Hauptseminar

self-driving car technology introduction

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12.07.2018

Contents of this presentation

Motivation

Motivation

Necessity :

- to prevent from traffic accidents
- to help people with disabilities

Possibility:

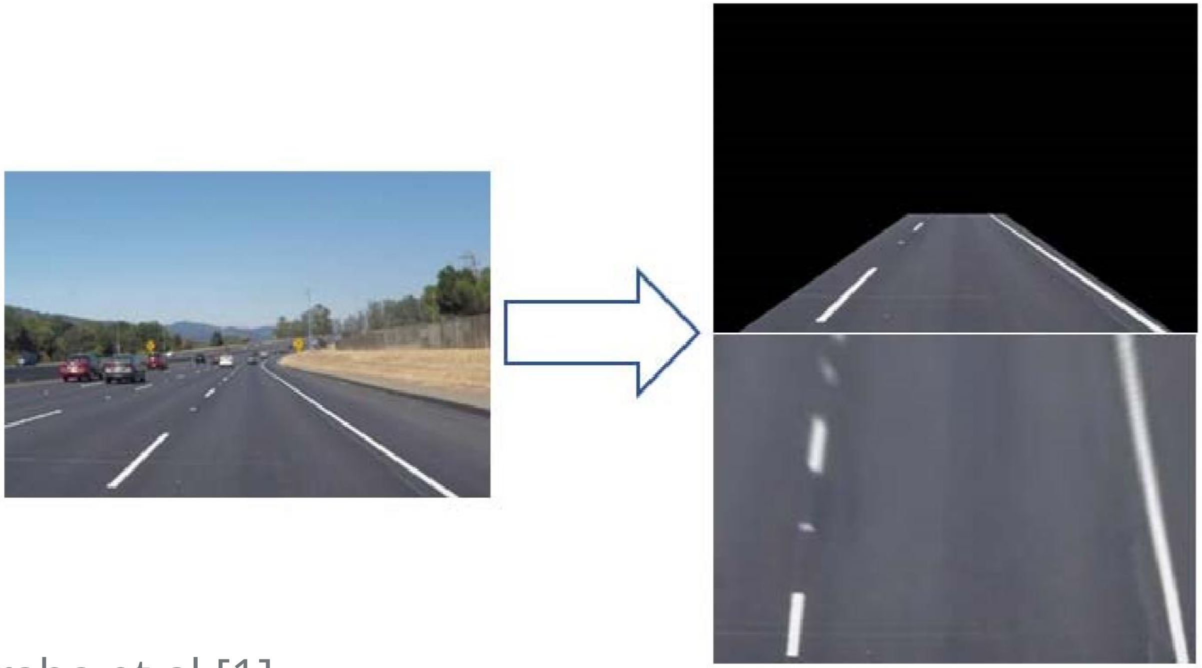
- the development of deep learning technology
- the improvement of computing power

