. Top speed

This is randomized from 50 KPH to 10 KPH. Randomized since some of the Cars/Logistics/Motorcycles have deprecated top speed.

iii. Patience

This indicates the patience of the driver. This accounts for the utility factor affecting the driver. For example, if the front vehicle is a bus and it slows down the speed of the driver, it will decrease the patience of the driver.

iv. Target U-turn

This is the target U-turn of the driver. e.g., if a driver decides that (s)he will turn at U-turn 10, the driver will try to turn to that U-turn.

v. Acceleration

Acceleration of Car/Logistics/Motorcycle; configurable through slider

vi. Deceleration

Deceleration of Car/Logistics/Motorcycle; configurable through slider

e. State of the Agents

f. Bus Drivers

Bus drivers have a limited set of actions. They will just continue to move-forward. If there is a vehicle in front, they will slow down otherwise speed up until top speed is achieved. If the front vehicle is a bus, a driver will consider an additional space. This is because bus drivers don’t see the rear of a bus and this might cause accidents.

Fig 2. Additional Spacing if Front Vehicle is Bus

g. Logistics/Car Drivers

i. Moving forward

Drivers continue to move-forward. If there is a vehicle in front, they will slow down otherwise speed up until top speed is achieved. If the front vehicle is a bus, a driver will consider an additional space. This is because bus drivers don't see the rear of a bus and this might cause accidents.

ii. Make a U-turn

Drivers will try to get close to the leftmost lane if their U-turn distance is close. If the left lane contains 6 vehicles, the driver will decide to go to the next U-turn. If they are near the U-turn and they are at the leftmost or second leftmost lane, they will make a U-turn. If the U-turn is closed, it will proceed to the next U-turn. If it's the last U-turn, the driver will have no choice but to make a U-turn. The driver will slow down upon turning.

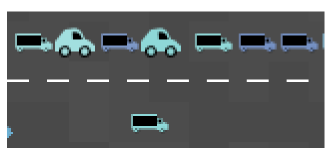


Fig 3. Left Lane Switch Constraint

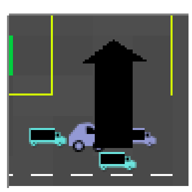


Fig 4. Vehicle Making a U-turn

iii. Choosing Target Lane

If the patience of a driver is below or equal to 0, (s)he will choose a new lane closest to him/her on the basis of his/her target lane. If a driver is stuck within his/her space and cannot move, the driver will remain in his/her current lane.

iv. Move to Target Lane

If a driver decides to move to the target lane but there is/are blocking vehicle(s), the driver will slow down otherwise continue to move to the target lane.

h. Motorcycle Drivers

The behavior of motorcycle drivers is the same as the Logistics/Car Drivers but their vision considerations for gaps are smaller because they can navigate to tight spaces.

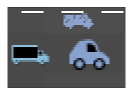


Fig 5. Motorcycle Dynamics

3. Environment
   a. EDSA

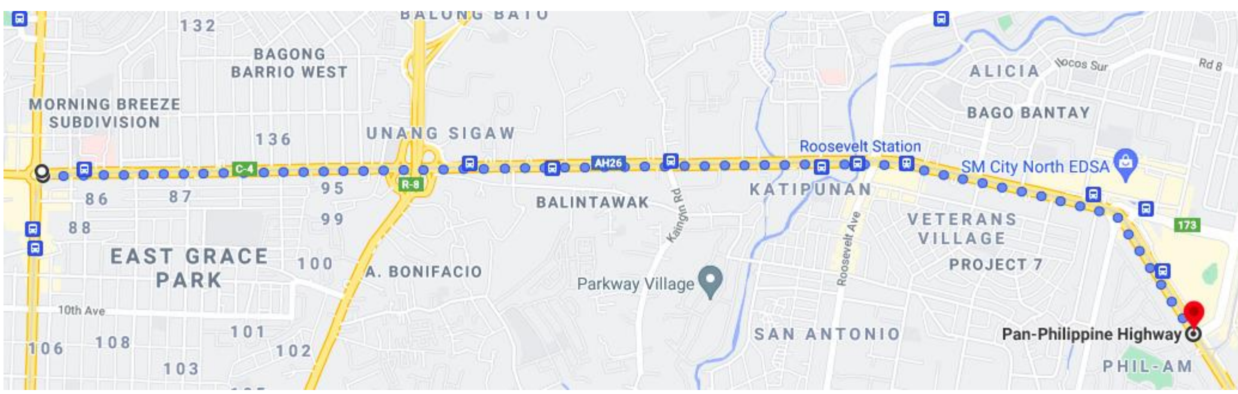


Fig 6. Chosen Section of EDSA. Link: https://www.google.com/maps/dir/14.6571273,120.9842275/14.6572447,120.9842578/14.6505656,121.033342/@14.6547879,121.0244245,15.25z/data=!4m2!4m1!3e2

