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The Reality of Perception
From Human Intuition to Machine Vision

"Reality is merely an illusion, albeit a very persistent one." - Albert Einstein

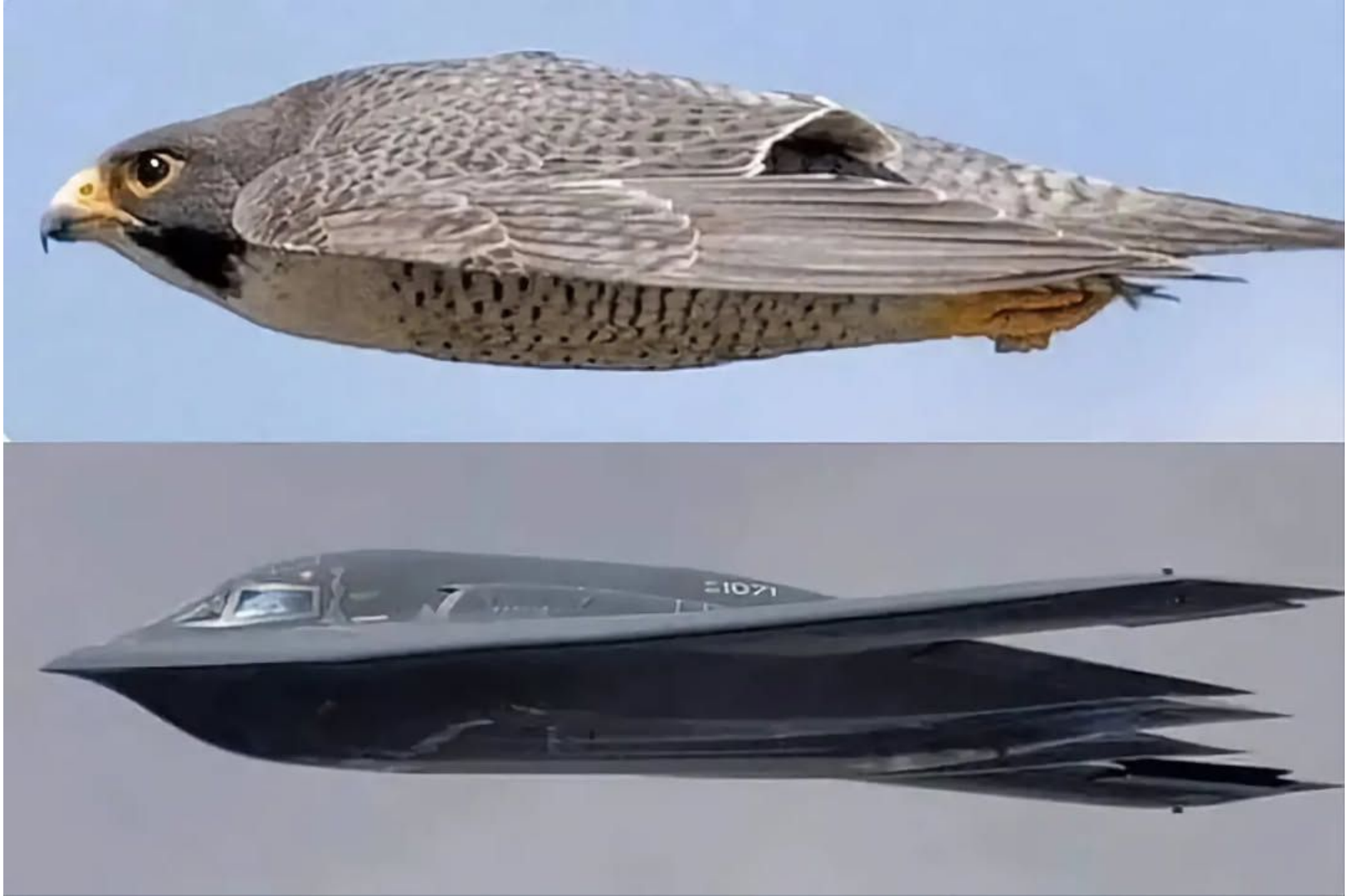
What’s perception?