Method: road lane detection

Method: road lane detection

1) image warping process and polynomial regression

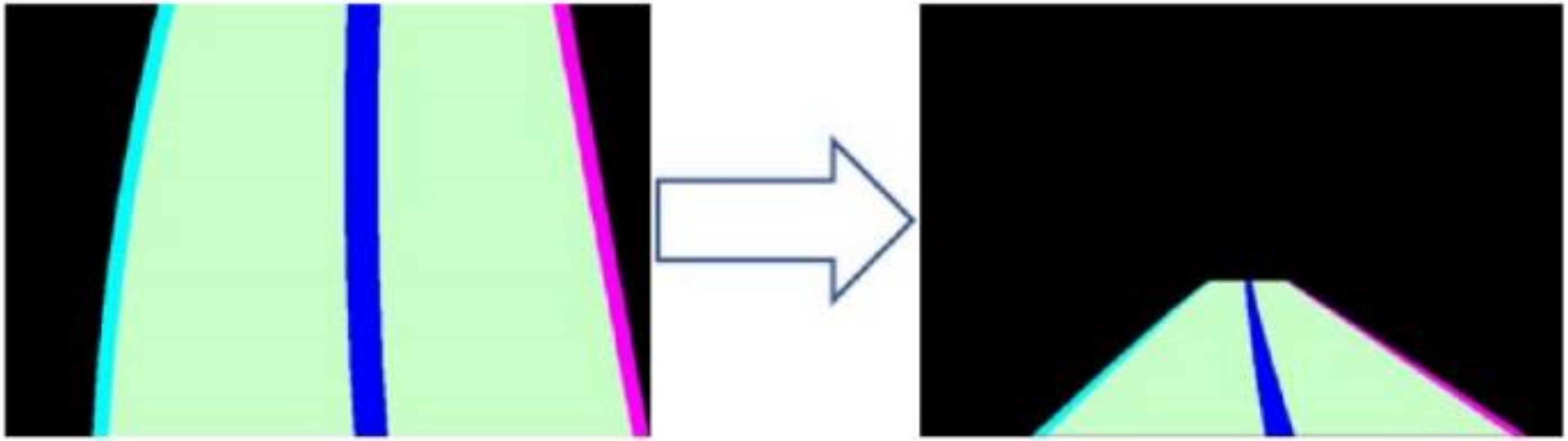
a) changing the perspective



Source: Nugraha et al.[1]

Method: road lane detection

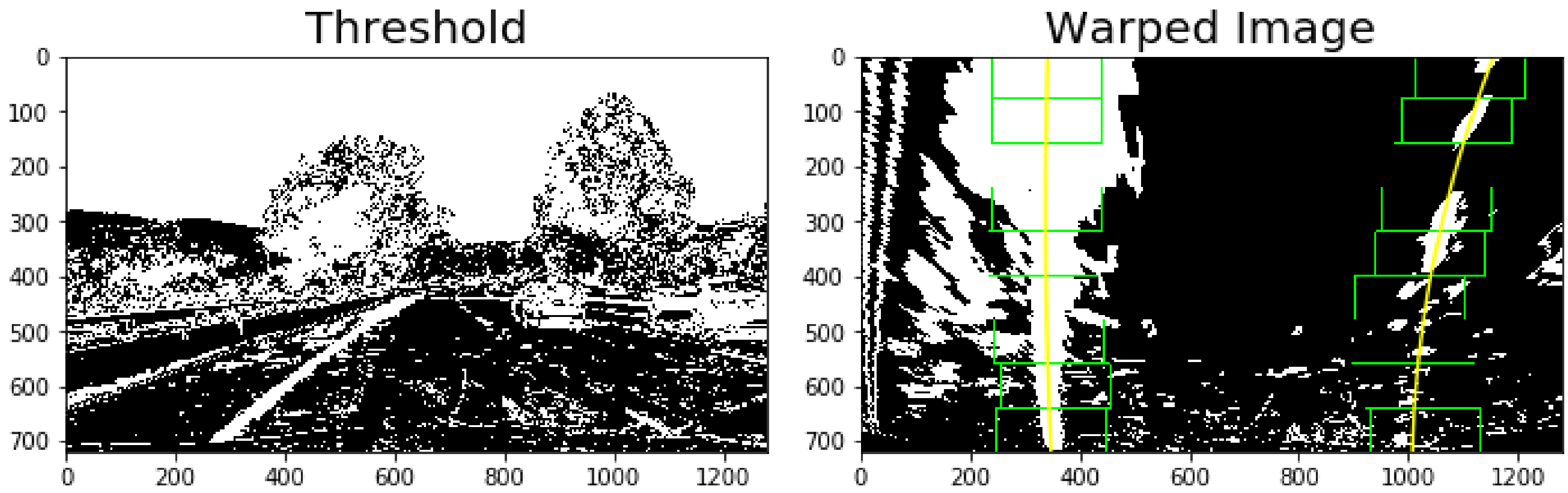
b) approximating the lane with polynomial regression



Source: Nugraha et al.[1]

