Department of Electrical Engineering
電機工程學系

PolyU STEM Lecture Series

Self-driving Car Technology

Department of Electrical Engineering (EE)
Dr Isaac Fung
yu-fai.fung@polyu.edu.hk

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Department of
Electrical Engineering
電機工程學系

Engineers
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Can a car drive itself?

Reference: https://www.youtube.com/watch?v=aaOB-ErYq6Y

How it drives by itself?

- Need to know the location (current and destination)
- Need a map
- Need data from the environment
- Need to identify other users and objects

Location

- GPS – Global Positioning System
- Track latitude
  緯度, longitude 經度 and altitude高度
  - Speed
  - Bearing
  - Track
  - Trip distance
  - Distance to destination

GPS

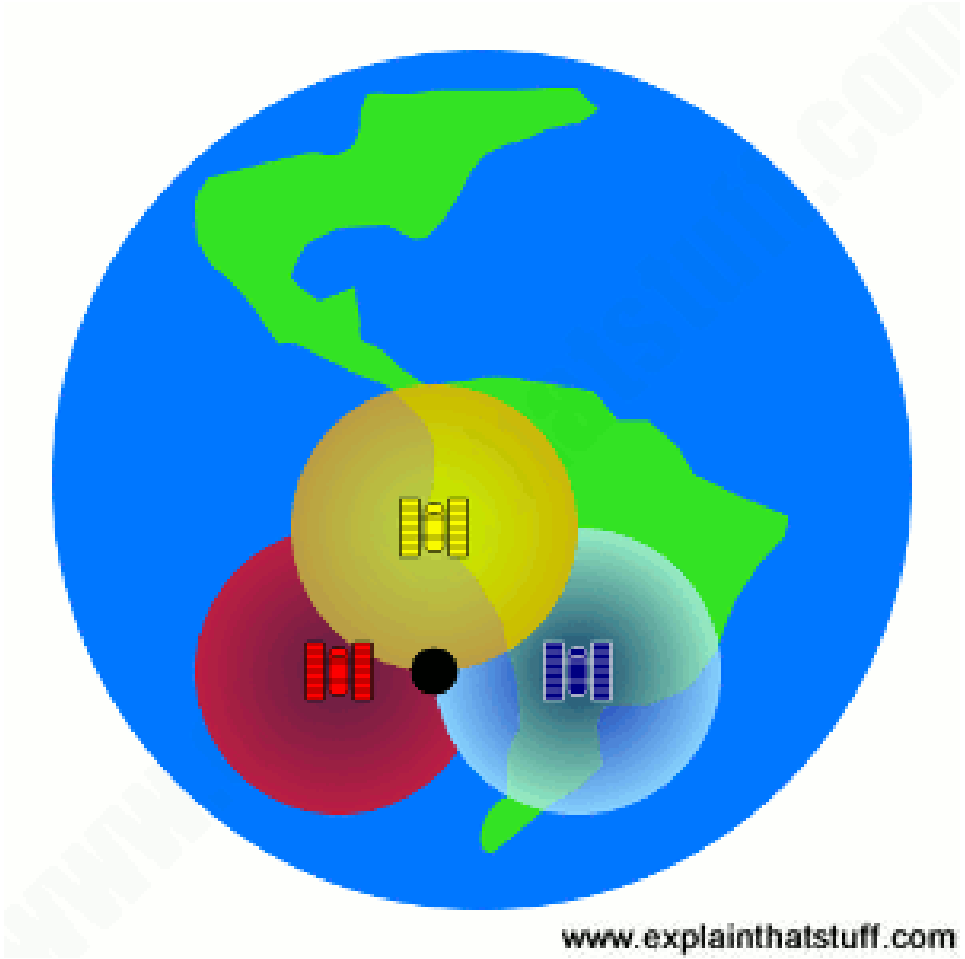

Yau Ma Tei
油麻地
Nathan Rd
Temple St
Market, Jordan
香港玉器市場
KING'S PARK
京士柏
YAU MA TEI
油麻地
Jordan
佐敦
Pao Yue-Kong Library
Austin Rd
Cheong Wan Rd
Kowloon Park
九龍公園
TSIM SHA TSUI
尖沙咀