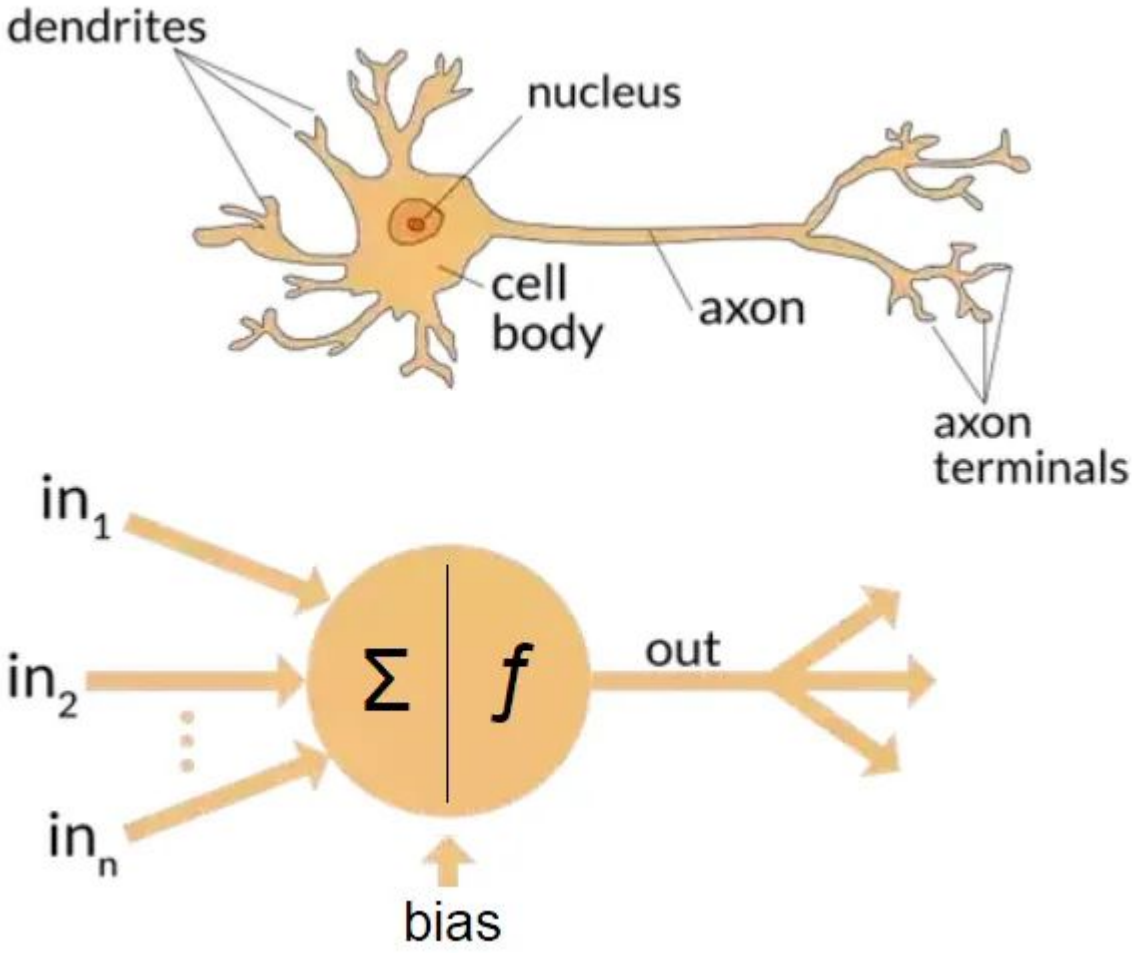
- In cognitive psychology, perception is defined as the cognitive activity through which humans become aware of their environment, receive, and interpret the information around them
- Machine perception refers to the capability of machines to interpret and make sense of sensory information from the environment.
- This information can include data obtained from sensors such as cameras, microphones, or other sensors.

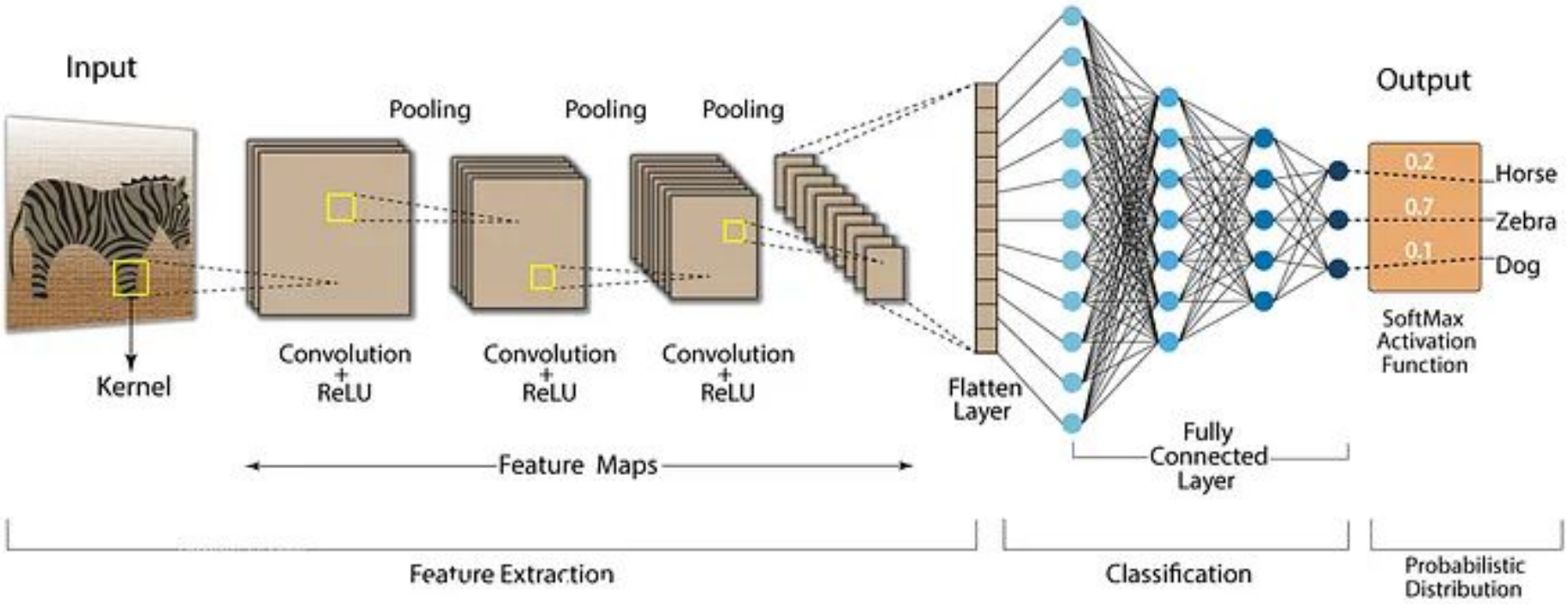
"Everything we hear is an opinion, not a fact. Everything we see is a perspective, not the truth." - Marcus Aurelius

