Project Proposal CSCE 475/875
Team: The Nashtags October 16, 2013

Commented [LS1]: Quite complete. Need better definitions of safety and efficiency. And also how to simulate accidents and repercussions of accidents?

Problem Statement:

A city traffic system is an example of an environment too complex and dynamic for a centralized controller to manage feasibly and efficiently. There are simply too many interactions and possible states of such a system for a top-down design to achieve desirable behavior. A distributed solution is the best way to approach such an environment. The goal of any traffic control system is twofold: to optimize both the safety and efficiency of the system. Optimizing the safety of the system means minimizing the number of traffic collisions in it, and optimizing the efficiency of the system means minimizing the amount of traffic congestion and maximizing the traffic flow within the system.

Commented [LS2]: Okay.

Agent Design:

The traffic control system will be comprised of two classes of agents: intelligent cars and intelligent traffic signals. Both will be self-interested agents; that is, both classes of agents will make local decisions to maximize their personal benefits. The traffic signals will be paid for the number of cars they allow to pass through their intersections and they will be charged for the amount of time they make cars wait at their intersection. Their interest is to maximize their profits–or at least minimize their losses. The signals have only a local view of their own intersections and the cars waiting at their intersections. Each signal will receive a fixed payment of k dollars for each car they allow to pass through their intersection. The amount each signal is charged for keeping each car waiting at their intersection will be a function, *c(t)*, of the amount of time each car has been stopped at its intersection:

Commented [LS3]: NICE!!!

$$cost = \sum_i c(t_i)$$

$$c(t) \in \Omega(t)$$

Commented [LS4]: What is Omega(t)?

Where t_i is the amount of time car_i has been waiting at the signal's intersection. The cost function will be lower bound by $f(t) = t$ because even when there is a busy road with many cars passing through the intersection and only one car waiting, eventually the signal should allow that one car to pass through. By defining the cost function in this way, eventually the traffic signal will be charged too high of a price to keep that one car waiting. Each light will make its own decision based on its own local view of the environment as to what its state will be with the constraint that its chosen state must be consistent (i.e. the signal cannot be green for east-west traffic at the same time it is green for north-south traffic). The signals will choose the state that will maximize their profits (or at least minimize their losses).

Commented [LS5]: I don't understand this. Clarify?

A comparison class of agents would be their equivalent dumb versions. The "dumb" traffic signals will not decide on their own state but will simply run through a regular cycle of lights regardless of their local environment. The "dumb" vehicles will only be able to "see" and react to the car immediately in front of them, and this reaction will be delayed to simulate the reaction time of real drivers. All cars, intelligent and dumb, will have a destination that is either in the city or a road that leads out of the city. They will also have a position vector <x,y> and a velocity vector $<v_x,v_y>$ to represent their state. To model real-world drivers, each car will choose travel at a random proportion of the speed limit when it is not behind any other cars. The distribution of speeding tendencies will follow a Gaussian distribution centered at one so that, on average, the vehicles will travel the speed limit. When arriving at an intersection, the dumb cars will randomly choose which direction to take from those directions that move them closer to their destination. The intelligent vehicles will communicate their actions and their

Commented [LS6]: Hmm … randomly generated cycles? Fixed cycles? Or synchronized? Need more clarification on this.

velocity to the other vehicles nearby. Thus a vehicle will be able to predict what the other vehicles around it will do because it is aware of all of its neighbors' states. For example, when a car is travelling behind another it will calculate the safe following distance based on the speed of itself and the car in front of it. When one car brakes, it will send a signal to the other cars so they can respond appropriately, and thus the reaction time that was present in the dumb cars will be instantaneous in the intelligent vehicles. If the reaction time is not sufficient, the car will continue forward and rear-end the car ahead causing a collision. When a vehicle enters an intersection it will broadcast that information to the cars nearby that it is in that intersection so that no other cars will enter. When an intelligent car encounters an intersection, it will choose which direction to take based on the traffic flow of each direction as reported by the cars nearby which it will use to calculate the route that will be the fastest/minimum time to its destination.

Commented [LS7]: How far?

Environment Design:

Commented [LS8]: Do you have accidents? Constructions? Detours?

The environment will be modeled as an $m \times n$ grid of two-way city streets with a traffic signal at each intersection. Each street will have a speed limit which the cars will base their speed on. Every street will have sources (entry points) and sinks (exit points or destinations) at the edge of the environment. Sinks and sources will also be scattered throughout the city to model vehicles coming and going from within the city. Each source and sink will be given a weight to determine how likely a car will enter or leave from it. Certain regions of the city may be weighted higher to represent busier areas.

Commented [LS9]: Nice.

Desired Emergent Behavior:

The desired emergent behavior of the traffic control system with intelligent agents is that fewer accidents will occur and traffic flow will be more efficient than when the system does not contain any intelligent agents. The communication between the vehicle agents will serve to both increase the safety in the system as well as to increase the efficiency of the system. The intelligent traffic signals making their own decision as to what state they are in will serve to increase the efficiency of the traffic system.

Commented [LS10]: But how do you simulate accidents in your environment? If you don't simulate them in your environment, how would you test for this?

Commented [LS11]: I think regarding efficiency, yes, but I can't see the safety aspect … Clarify.

Hypotheses:

Hypothesis 1: A system comprised of intelligent traffic signals and dumb cars will be more efficient than a system of dumb traffic signals and dumb cars.

Hypothesis 2: A system comprised of intelligent vehicles and dumb traffic lights will be both more efficient and safer than a system of dumb traffic signals and dumb cars.

Hypothesis 3: A system comprised of both intelligent vehicles and intelligent traffic signals will be the most efficient and the safest.

Commented [LS12]: How do you measure "efficiency" and "safety"? Clarify.

Experiments:

A control experiment will be run using only dumb traffic lights and dumb vehicles in order to serve as a baseline for comparison.

An experiment will be run using intelligent traffic signals and dumb vehicles in order to find a cost function that improves the efficiency of the system as measured by the average time to destination for each vehicle normalized by the distance to the destination.

Commented [LS13]: Ah! Here, how efficiency is defined.

An experiment will be run using intelligent vehicles and dumb traffic lights to test hypothesis two. The safety of the system will be measured by the number of accidents that occur in the system with respect to the amount of traffic in the system.

An experiment will be conducted with intelligent vehicles and intelligent traffic signals to test hypothesis three

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Commented [LS14]: But how do you determine this?

Commented [LS15]: ... and ???