Information Percolation Schemes for Traffic Congestion Avoidance

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1 Problem Description and Goals

This project focuses on the construction of a simulation environment that enables the testing and validation of different information percolation schemes to be used for congestion avoidance on traffic networks. Moreover, the implications and impact of different technologies on the road network will be studied, such as connected and autonomous vehicles (CAV).

Specific goals of this project would be:

- Model a traffic network populated by normal and/or connected and autonomous vehicles (CAV)

- Simulate scenarios of traffic congestion originated by different phenomenon e.g. Braess Paradox[1]

- Idealise and Model different information percolation systems that can potentially mitigate the traffic congestion problem

- Evaluate the methods implemented in their success

Essentially, the project aims to answer the following questions:

- Can information percolation systems have an impact in mitigating certain traffic congestion scenarios?

- What information percolation systems work best and worse?

- What implications and impact can Connected and Autonomous Vehicles (CAV) have in these traffic congestion scenarios?

2 System Components

2.1 Entities and Attributes

- Vehicles

    - Connected Autonomous Vehicle (CAV): boolean
    - GPS: boolean
    - Goal speed: integer

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[1]https://en.wikipedia.org/wiki/Braess%27s_paradox

2.2   Resources

- Roads

    - Vehicle Capacity

2.3   Variables and States

2.3.1   Variables

- **System Utilisation Related**

    Avg Vehicles per N meters of lane Average number of vehicles per N meters of lane in a route.

    Throughput Number of vehicles going through the routes per hour.

    System capacity Percentage value indicating how full a certain route or sector is.

    Number of vehicles Number of vehicles in the system.

- **System Balance Related**

    Throughput Balance Average of the difference in 'throughput' between routes.

    Avg Period to stop Balance Average of the difference in 'Average Period to stop' between routes.

    Avg vehicle per 100m of lane Balance   Average of the difference in 'Avg vehicle per 100m of lane' between routes.

    Avg Period to route traversal Balance Average of the difference in 'Avg Period to route traversal' between routes.

- **System Congestion Related (Ease of Use)**

    Avg Period to stop Average time interval between stops caused by traffic jams in a route.

    Avg Period to route traversal Average time interval for the traversal of a route.

    Number of idle vehicles Number of stopped vehicles in the system.

    Percentage of idle vehicles Percentage of stopped vehicles in the system.

- **Miscellaneous**

    CAVs Proportion Percentage of vehicles in the system that are connected and autonomous.

    Avg Vehicles Speed Average speed of vehicles.

    Speed Deviation Average of the difference between the maximum allowed speed and the average speed of vehicles.

2.3.2 States

Congested Overall All routes are equally and completely congested.

Congested Routes Only some routes are congested.

Medium Congested Overall All routes are neither free nor fully congested.

Medium Congested Routes Only some routes are neither free nor fully congested.

Free Overall All routes are equally free. Low throughput and low 'Avg Period to route traversal'.

Optimal State High 'Throughput' and low 'Avg Period to route traversal'.

2.4 Events and Activities

- Entrance of a vehicle in a road

- Exit of a vehicle off a road

- Stoppage of a car due to congestion

3 Scenarios to be tested

1. Only Regular Cars

   - Auction methods
   - Traffic Informative Tablets
   - Prior Reservation
   - Random allocation (GPS)
   - Smart allocation (GPS)
   - etc.

2. Partial number of CAVs

   - Auction methods
   - Traffic Informative Tablets
   - Prior Reservation
   - Random allocation (GPS and CAV)
   - Smart allocation (GPS and CAV)
   - etc.

3. Only CAVs

   - Random allocation
   - Smart allocation
   - Prior Reservation
   - etc.

4 Performance indicators and Decision criteria

4.1 Performance Indicators

- Avg Period to stop

- Avg Period to route traversal

- Percentage of idle vehicles

4.2 Decision Criteria

- To add or not to add CAVs

- To add or not to add another route

- To add or not to add a percolation method

5 Data Requirements

The data required to execute this simulation project is only related to the development of traffic in different road network structures, which can be synthetically generated by the simulation tools used. As such, there are no data sets or data sources to list or describe.

6 Tools

Simulator SUMO Simulator[2]

Programming Language Python[3]

Libraries TraCi[4]

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[2]https://sumo.dlr.de/docs/index.html
[3]https://www.python.org
[4]https://pypi.org/project/traci/