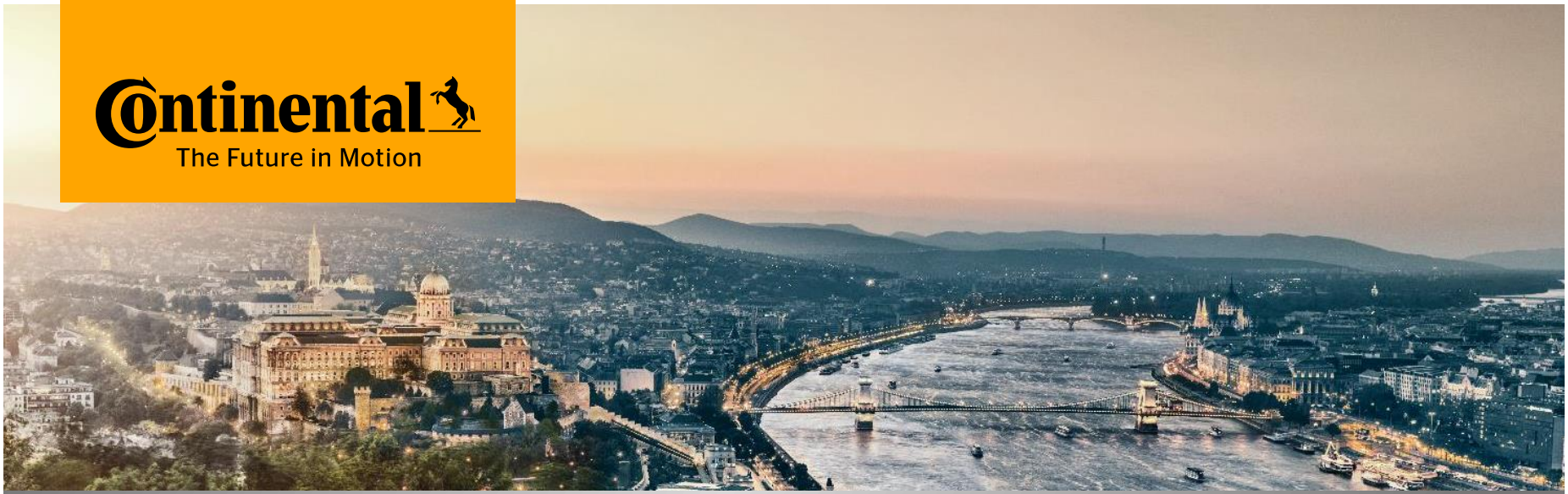
Continental
The Future in Motion



Lane Keeping Assist: Segmentation of Visual Input

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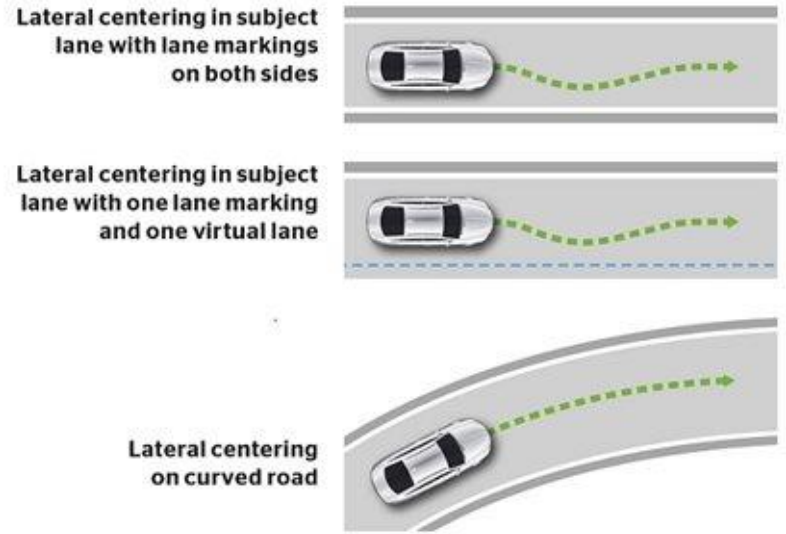
BU ADAS

