Electrical Self Driving car

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Presented by:
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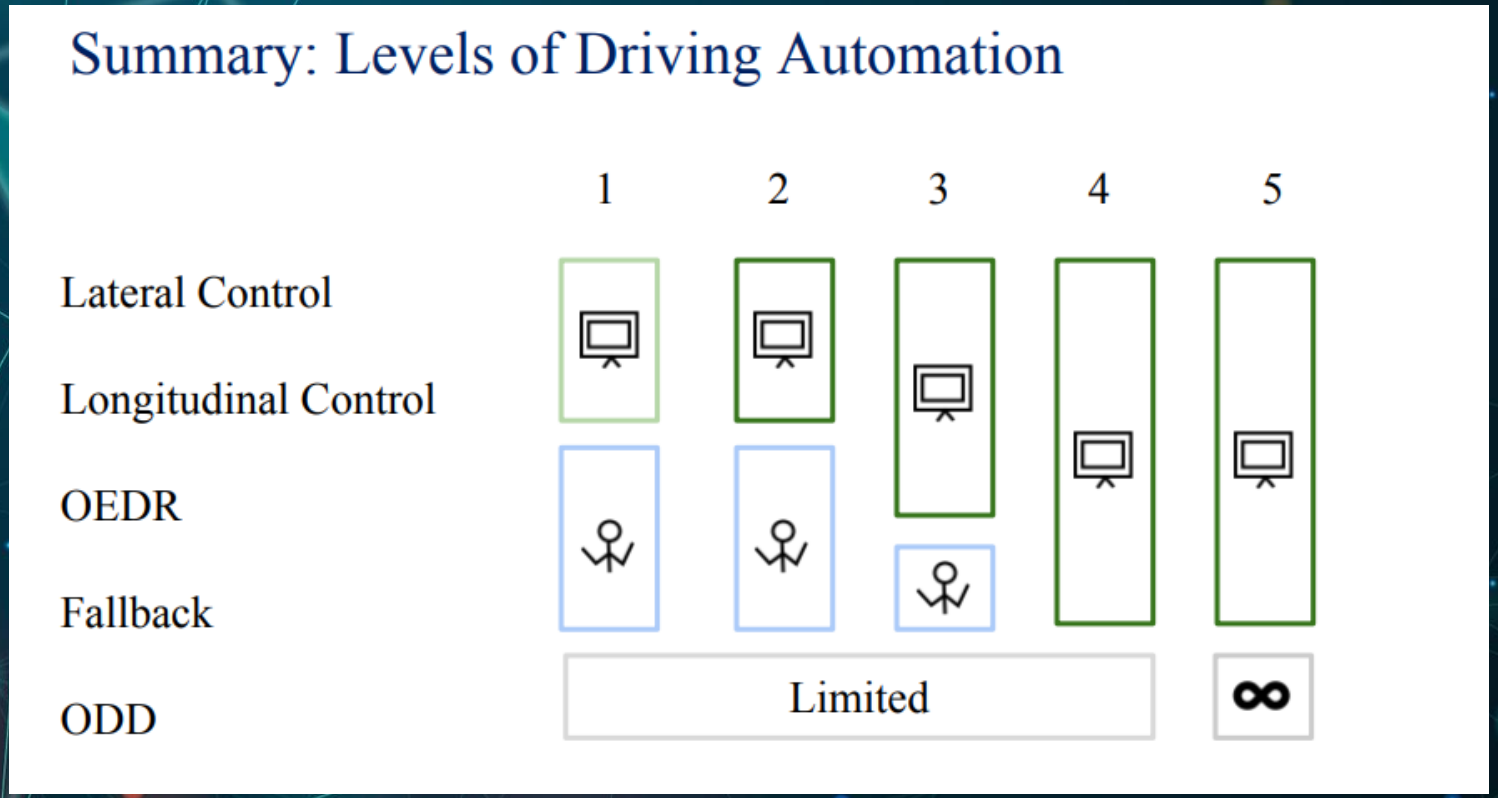
Ahmad Mohamed Awad
Mohamed Alaa Ramdan
Omar Ibrahem Elsayed Ali

