CA4024 Assignment 1

ABM Traffic Simulation Project Documentation

2nd April 2022

1 Code

The link to the code can be found in this GitLab repository, along with the README.md file explaining how to run the simulation.

The code can be run on the command line by using the ‘python ABM_traffic_simulator.py”. The command line will accept input if you would like to change parameters (specifically the size of the map, the number of drivers and the initial tiredness rate). The input of these commands will be checked and new input will be requested if entries are invalid. The command line will show as follows:

```
C:\Users\laram\CA4024\CA4024_Assignment1>python ABM_traffic_simulator.py
Enter a map size (or leave empty to use the default map size of 50):
Enter a number of drivers (or leave empty to use the default number of drivers of 10):
```

2 Model Description and Purpose

2.1 Model Purpose and Reasoning

The purpose of this model is to simulate the effects of tiredness on drivers. Drivers may be more likely to cause an accident if they are tired. This model highlights the potential disregard shown by drivers to the rules of the road when they are tired. The more tired the driver, the more likely they are to overlook the rules of the road. The model also simulates the possibility that a driver falls asleep at the wheel, and the traffic jams or crashes that may occur as a result. Drivers can wake up after falling asleep and continue driving.

The purpose of this simulation is to visualise drivers in a map. This requires the drivers to be able to identify and abide by the rules of the road. Each driver has to maintain on the left side of the road, they can’t enter a junction if it’s already in use and they have to give way to drivers entering the junction from their left. These sets of rules can be broken when drivers get tired. Drivers do not get tired at a constant rate, it is dependent on their environment. In this model, drivers' tiredness levels increase when they are driving on junctions, as it requires more concentration than driving on a straight road. Tiredness levels also increase if the driver has to wait at the junction, as the driver is sat idle and could feel more sleepy as a result. If a driver falls asleep and wakes up again, the driver is not considered tired anymore.

2.2 Explicit Rules of the Model

As the purpose of using ABM models is to simulate randomness, the position and direction of all the drivers is set randomly. Drivers can be initialised in any random position on the map (excluding junctions), and will go in the direction associated with that position (remain on the left side of the road). The initial tiredness of each driver will depend on numerous factors, such as time of day, how much sleep they got the night before, etc. To account for this, the initial tiredness score assigned to a driver is a random number between 0 and 0.5. Each driver has many sets of rules in this simulation, which can be split into two categories, and are listed as follows:

- Rules of the road:
    - Remain on the left side of the road at all times
    - Do not enter a junction if there is a driver already on the junction
    - Give way to drivers about to enter the junction to the left
- Rules/effects of tiredness:
    - Increase the tiredness by a random number between 0 and 0.2 if the driver has to wait at a junction
    - Increase the tiredness by a random number between 0 and 0.01 if the driver is on a junction
    - The drivers tiredness score is the likelihood that they go through a junction without acknowledging the rules of the road
    - If the driver's tiredness score reaches 1 or above, the driver falls asleep (stops moving on the map)
    - The driver will wake up depending on the time they have spent asleep. If the time they have spent asleep is smaller than a random number between 100 and 500, then the driver will wake back up and their tiredness score will be reset to 0.

3 Model Results

3.1 Intended Results

As this is a simulation for the effect of tiredness on drivers, the intended result should show an increase in crashes when drivers' tiredness levels are high. With the map size and number of drivers being adjustable, this would also lead us to expect that the more dense the population of drivers in a map, the quicker and more often crashes will occur.

Things we can monitor are the rate at which drivers crash and the tiredness levels of drivers. Both of these metrics can be seen on the accompanying graph during the simulation, titled 'Tiredness Scores for Each Driver'. This plots a line for each driver, visualising their tiredness levels over time, and plots the moment/time at which they crash. We can see if there are lots of crashes when the tiredness scores are above or equal to 1, that there are a lot of crashes as a result of drivers falling asleep. Similarly, we can deduct that if there are not many crashes involving a sleeping driver that a lot of them are collisions as a result of ignoring the rules of the road.

3.2 Testing the Model with Adjusted Parameters

Images are hyperlinked to GitHub to enable you to see them on a larger scale.

3.2.1 Using Default Values for Map Size and Number of Drivers

The default value for map size is 50 (meaning the simulation grid is 50x50), and the default value for the number of drivers is 10.

