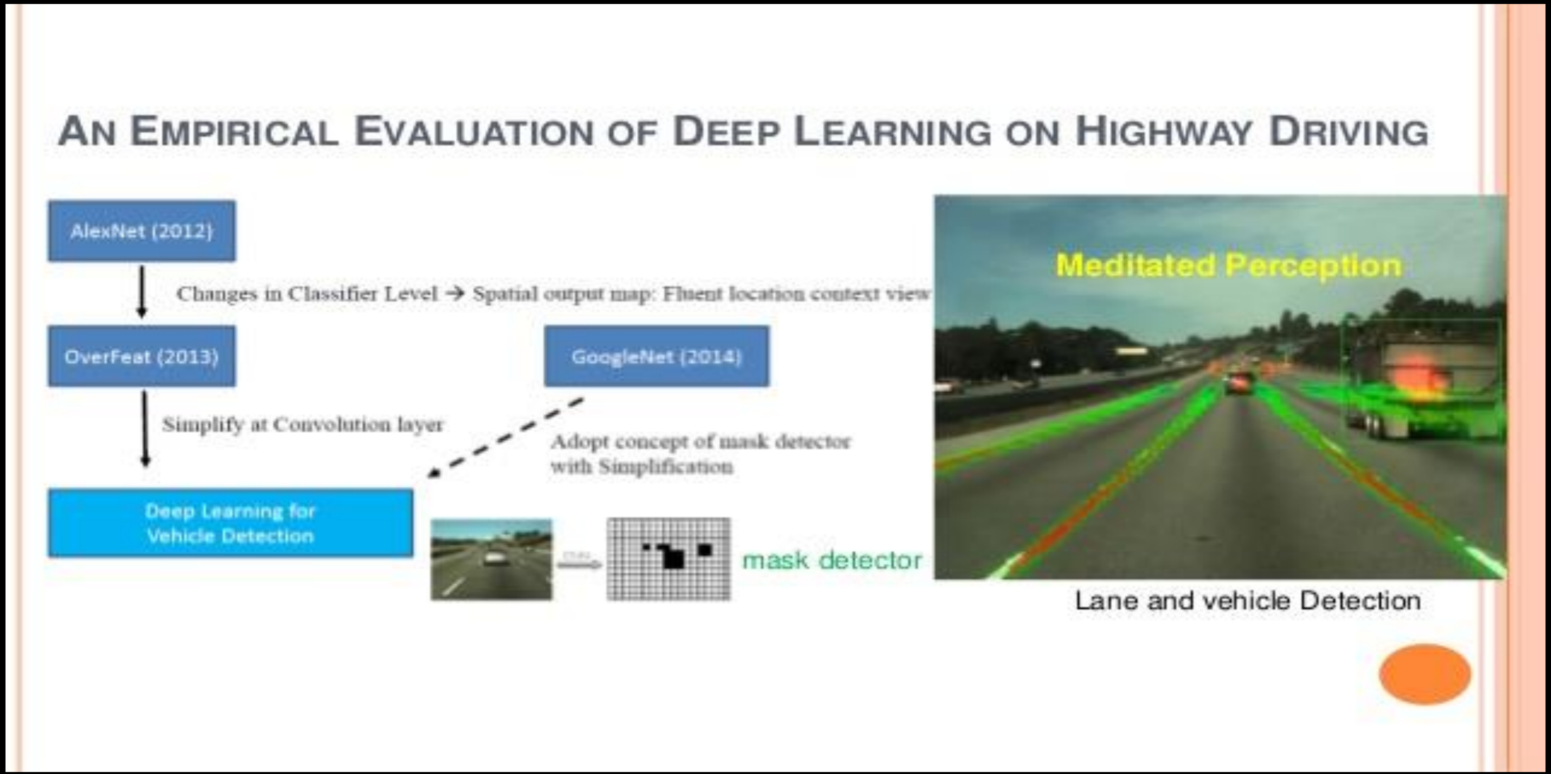
Spatial-Temporal Knowledge Filtering Model



Manish Tomar
Akashdeep
Supervisor : Dr. Sanjoy Partihar

Spatial-Temporal knowledge filtering model (statistical Learning)

Objective >> Lane boundary detection in videos

Challenges >> diversity of structure, large noise, complex illumination

Proposed method

Based on two constraints ->

1. Spatial structure constraints
2. Temporal location constraints

- The model first extracts line segments in video frames. Two novel filters—the Crossing Point Filter (CPF) and the Structure Triangle Filter (STF)—are proposed to filter out the noisy line segments.
- The two filters introduce spatial structure constraints and temporal location constraints into lane detection, which represent the spatial-temporal knowledge about lanes.
- A straight line or curve model determined by a state machine is used to fit the line segments to finally output the lane boundaries.
- Dataset and other standard dataset demonstrate the strength of this method.
- The proposed method has been successfully applied to autonomous experimental vehicles.


Cruise
0 MPH
SPEED LIMIT 35

Spatial temporal knowledge filtering

a spatial-temporal knowledge filtering method to detect lane boundaries in videos.

This model unifies the feature-based detection and knowledge-guided filtering into one framework. With a video frame, the model first extracts line a spatial-temporal knowledge filtering method to detect lane boundaries in videos.