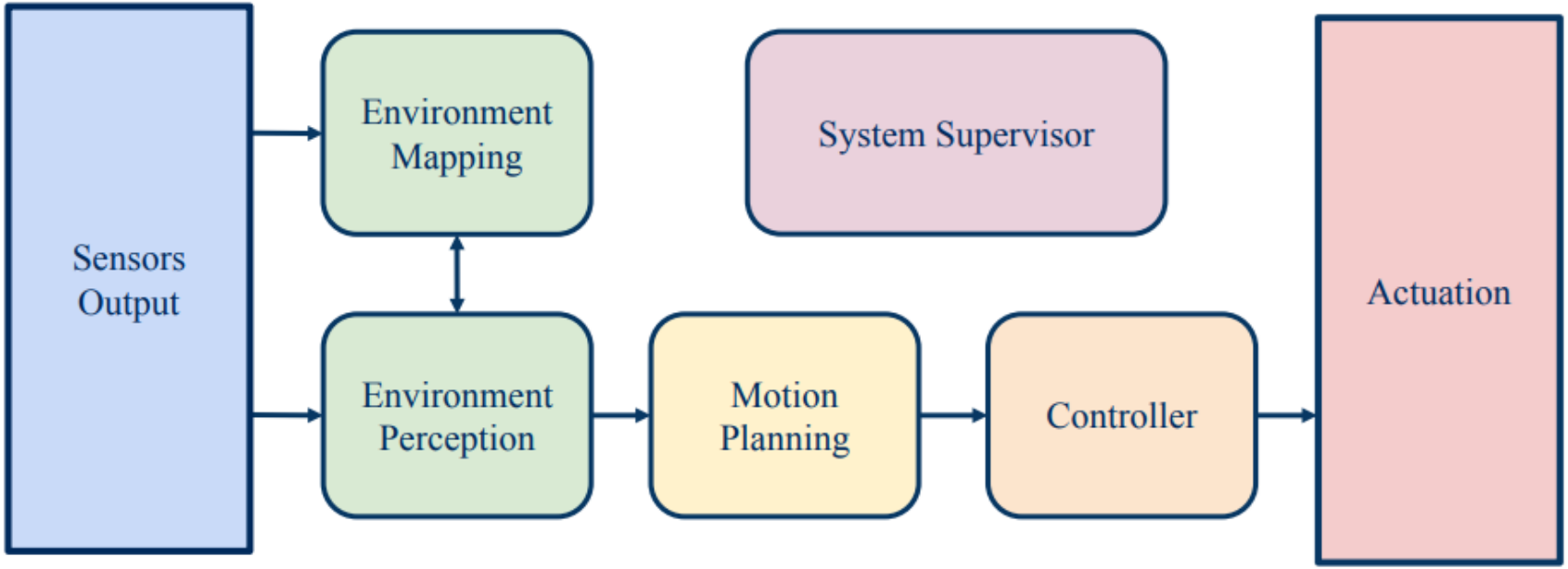
Introduction

01.1

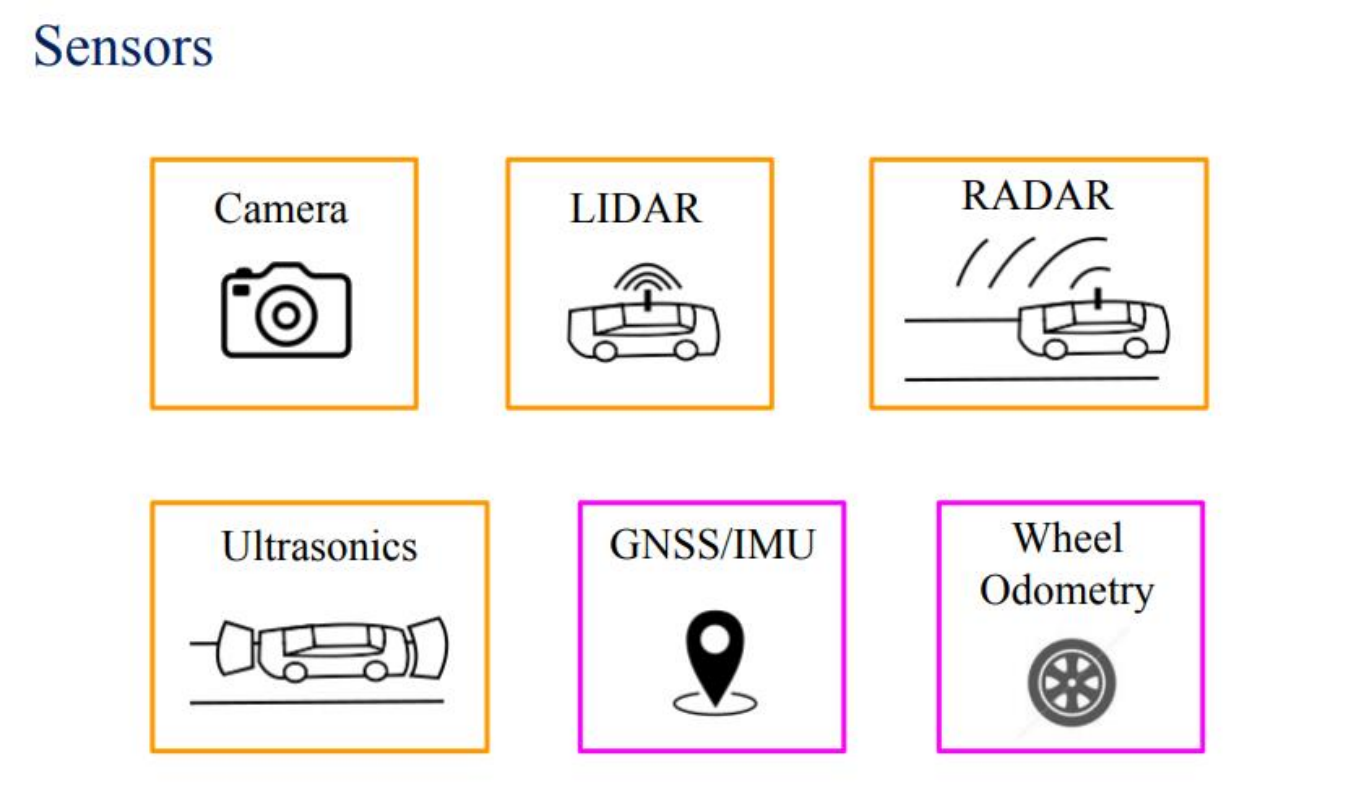
Levels Of Autonomy



Software Architecture



Hardware

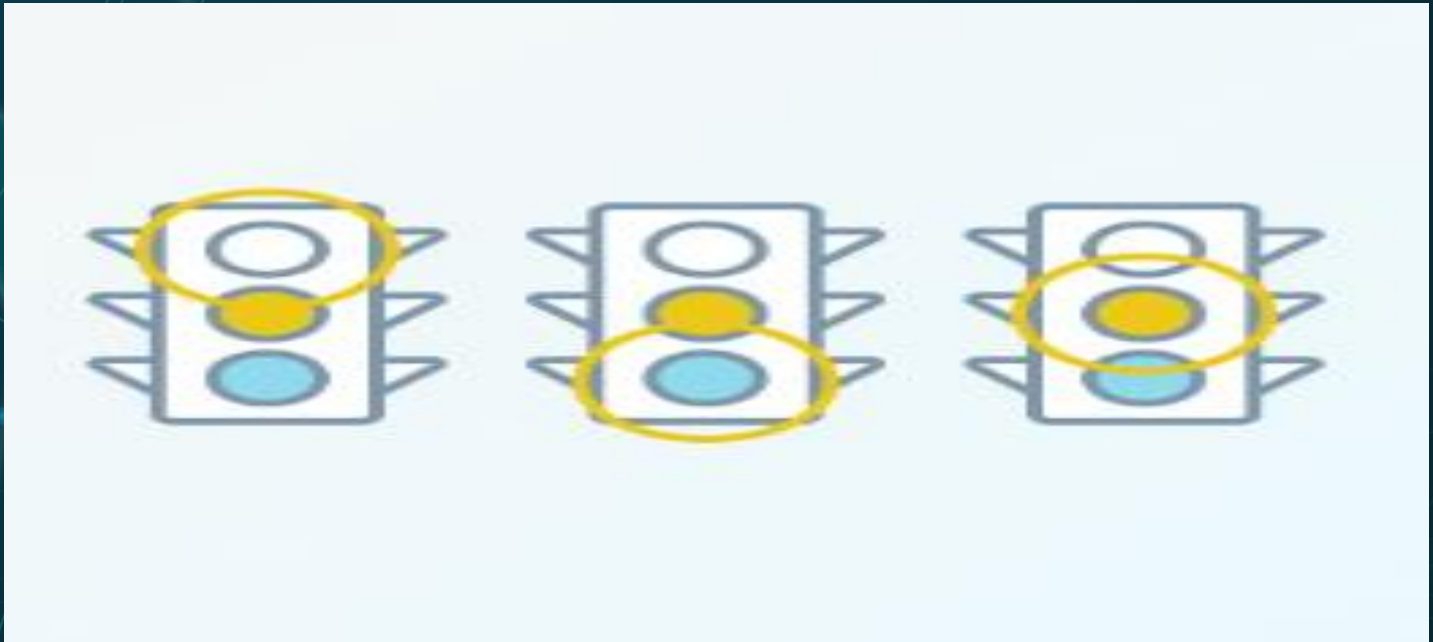

Sensors
Camera
LIDAR
RADAR
Ultrasonics
GNSS/IMU
Wheel Odometry

