Towards Stress-Free Driving

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Urban Traffic Control

Background and Motivation
- Traffic congestion is a big problem in modern societies.
  - Traffic costs money.
  - Roads cannot expand indefinitely.
  - Bad for the environment and the economy.
  - Lower quality of life.
- There are many traffic control systems
  - Majority of solutions focus on reducing waiting and travel times.
  - No focus on the driver.
- People spend significant amounts of time in their cars every day.
  - It is commonly accepted that driving, especially in congested traffic, is a stressful activity.

The Idea
- Control traffic so as to reduce drivers’ stress specifically and not just manage the traffic conditions.

Stress

Psychological aspects
- Personal characteristics (trait stress).
  - Measured with questionnaires and surveys.
  - Cannot be easily quantified.
  - Not sensitive to real-time changes in stress levels.
- Sense of urgency (lateness).
- Measured with questionnaires and surveys.

Physiological aspects
- Stress reactions are controlled by the Autonomic Nervous System (ANS).
  - Fight-or-flight response.
  - Manifestations of stress in the human body include fluctuations in:
    - Heart rate
    - Respiration
    - Skin conductivity
    - Heart Rate Variability
    - Reflects ANS activity, suitable for stress measuring.
- Traffic induced stress
  - Limited findings on the effects of stress in urban settings.
  - We assume that driver stress is mainly affected by:
    - Waiting times on junctions.
    - Number of cycles waiting on a specific junction.
    - Overall ratio of waiting time to moving time.

Stress Model

Hypothesize the relationship between stress and driving, and model the quantity we want to minimize.

Measuring Stress
- A combination of the above parameters.
  - Psychological stressors = function (trait stress, hassles, lateness)
  - A form of “baseline stress” for each driver.
  - Traffic induced stress = function (WaitingTime, MovingTime, numberOfCyclesWaiting)

Reducing Stress
- For every time step, until reaching the baseline:
  - If the vehicle is moving, reduce the stress level by a factor λ, λ<1.
  - If the vehicle is stopped (queuing), double the stress level.
  - If the vehicle clears the junction, half the stress level.

Simulation

- Using VISSIM, a “microscopic, behavior-based multi-purpose traffic simulation program” to simulate and test the stress model.
  *(Source: VISSIM User Manual)*

Simulation data
- Map of inner Dublin city centre
- Simulation Time : 1 hour
- Approximately 20,000 cars entering the map from 8 points and targeting 9 exits on the city map.

Modeling Stress
- Vehicles communicate their “stress level” to the traffic light agent as they approach a junction.
- Traffic light agent decides on the next phase of the junction which will result in less stress among all the drivers.
- New stress levels are calculated for each vehicle.

Results and Evaluation

- Stress graph highly depends on the route the vehicle follows and the traffic it encounters.
- Stress is not completely reduced, since the stressors are still there throughout the trip.
- Stress level of a random car throughout the simulation.

However, stress levels are kept relatively close to the baseline and prevented from rising indefinitely.

Future Work

- Have real physiological data related to stress that would lead to a more realistic model of stress and its relation with driving.
- Real-life experiments
- Use Reinforcement Learning as the agents stress reducing algorithm.
- Simulate and compare with more Urban Traffic Control systems.