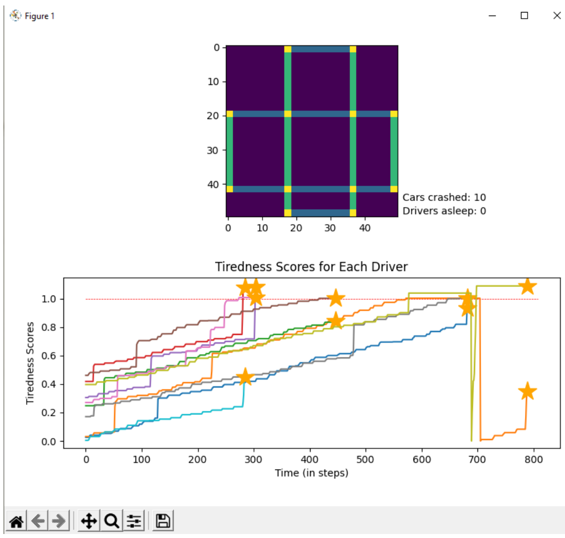


Fig 1.

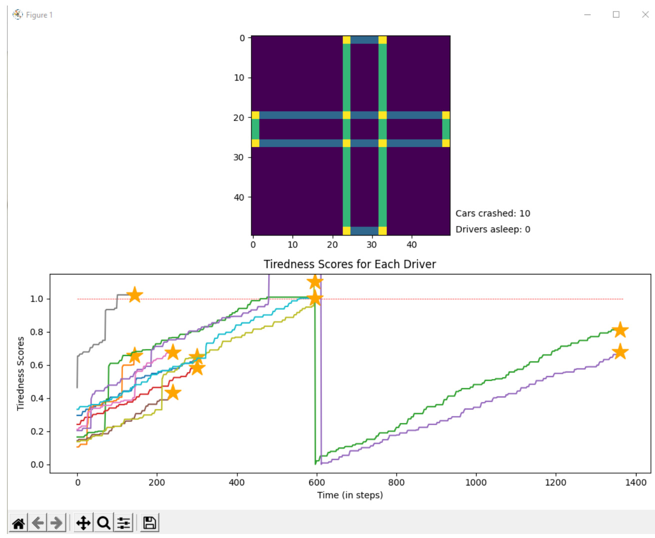


Fig 2.

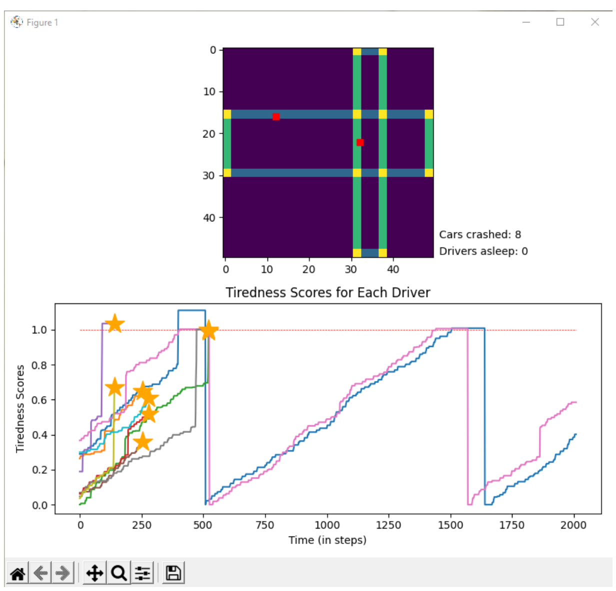


Fig 3.

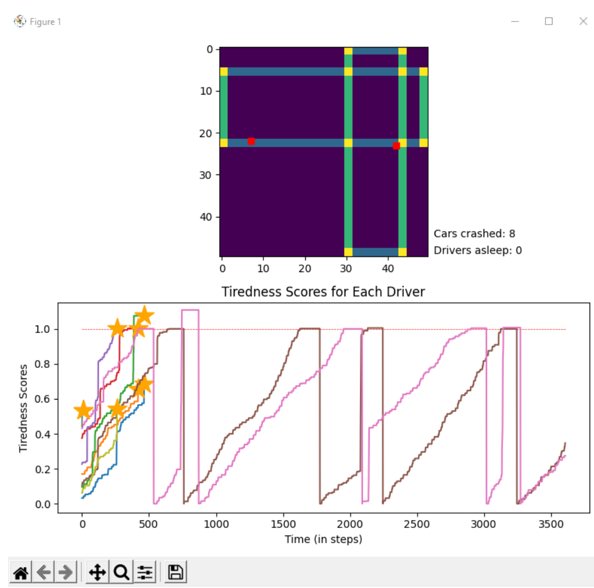


Fig 4.

