Undergraduate Research Symposium

Motion Planning For Self-Driving Vehicles

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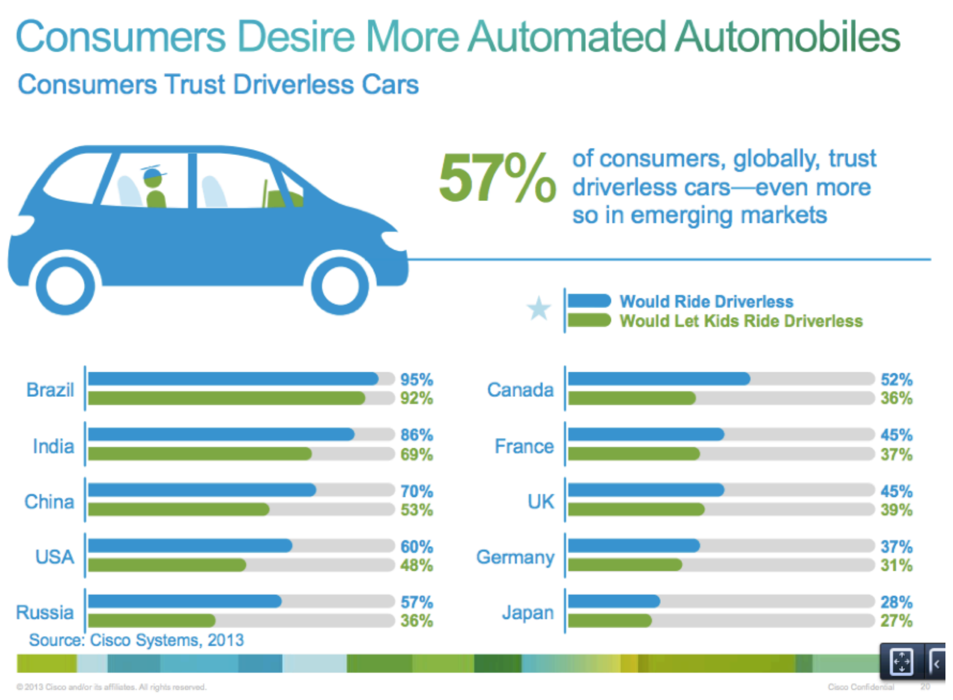
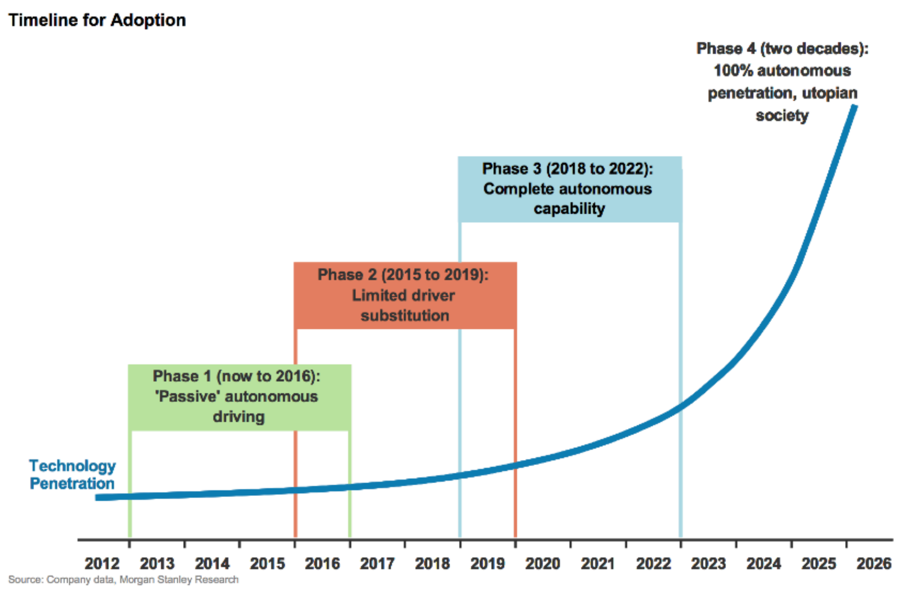
Introduction:

- Travelling from one place to another safely, comfortably and fast, has always been an important topic to deal with, because we have been facing issues while travelling on roads, everyday for over decades.
- Controlling traffic of human-driven vehicles is difficult because we tend to make a few mistakes, as we drive based on instinct and reaction. So, to remove human error from driving, we need vehicles to move safely on their own based on the environment they face.
- Therefore, the introduction of *self-driving/autonomous* vehicles. These vehicles are not only safe, but also reduce traffic congestion, hence decreasing the time of travel.
- The future of travelling lies in the expansion of their abilities. The transition from human-driven vehicles to *self-driving* vehicles is bound to happen. The process maybe gradual and may take some years for all the vehicles to become *autonomous*.
- For a system of pure *self-driving* vehicles which is to be achieved , one of the key aspects to take care of, is motion planning i.e. to create a plan of how the vehicles should move in order to reach their destinations.