Method: road lane detection

problem: too much noise



a possible solution: segment the objects in images

Method: road lane detection

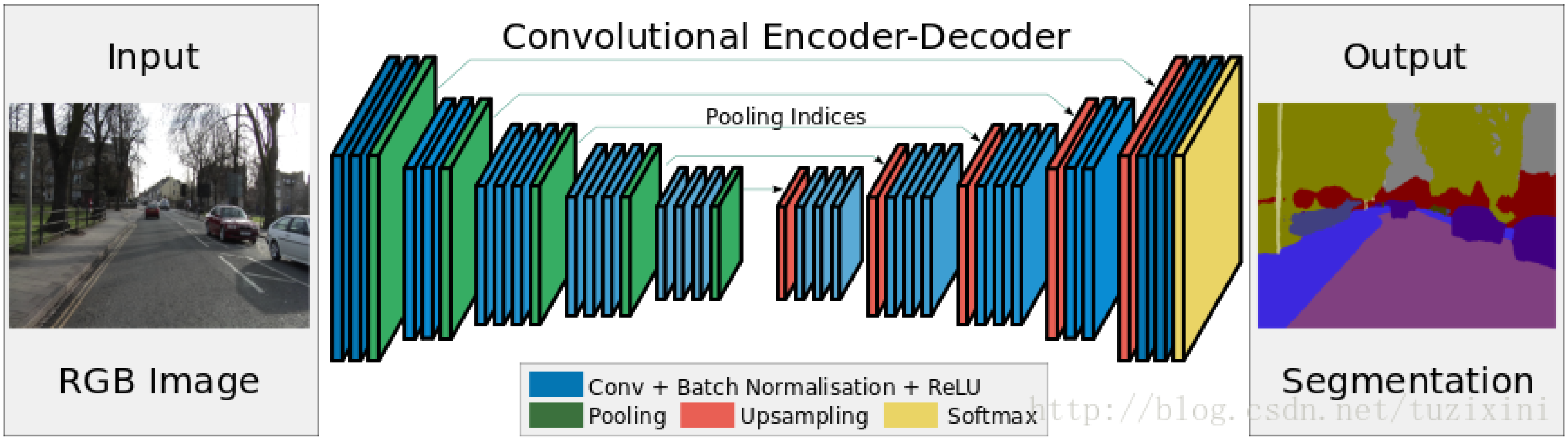
2) SegNet (segmenting network)

a) aim: improving the accuracy of lane detection

Source: Lim et al.[2]

Method: road lane detection

b) a deep convolutional encoder-decoder architecture



Source: Badrinarayanan et al.[3]