150 YEARS

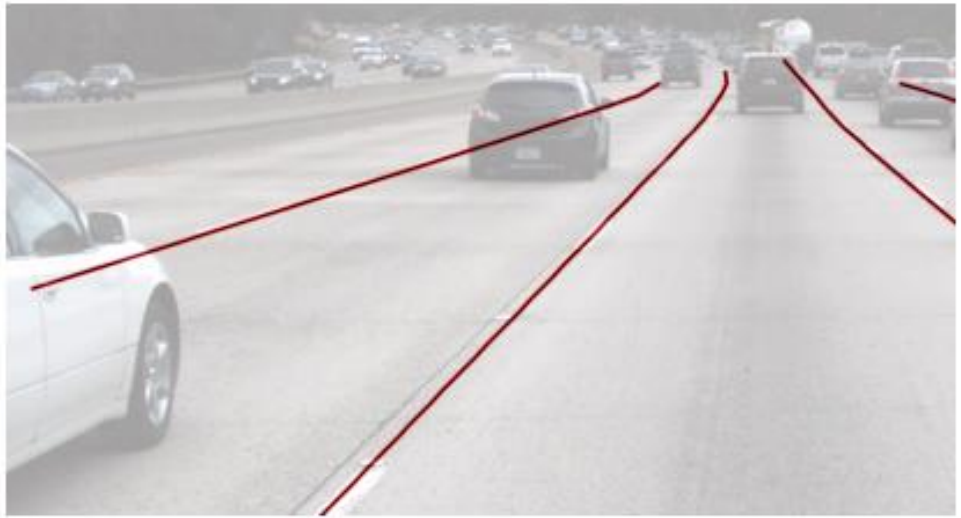
Lane Keeping Assist

- Supports the driver
  - Scenarios
    - Unintended lane change
    - Misjudged bend
  - Warns the driver
    - Alarm sound, wheel vibration
- Visual perception: lane marker detection



Outline

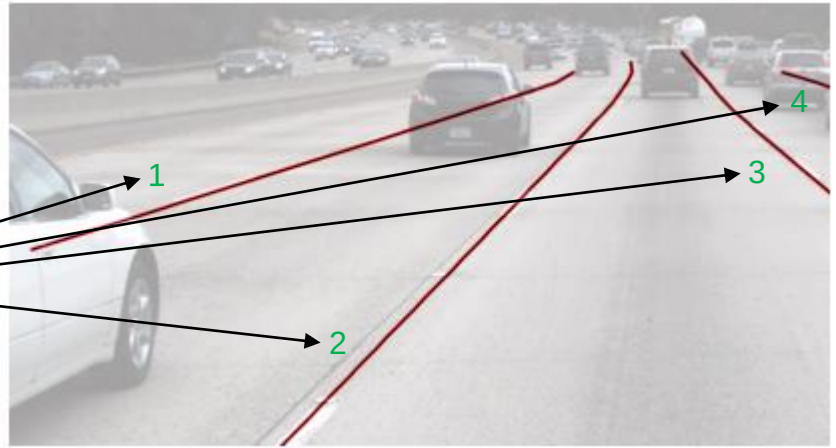
- Lane marker representations
  - Pixel-level segmentation map
  - Key-point coordinates (polyline)
  - Parametric curves
- Quality metrics
- Demo



Source: [Ghafoorian et al. 2018]

Pixel-level Segmentation

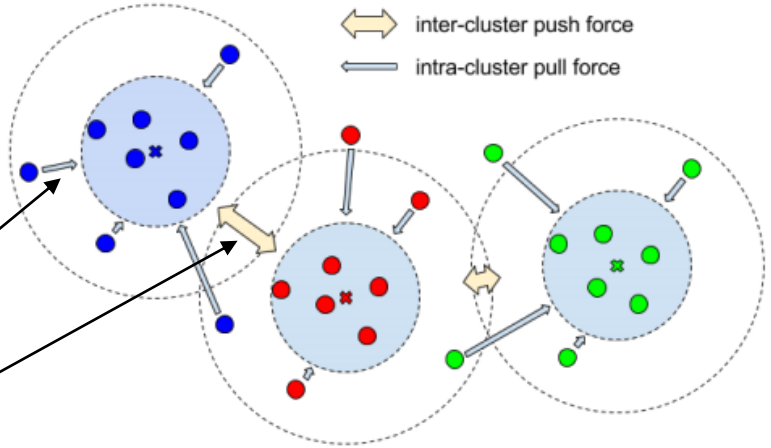
- Per-pixel predictions
  - Predictions
    - Non-marker vs marker → binary (0 or 1)
    - Marker ID: group pixels – 1,2,3,4,…
  - Neural network
    - Task = instance segmentation
    - Losses: i) pixel classification error, ii) clustering ‚quality'



Source: [Ghafoorian et al. 2018]

