Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

MIN Faculty
Department of Informatics

Lane Detection for Intelligent Cars

Daniel Ahlers

University of Hamburg
Faculty of Mathematics, Informatics and Natural Sciences
Department of Informatics
Technical Aspects of Multimodal Systems

05. December 2016

Table of Contents

Introduction

- Major research topic
- Traffic accidents are a serious growing problem
- Goals:
  - Safety
  - Comfortability
  - Saving energy

Introduction

- Part of autonomous mobile robots
- Challenges:
  - Real time dynamic complex environment
  - Large amount of data
  - Vehicle motion control
  - ...

Intelligent Cars

- Autonomous cars
- Driver assistance
  - Lane departure warning
  - Adaptive cruse control
  - Anti sleep system
  - ...

Camera

+ Can sense lane marks
+ Cheap
+ Passive

- Sensible to changes in light
- No depth information

LIDAR

(LIght Detection And Ranging)

+ Can sense 3D structure
+ Independent of natural light issues
+ Can sense ground roughness

- Cannot sense lane markings
- Expensive
- Active sensors
- Latency

GPS and IMU

(Global Positioning System and Inertial Measurement Unit)

+ Can calculate the position with 1m accuracy
+ Can measure the vehicle dynamics

- Needs highly accurate map data

Road

"A wide way leading from one place to another, especially one with a specially prepared surface which vehicles can use." [1]

Lane

"A division of a road marked off with painted lines and intended to separate single lines of traffic according to speed or direction." [1]

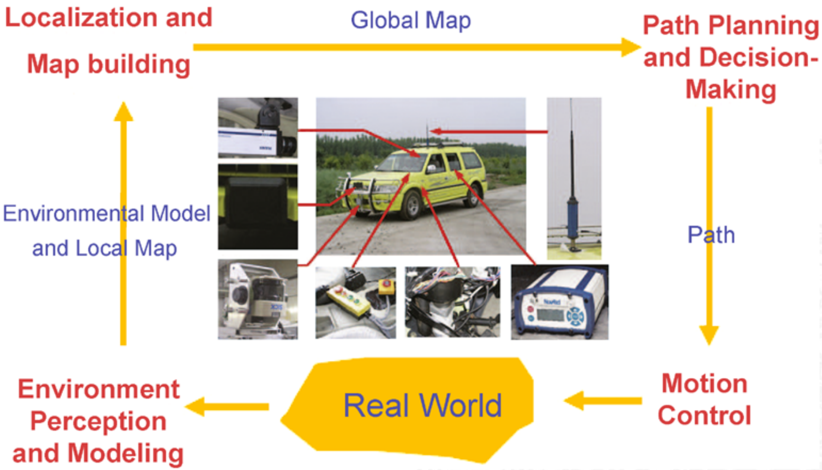
[2]

Problem

upper:[3] lower:[4]

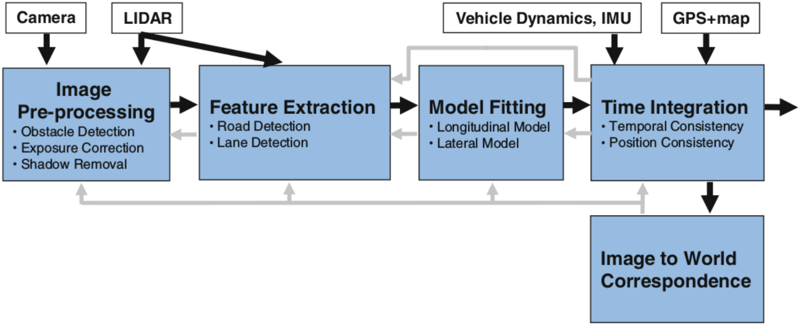
lower:[5]

Basic Framework of Intelligent Cars



[6]

Generic Lane Detection Algorithm

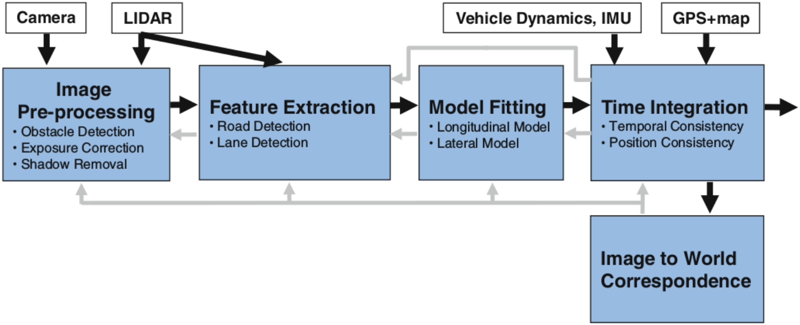


[7]