Traffic light classification

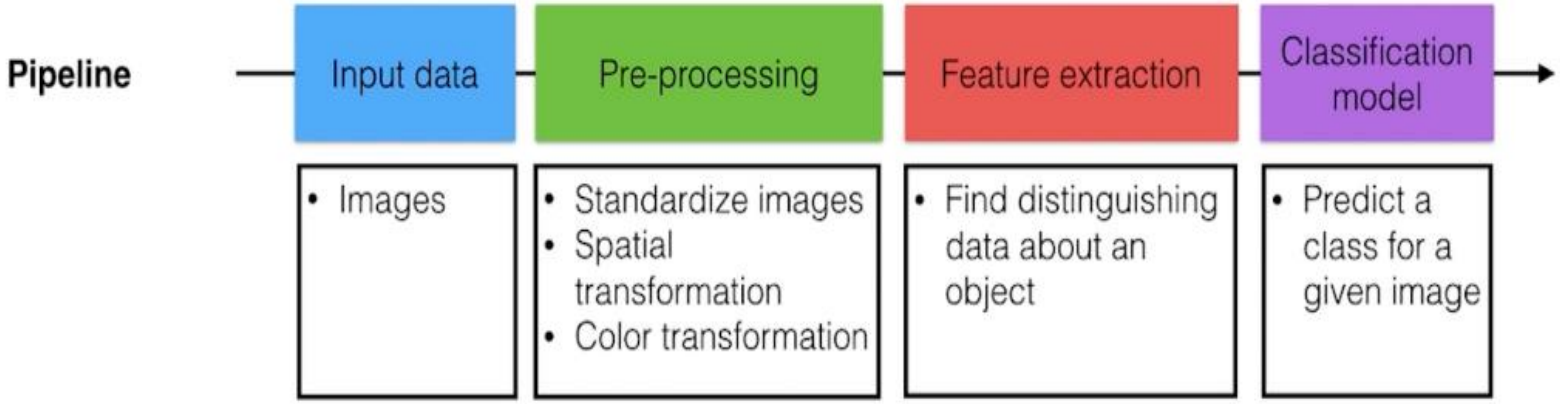
01.2

Computer Vision & Classification

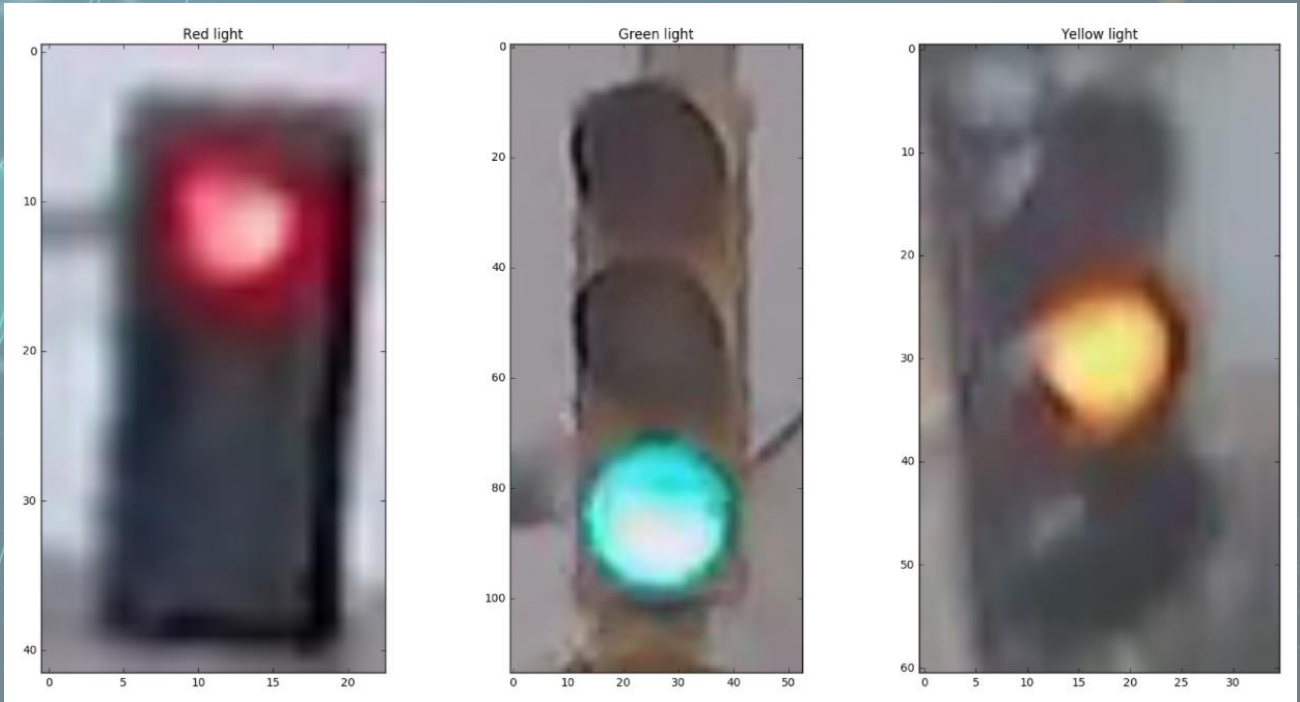
Traffic Light Classifier



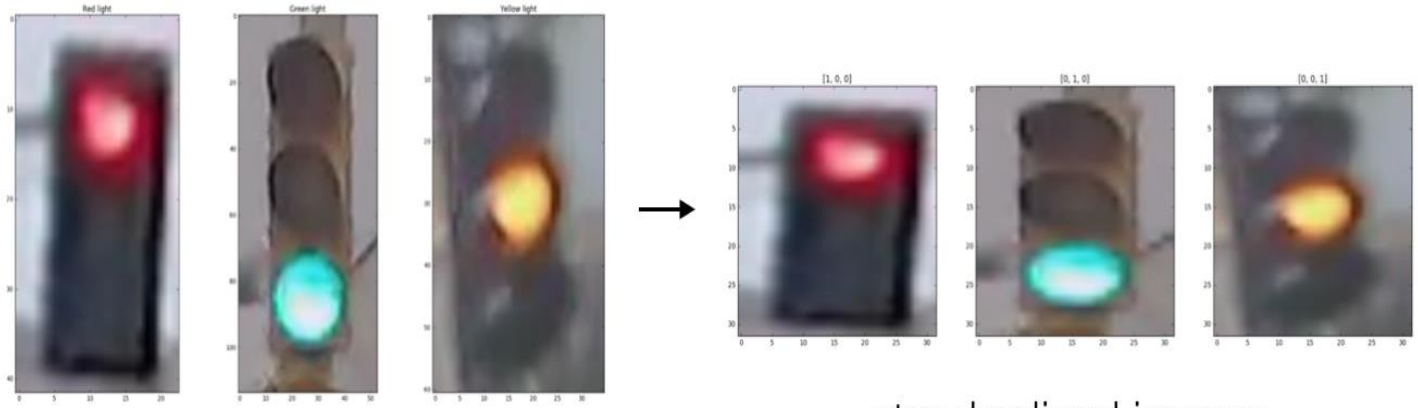
Classification Steps



Loading and Visualizing the Data