Method: collision avoidance

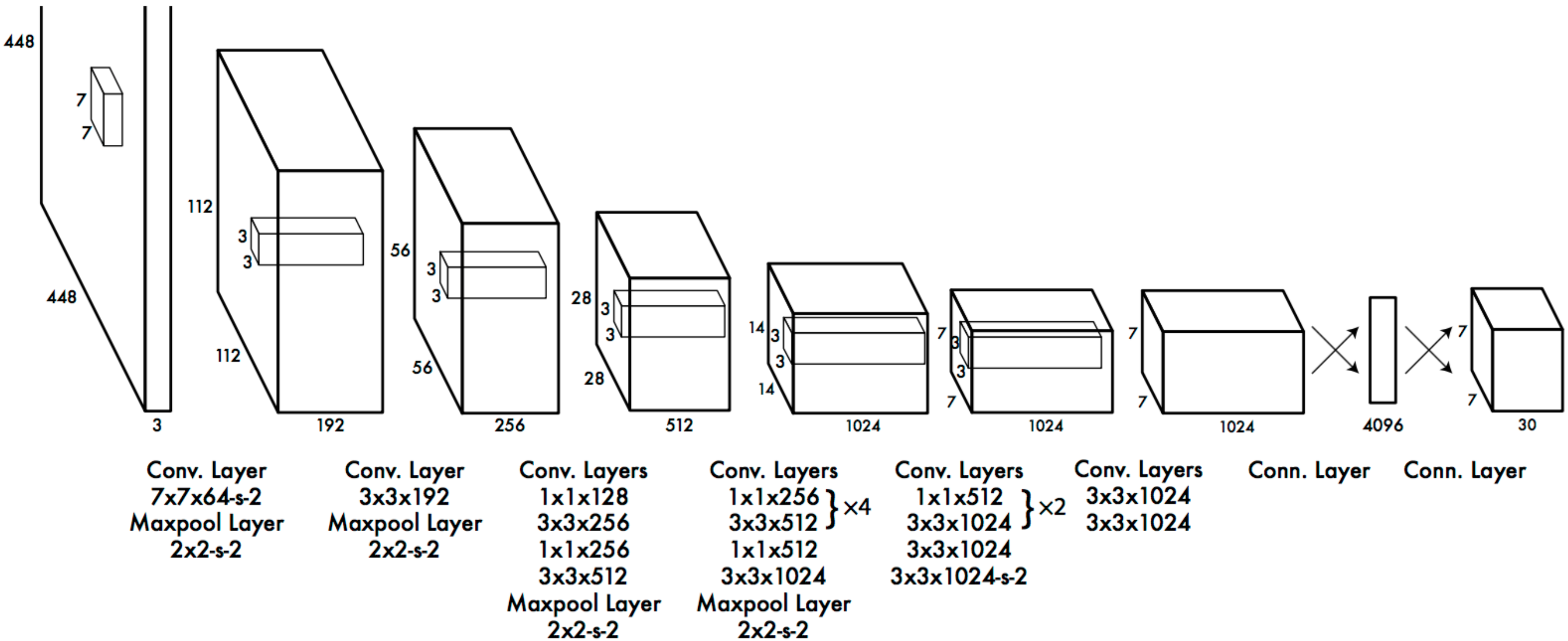
Method: collision avoidance

1) YOLO network ("you only look once" network)

a) aim: real-time object detection

Method: collision avoidance