Image Pre-processing

- Enhance image
  - Weaken shadows
  - Remove over and under exposure
  - Remove misleading image artifacts
  - Remove lens flair
- Pruning the image
  - Obstacle regions
  - Remove unnecessary regions

Generic Lane Detection Algorithm



[7]

Feature Extraction

Lane detection:

- Define a threshold to get a binary edge map[8]
- Divide the image into blocks

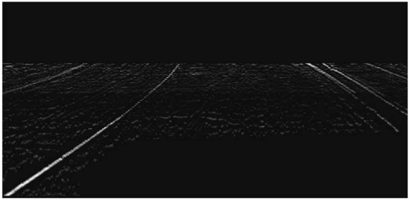
  Classify each block as lane mark or not[9]
- Compensate perspective by calculating “bird’s-eye view”

  Identify lanes by predefined color[10]
- Train a neural network to detect lanes[11]
- Search for low-high-low intensity pattern along image rows[12]

Feature Extraction

(a) Original image

(b) Horizontally filtered image



(c) Vertically filtered image

(d) Horizontal local maxima w/orientations

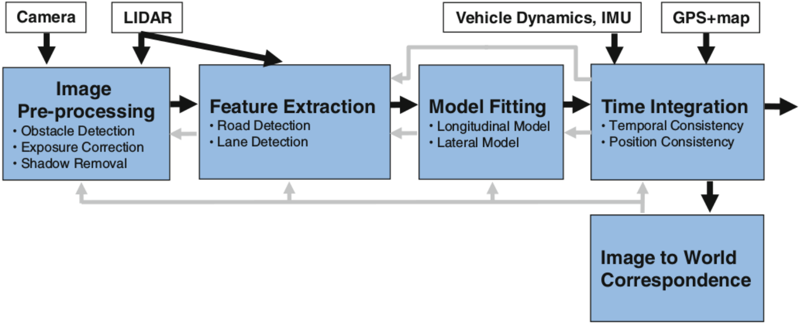
[12]

Feature Extraction

Road detection:

- Scan with LIDAR and detect surface elevation variance
  First elevation variance is estimated as road boundary[12]
- Convert image to illumination-invariant intensity image
  Place seed point in front of car
  Grow the region with similar appearance[13]
- Identify by road texture with a pre-trained Adaboost classifier[14]
- Train a neural network to detect the road[11]

Generic Lane Detection Algorithm



[7]

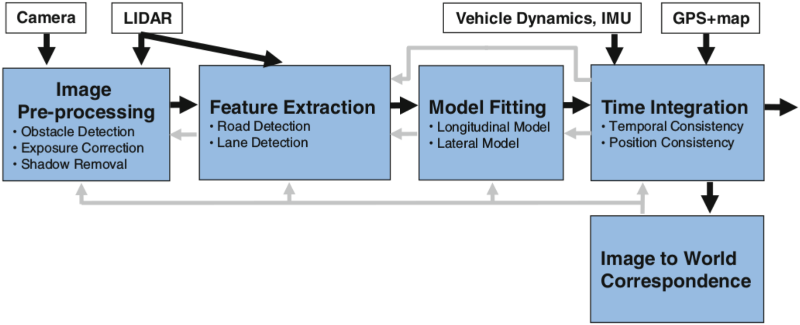
Model Fitting

- Similar methods for both roads and lanes
- Model represented by boundary points or centerline
- Transform frame to “bird’s-eye view”
- Parametric models:
  - Straight lines
  - Parabolic curves
  - Using RANSAC with least squares optimization[10]
  - Hough transform[15]
  - Integration over the y-axis[14]

Model Fitting

- Semi-parametric models:
  - No specific global geometry
  - Carefully modeled
  - Hough transform on horizontal stripes[9]
  - Generate spines[16]
- Non-parametric models:
  - Line is continuous but not necessarily differentiable
  - With ant colony optimization[17]
  - With hierarchical bayesian network[17]