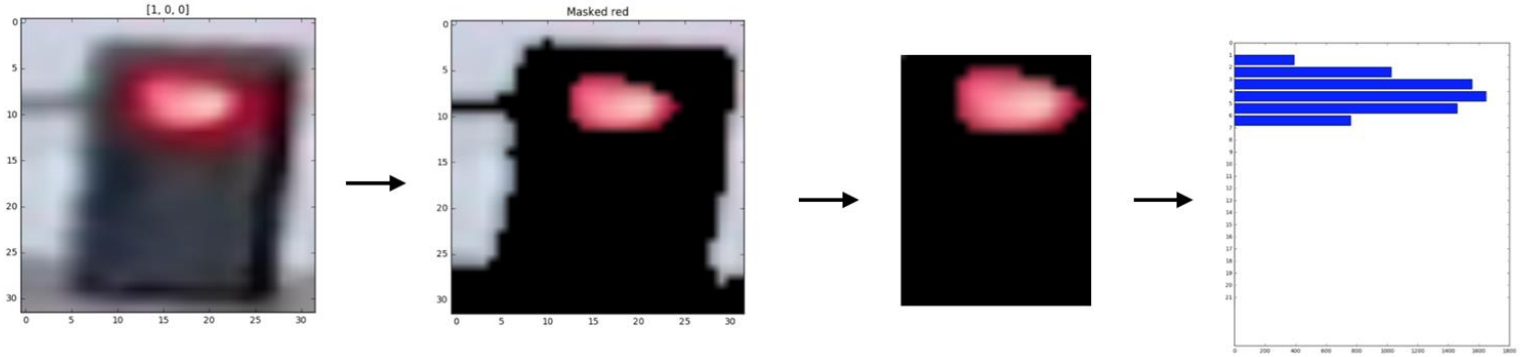
Pre Processing



original images

standardized images

Feature Extraction; Simple Model



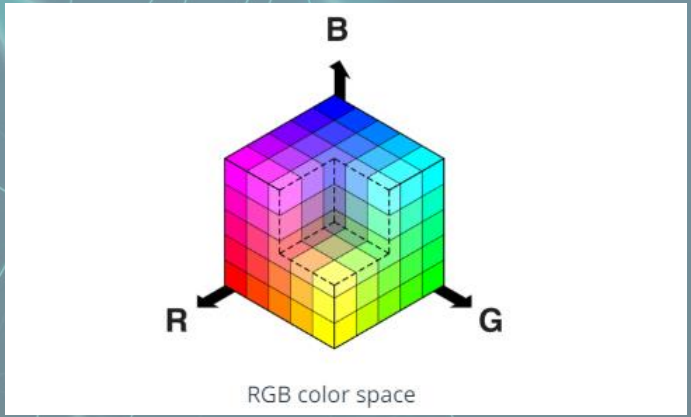
standard red light image

masked image

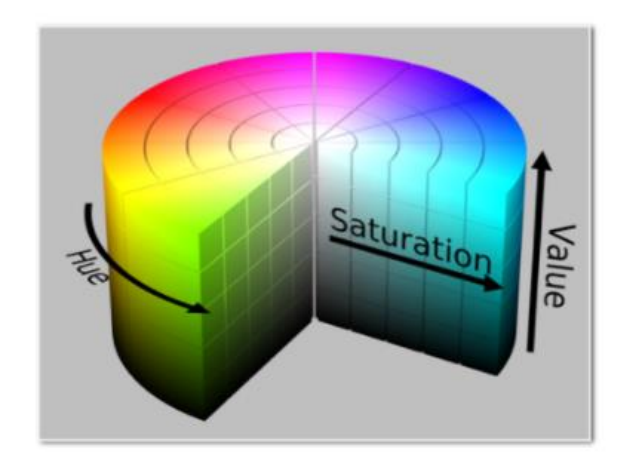
cropped image

brightness feature