Advantages of using autonomous Vehicles:

- Over 80% of car crashes in the USA are caused by driver error. There would be no bad drivers and less mistakes on the roads, if all vehicles became driverless. No drunk and drugged drivers.
- Travelers would be able to journey overnight and sleep for the duration. Speed limits could be increased to reflect the safer driving, shortening journey times.
- Reduced or non-existent fatigue from driving, plus arguments over directions and navigation would be a thing of the past.
- Traffic could be coordinated more easily in urban areas to prevent long tailbacks at busy times. Commute times could be reduced drastically… and many other advantages.

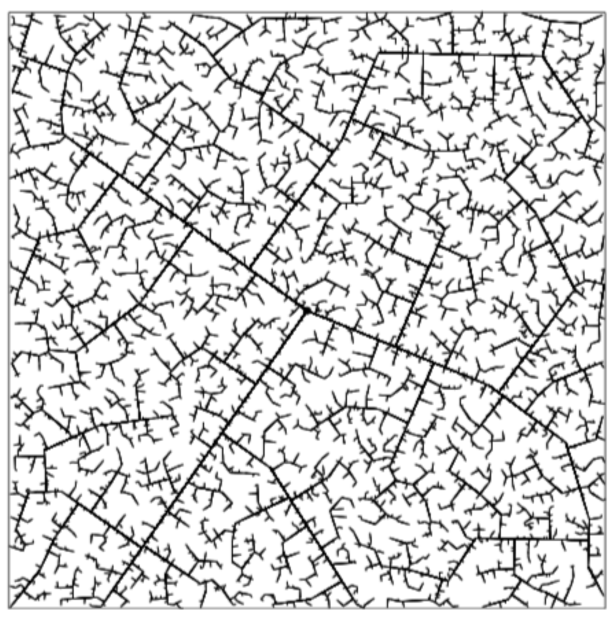
Motion planning Algorithm and Simulation:

- An algorithm known as rapidly exploring random trees(RRT) which is widely used in robotics for motion planning was chosen due to the fact that new features can be added to it.
- RRT algorithm efficiently searches high-dimensional spaces by randomly building a space-filling tree by sampling.
- RRT* algorithm, a later version inherits the properties of RRT. But, it introduced, near neighbour search and rewiring. Near neighbour operations finds the best parent node for the new node before its insertion in tree. This process is performed within the area of a ball of radius defined by

$$k = \gamma\left(\frac{\log(n)}{n}\right)^{\frac{1}{d}}$$

Where d is the search space dimension and γ is the planning constant based on environment, n is the number of nodes.

- Rewiring operation rebuilds the tree within this radius of area k to maintain the tree with minimal cost between tree connections.