How GPS work

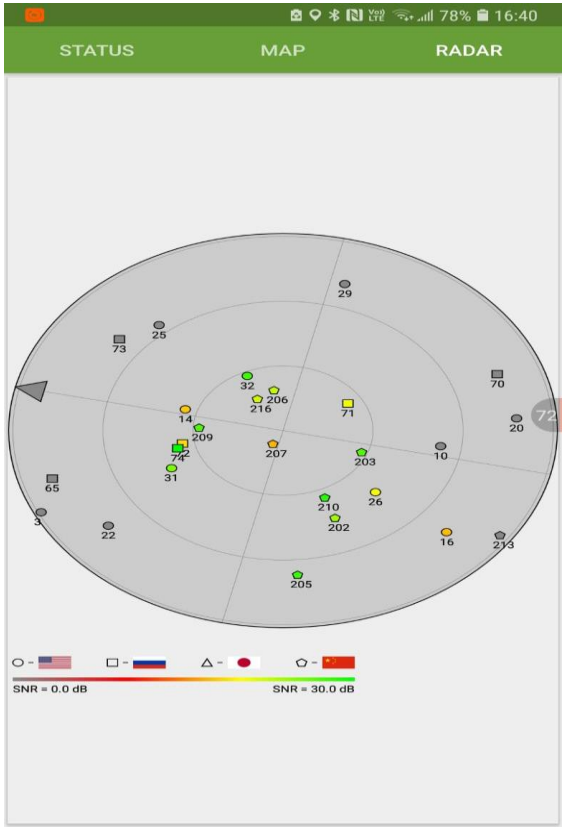
- GPS receiver (such as your cell phone) receives signal sent from satellites
  - Time and position
- Calculate the distance between the receiver and the satellites based on the time
- Using distances from 3 satellites then can determine your location

GPS RAW DATA
*$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A*

GPS Triangulation



GPS test results



PRN	GNSS	SNR	Elev	Azim	Flags
3		0.0dB	1.0°	322.0°	A
10		18.8dB	37.0°	175.0°	EAU
14		13.8dB	56.0°	4.0°	EAU
16		22.1dB	18.0°	208.0°	AU
20		0.0dB	12.0°	163.0°	EA
22		0.0dB	17.0°	310.0°	A
25		0.0dB	26.0°	37.0°	EA
26		34.3dB	47.0°	210.0°	EAU
29		17.7dB	19.0°	94.0°	EAU
31		26.9dB	49.0°	320.0°	EAU
32		27.6dB	62.0°	50.0°	EAU
65		0.0dB	10.0°	331.0°	A
70		0.0dB	14.0°	147.0°	A
71		17.9dB	65.0°	137.0°	AU
72		17.9dB	56.0°	337.0°	AU
73		0.0dB	21.0°	25.0°	A
74		21.9dB	54.0°	334.0°	EAU
194		17.9dB	58.0°	36.0°	
195		15.8dB	33.0°	133.0°	A
201		0.0dB	49.0°	127.0°	A
202		31.6dB	46.0°	234.0°	EAU
203		25.7dB	62.0°	188.0°	AU
204		18.1dB	32.0°	109.0°	AU
205		18.9dB	23.0°	253.0°	AU
206		16.8dB	71.0°	68.0°	EAU

Reference: GPS Test Apps from Cache.Wind

GPS and Map

- Google Map

Google Map

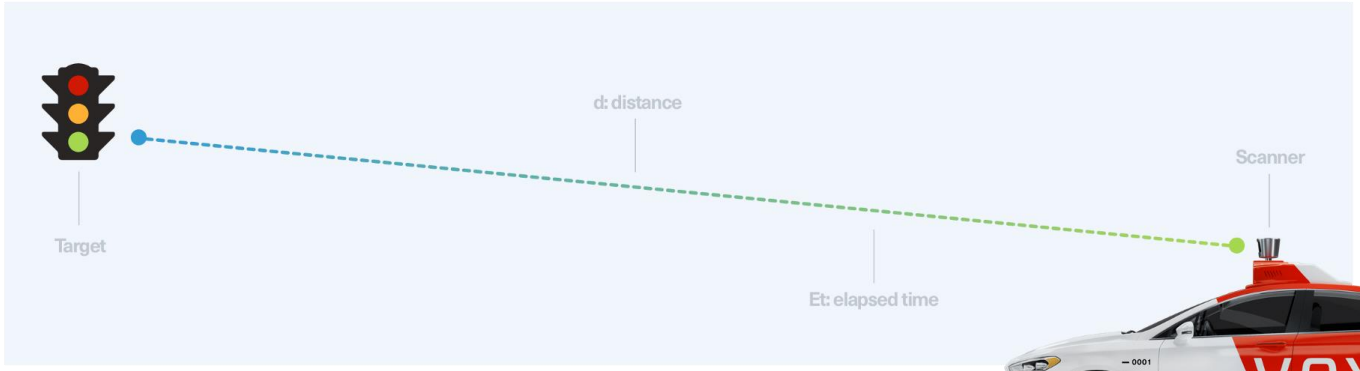
- Using Google Map with GPS coordinates
- http://maps.google.com/maps/?saddr=0.1,0.1&daddr=0.2,0.2, where the numbers are GPS coordinates this will show directions

