Vehicle maneuver-based long-term trajectory prediction at intersection crossings

Identifying the trajectory of a vehicle during 4-leg intersection approaching, given its kinematics, map position & short-term maneuvering intention.

Highlights of the approach

- Trajectory fusion for long-term trajectory generation: A classical kinematic-based vehicle trajectory, accurate only in short-term and map-agnostic, is fused with a long-term map-aware trajectory derived based on the vehicle’s maneuver classification and the associated target lane.

- Experimental setup and results: Quantitative experiments on simulation datasets of crossing tracks on a 4-leg intersection. Effective and robust extension of the trajectory prediction horizon:
  - Turn prediction horizon longer than 3 secs (average classification time at 3.67 for turning left and 3.07 seconds for turning right)
  - Trajectory prediction horizon considerably extended (over 5 secs ahead) based on the associated target lane information.

Methodology

- The system is divided into two main parts: the maneuver classification and the trajectory prediction (Fig. 2).

- HMM classifier that incorporates lane-level map information with past position and kinematics of the vehicle (Fig. 3).

- Derivation of smooth long-term trajectory, given the targeted map lanelet. Final predicted trajectory as a combination of the motion-based and long-term trajectories.

Results

- Maneuver classification evaluation window (Fig. 1) consists of the road area between lines L1 and L0.

- Evaluation of HMM classifier’s performance by the prediction horizon length and the classifier’s precision/recall rates.

- Turning detection consistency & qualitative performance against TTI (Fig. 4).

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<table>
<thead>
<tr>
<th>Type of Trajectory and prediction evaluation window</th>
<th>TL</th>
<th>LK</th>
<th>TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-range CTRA (3 points)</td>
<td>1.19</td>
<td>0.54</td>
<td>1.01</td>
</tr>
<tr>
<td>Short-range Fused (3 points)</td>
<td>0.51</td>
<td>0.32</td>
<td>0.53</td>
</tr>
<tr>
<td>Long-range CTRA (8 points)</td>
<td>1.86</td>
<td>1.18</td>
<td>2.54</td>
</tr>
<tr>
<td>Long-range Fused (8 points)</td>
<td>0.38</td>
<td>0.39</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Fig. 3. HMM layers

Fig. 4. Average probability of left-turn (on the left) and of right-turn (on the right) intention as the OV crosses the HMM evaluation window (L1-L0 area depicted in Fig. 1)

Fig. 5. Trajectory RMSE comparison