Identifying Aggressive Driving Behaviors in a Traffic Scene

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Goals of this project

- Given the trajectory information for the vehicles on a road, we would like to apply a mathematical model that can differentiate between safe and aggressive vehicles.
- After identifying aggressive vehicles, we would like to determine which types of aggressive behavior that vehicle exhibits.
Common Aggressive Behaviors

- Aggressive behaviors can be grouped into four categories
  - Road Rage (hand signals, yelling, etc.)
  - Speeding
  - Tailgating
  - Unsafe or excessive lane changing

- Using vehicle trajectories, the latter three can be identified

- Using only the Intelligent Driver Model (IDM), Speeding and Tailgating can be identified
The Intelligent Driver Model

- Developed by sociologists for use in simulating traffic flows
- Output is an expected acceleration, based on distance to the previous vehicle, velocity, etc.
- The model is ‘safe’, meaning that it does not allow collisions

\[ \dot{v}_\alpha = a^{(\alpha)} \left[ 1 - \left( \frac{v_\alpha}{v_0^{(\alpha)}} \right)^\delta - \left( \frac{s^{*}(v_\alpha, \Delta v_\alpha)}{s_\alpha} \right)^2 \right]. \]

\[ s^{*}(v, \Delta v) = s_0^{(\alpha)} + s_1^{(\alpha)} \sqrt{\frac{v}{v_0^{(\alpha)}}} + T^\alpha v + \frac{v \Delta v}{2 \sqrt{a^{(\alpha)} b^{(\alpha)}}} \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired velocity ( v_0 )</td>
<td>120 km/h</td>
</tr>
<tr>
<td>Safe time headway ( T )</td>
<td>1.6 s</td>
</tr>
<tr>
<td>Maximum acceleration ( a )</td>
<td>0.73 m/s²</td>
</tr>
<tr>
<td>Desired deceleration ( b )</td>
<td>1.67 m/s²</td>
</tr>
<tr>
<td>Acceleration exponent ( \delta )</td>
<td>4</td>
</tr>
<tr>
<td>Jam distance ( s_0 )</td>
<td>2 m</td>
</tr>
<tr>
<td>Jam distance ( s_1 )</td>
<td>0 m</td>
</tr>
<tr>
<td>Vehicle length ( l = 1/p_{\text{max}} )</td>
<td>5 m</td>
</tr>
</tbody>
</table>
Method Used

- For each vehicle, we smooth the trajectory by averaging over several frames.
- We then calculate velocity and acceleration at each time-instance, smoothing at each step.
- For each vehicle, at each time instance, the expected acceleration is calculated using the IDM.
- The error between the expected and actual accelerations is compared and thresholded:
  - \( \text{error} = (a_{\text{actual}} - a_{\text{exp}})^2 \)
  - if error > threshold, vehicle is marked as abnormal.
Graph of Accelerations

Vehicle 63

- Actual Acceleration (Calc)
- Expected Acceleration (IDM)
- Error Squared

Acceleration [m/s²]

Time (frames) [1/10s]
Method Used

- Times when a vehicle has an abnormal acceleration are compared to when the vehicle is known to be exhibiting an aggressive behavior.
- If there is a strong relationship between vehicles we identify as abnormal and vehicles that exhibit a behavior, the model is assumed to be working well.
Data Set Used

- NGSIM, US 101 in Los Angeles, CA
- 7:50-8:05 AM
- 8 cameras over a 2100 foot stretch of road
- Total of 2169 vehicles
  - For each vehicle, the position in each frame is given along with acceleration, velocity, and lane information
  - The information was collected using an advanced tracking algorithm
Results
Results
Weaknesses

- The IDM is based only on a single lane of traffic, so it is unable to detect unsafe lane changing behaviors.
- In the current data set, traffic is relatively dense, so very little speeding occurs.
  - We are looking into ways to identify vehicles traveling in excess of the local average speed.
- Some issues that were arising:
  - Too many vehicles were being detected as abnormal, we are only interested in the vehicles that are very aggressive.
  - This was fixed by using a new error calculation.
Future Plans

- Currently, we are using the vehicle’s behavior to determine appropriate values for the IDM parameters through learning.

- We are also looking into a method that creates an overall aggression or safety score for a driver
  - This model would be similar to the one currently used, however it would include factors related to the safety of a lane change

- Would like have several people watch the videos and identify the vehicles that they believe to be aggressive
  - This can be used to compare how well our model identifies what real people consider aggressive