Vision (eye)

Perception (brain)




dendrites
nucleus
cell body
axon
axon terminals
in1
in2
inn
Σ
f
out
bias


Convolution Neural Network (CNN)
Input
Kernel
Pooling
Pooling
Pooling
Convolution + ReLU
Convolution + ReLU
Convolution + ReLU
Feature Maps
Flatten Layer
Fully Connected Layer
Output
0.2
0.7
0.1
Horse
Zebra
Dog
SoftMax Activation Function
Feature Extraction
Classification
Probabilistic Distribution

Basics of computer vision

Is this a dog?

Image Classification

What is there in image and where?

Object Detection

Which pixels belong to which object?

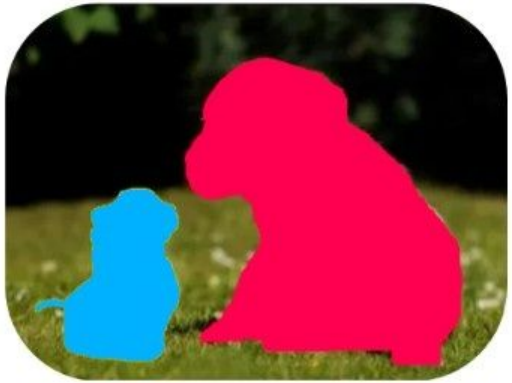
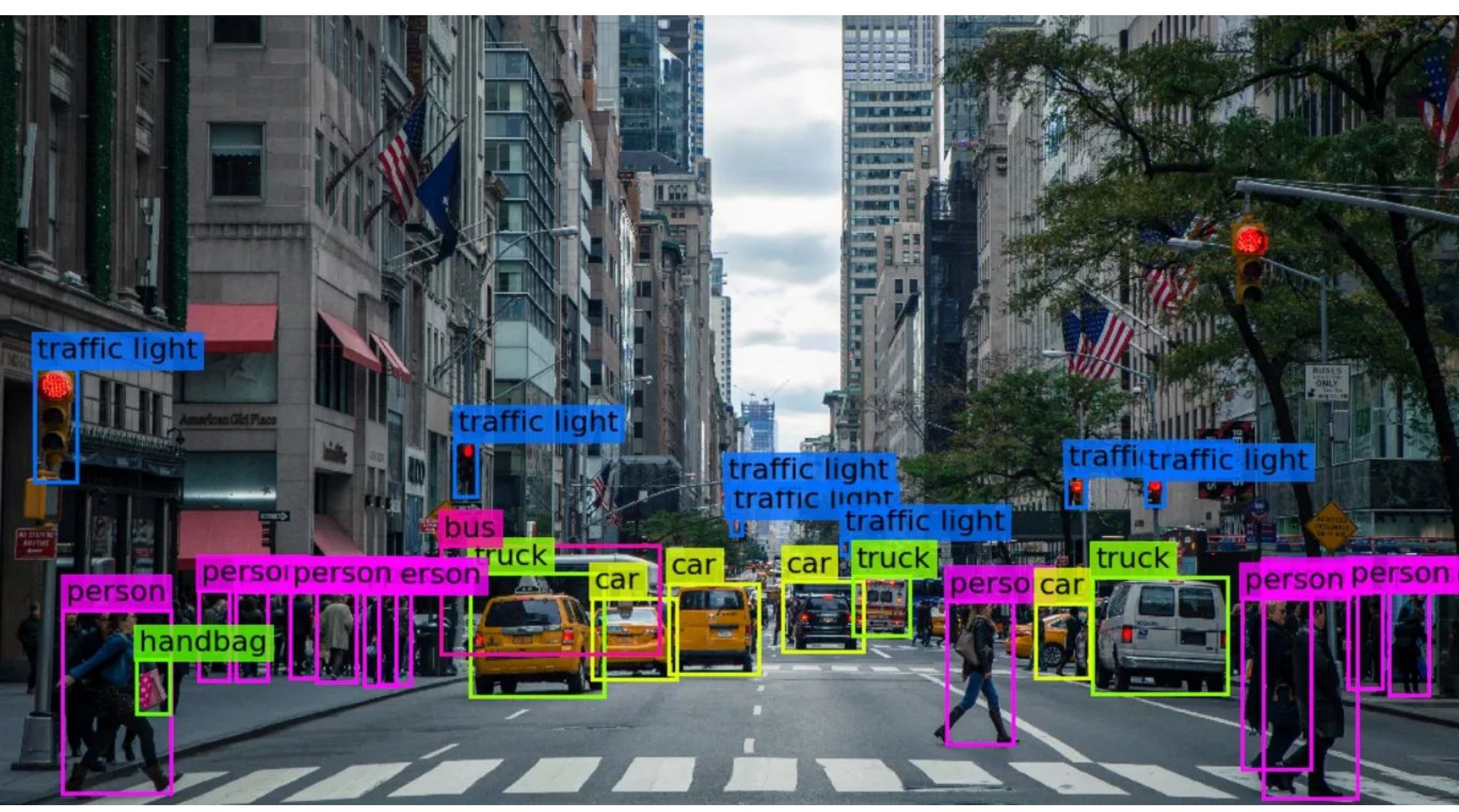
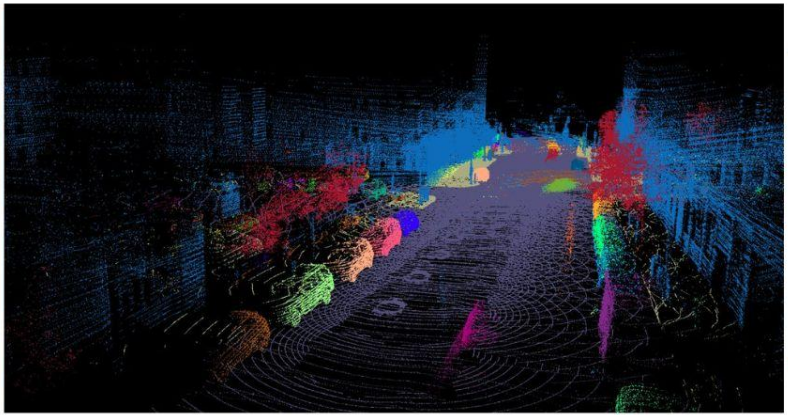