How to build a real-time map of the environment

Source: https://medium.com/enrique-dans/have-you-started-thinking-about-the-impact-of-self-driving-cars-e9c2f692f162

LIDAR

- Uses laser beams to generate a 360-degree image of the car's surroundings



Source: https://www.pngkey.com/download/u2t4r5i1r5u2i1w7_a-lidar-sensor-continually-fires-off-beams-of/

How LIDAR works

1. LIDAR generates *huge* 3D maps, which you can then navigate the car.
2. By using a LIDAR to map and navigate an environment, you can know ahead of time the bounds of a lane, or that there is a stop sign or traffic light 500m ahead
3. LIDAR is expensive! – $80K USD
4. LIDAR demo

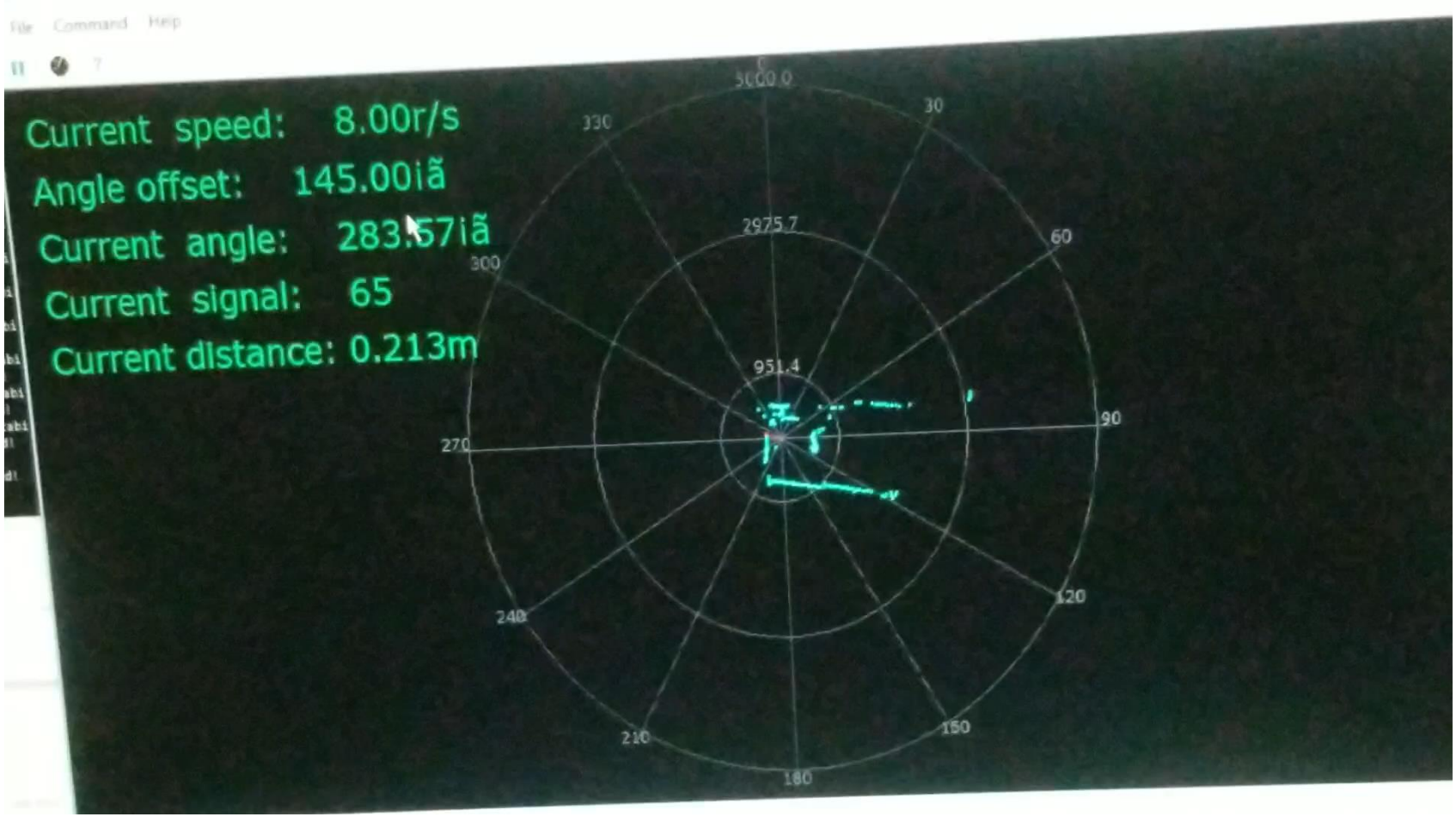
LIDAR

- A low-end LIDAR system