Exploration of the search space

Basic Algorithm

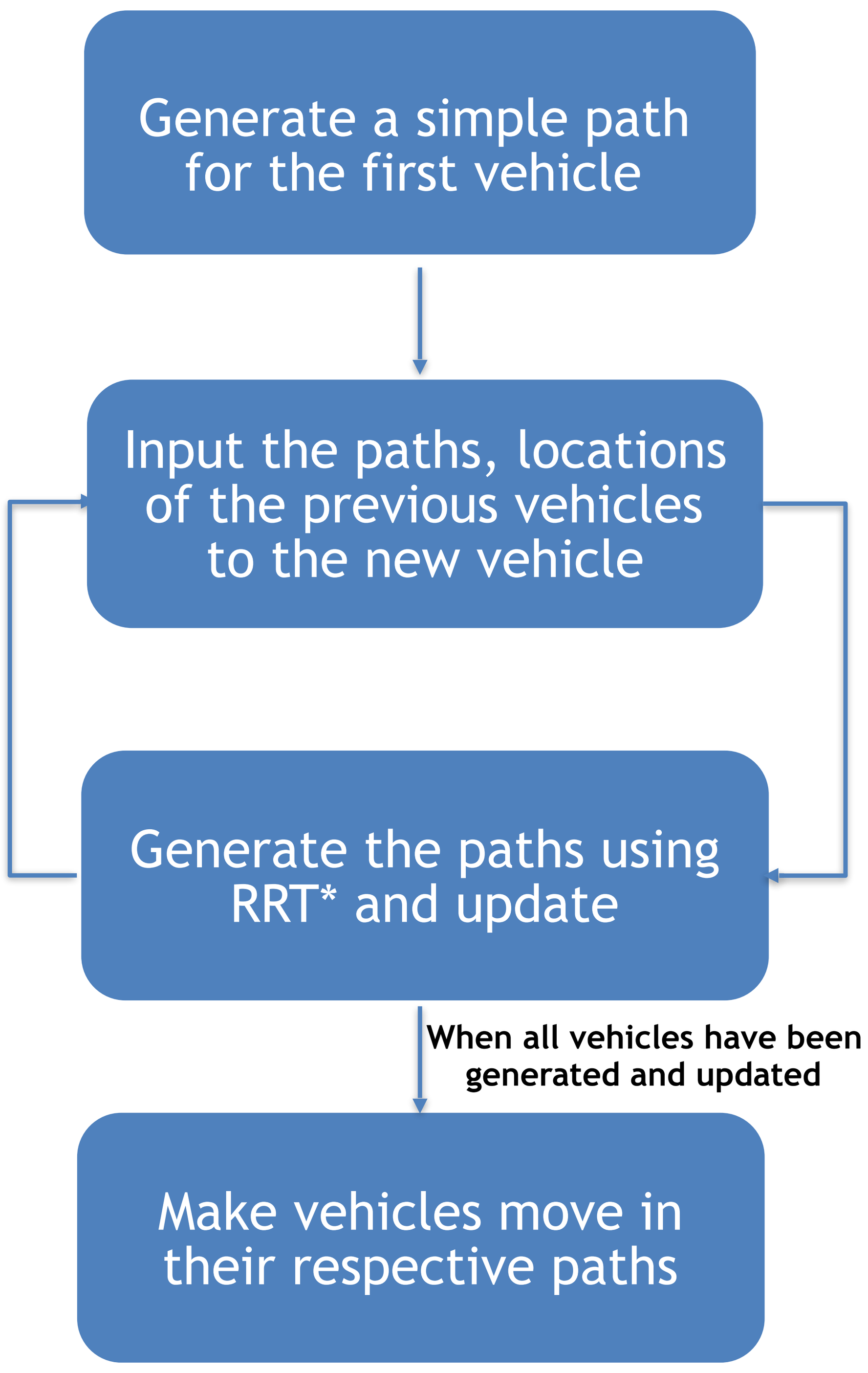
$T = (V, E) \leftarrow$ RRT*(z_{ini})

1 $T \leftarrow$ InitializeTree();
2 $T \leftarrow$ InsertNode($\varnothing$, z_{init}, T);
3 ***for*** i=0 to i=N ***do***
4 $z_{rand} \leftarrow$ Sample(i);
5 $z_{nearest} \leftarrow$ Nearest(T, z_{rand});
6 (z_{new}, U_{new}) $\leftarrow$ Steer ($z_{nearest}$, z_{rand});
7 ***if*** Obstaclefree(z_{new}) ***then***
8 $z_{near} \leftarrow$ Near(T, z_{new}, $|V|$);
9 $z_{min} \leftarrow$ Chooseparent (z_{near}, $z_{nearest}$, z_{new});
10 $T \leftarrow$ InsertNode(z_{min}, z_{new}, T);
11 $T \leftarrow$ Rewire (T, z_{near}, z_{min}, z_{new});
12 ***return*** T

It considers the object traversing to be point sized but in reality, the objects have sizes and they interact, so the work is on a new version of RRT* that incorporates size of the object into it and also to modify it so as to apply it for a stream of *autonomous* vehicles.

Flow of the simulation and Result:

- The simulation is being done through python programming language in the form of an animation using its pygame library.
- The inputs to the simulation can either be the number of vehicles and their sizes or the traffic flow rate with a standard deviation of sizes and other necessary variables(start points, destinations) are randomly generated.
- The output will be the paths of each vehicle and its motion along that path along with an excel file showing where each vehicle is at a particular instant .
- The simulation is in process and improvisations are being made.



- On completion, the autonomous vehicles move smoothly in their paths without colliding with any other vehicle, assuring comfort and safety and when implemented in large scale can save a lot of travelling time.

Conclusion and Future extensions :

- When motion planning generated using the stated algorithm and its extension, is applied to multiple streams of autonomous vehicles, traffic management becomes easier as it becomes a planned way of moving, hence, decreasing the need for traffic signals along with an assurance of safety, comfort and speed.
- It can be extended for traffic consisting of driver-less and with-driver vehicles and also to traffic in signals and in junctions.

Important References:

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