b) a convolutional neural network architecture



Source: Nugraha et al.[1]

Method: collision avoidance

2) LIDAR (light detection and ranging)

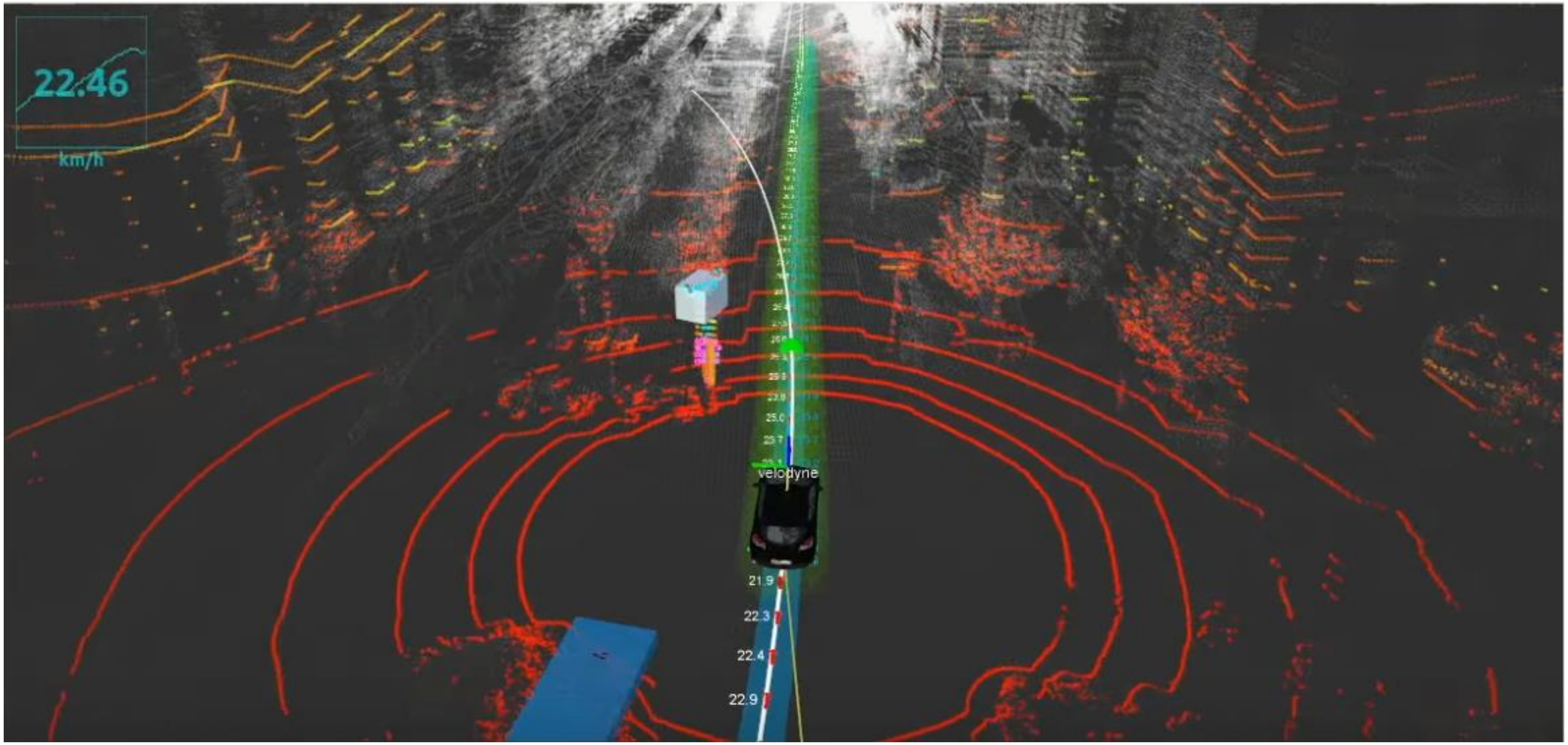
a) working principle : time of flight method