  - Using wavelength at 780nm
  - Scanning frequency 6.2Hz
  - Distance up to 8m

LIDAR Demo

- Demo1

LIDAR Demo


Current speed: 8.00r/s
Angle offset: 145.00iã
Current angle: 283.57iã
Current signal: 65
Current distance: 0.213m
5000.0
2975.7
951.4
30
60
90
120
150
180
210
240
270
300
330

Cameras

- Find distance to various objects using 2 cameras
- Detect traffic lights and signs
- Recognize moving objects – pedestrians
- Camera is cheaper comparing to LIDAR
- But processing images requires powerful computing power

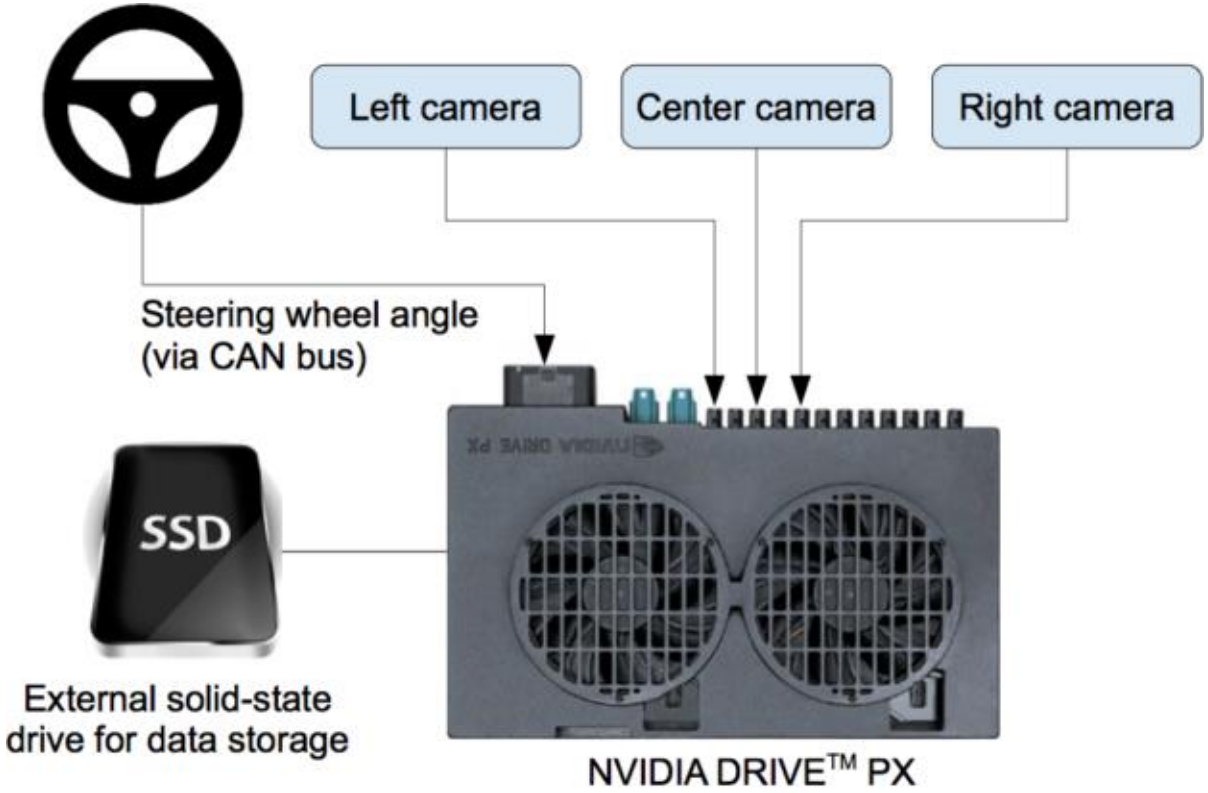
Sensing by images

- NVIDIA self-driving car

Source: https://www.pcworld.com/article/3052329/the-specs-and-story-behind-the-roborace-autonomous-car-and-its-nvidia-drive-px-2-brains.html