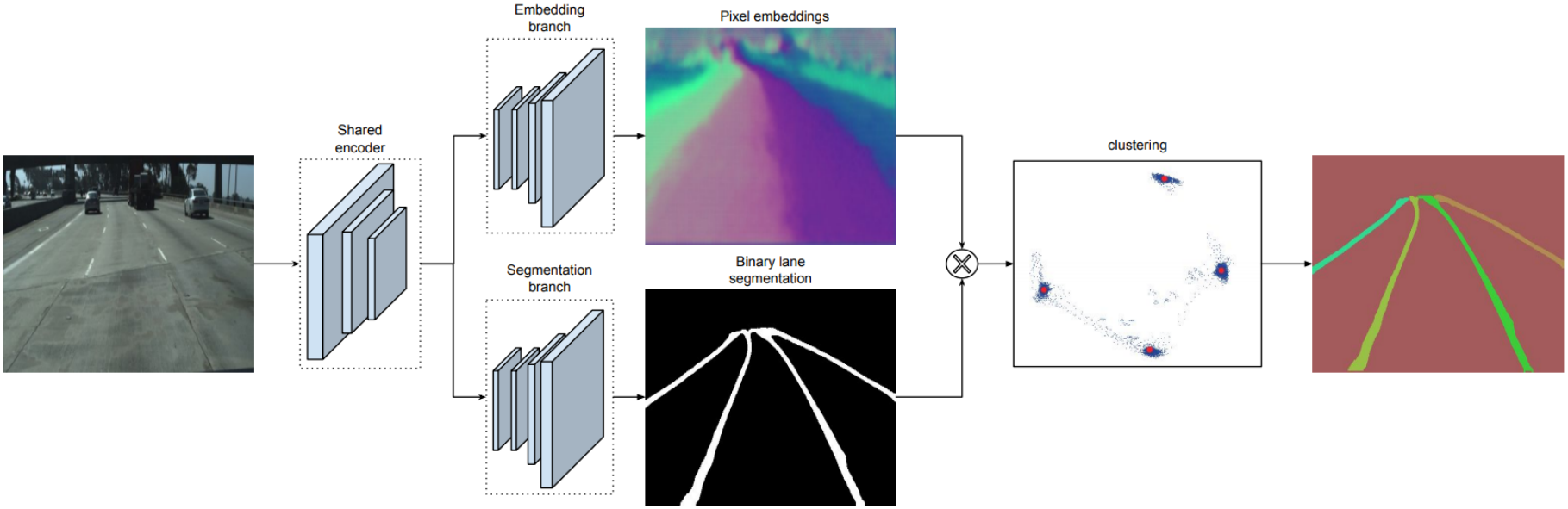
Pixel-level Segmentation

- Example: Neven et al. Towards End-to-End Lane Detection: an Instance Segmentation Approach, 2018
  - Learning tasks
    - Pixel-wise classification: non-marker vs marker
    - Marker ID: learned embedding vector – 1, 2, 3
      - Same marker: similar embeddings → pull force
      - Different markers : distant embeddings → push force
  - Complex postprocessing: clustering of embeddings



Source: [Brabandere et al. 2017]

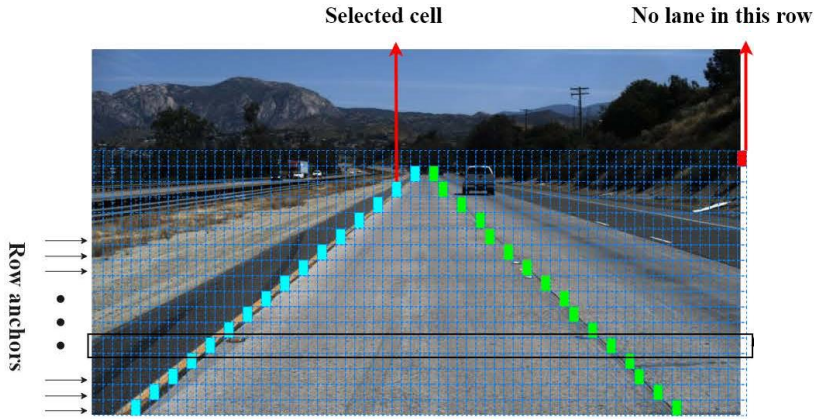
Pixel-level Segmentation



Source: [Neven et al. 2018]

Key-point Coordinate Estimation

- Row-wise coordinate predictions
  - Predictions
    - Location: x coordinate (at fix y)
    - Key-point visibility: visible or not
  - Neural network
    - Tasks: i) coordinate regression, ii) visibility classification
    - Losses: i) distance, ii) classification error