Generic Lane Detection Algorithm

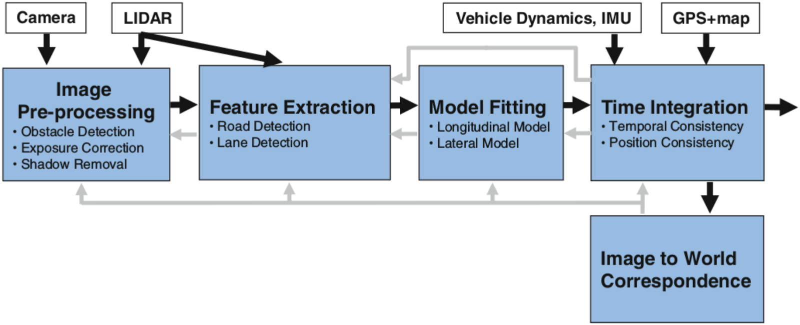


[7]

Time Integration

- Correcting detection
  - Estimate new position in world with car odometry
    Combine expected lanes with detected ones[12]
- Remove wrong detections
  - Compare with lanes from previous frame
    Reject when discrepancy too large[12]

Generic Lane Detection Algorithm



[7]

Image to World Correspondence

- Connects the 2D image to 3D world
- Calculating the real position of the car
- Needs exact camera position and orientation for calculation

Conclusion

- No best algorithm
- Fusing multiple sensors
- Even simple algorithms can handle 90% of the situations
- 100% detection is necessary
- Use more than one algorithm for a single step
- No comparable test for the different implementations[7]
- Recent research mostly unpublished

Bibliography

[1] A. Stevenson, *Oxford Dictionary of English*.
Oxford Dictionary of English, OUP Oxford, 2010.

[2] http://stockproject1.deviantart.com/art/Empty-Highway-14430767-189713463.

[3] https://de.wikipedia.org/wiki/Fahrbahnmarkierung.

[4] http://www.nahverkehrhamburg.de/hamburgs-berufsverkehr-am-limit-ein-minutenprotokoll-7

[5] http://www.fahrtipps.de/frage/regen-aquaplaning.php.

[6] H. Cheng, *Autonomous Intelligent Vehicles: Theory, Algorithms, and Implementation*.
Advances in Computer Vision and Pattern Recognition, Springer London, 2011.

Bibliography (cont.)

[7] A. Bar Hillel, R. Lerner, D. Levi, and G. Raz, "Recent progress in road and lane detection: A survey," *Mach. Vision Appl.*, vol. 25, pp. 727–745, Apr. 2014.

[8] R. Labayrade, J. Douret, J. Laneurit, and R. Chapuis, "A reliable and robust lane detection system based on the parallel use of three algorithms for driving safety assistance," *IEICE - Trans. Inf. Syst.*, vol. E89-D, pp. 2092–2100, July 2006.

[9] X. Shi, B. Kong, and F. Zheng, "A new lane detection method based on feature pattern," in *2009 2nd International Congress on Image and Signal Processing*, pp. 1–5, Oct 2009.

[10] A. Borkar, M. Hayes, and M. T. Smith, "Robust lane detection and tracking with ransac and kalman filter," in *2009 16th IEEE International Conference on Image Processing (ICIP)*, pp. 3261–3264, Nov 2009.

Bibliography (cont.)

[11] M. Foedisch and A. Takeuchi, "Adaptive real-time road detection using neural networks," in *Proceedings. The 7th International IEEE Conference on Intelligent Transportation Systems (IEEE Cat. No.04TH8749)*, pp. 167–172, Oct 2004.

[12] A. S. Huang, D. Moore, M. Antone, E. Olson, and S. Teller, "Finding multiple lanes in urban road networks with vision and lidar," *Autonomous Robots*, vol. 26, no. 2, pp. 103–122, 2009.

[13] J. C. McCall and M. M. Trivedi, "Video-based lane estimation and tracking for driver assistance: survey, system, and evaluation," *IEEE Transactions on Intelligent Transportation Systems*, vol. 7, pp. 20–37, March 2006.

[14] Y. Alon, *Off-road Path Following Using Region Classification and Geometric Projection Constraints.*
Hebrew University of Jerusalem, 2005.

Bibliography (cont.)

[15] Y. Jiang, F. Gao, and G. Xu, "Computer vision-based multiple-lane detection on straight road and in a curve," in *2010 International Conference on Image Analysis and Signal Processing*, pp. 114–117, April 2010.

[16] Y. Wang, E. K. Teoh, and D. Shen, "Lane detection and tracking using b-snake," *Image and Vision Computing*, vol. 22, no. 4, pp. 269 – 280, 2004.

[17] A. Broggi and S. Cattani, "An agent based evolutionary approach to path detection for off-road vehicle guidance," *Pattern Recogn. Lett.*, vol. 27, pp. 1164–1173, Aug. 2006.