Sensing by images

- Collection system of training data

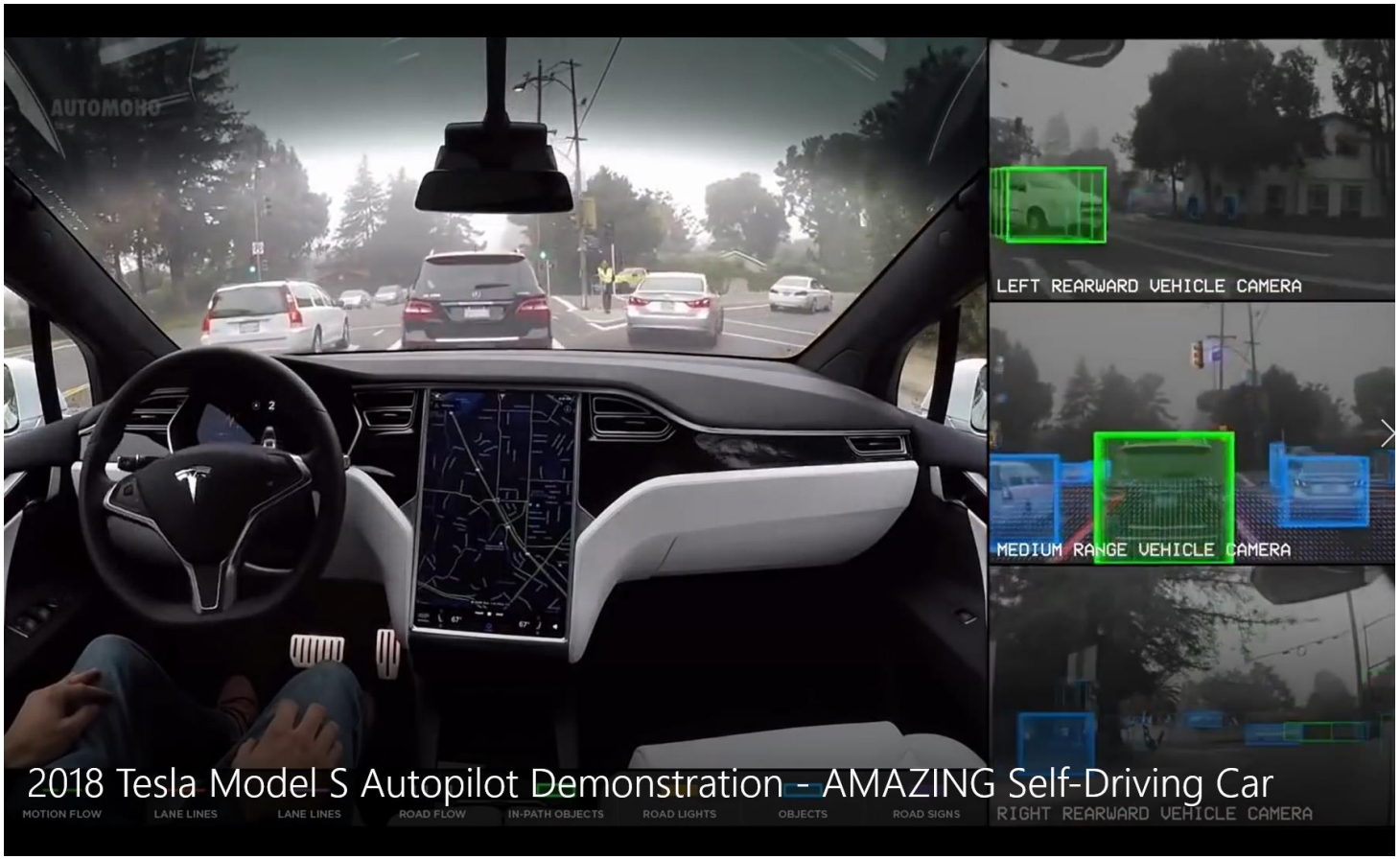


Source: Nvidia.com

NVIDIA Drive AGX

- NVIDIA DRIVE AGX self-driving compute platforms are built on NVIDIA Xavier™, the world's first processor designed for autonomous driving
- The auto-grade Xavier system-on-a-chip (SoC) is in production today and architected for safety, incorporating six different types of processors to run redundant and diverse algorithms for AI, sensor processing, mapping and driving
- The Jetson AGX Xavier has a computing module capable of 32 trillion operations per second

Camera based self-driving



Source: https://www.tesla.com/videos/autopilot-self-driving-hardware-neighborhood-long

How to navigate?

