{ 1. }good afternoon everyone, welcome to my presentation, my name is Hu Xi and I'm a master student of computer science. the topic of my presentation today is "self-driving car technology introduction"

firstly I want to apologize that I am not able to speak German fluently, so this presentation will be in English.

{ 2. }

And here is the outline of this presentation. first of all I will explain why I choose the topic, the motivation. Then I would like to introduce some methods used in self-driving car, and there are two main parts :

road lane detection and collision avoidance. And then I will give you a summary so that you can know the whole process in general and lastly we will talk about the future work. Now let's beginn!

{ 3. }

Firstly, Why I choose this topic, { 4. } because in my opinion self-driving technology is very necessary in the future. Every year more than 1.2 million(one million 2 hundred thousand) people are killed by traffic accidents. These accidents often happened because of the driver’s inattention. If cars could be driven by computers instead of human, these accidents would less happen. besides it could also help people with disabilities to travel around. And because of the improvement of computing power and development of deep learning technology recently, it is possible to design such a self-driving system. So That’s why this technology become more and more popular and that’s why I want to introduce it to you .

{5. }Then concretely, let’s see what kind of methods will be used in a self-driving car? Well no matter for a human driver or a “computer driver”, how to find a road lane and move according to it, is always a important and basic problem. { 6. }Assuming we have a camera in the roof of the car. We will get images like this, in order to find the road line, we can cut out the region we are interested in, and then change the perspective to birds‘ view, so that we can know if the car drives in a straight line or a curve. {7.}Then we use polynomial regression to approximate the road lane (usually quadratic curve is enough to approximate). And I did a implementation, we can see how it works. { 视频 }

As you can see, the road lane can be detected and drawed out.

With this method we always know if the cars are still moving correctly nor not.

{8.}

Okey as you can see this is very useful method, but it has also a problem : here is a image, which I processed during implementation, you can see there is too much noise in this image, I tried a lot of methods to reduce it, but usually doesn’t work well. So if we have a way to segment the objects in an image, which part is the lane line and which part is the road surface, it will help to improve the effect of detection. { 9. } yep that’s the next method I want to introduce, SegNet, and it stands for segmented network ! as you can see in this image, this model could segment the objects in image, and it is important not only for the road lane detection but also for vehicle detection, which we will discuss latter.{ 10. } And it is a deep convolutional encoder-decoder network, if you want to learn more details about it, I recommend you to read this paper. In this presentation we will not discuss.

{11.}

So that’s methods for road lane detection, and another important part of self-driving car is collision avoidance. Let’s think about how human driver can avoid collision : well firstly we need to find the vehicles around us and then plan a path we want to go with, decide to step on the gas or adjust the steering wheel. Right? Actually the self-driving car dose a very similar work.

{ 12. }

So firstly for detecting the vehicles, there is a very useful model called YOLO network, “you only look once” network, and actually I don’t know what it means either. comparing with other model, it can detect objects in a very short time, and here is image shows how object detection works. { 13. } And also it’s a deep convolutional neural network，again about more details you can find in this paper, in this presentation we will not discus. And also I made a implementation, let’s see how it works { 视频 }.

{在放视频时} By the way, actually I implement this part with a normal classifier called “support vector machine” instead of YOLO network. Because training such a deep network in my laptop cost too much time. But the general result will look very similar. And of course if we use YOLO network we will get a more accurate result with less time.

All right, after finding the vehicles, the next question is, how far is the distance between us? In a 2D (two dimensional) image we can never measure the distance, so we need another tools : { 14. } that’s next part we will talk about, LIDAR! LIDAR is a [device](http://www.baidu.com/link?url=_YakCyyzAtrG_hB1bXDWwVIvZztNx5XIQk6JUM9Yew1FVhkjmDOtNJPaTy2X6VUeeME7OKBLBlIlP5KAZVUy87UeCxa9vWgN9dQShrbC6Da), which can shoot a beam of laser, and measure the distance between objects with calculating the time it gets reflected laser, that called “time of flight method”. With LIADR we can get so called “point cloud image”, and further we can use it to construct a 3 dimensional environment map. It’s a very powerful tool in self-driving car system, but the price is very expensive. ( almost equal to a normal car ).

{ 15. }

Here is an example of a 3D environment map which can be constructed by LIDAR. [ 3s ]

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{ 16. }

All right, we know the vehicles and the distance, then we can plan a path, and a common way to do it, is the artificial potential field. In this model, we assume that the self-driving car is moving under a virtual potential field, （{ 模型 } in order to better explain it, I made a easy model : assuming our car is moving on the road, here we detect a car, here is another car）, in this field theory, our initial point is a higher “mountain head”, target point is a “mountain foot”, the car moves like a river, from high to low. And in every point we find vehicles, we set a small mountain. And this mountain will produce repulsion against the car. So the car will never go there. Yep that’s the artificial potential field.

{ 17. }

This image also shows how it works. [ 3 s ]

{ 18. }

All right, now we come to the last step : how can we control the car? And for this part we need an algorithm called “ model predictive control ”, MPC. Well, firstly let’s think about such a 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. And how to get those parameters is the problem that this algorithm want to solve.

In order to figure out how MPC works, we need some physics calculation. here is a vehicle kinematic model. { 19. } Assuming at time t we have already known the position ( x, y ), rotation angle ψ and velocity v, we can call all of them as a status. If we get a new control parameters acceleration a and steering angle δ, then we can predict the status at time t+1 according to these formulae. { 20. } then we can compare these value ( or you can say status ) in time t+1 with reference path, which we have planned before, with a loss function like this. And if we minimize this function we can finally obtain the control parameters. And according to the paper, MPC can also deal with environmental noise automatically, such as the difference in slope and roughness of the road surface.

After MPC, finally we can drive the car ! { 21. }that the main process, so let me make a summary in general, so that you can better understand :

{ 22. }

• 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

And, lastly

{ 23. } we should know there are still much future work to do.

{ 24. }

For example, sensor control and fusion. We know in a self-driving car, the most important thing is the safety of diviers. So if we can fusion data from different sensors, the whole system could provide a higher redundancy. For example in a rainy day the camera maybe doesn’t work very well, and we can use more LIDAR data. How to fusion those data, it still requires further research.

Another point is positioning and navigation, if the cars want to go somewhere, they should know where are they in real time, GPS could be a choice, but it can be blocked by such as buildings or trees. So how to get a high-precision map and use it to navigate is also a valuable subject.

{ 25. }And that’s all about my presentation, thank you for attention!

{ 28. }And now it’s time for Q&A. Dose anyone have questions ?

备选问题：

Loss function 中n的作用：

(as you can see in the loss function, n means when you have a planned path, you can cut it to n segment, and calculate the loss separately then sum them up).

8页中怎么得到框的：

I cut the image to 9 parts vertically, and count the pixel in a slide box, and choose the box with the most white dots.

不会答的：I’m sorry I don’t know either, the author didn’t mention this point in the paper.