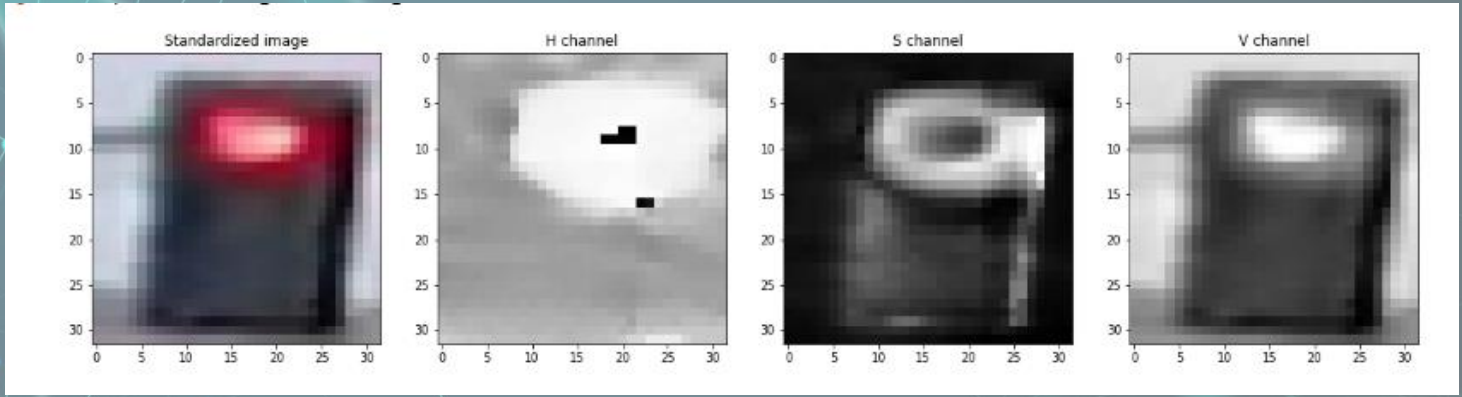
Now; more advanced model



RGB color space



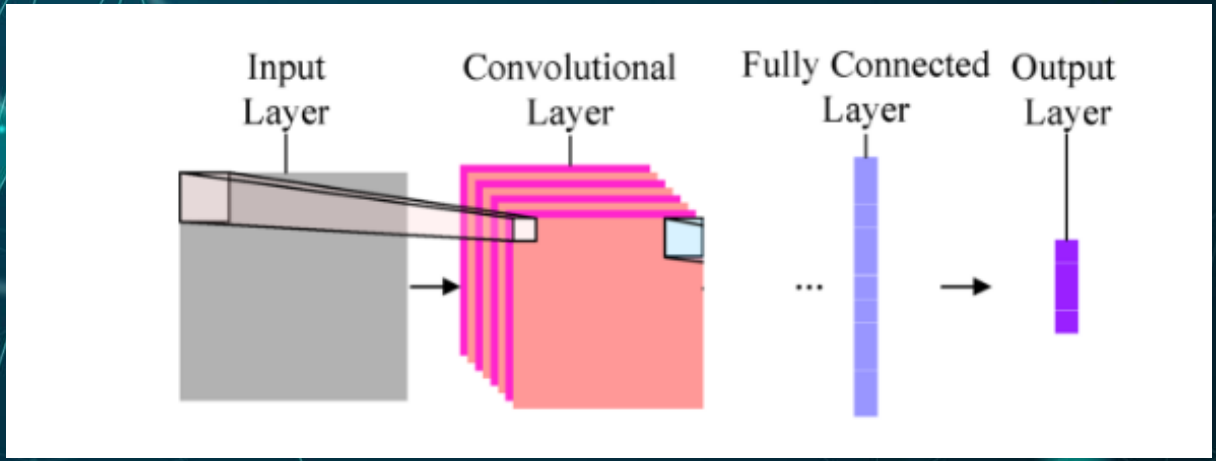
HSV color transformation



Classification & Accuracy

But How to Improve Accuracy

Deep Learning Approach

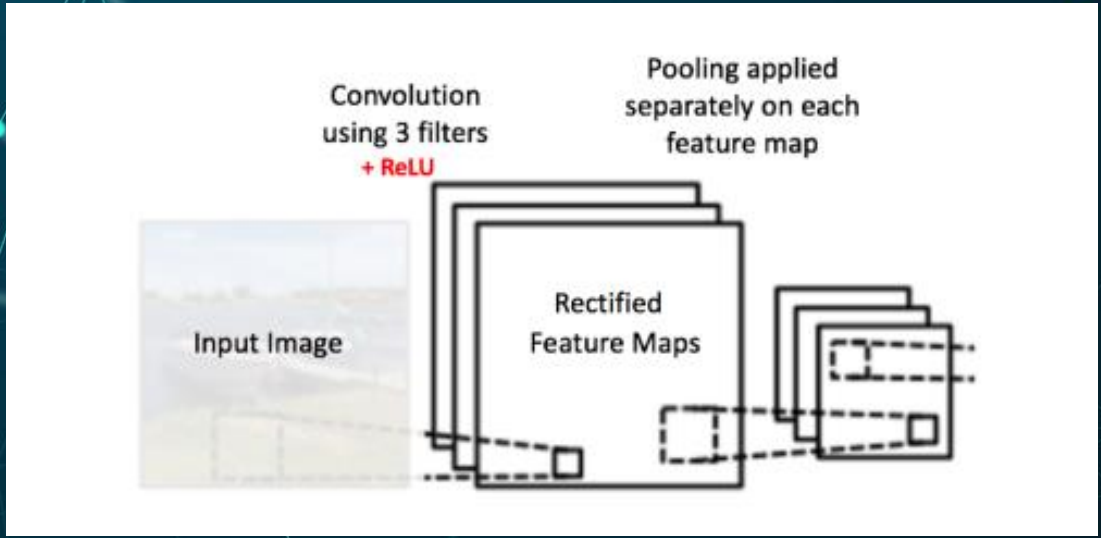