Image Segmentation


traffic light
traffic light
traffic light
traffic light
traffic light
traffic light
bus
truck
car
car
car
truck
truck
person
person
person
person
person
person
handbag

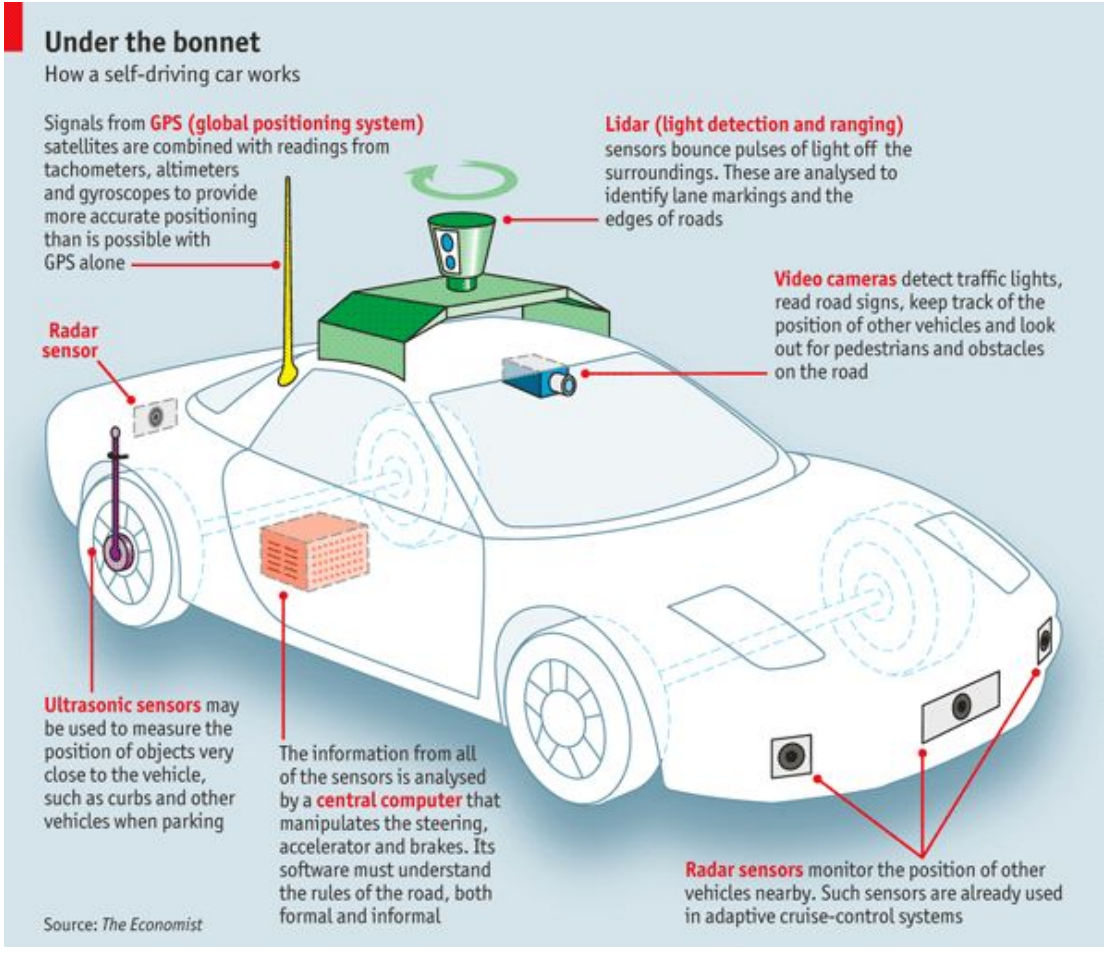
Perception approaches

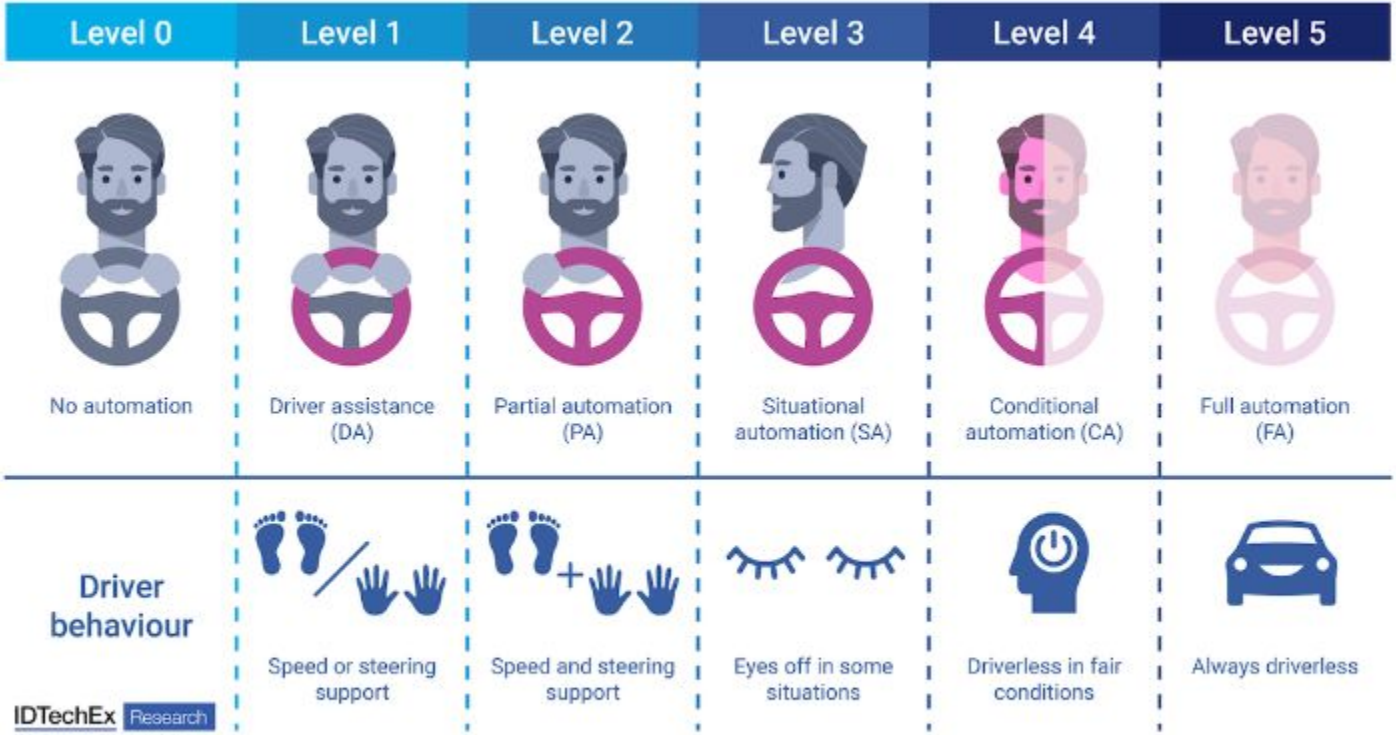


How a Self-Driving Car Works

How self-driving cars “sees”

- Global Positioning System (GPS)
- Light Detection and Ranging (LIDAR)
- Cameras (Video)
- Ultrasonic Sensors
- Central Computer
- Radar Sensors





The SAE levels of driving automation. Source: IDTechEx

LEVELS OF DRIVING AUTOMATION

0

NO AUTOMATION

The human has full control of the driving tasks (steering, braking, acceleration, etc.).

1

DRIVER ASSISTANCE

The vehicle features a single automated system (e.g., it monitors speed through cruise control).

2

PARTIAL AUTOMATION

The vehicle can perform steering and acceleration (ADAS). The human can take control at any time.

3

CONDITIONAL AUTOMATION

With environmental detection capabilities, the vehicle can control most driving tasks, but human override is still required.

4

HIGH AUTOMATION

The vehicle performs all driving tasks under specific circumstances. Geofencing is required. Human override is still an option.

5

FULL AUTOMATION

The vehicle performs all driving tasks under all conditions. No human attention or interaction is required.