In Figure 1 and 2 above, it shows that all drivers have crashed by step 800 and 1400. In figures 3 and 4, it shows that 80% of drivers crash within the first 500 steps. After running this experiment approx. 10 times, figures 1 and 2 show the only times where all drivers crashed. This experiment has shown that the largest contributor of crashes is the number of drivers on the road. For this example, when the map size is 50, there are at least 368 positions (not including edge roads, as the lengths are random) that a driver can have at any given time. When there are only two drivers left, both drivers have to collide by having the exact same position, and the likelihood of this is also affected by the tiredness levels of the driver and whether they will follow the rules of the road. As you can see, in Figures 3 and 4, the drivers seem to just follow a pattern of driving until they fall asleep, and then waking up again and driving until they fall asleep, and so on. This can lead the simulation to continue indefinitely.

3.2.2 Effects of Adjusting Map Size

The map size represents the width and height of the simulation grid. It would be expected that (given a fixed number of drivers), increasing the map size will slow the rate of crashes, and decreasing the map size will increase the rate of crashes.

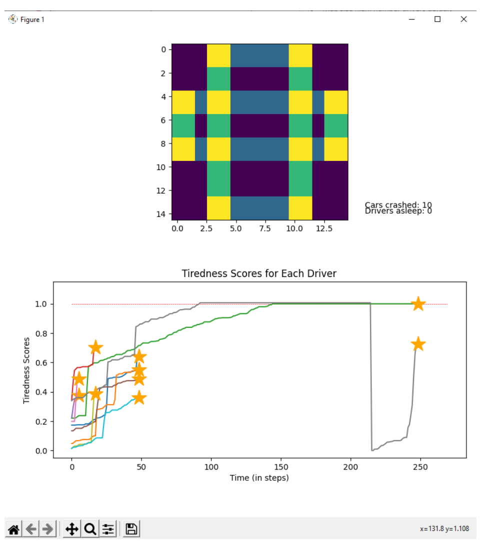


Fig 5.

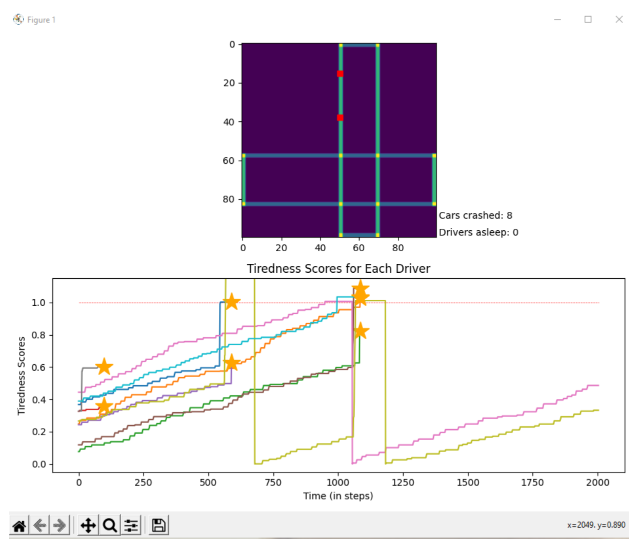
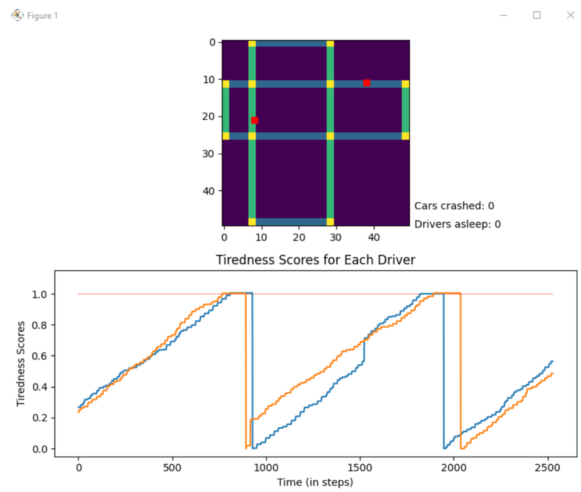


Fig 6.

Figure 5 shows the simulation with 10 drivers and a reduced map size of 15, and figure 6 shows the same simulation with an increased map size of 100. As expected, with the reduced map size, all drivers end up crashing at a very quick rate. All drivers crash within 250 steps on the reduced map, which is much quicker than the increased map, with only 8 out of 10 having crashed within 2,000 steps. Judging by the length of time for 80% of the drivers to crash, it takes 20 times longer when the map size is increased from 15 to 100.