Convolutional Layer

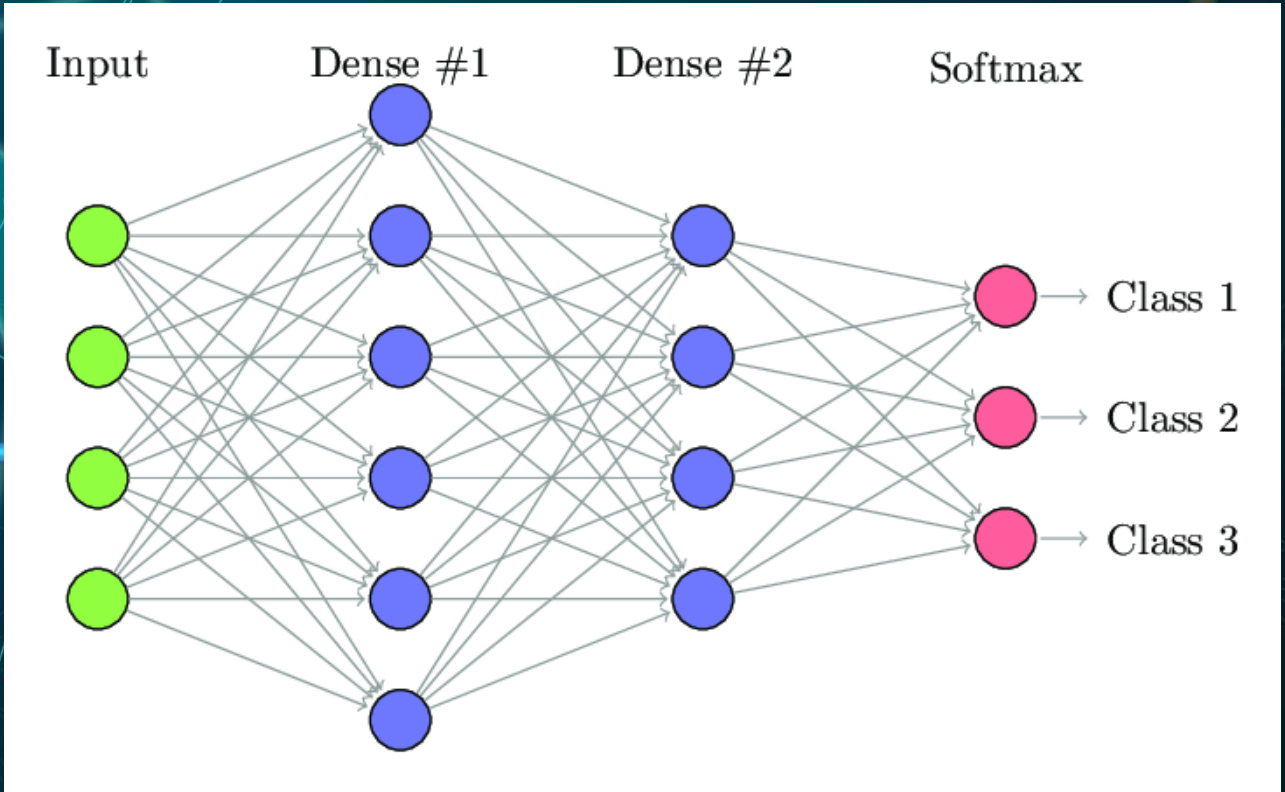
Filters, Feature Extraction

Operation	Filter	Convolved Image
Identity	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	
Edge detection	$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$	