THE HUMAN MONITORS THE DRIVING ENVIRONMENT

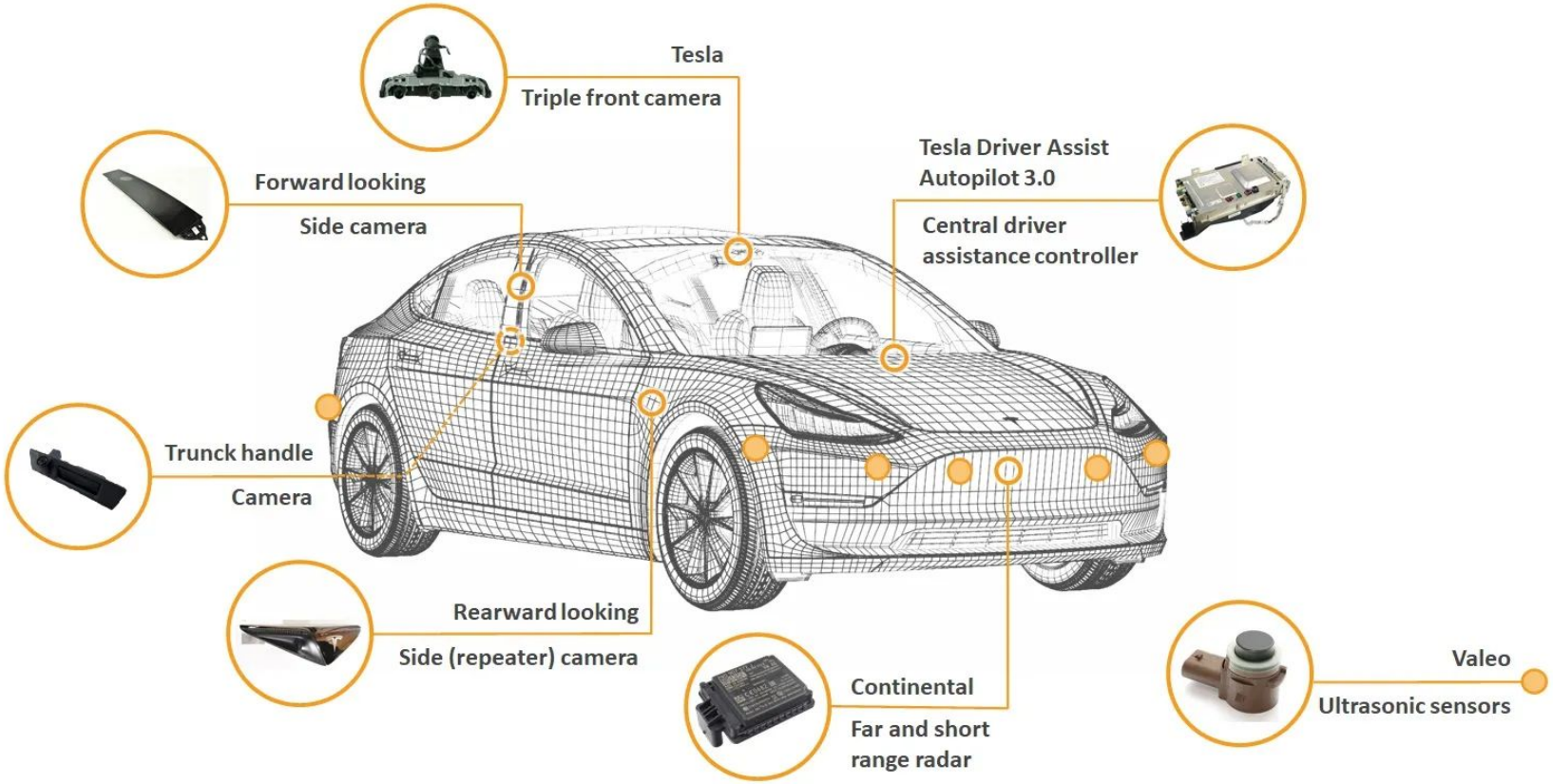
THE VEHICLE CONTROLS THE DRIVING ENVIRONMENT

Image provided by Synopsys. www.synopsys.com/automotive/autonomous-driving-levels.html

JABIL

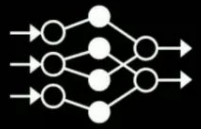
Tesla Model 3 Sensors and Computing - analyzed by System Plus Consulting