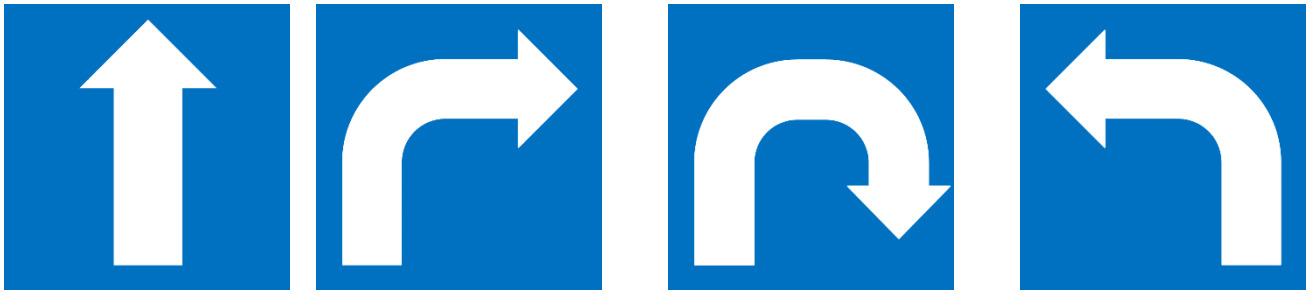
Source: https://medium.com/@mrhwick/simple-lane-detection-with-opencv-bfeb6ae54ec0

How to navigate

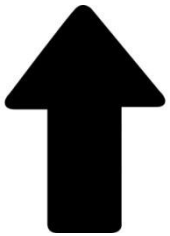
Source: https://medium.com/@mrhwick/simple-lane-detection-with-opencv-bfeb6ae54ec0

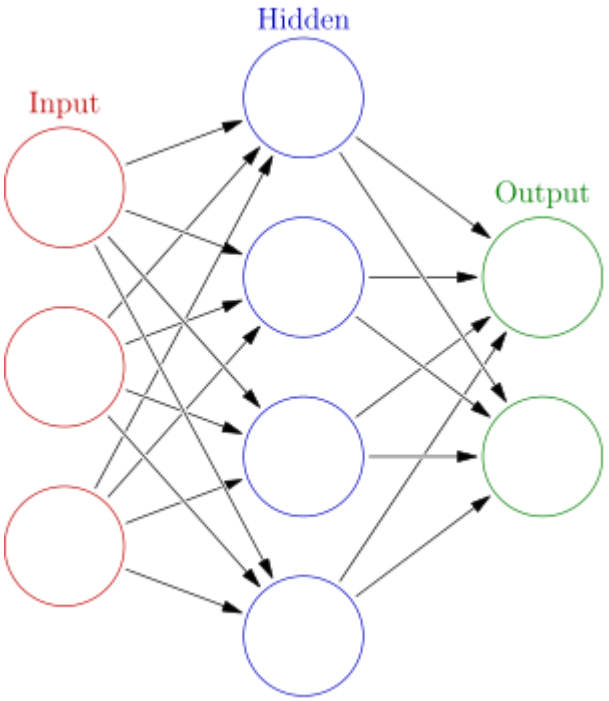
Neural Network and Deep learning

How to recognize the road marking or road signs?



