RONELD: Robust Neural Network Output Enhancement for Active Lane Detection

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Problem Overview

Active lane detection: identifying the lane that the vehicle is currently travelling on
Motivation

Poor performance of deep learning models on unseen datasets

CULane-trained models on TuSimple datasets
Method
Method
Method
Method

- Curved lane detection
- Minimum length: 9 points

$r^2 = \frac{[\text{Cov}(X,Y)]^2}{\text{Var}(X)\text{Var}(Y)}$
Method
Method

- Lane construction
  - For curved lanes, we use quadratic splines to connect the lane points
  - For straight lanes, we use weighted least squares linear regression

\[
\hat{\beta} = \arg \min_{\beta} \| C^{\frac{1}{2}} (y - X\beta) \|^2 = (X^T C X)^{-1} X^T C y.
\]

\[
y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_m \end{pmatrix}, \quad X = \begin{pmatrix} 1 & x_1 \\ 1 & x_2 \\ \vdots & \vdots \\ 1 & x_m \end{pmatrix}, \quad \beta = \begin{pmatrix} \beta_0 \\ \beta_1 \end{pmatrix}, \quad C = \begin{pmatrix} c_1 & 0 & \ldots & 0 \\ 0 & c_2 & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \ldots & c_m \end{pmatrix},
\]
Method
Method

• Tracking preceding frames

• Weight of lane is dependent on:
  • Number of points in lane marking
  • Confidence of points in lane marking
  • Whether the lane is an identified active lane
  • Number of frames where lane was missing
Results
Results

CULane

TuSimple
Limitations

• Added runtime to the lane detection model

**TABLE V**

**Average runtime of SCNN + RONELD and ENet-SAD + RONELD on the CULane and TuSimple test sets (in milliseconds) using a Python 3 + Numba [35] implementation.**

<table>
<thead>
<tr>
<th>Dataset</th>
<th>SCNN + RONELD</th>
<th>ENet-SAD + RONELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CULane</td>
<td>5.68</td>
<td>6.29</td>
</tr>
<tr>
<td>TuSimple</td>
<td>2.80</td>
<td>3.55</td>
</tr>
<tr>
<td>Mean</td>
<td>4.24</td>
<td>4.92</td>
</tr>
</tbody>
</table>
Conclusion

• Current state-of-the-art deep learning lane detection models work well on test sets that are similar to their train sets but do not work well when datasets start to differ significantly
• RONELD enhances the output of deep learning lane detection models to achieve higher accuracy through a four step method: adaptive lane point extraction, curved lane detection, lane construction, and tracking preceding frames

Code: github.com/czming/RONELD-Lane-Detection
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