	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	
Sharpen	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	

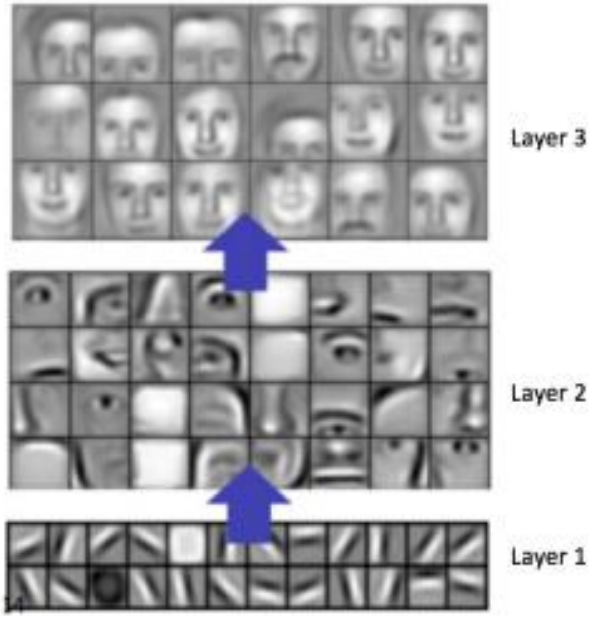
Pooling


Convolution
using 3 filters
+ ReLU
Pooling applied
separately on each
feature map
Input Image
Rectified
Feature Maps