Source: Automotive Teardown Tracks, 2020



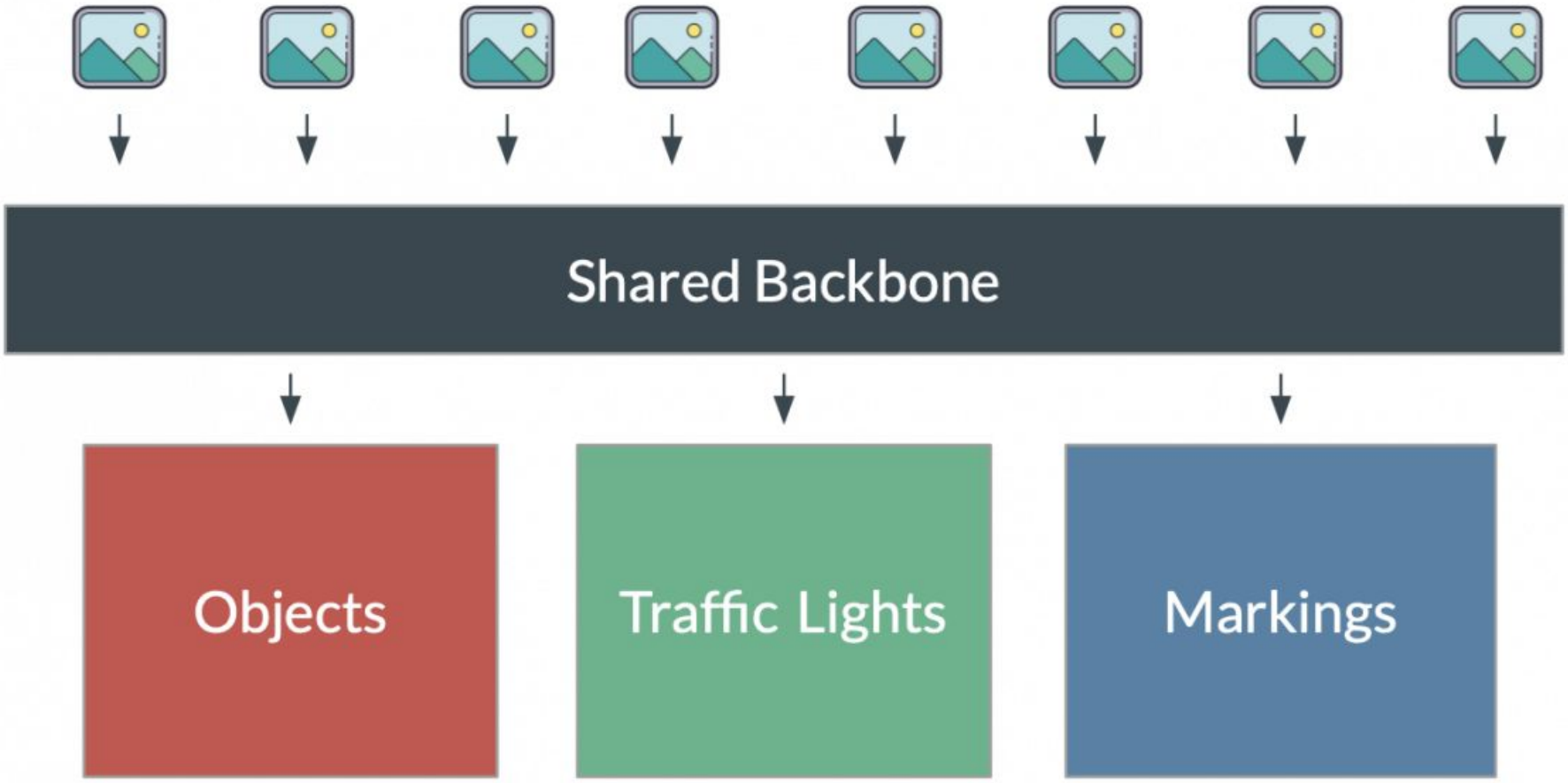

Rearward Looking Side Cameras
Max distance 100m
Wide Forward Camera
Max distance 60m
Main Forward Camera
Max distance 150m
Narrow Forward Camera
Max distance 250m
Rear View Camera
Max distance 50m
Forward Looking Side Cameras
Max distance 80m

8 Cameras

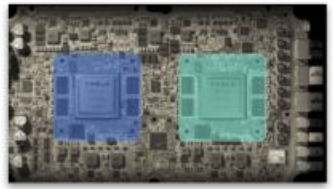


3-Dimensional “Vector Space”


STOP


Shared Backbone
Objects
Traffic Lights
Markings

Tesla's HydraNet



video queue
(N images)

Extractor
(ResNet)

Extractor
(ResNet)

Extractor
(ResNet)

video queue
(N images)

Multicam Fusion (Transformers, ...)

Time Fusion
(3D CNNs,
Transformers, RNNs)

Time Fusion
(3D CNNs,
Transformers, RNNs)