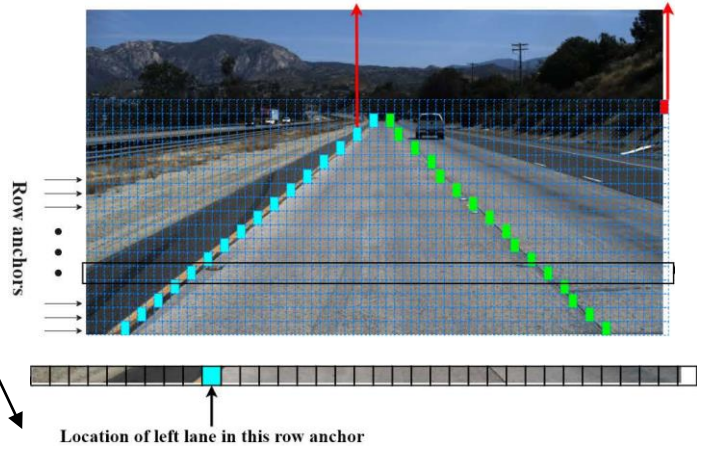


Source: [Qin et al. 2020]

Key-point Coordinate Estimation

- Example: Qin et al. Ultra Fast Structure-aware Deep Lane Detection, 2020
  - Learning tasks
    - Discretize x coordinates → classification
    - Tricks
      - Adjacent rows: key-points are close
      - Shape: straight lane markers
  - Simple postprocessing
    - Select the most confident bin

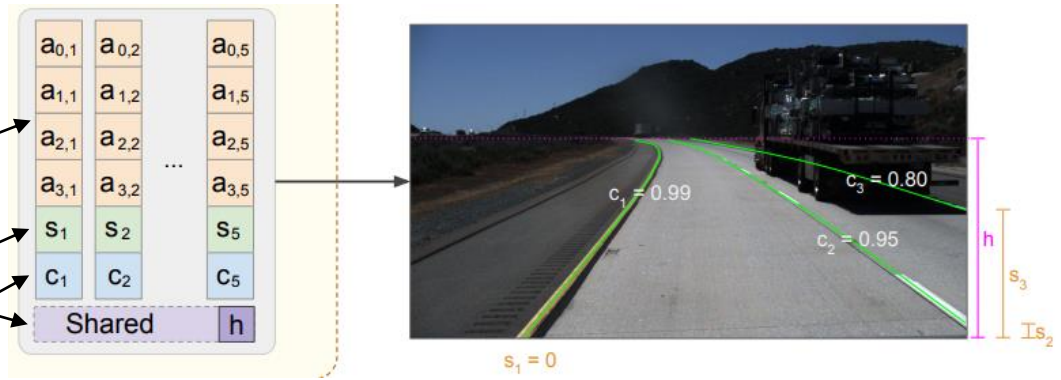
Source: [Qin et al. 2020]



Classification: which horizontal bin contains the marker?

Parametric Curves

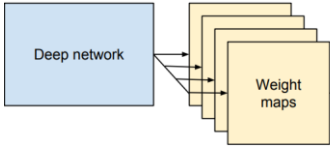
- Lane marker = parametric curve
  - Predictions
    - Parameters of the curve
    - Start/end position of the curve
    - Lane marker: visible or not
  - Neural network
    - Tasks: i) coefficient regression, ii) start/end regression, iii) visibility classification
    - Losses: i) coefficient error, ii) start/end distance, iii) classification error



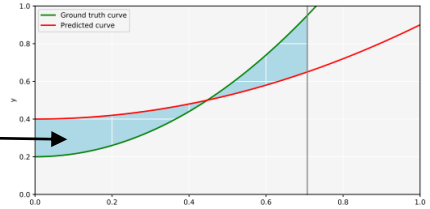
Source: [Tabelini et al. 2020]

Parametric Curves

- Example: Gansbeke et al. End-to-end Lane Detection through Differentiable Least-Squares Fitting, 2019
  - Learning tasks
    - Weight map per lane marker
      - Coefficient: weighted least squares fit
    - Horizon position
    - Lane marker visibility
  - Geometric loss: area between GT and predicted

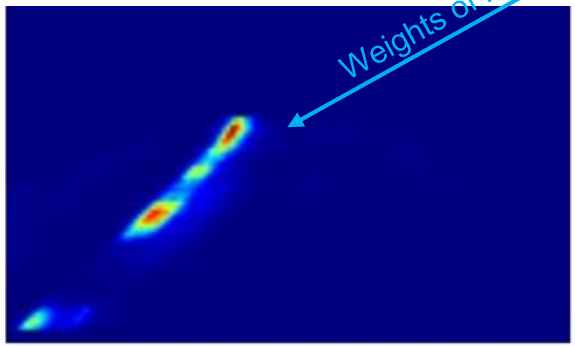


Source: [Gansbeke et al. 2020]