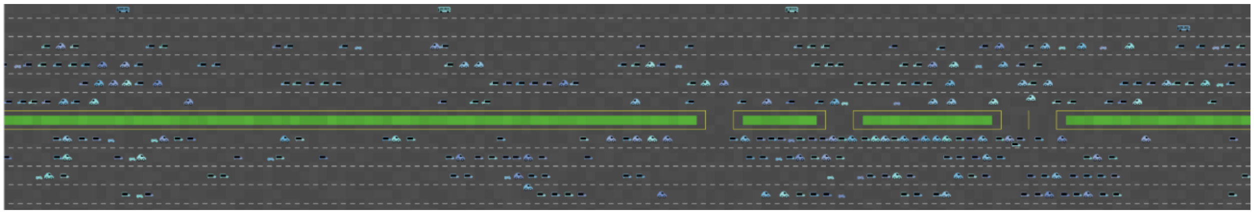


Fig 7. Portion of the Environment

i. Properties
1. 6 lanes northbound and 6 lanes southbound.
2. 16 u-turns with coordinates on Netlogo basis [-173 -160 -141 -138 -27 -24 5 8 71 74 117 120 145 174 177 188]
3. 500 width patches on Netlogo basis
4. 2 height patches for lanes on Netlogo basis
5. 6 patches forming a square for U-turns

We modeled a portion of EDSA as a straight line with different points for U-turns. We did not include the intersection roads. Vehicles are restricted to the road section only. They cannot overshoot from the road. Road lines separate the agents per lane.

4. Timestep

Each time step, the drivers will drive through the lane. The drivers choose a target lane and look for gaps in order to move to that lane. If the driver is already in that lane, he/she will remain. If the gap is not acceptable, he/she is still observed in the current lane. This model can only explain one lane change at a time. Utility is based on the driver's patience. Drivers can also turn into a U-turn slot, speed-up, and decelerate.

5. Initial Configuration
   a. Max Patience

This is the driver's patience. This mostly affects the decision making of the driver.

   b. Spawn bus lanes

This indicates where the bus should spawn. It also has an indication if it is exclusive for bus only. This mostly affects the lanes of non-exclusive vehicles.

c. Acceleration of vehicles

This influences the speed of the driver. The higher the acceleration of the vehicle, the faster it can achieve its top speed. This is configured for every vehicle.

d. Deceleration of vehicles

This influences the speed of the driver. The higher the deceleration of the vehicle, the faster it can decrease its speed. This is configured one per vehicle.

e. Number of vehicles

Number of vehicles on the road. This is configured one per vehicle. This mostly contributes to the congestion.

f. U-turn constraint

U-turns in the simulated map. Can either be northbound or southbound. This mostly contributes to the congestion.

6. Outputs/Results and Discussions

Since our main goal is to find the optimal configuration of U-Turn slots, we initially simulated the current U-Turn slot configuration in EDSA as of this moment. Then we created 14 more U-Turn slots configurations having a goal to find a more optimal configuration in EDSA that would make the vehicles in EDSA run faster. (For clarification, each U-turn slot configuration is a sequence of U-Turn's state if its either closed, from left bound-to-right bound only or from right bound-to-left bound only.) All 15 configurations simulated are listed on table 1.

Table 1. List of Configurations simulated

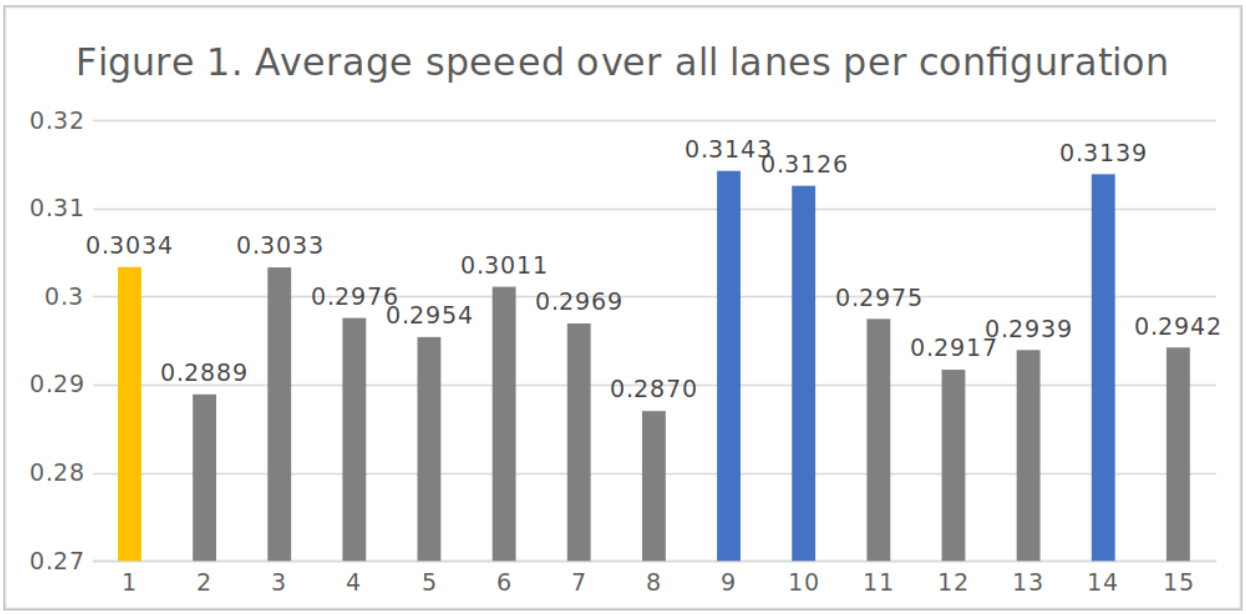
Configuration	{[left-to-right bound U-turns], [right-to-left bound U-turns], [closed U-turns]}
1 [Current in Edsa]	{[1,2,3,5,14], [4,6,15], [7,8,9,10,11,12,13,16]}
2	{[1,2,3,4,5,6,7,8], [9,12,11,12,13,14,15,16], []}
3	{[1,3,5,7,9,11,13,15], [2,4,6,8,10,12,14,16], []}
4	{[1,7,9,14], [3,8,11], [2,4,5,6,10,12,13,15,16]}
5	{[1,3,5,9,13,16], [2,4,7,12,14], [6,8,10,12,15]}
6	{[3,7,14], [4,8,15], [1,2,5,6,9,10,11,12,13,16]}
7	{[3,9,14], [4,10,15], [1,2,5,6,7,8,11,12,13,16]}
8	{[1,7,14], [2,8,15], [3,4,5,6,9,10,11,12,13,16]}
9	{[3,5,7,9,11], [4,6,8,10,12], [1,2,13,14,15,16]}
10	{[1,4,6,7,10], [12,15,16], [2,3,5,8,9,11,13,14]}
11	{[12,15,16], [1,3,5,9], [2,4,6,7,8,10,11,13,14]}
12	{[1,9,16], [2,7,12,13], [3,4,5,6,8,10,11,14,15]}
13	{[1,5,9,14], [2,6,10,15], [3,4,7,8,11,12,13,16]}
14	{[1,7,11], [2,8,12], [3,4,5,6,9,10,13,14,15,16]}
15	{[1,5,9,13], [2,6,10,16], [1,5,9,13,2,6,10,16]}