b) measuring the relative distance between the other vehicles and the self-driving car

c) constructing a so-called point cloud map
drawing a 3D environment map

d) better way to detect vehicles, but too expensive

Method: collision avoidance



Source: udacity's self driving car course

Method: collision avoidance

3) path planning: artificial potential field

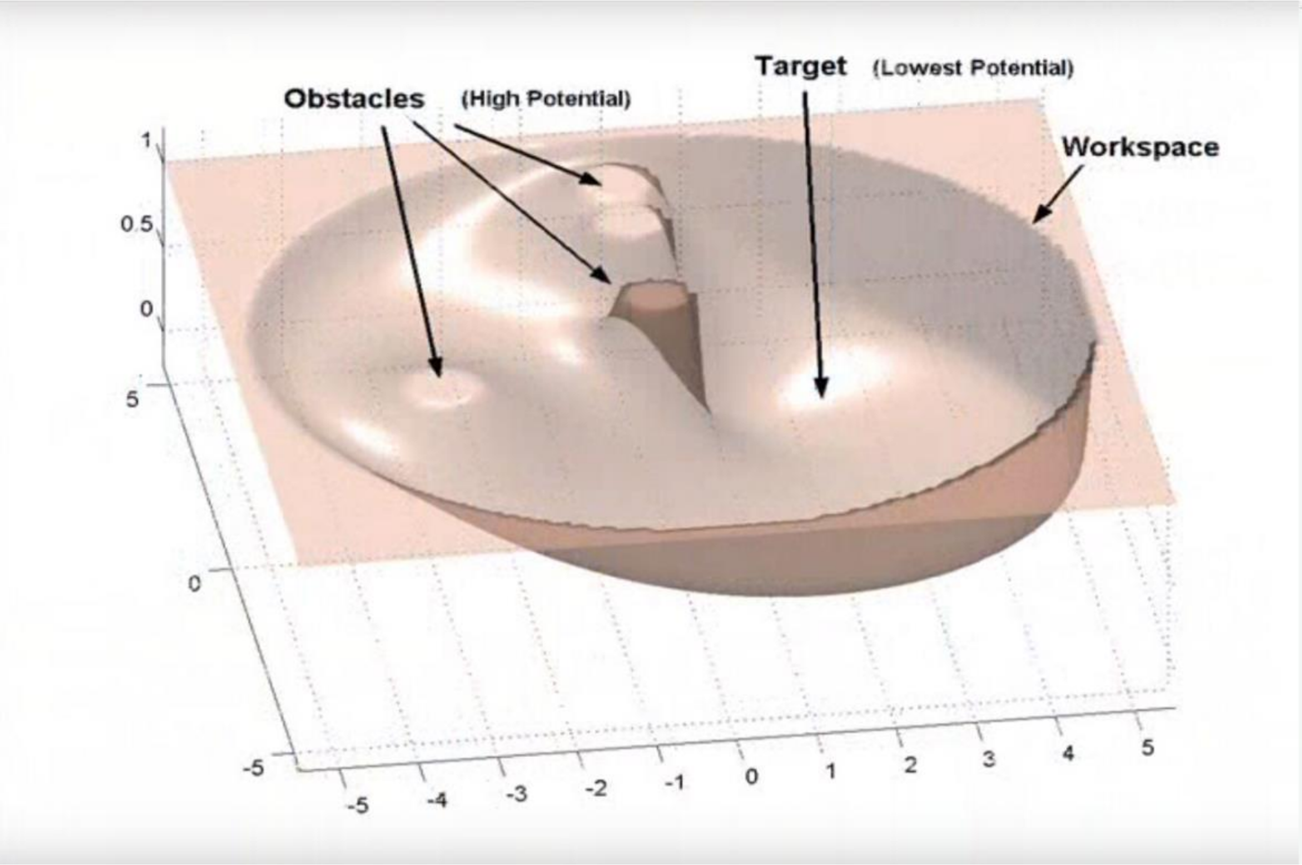
a) assumption: the self-driving car is moving under
a virtual potential field

b) initial point: the higher “mountain head”
target point: the “mountain foot”

c) principle: repulsions of obstacles against the car

Method: collision avoidance

an example for an artificial potential field :



Source: junshen's blog [6]

Method: collision avoidance

4) model predictive control

a) to control a process while satisfying a set of constraints

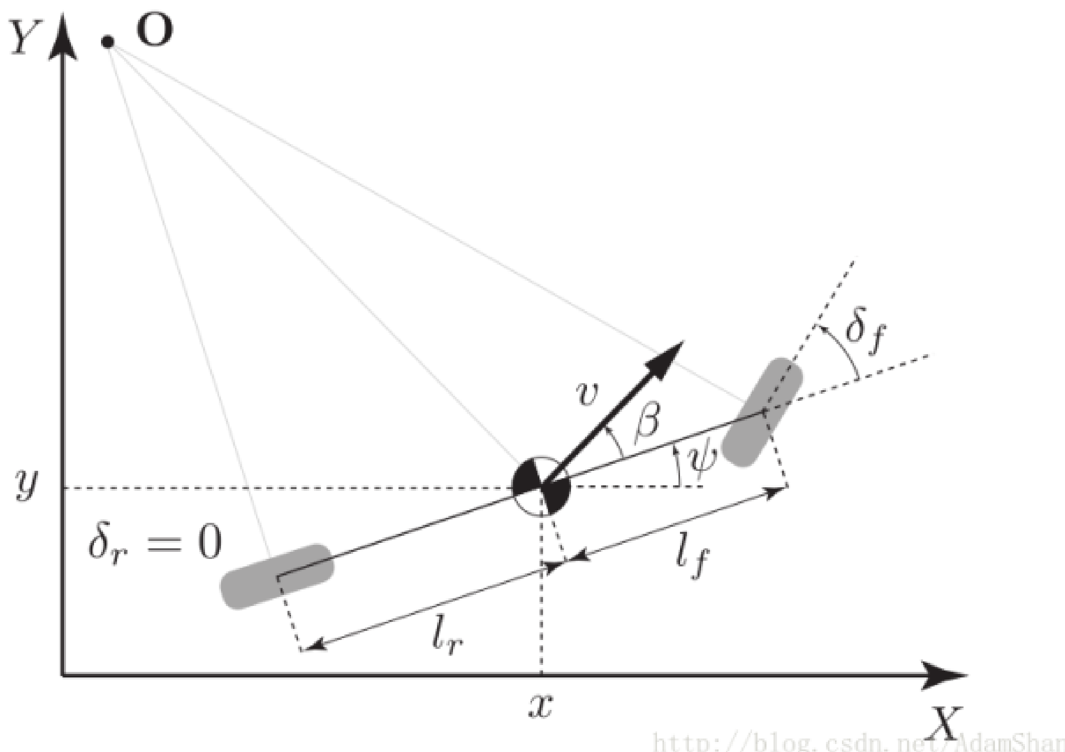
b) scenario:

after the path is planned, the vehicle parameters need to be known in order to make the car move in the planned path as possible.

parameters: acceleration (a)
steering angle (δ)

Method: collision avoidance

c) vehicle kinematic model



$$x_{t+1} = x_t + v_t \cdot \cos(\psi_t + \beta) \cdot dt$$

$$y_{t+1} = y_t + v_t \cdot \sin(\psi_t + \beta) \cdot dt$$

$$\psi_{t+1} = \psi_t + \frac{v_t}{l_r} \cdot \sin(\beta) \cdot dt$$

$$v_{t+1} = v_t + a \cdot dt$$

$$\beta = \tan^{-1}\left[\frac{l_r}{l_f + l_r} \cdot \tan(\delta_f)\right]$$

Source: AdamShan's blog [5]

Method: collision avoidance

d) measuring and minimizing the difference between actual driving path and reference path with a loss function:

$$Loss = \sum_{i}^{n} \left(z_i - z_{ref\,,\,i} \right)^2$$

e) obtaining control parameters

dealing with environmental noise automatically

parameters: acceleration (a)

steering angle (δ)

Summary

Summary

- using SegNet and regression to detect the lanes
- using the YOLO algorithm and LIDAR to detect the vehicles
- using artificial potential fields to plan a path to avoid collisions
- using model predictive control to control the car on the path

Future work

Future work

1. sensor control and fusion

prerequisite: complementary capabilities of different sensors

aim: providing higher redundancy

2. positioning and navigation

aim: obtaining the exact location of the vehicle

drawing high-precision maps for path planning

Thank you for attention

Reference

[1] Nugraha B T, Su S F. Towards self-driving car using convolutional neural network and road lane detector[C]//Automation, Cognitive Science, Optics, Micro Electro-Mechanical System, and Information Technology (ICACOMIT), 2017 2nd International Conference on. IEEE, 2017: 65-69.

[2] Lim K L, Drage T, Brä T. Implementation of semantic segmentation for road and lane detection on an autonomous ground vehicle with LIDAR[C]//Multisensor Fusion and Integration for Intelligent Systems (MFI), 2017 IEEE International Conference on. IEEE, 2017: 429-434.

[3] Badrinarayanan V, Kendall A, Cipolla R. Segnet: A deep convolutional encoder-decoder architecture for image segmentation[J]. arXiv preprint arXiv:1511.00561, 2015.

[4] Ji J, Khajepour A, Melek W W, et al. Path planning and tracking for vehicle collision avoidance based on model predictive control with multiconstraints[J]. IEEE Transactions on Vehicular Technology, 2017, 66(2): 952-964.

[5] Funke J, Brown M, Erlien S M, et al. Collision avoidance and stabilization for autonomous vehicles in emergency scenarios[J]. IEEE Transactions on Control Systems Technology, 2017, 25(4): 1204-1216.

Reference

[6] Blog of AdamShan : https://blog.csdn.net/adamshan/article/details/79083755

[7] Blog of junshen : https://blog.csdn.net/junshen1314/article/details/50472410

[8] Szegedy C, Liu W, Jia Y, et al. Going deeper with convolutions[C]. Cvpr, 2015.

Q & A