Video Module

Video Module

Video Module

Video Module

Trunk

Trunk

Trunk

Trunk

terminals

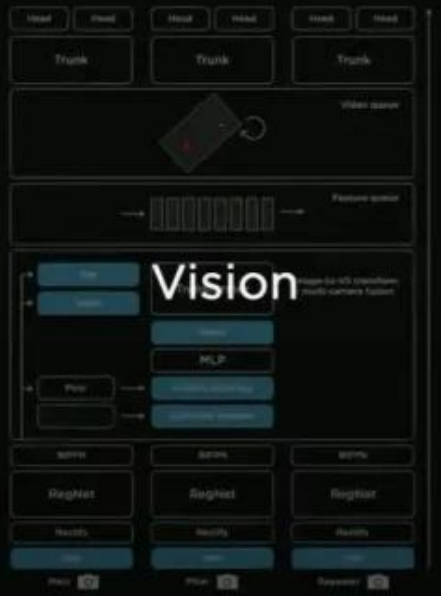
detection

trajectory

detection

trajectory

The Final Architecture



Vector Space

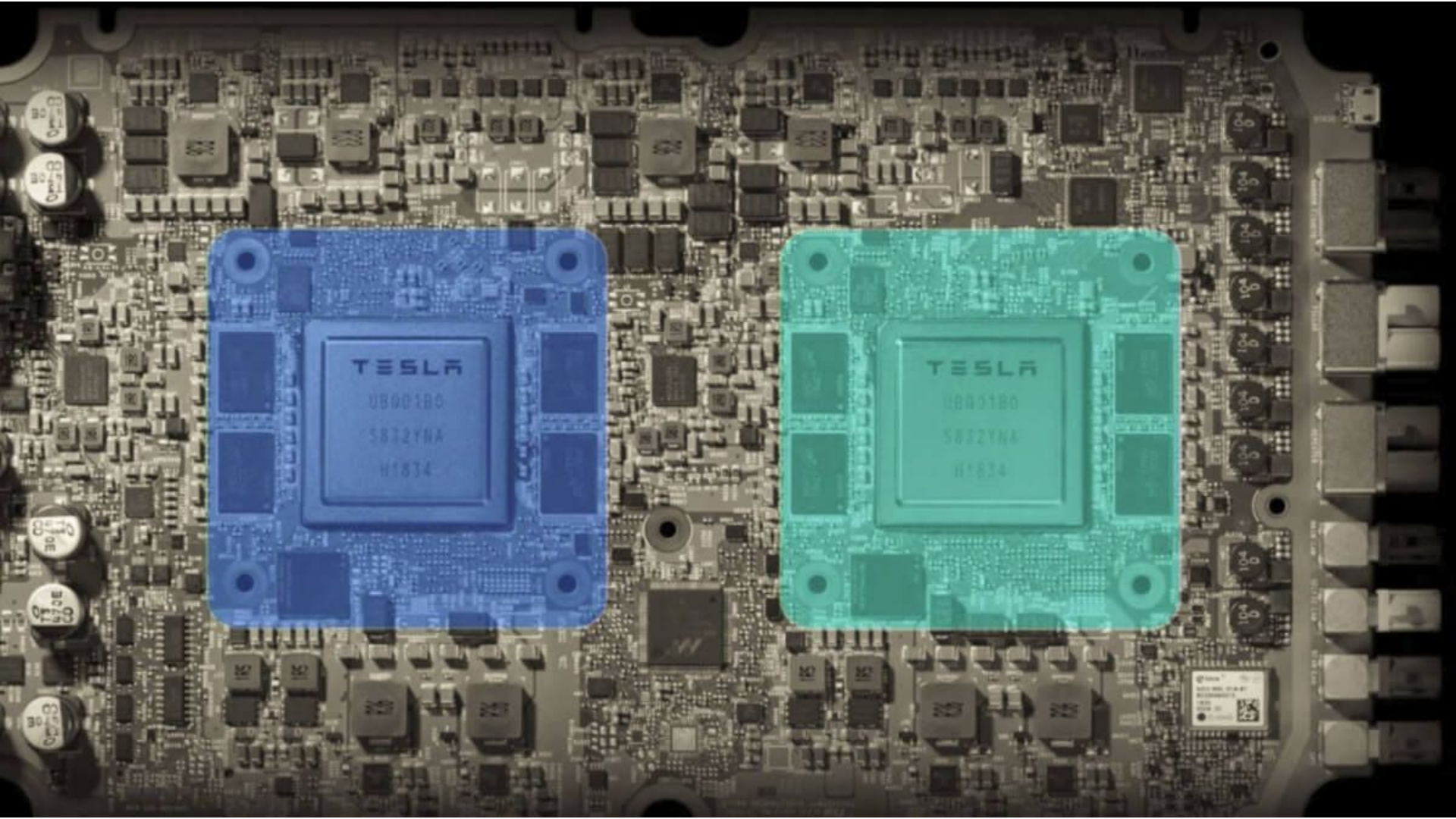
Intermediate Features

Explicit Planning & Control

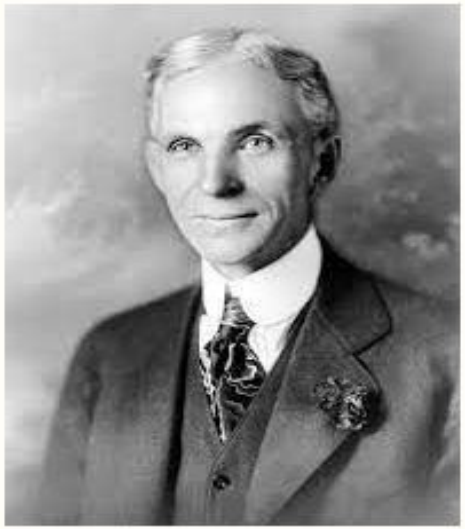
Trajectory Distribution

Neural Net Planner

Steering & Accel


TESLA
TESLA


Ego Speed: 45.40 MPH
time: 1545.468181000
CAL P 0.60 Y 1.20 R 0.00 deg
Vision fps: 18.05 Draw fps: 17.67 Display fps: 21.34
NL(0.00), E(0.93), F(0.08), TF(0.00), S(0.00)
NRW: FLP(0.00), FRP(0.00)
+0.0001 AUTO_HIGH_BEAM
+0.0000 BLINDED
+0.0001 RAINING
+0.0000 TIRE_SPRAY
+0.0013 WET_ROAD
0.1539 CONTROLLED_ACCESS
R:0 T:2 ON:0
VS: 46.4 MPH St: 1
merge: 1.0
MAIN



Anyone who stops learning is old, whether at twenty or eighty. Anyone who keeps learning stays young.

- Henry Ford

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