**Research Question**

Traffic jam is a common problem as well as a hot research topic that every driver has to face at least once in their lifetime. Multiple factors are involved in the cause of this issue e.g. driver’s behavior, quantity of vehicles, weather…etc. To avoid such inefficient and time-wasting circumstance, the driver normally prefers to stay informed about the traffic situation before they depart. However, the information is not always up-to-date due to the fact that traffic jam is not absolute predictable and is usually not timely reported. If the newest information can be delivered to every driver/vehicle in real time, the ongoing traffic can then be diverted to the other route, instead of all arriving at the same jam. Therefore, how to construct an ideal updating and communicating system which helps the vehicles with avoiding the traffic jam in advance is the main goal of this project.

**State of the Art**

* **Traffic Simulation**

The modeling of traffic flow has been quite popular since the later half of the 20th century. Existing models, like the Macroscopic ones (e.g. the Lighthill-Whitham-Richards model) where the entire traffic flow is represented by mathematical equations, mostly continuous, ignoring the individual drivers can often produce realistic outputs but lacks the complexity to model the complex driver behaviors. [1]. More popular models include treating the vehicles as individual agents with a set of given rules to follow. Models as such like the cellular automata model designed by Nagel and Schreckenberg are simple in construction but are able to exhibit the complex phenomena associated with real traffic. [1][2] Also in Microscopic models, classed as discrete models, which model the individual entities separately at a high level of detail, the individual entities (vehicles) are tracked separately as they interact with other vehicles and the environment. The interactions are largely governed by car-following and lane-changing logic.[3][4][5] . One well-known model, among various vehicle following models, which attempt to describe vehicle following based on anti-collision concept is the “Gipps model”, developed in 1981 [5], [6]. In this model a vehicle always aims to be able to stop safely if the vehicle it is following performs an emergency stop [6]. Another class of models known as the “Psycho-physical” vehicle following models attempt to capture both the physical and human components of vehicle control. They do this by maintaining a vehicle state, where the current state is determined through the differences in speed and distance to the leading vehicle [4].

* **Agent Based Simulation**

A relatively new concept, Agent based systems have gained popularity over the years. Agents defined as the computing entities, which receive input, form their environment and react in a manner that influences their environment. Agents have objectives, and can aim to achieve these objectives through plans or actions that they decide to perform [7] . In agent based traffic simulation, the environment is the road network and the agents are the vehicles who can influence the agents in its sphere of influence [5] .

* **Cloud based communication**

Tesla has not only made pure electric cars possible on the market, but also introduce the swarm intelligence learning network among their Tesla vehicles. This implantation, for example, collects the traffic information (number of lanes, speed limit, obstacle…) from each car while they are being driven around the globe. The information is shared with other Tesla vehicles through an over-the-air updating system [9], which improves the autopilot system efficiently.

* **Vehicle Networks**

Vehicle Networks are dedicated short-range communication (DSRC) technology (10 m – 500 m) implemented for communicating information such as traffic, accident prevention, accidents, etc. There are three components to the system:

* + Onboard unit (OBU) – This unit is dedicated solely for communication with other OBUs and roadside units (RSU) through wireless radio ad-hoc technology. The board is also responsible for data security and mobility IP (a unique identifying address for mobile devices).
  + Application unit (AU) – This unit is dedicated by the carmaker for communicating through the OBU and making use of the information for all mobility and networking functions.
  + Roadside unit (RSU) – This unit communicates with the OBUs, also other RSUs, thus extending information through the network. It also provides internet connectivity to OBUs.

The vehicle networks provide a better user experience with information about restaurants, parking places, and gas stations. As well, it can decrease roadside accidents at crossings by sharing information with two approaching cars that are not in each other’s vicinity. It also can inform the necessary authorities in case of an accident, so that immediate actions can be taken. [10]

* **Sensors for collision avoidance**

Several sensors are currently in use, also are being researched to be used in collision avoidance system.

camera: It is of low cost, and high information, but requires high computing power and the quality of information depends on ambient conditions.

Lidar/Laser: Longer range and high amount of information (less compared to cameras), but high power consumption and expensive.

Ultrasonic: Real time and economical, but high noise and is omnidirectional.

Radar: Robust to varying weather conditions and not so expensive computationally, but high power consumption and identifying an exact object is not possible.

Therefore, a combination of sensor information is always used to get a system with better information and robustness. However, the system is computationally expensive. [11]

**Methods**

Since the design and development process for multi-agent simulations is different to traditional systems, literature suggests that the modeling is essentially a 7-stage process: brainstorming, theory, hypothesis, flowchart, code, analyze and publish [5]. Although complex design and development methodologies [8] like MESSAGE, PASSI, Tropos, Prometheus, MaSE etc. exist, for the purpose of this project, existing methodologies such as the Agent UML will be incorporated also keeping in mind the 7-stage process. The idea is to write the Multi-agent traffic system in an OO language like C++ or Java. This is mainly because agents can be considered as an extension to objects.

A multilane traffic scenario with different vehicles (agents) will be implemented in ROS (Robot Operating System). The integrated Stage simulator is chosen to be the testing environment because of its readily available models such as laser scanner and ultrasonic sensors, which are going to significantly reduce the time we invest in building up basic functions and in turn focusing more on designing agent’s behavior.

The simulation is split into main three parts, such as modeling of the world, the vehicle, and traffic scenarios. According to different scenarios, one or more lanes may be blocked by an obstacle that either slightly or heavily impact the traffic flow. While the former arriving group of vehicles might be stuck in the traffic jam, the later coming traffic will need to coordinate with each other in order to bypass the obstacle or choose another route in a most efficient manner. In addition, the vehicle model will consist of the dynamics of real vehicle aptly scaled for simulation so that the results shall be realistic.

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[11]

**Timeline**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | April | | | May | | | | | June | | |
| 4/10 | 4/17 | 4/24 | 5/1 | 5/8 | 5/15 | 5/22 | 5/29 | 6/5 | 6/12 | 6/19 |
| Expose |  |  |  |  |  |  |  |  |  |  |  |
| - Research questions |  |  |  |  |  |  |  |  |  |  |  |
| - Project timeline |  |  |  |  |  |  |  |  |  |  |  |
| - Research State of the art |  |  |  |  |  |  |  |  |  |  |  |
| - Project structure |  |  |  |  |  |  |  |  |  |  |  |
| Model the system |  |  |  |  |  |  |  |  |  |  |  |
| - UML-diagrams |  |  |  |  |  |  |  |  |  |  |  |
| Implementation |  |  |  |  |  |  |  |  |  |  |  |
| - Set up platform |  |  |  |  |  |  |  |  |  |  |  |
| - Implement the world |  |  |  |  |  |  |  |  |  |  |  |
| - Implement a single car |  |  |  |  |  |  |  |  |  |  |  |
| - Test run |  |  |  |  |  |  |  |  |  |  |  |
| - Expand the population |  |  |  |  |  |  |  |  |  |  |  |
| Project Report |  |  |  |  |  |  |  |  |  |  |  |
| Project Presentation |  |  |  |  |  |  |  |  |  |  |  |