LINE SEGMENT DETECTOR(LSD)

*With a video frame, the model first extracts line segment features with the Line Segment Detector (LSD). This approach differs from traditional
edge detection and can obtain robust and accurate line segments in various traffic scenes.

*A Crossing Point Filter (CPF) and a Structure Triangle Filter (STF) are proposed to filter out noisy line segments.
*These two filters characterize the spatial structure constraints and temporal location constraints, which represent the prior spatial-temporal knowledge about the lanes.

*A straight line or curve model that is determined by a state machine is used to fit the line segments and finally to produce the lane boundaries.

FEATURE EXTRACTION

Edges are among the most widely-used features in lane representation and detection .

Canny edges are composed of pixels with strong gradient magnitudes.

The steerable Gaussian filter extracts edge features by utilizing the gradient orientation information.

The thresholds to determine edges in these methods are manually set to be constant, which causes the method to be inapplicable to dynamically-changing traffic scenes.

Color is another widely-used feature in lane detection. It is sensitive to illumination changes.

FEATURE REFINEMENT

*To refine the extracted features, classical image processing algorithms, such as the threshold segment and the Gaussian filter are usually employed.

*These methods need to set the thresholds manually and do not take advantage of the information of road geometry structures.

*Filtering methods based on geometry constraints are also explored to refine line features.

*The IPM-based methods eliminate noise by searching for horizontal intensity bumps in bird's eye-view images based on the assumptions of parallel lane boundaries and flat roads.

LANE FITTING

- Many straight and curve fitting methods have been developed. Hough transform is frequently used for straight line fitting The parabola and hyperbola are classical curve models that are adopted .
- The major limitation of the quadratic curve is the lack of flexibility to model the arbitrary shape of lane boundaries. Therefore, other curves, such as Catmull–Rom, B-spline, Bezier and the cubic curve are also widely used.
- Generally, when fitting a lane, many candidates are generated by RANSAC and the candidate with the maximum likelihood is chosen.
- In this method, a state machine is designed to estimate if a lane is straight or curved.
- The straight line or curve fitting model is used to fit lanes.

LANE TRACKING

- Tracking technology is used to improve the computation efficiency and detection performance by utilizing the information of temporal coherence. Among tracking methods
- the Kalman filter and the particle filter are the most widely used.
- The model defines the particle as a vector to represent the control points of lane boundaries. such methods often assume that the changes of lane boundary positions between two consecutive frames are small, which may be inapplicable when a vehicle turns at a crossroad or changes lanes.
- The road paint, heavy traffic and worn lanes also bring challenges to these methods.

Crossing Point Filter

- According to the camera projection, lane boundaries in a 2D image that are parallel in the 3D world will intersect at the same vanishing point. The general idea of CPF is to filter out those line segments not passing the vanishing point.
- However, a single point is prone to be interfered with by noise and difficult to estimate accurately Inspired by previous studies that use vanishing points to detect lanes.
- It uses a bounding box near the vanishing point to refine the line segments. We call this bounding box , the vanishing box.
- A line segment is filtered out if all of the crossing points of this segment with other segments are outside the vanishing box. Figure 4c shows that many noisy line segments are filtered out.

Vanishing Box Search

Since the vanishing box is close to the vanishing line, we search for thevanishing box in a restrictive region R centered on the vanishing line, as the green box.

The restrictive region R is defined as:

$$R = \{rx, ry, rw, rh\}$$

where rw is the width of R and set as the width of the image. Rh is the height of R and set as rh = 60 in this work. rx = 0 and ry = v0 − 0.5 rh are the top-left point of R, where v0 is the vertical position of the vanishing line in the image.

Within R, we search for the vanishing box bn at the positions by a spacing step d= 5 in the horizontal and vertical directions.

The candidate box at the local coordinate (i, j) relative to the top-left

point of R is b^ijn = {x^ijn , y^ijn, w^ijn , h^ijn,s^ijn }.

Structure Triangle Filter

- **CPF cannot filter out the noisy line segments that are parallel to the lanes.The noisy line segments on the arrow traffic signs still remain after applying CPF.**
- **Structure Triangle Filter (STF) to further remove those noisy line segments that are parallel with the lane boundaries.**
- The Four intersection points of the lanes and the image bottom line named arbitraily B,C,D,E.
- The STF filtering is based on reasonable estimation of B and C.

LSD ALGORITHM

Algorithm : Computing La

1: Initialize Q = 0, Lsum = 0, La

2: while (capture frame) do

3: if LBC applicable then

4: Lsum+ = LBC

5: else

6: Lsum+ = La

7: end if

8: Q = Q + 1

9: La = Lsum/Q

10: end while

Road State Machine

The state machine includes three states:

1. Turn-left road,
2. Turn-right road and
3. Straight road

*One assumption is made here that the state cannot directly transfer between ‘turn-left’ and ‘turn-right’ in two consecutive frames.

*The road state is jointly decided by two types of measures. Only if the two measures indicate the same state, the state of the current road is assigned the indicated state.

Thank You !

Thank You Everyone for your valuable time.
We are working hard to take this Project to its new height under the supervision of Dr. Sanjoy Partihar

- **Manish Tomar**
- **Akashdeep**
- **SUPERVISOR : Dr. Sanjoy Partihar**