Each configuration is simulated 8 times, then its results are averaged for precision. Results are shown on Table 2. The averaged results over all lanes per configuration is shown on Figure 1. According to the results, there exists a U-turn slots configuration that is more optimal than the present one in EDSA (Configuration 9, 10, and 14 have achieved better results than Configuration 1). One possible reason that we learnt when simulating configurations is that to achieve better average speeds throughout the lane, the configuration should have a right amount of U-turn slots, not too many, not too few, and U-turn slots should be spaced evenly, not too close nor far with one another.

Table 2. Average speed per lane on each configuration.

	Right Bound Lanes						Left Bound Lanes					
Config	1	2	3	4	5	6	1	2	3	4	5	6
1	0.180	0.167	0.242	0.360	0.444	0.451	0.238	0.220	0.246	0.273	0.417	0.402
2	0.192	0.201	0.280	0.362	0.444	0.456	0.124	0.162	0.195	0.244	0.401	0.408
3	0.140	0.266	0.321	0.387	0.457	0.456	0.168	0.189	0.199	0.241	0.400	0.414
4	0.155	0.186	0.266	0.379	0.461	0.447	0.178	0.214	0.234	0.241	0.414	0.395
5	0.169	0.193	0.281	0.381	0.444	0.447	0.201	0.195	0.215	0.210	0.406	0.403
6	0.194	0.181	0.263	0.364	0.454	0.472	0.176	0.215	0.245	0.246	0.395	0.407
7	0.207	0.189	0.176	0.319	0.452	0.456	0.195	0.232	0.266	0.281	0.398	0.393
8	0.183	0.169	0.208	0.313	0.462	0.459	0.197	0.179	0.218	0.257	0.404	0.396
9	0.190	0.195	0.262	0.338	0.461	0.462	0.249	0.257	0.263	0.279	0.406	0.410
10	0.205	0.199	0.295	0.357	0.452	0.447	0.259	0.236	0.247	0.257	0.388	0.409
11	0.140	0.193	0.262	0.399	0.452	0.461	0.166	0.190	0.228	0.260	0.404	0.415

12	0.144	0.189	0.251	0.348	0.452	0.450	0.178	0.212	0.220	0.261	0.393	0.403
13	0.185	0.179	0.196	0.265	0.455	0.451	0.228	0.242	0.251	0.264	0.402	0.410
14	0.179	0.185	0.232	0.342	0.454	0.453	0.260	0.271	0.293	0.297	0.394	0.407
15	0.181	0.182	0.211	0.353	0.470	0.451	0.193	0.207	0.231	0.250	0.400	0.401



There are millions of possible combinations for U-turn configuration, thus finding the most optimal one is intractable, so we currently simulated 15 for this project.

References:

Choudhury, C. F. (2005). *Modeling lane-changing behavior in presence of exclusive lanes* (Doctoral dissertation, Massachusetts Institute of Technology).

Choudhury, C. F., & Islam, M. M. (2016). Modelling acceleration decisions in traffic streams with weak lane discipline: A latent leader approach. *Transportation research part C: emerging technologies*, *67*, 214-226.

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