Milestone 1 Scribe

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Project Theme:

Probabilistic Model for Minimization of Traffic Signals.

Purpose:

To reduce traffic congestion within a four-way intersection.

Background:

Traffic flow is stochastic (random) in nature, and thus traditional fixed-time signal controllers are not efficient.

Motivation:

Waiting will be reduced and will lead to the reduction of fuel consumption and frustration.

Problem Formulation:

Can we develop an algorithm which can be utilized to provide the probability of arrival of a vehicle and schedule signals in time to minimize the sum of the foreseen waiting time?

Question 1 Scribes: Project System and Objective

What is your part of the project probabilistic problem? Get the system objective straight and identify the major sources of uncertainty that are available.

Our project is assisted by building a four-way intersection of a road smarter probability-wise. Their major concern when handling the conventional traffic lights is that it is time based. That is, it means that a signal may remain green in spite of the number of cars waiting even though the time left is 30 seconds. The other roads will be left with no option but to wait as a signal can be switched beforehand. This causes time and traffic jam wastage.

This project will aim at establishing the duration of the green light by monitoring the traffic. The system will detect the passing cars and the speed of the cars and hence alter the signal time. This is so that the time spent by cars waiting is reduced to the lowest possible.

The movement of traffic is unforeseeable. We are not aware when the next vehicle will arrive as we are not aware how soon the vehicles will pass through the signal. The vehicles may be of varying speeds according to the driver, the type of the vehicle or road. This insecurity causes the application of probabilities in making an estimation of how the traffic is likely to behave and devising better conclusions on the time the signal will be switched on.

Question 2 Scribes: Any Random Uncertainty Modelling and Critical Variables

State the major random variables in your project and specify how the uncertainty is modelled in each of the variables. It should formulate probabilistic assumptions that are clear and obvious.

We are pointing to three important random variables that will be used in the modelling of the uncertainty of the traffic system.

The first is the arrival rate (X).

Where $X =$ the total number of vehicles that pass into the intersection at any given point. We simulate this using Poisson distribution because on the short run arrival of vehicles is a random and independent event. The density of traffic is denoted by the parameter used.

The second one is vehicle speed (V).

Vehicle distribution speed is normally distributed. The data concerning the average speed will also come in handy to determine the speed at which cars can clear through the crossing and it is a direct determinant of the duration of time during which the green light will be in operation.

The third model is the arrival rate at time ($\lambda(t)$).

It is not even a traffic 24 hours a day. It is simpler with big crowds as they follow them and there is high probability of taking a greater number of vehicles to their destinations. Arrival rate during the slack time is minimal and the number of vehicles is likely to be reduced. This is possible with the λ temporal dependence of λ representation feature which enables a system to be tailored to the changing traffic conditions.

Question 3 Scribe: Probabilistic Reasoning and Dependencies

How do you use probabilistic relationships (e.g. dependence, independence, conditionality) in your project system to make reasoning, inference or decision making easier.

We also possess a conditional probabilistic decision maker which depends on reasons to make a decision and not on a collection of rules or the amount of vehicles. This algorithm approximates the likelihood of a congestion based on which the time of the green signal is adjusted but not calculating the amount of cars in a queue.

In a bid to simplify things, we assume that the number of vehicles entering the North-South direction will not be conditioned on the number of vehicles entering the East-West direction. On this, it is established that the model is simpler to manipulate and makes sense compared to two simple traffic intersections.

Conditionality is essential in decision making. As an example, the system may choose to add several seconds to the green time when there is too much likelihood of the length of a queue becoming too long at the time when the green time is nearing its expiration.

The concept of total expectation is also used in the system to give the duration of time which the green signal may be held in operation. L is assumed to be the waiting cars, and V is the average speed of cars. The two values are expected to form the basis of green time. Such an approach can help the system to deal with the uncertainty in a realistic systematic way.