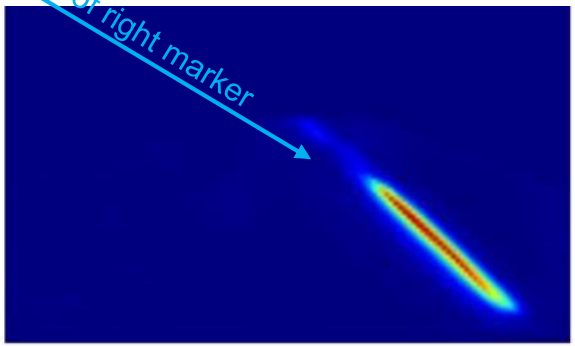


Parametric Curves

Weights of left marker



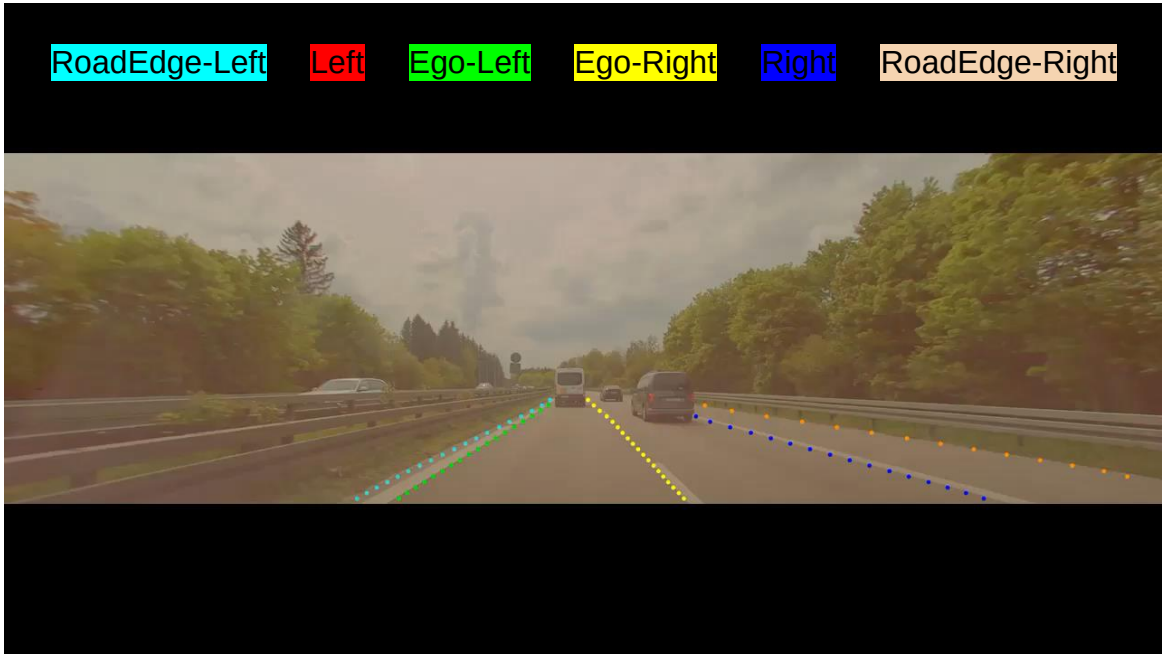
Weights of right marker



Metrics

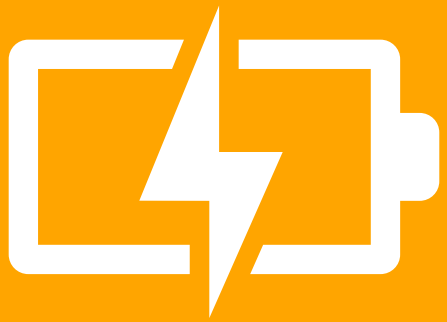
- Key-point detection quality
  - In fixed rows: distance between GT and predicted position
  - Key-point match: distance is small (e.g. < 20 pixels)
  - Accuracy = ratio of matching key-points
- Lane marker detection quality
  - Find matching key-points
  - Lane marker match: ratio of matching key-points is high (e.g. > 80%)
  - Accuracy = ratio of matching lane markers

Demos



Summary

- Lane keeping assist
  - Prevent unintended lane change
- Perception: lane marker detection
  1. Pixel-level segmentation
  2. Key-point coordinate estimation
  3. Parametric curves
- Quality metrics



Thank You! Questions?

slack: #ml21-deep-learning-sig