3.2.3 Effects of Adjusting the Number of Drivers

Fig 7.



The first adjustment made to the number of drivers was to reduce the number of drivers. The minimum number of drivers required for a crash to occur at all is 2, so Figure 7 on the right shows the results of having 2 drivers on a map size of 50. This simulation ran for 2,500 steps without any crash. The likelihood of the only two cars on the road having a crash is very small. As you can see from the plot showing the tiredness for each driver, the drivers just repeat between driving and waking up.

The next simulation involved increasing the number of drivers. Increasing the number of drivers from 10 to 100 dramatically increased the rate at which crashes occurred, as expected. The following figures are screenshots of the same simulation at different times.

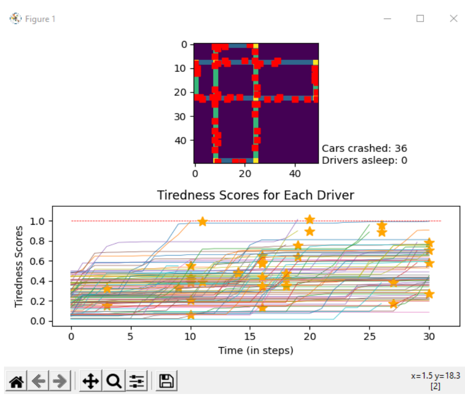


Fig 8.

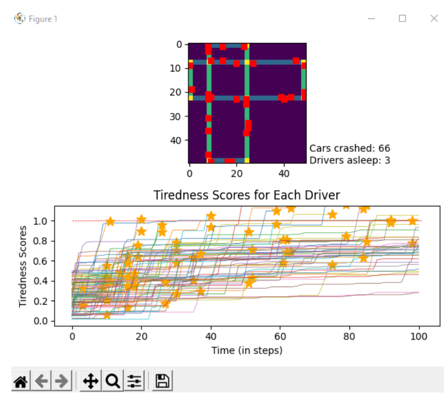


Fig 9.

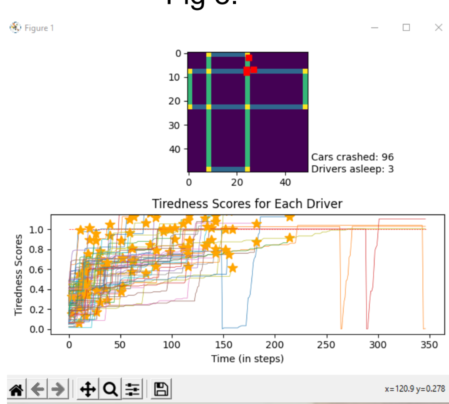


Fig 10.

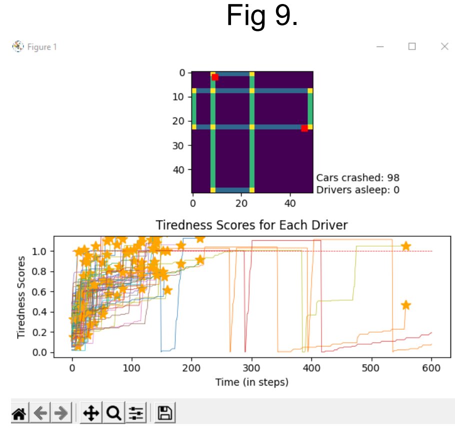


Fig 11.

Figure 8 shows the simulation after 30 steps, the map is very dense with drivers and the plot with the tiredness scores is difficult to interpret due to the number of lines. We can, however, see that 28 cars have crashed at this point, almost a third of the original number of drivers within 30 steps of the simulation. In Figure 9, we can see that the rate at which cars are crashing does not slow down, as the markers for crashes have remained dense. Figures 10 and 11 show the long-term simulation of having a large number of drivers. The same principle applies here when there is a small number of drivers left on the map, as when the number of drivers is set to any number. Figures 3 through 7 show that cars are unlikely to crash if there are only 2-4 cars on the road. This will apply no matter what the initial number of drivers was, unless the map size is reduced.

3.3 Overall Model Results

There is no anticipated end result for this model, as it is only a simulation. However, the model is functioning as we would expect. From testing model parameters, it is clear to see that increasing the map size reduces the likelihood of crashes, as the drivers are more spread out and less likely to collide. For the same reason, reducing the number of drivers reduces the likelihood of crashes. The map size is the ultimate contributor to the rate at which all of the drivers crash.