Question 4 Scribe: Model Implementation Alignment

Explain how the existing probabilistic model can be applied to the implementation or experiment of the project. Mark out any assumptions that affect the design or evaluation decisions.

We have implemented our probabilistic model using python Monte Carlo simulation.

Mayfaking Data (Faking Data):

Vehicle speeds are generated with the help of NumPy normal random distribution and vehicles arriving at the intersections are generated with the help of Poisson random distribution.

Weight Design: This is the randomization approach of the system which is based on weight as opposed to inefficient, rule-based logic. The green light of a lane is established by the percentage of total traffic of the intersection.

Assumption Simplification: We will only make assumptions that all the sensors are functioning well in order to focus more on the measurement of the algorithm performance only.

A case in point to imagine this is making a video game out of a crossroads. The number of cars will be generated randomly by the computer using a random number generator rather than placing the car manually and this will automatically determine which car was shown when in the simulation.

In order to produce the traffic that is random, the model relies on the Poisson distribution: the mean amount of cars per minute is 10 cars, however, a given minute can have as many as 15 cars or as few as 5 cars. A random speed is also assigned to each vehicle so that the behavior would not be unrealistic or robotized.

The "Smart" Traffic Light:

Most of the traffic lights are also founded on simple timers, but ours works in a different manner. It assumes the lanes as a balance scale. A computer throws a dice using weights and therefore when there are heavy traffic in one lane and there is light traffic in another then the heavy road is highly likely to run over the green light. This is as far as we have assumed that there are no faulty sensors and cameras. Before sensor failures are implemented, we would like to ensure that the project light, which is the core of everything, the Smart Light, is functioning.

Question 5 Scribe: Change and Cross-Milestone Consistency

Explain the present situation of your project probabilistic model. Determine what assumptions, components or relationships are currently well identified and which ones are likely to change or need further development in the next milestones. Explain your reasons in a few remarks.

The present model is quite efficient in the sense that it represents the traffic behavior, through a combination of Poisson-distributed arrival and normally distributed vehicle speeds. The underlying randomness of both arriving times and speeds is working as planned.

Currently, we suppose that cars come one by one. The truth of the matter is though, that cars usually come in a train, such as a short train of cars. This is referred to as bursty traffic hence arrivals are not independent and correlated. We come to understand that this assumption of independence is not absolutely real in real life.

The rate of arrival λ will be varied to produce such bursty patterns that will be added to our future milestones. Another model that we shall take into consideration is Markov chain models to model the transitions between congested and free traffic state. Adjustment of the mathematical model will make the tendency of the vehicles to be more represented in the mathematical model. Markov chains will also give us an opportunity to visualize, and to mathematically provide, transitions between a road with empty traffic and a jam with full traffic.

Question 6 Scribe: Open Issues and Attribution of Responsibility

At this point, determine any unresolved probabilistic questions or ambiguities in the project and point out what role(s) or activity can be held accountable in the next milestone.

Analysis of Queue Overflow (the “Mega-Jam” Test):

What will occur in case there is an unusual increase in the number of cars at the same time? To demonstrate that the traffic light will not fail to function even when the traffic jam is of emergency level, we will use Chernoff Bounds to approximate the likelihood of a serious congestion.

Equal Signal Distribution:

We do not want to have scenarios where the traffic on a minor road with a light traffic is stalled indefinitely as the one on a major road continues traffic jamming. In order to be fair and make sure that all the lanes are eventually served, we will need to adjust the logic of the signals. This will ensure that low-traffic lanes are not disregarded.

Noise Test (Simulated):

Practically, it is, perhaps, possible that these factors like rain, dust or dirt can affect the sensors and make them less reliable or even lose their way altogether. To generate the same we will randomly add noise or error to sensor readings. This is to find out whether the smart traffic light can still reach some form of reasonable judgment whenever it is not in its eyes so clean. This will be achieved by including a probabilistic sensor error error model and this will assist in measuring the robustness of the system when the system is not on the favorable conditions of sensing.