School of Mechanical Engineering
FACULTY OF ENGINEERING

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MECH5170M
Connected and Autonomous Vehicles Systems

Object Recognition and Convoluted Neural Network (CNN)

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Lane Detection

Detection algorithms for video data

Detection of segmented clusters from LIDAR data is done using traditional machine learning algorithms based on SVMs, Gaussian Mixture Models etc.

More interesting problem is detection from images

- Lane line marking detection
- Drivable path detection
- On-road object detection

Image pre-processing

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Typically first step before applying detection algorithms

- Remove obstacles (e.g. other vehicles)
- Weaken shadows
- Normalise images by controlling camera exposure
- Limiting region of interest

Lane marking detection

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Used as feedback to vehicle control systems
(Lane Departure Warning, Lane-Keep Assist, and Lane-Tracking Control)

Several decades of work, but still not fully solved because of uncertainties in traffic conditions, and road-specific issues such as shadows, worn-out markings, directional arrows, warning text, pedestrian zebra crossings etc.

Four/Five common steps:

- Lane lines feature extraction
- Fitting pixels into various models (lines, parabolas, hyperbolas)
- Estimating vehicle position based on fitted model
- (optional fourth step: use of temporal continuity, moving vehicle)
- Image to world coordinates transformation

Model fitting and Pose estimation

Simple case: lane lines are **straight lines** (straight road segments)

More complicated case: **curvy roads**, lane markings may have to be fit with **splines**, **contours** etc.

Positon estimation is typically done using Kalman filter or particle filter (typically more reliable)

Requires inverse **perspective transformation** to go from lane coordinates to world coordinates

Lane-level localisation involves estimating vehicle **lateral position** and **moving orientation** (again can use vehicle odometry + Kalman filter)

Lane line extraction

Based on lane markings having large contrast with road pavement

- Edge detectors followed by Hough Transform to get the complete lane

Basic idea in edge detection:

- **Edges** are **discontinuities of intensity** in images, correspond to **local maxima** of the “image gradient”
- Naïve image gradients can be affected by noise in the image, so solution is to take “smooth derivatives” i.e. **first smooth** an image by convolving it with a **Gaussian filter**, and then **take the derivative**
- Edges correspond to zero-crossings of the second derivative of the Gaussian or LOG (Laplacian of the Gaussian)
- Approach used in Canny edge detector (OpenCV) and Matlab

Lane detection Example

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Lane detection

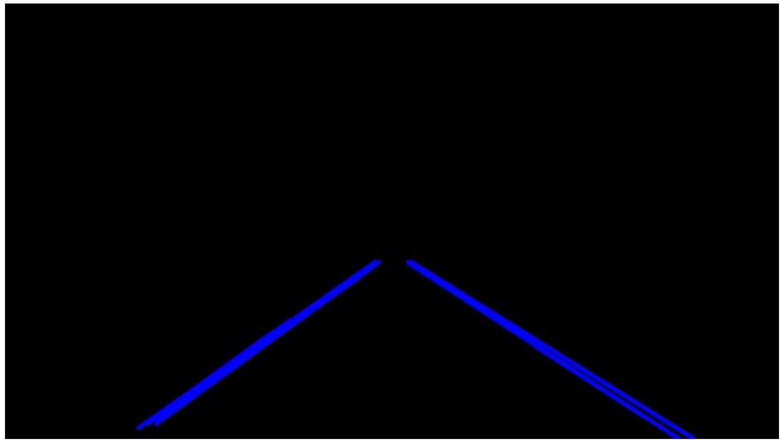
Grayscale image

Gaussian smoothing

Canny Edge Detection

Masked Edges Image

Hough Transform



[https://www.linkedin.com/pulse/finding-lane-lines-road-felipe-Martinez]

Drivable-path detection

Detecting road boundaries where vehicle can drive freely and legally without collisions

- Several image-processing based algorithms using feature detection or feature learning : generally deemed to be not robust enough for erratic driving conditions
- Deep learning provides the most popular set of techniques based on CNNs
- Other algorithms include exploiting GPS,OpenStreetMap and High Definition Maps data

On-road object detection

Detect other vehicles, pedestrians, bicycles etc.

Again, deep learning based methods seem to be clear winners

General pipeline for deep learning approaches:

- Set of proposal bounding boxes generated in the input image
- Each proposal box is passed through a CNN to obtain a label and fine tune the bounding boxes

Conclusions

Perception - creation of virtual representation of the world around the vehicle

Main steps:

- Data Acquisition (Lidar, Camera)
- Data Representation
- Segmentation

- Lane detection involve many pre and post processing steps.

ANY QUESTIONS ???