Artificial Neural Network Deep Learning





forward

Training set

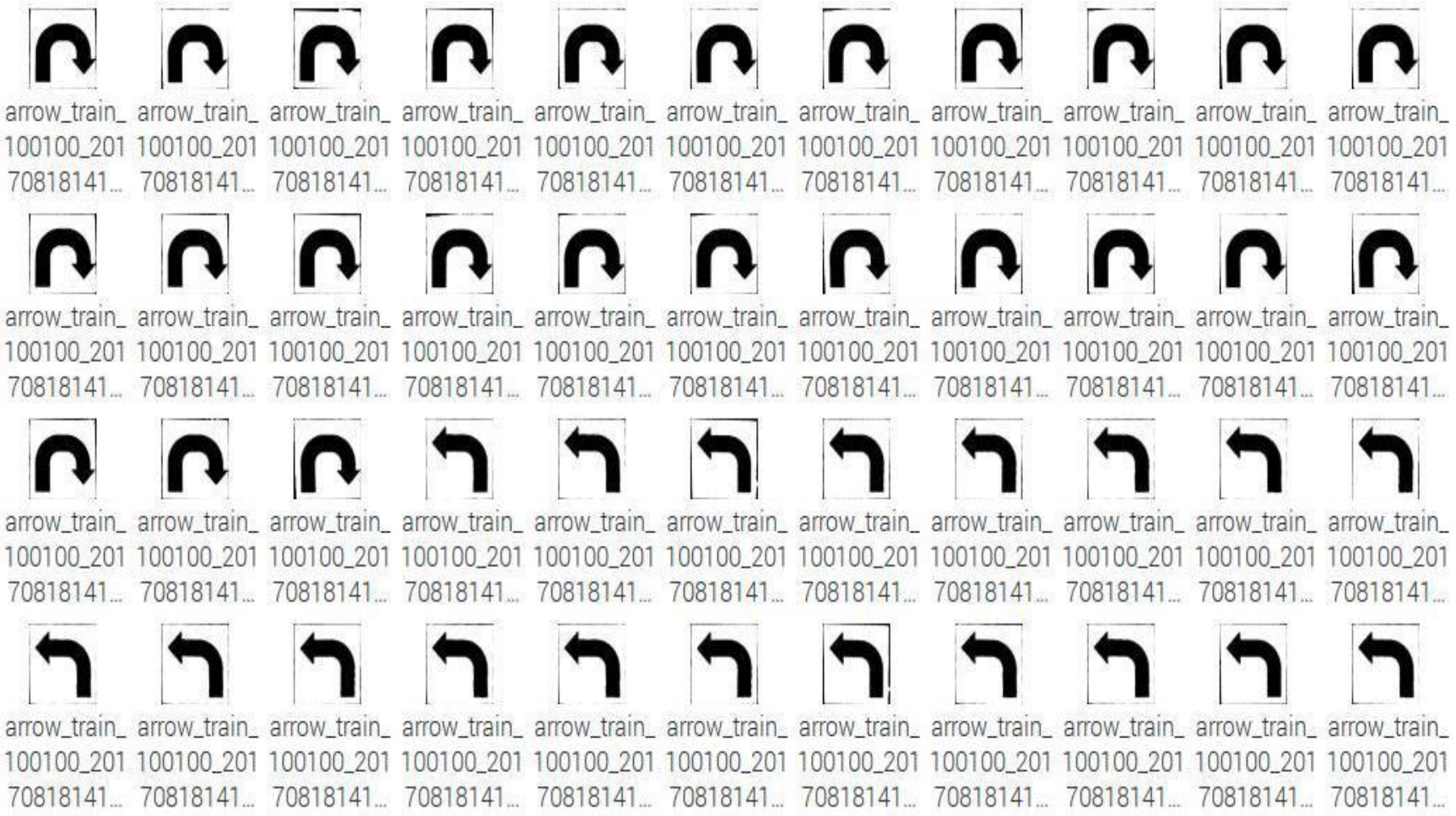
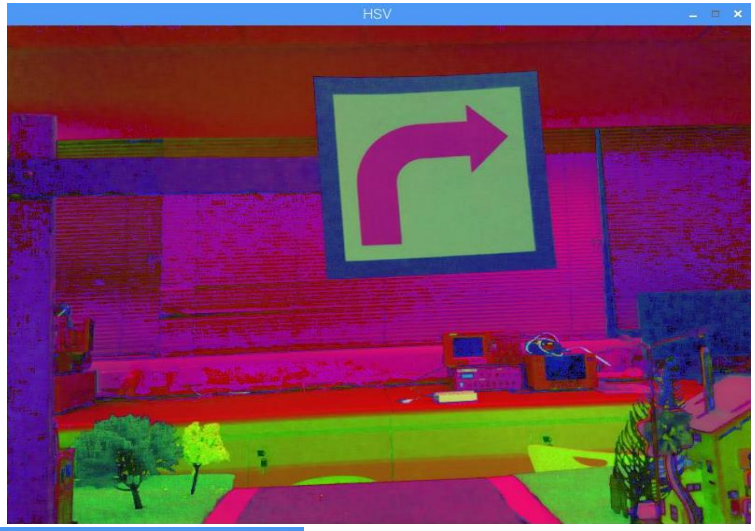
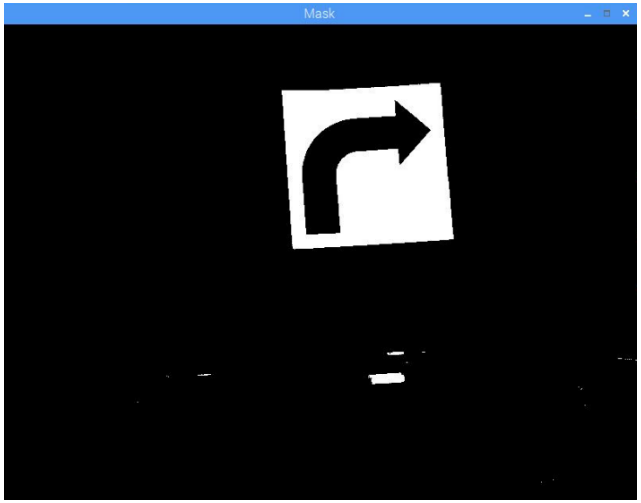
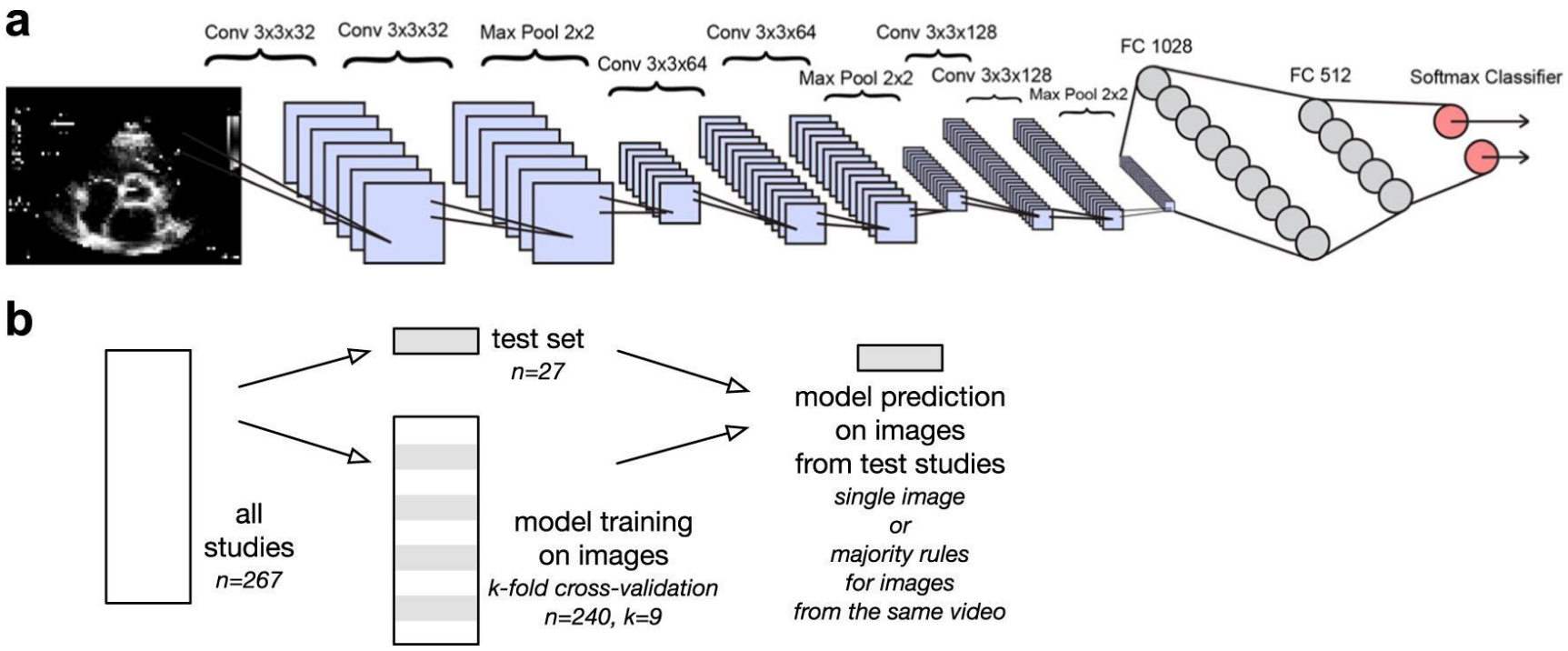


Image Processing





Deep Learning



Source:
https://cs.stanford.edu/people/karpathy/convnetjs/demo/cifar10.html

Radar or sonar

- Measure the distance from the car to obstacles
- Radar – based on radio waves
  - 200m
- Sonar – sound waves
  - 5m

Conclusions

- Techniques applied in self-driving cars can be used in traditional vehicle to enhance safety
  - To prevent accidents

Q & A

For contact:
Dr Isaac Fung
yu-fai.fung@polyu.edu.hk

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