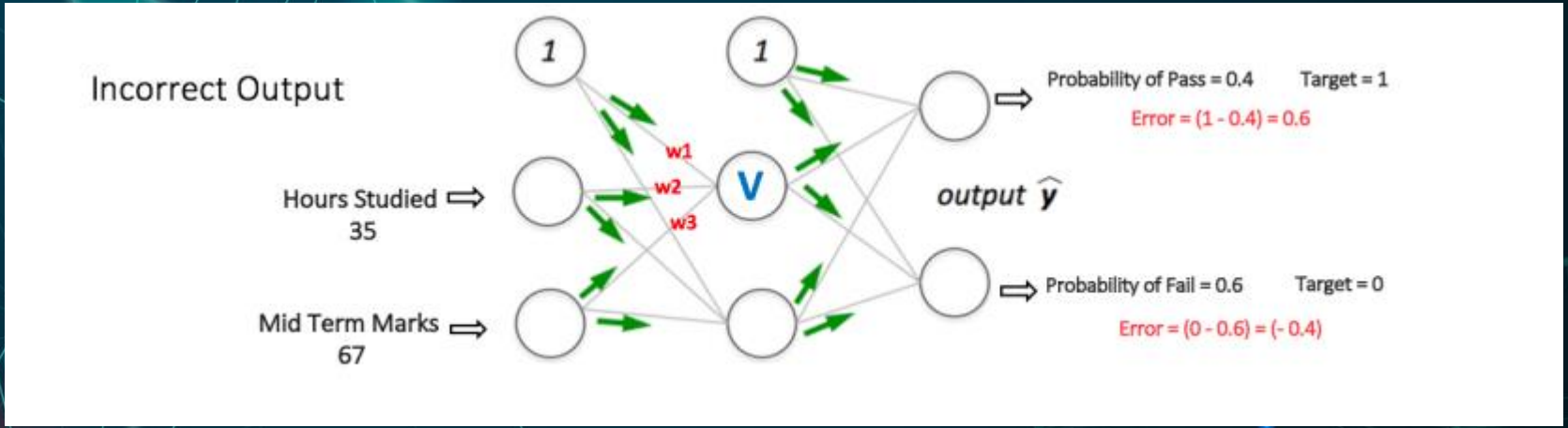
Fully Connected Layer



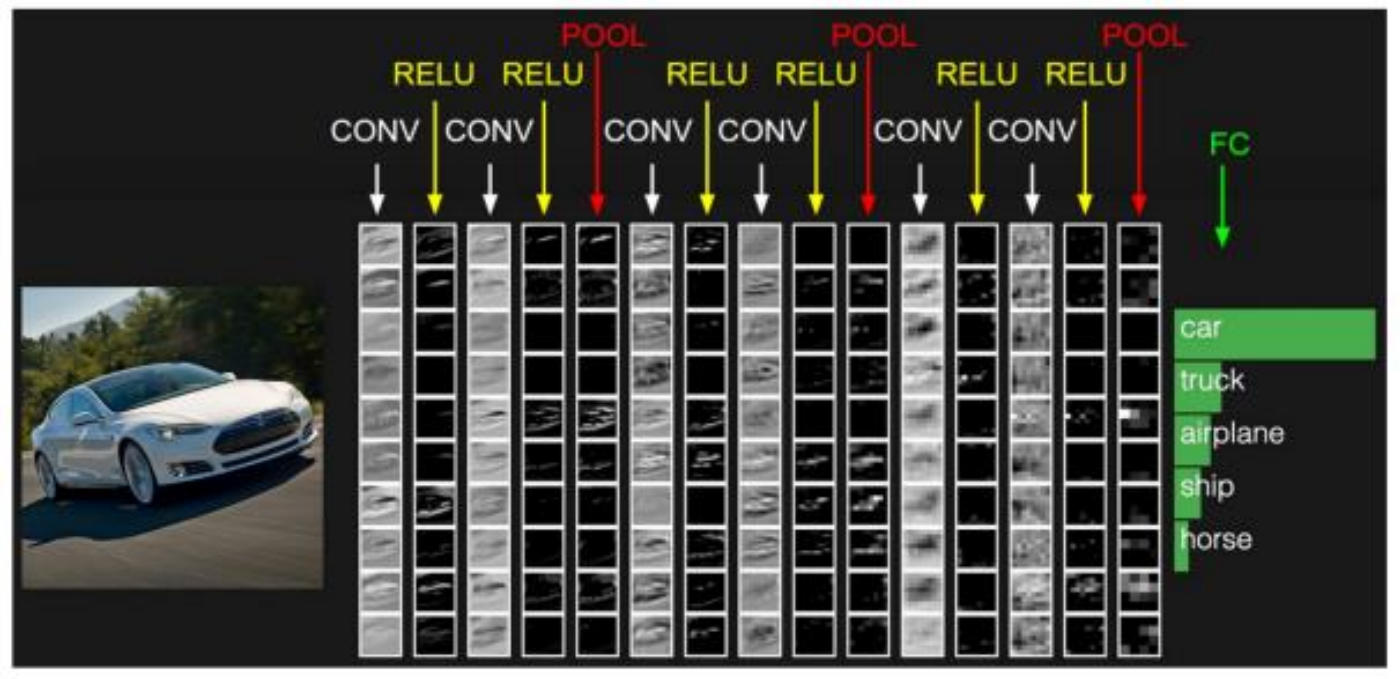
FC Example



Training Using Backpropagation

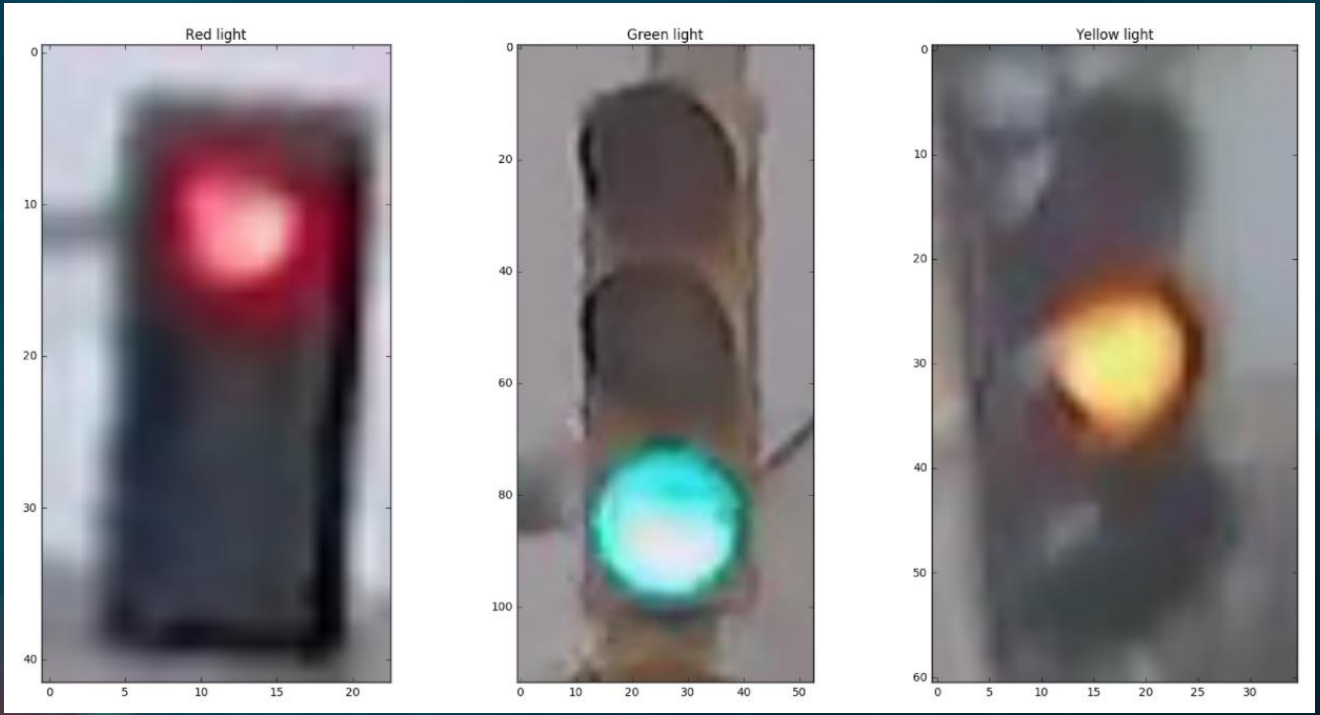


Example


POOL
POOL
POOL
RELU
RELU
RELU
RELU
RELU
RELU
CONV
CONV
CONV
CONV
CONV
CONV
FC
car
truck
airplane
ship
horse

Object Detection

01.3

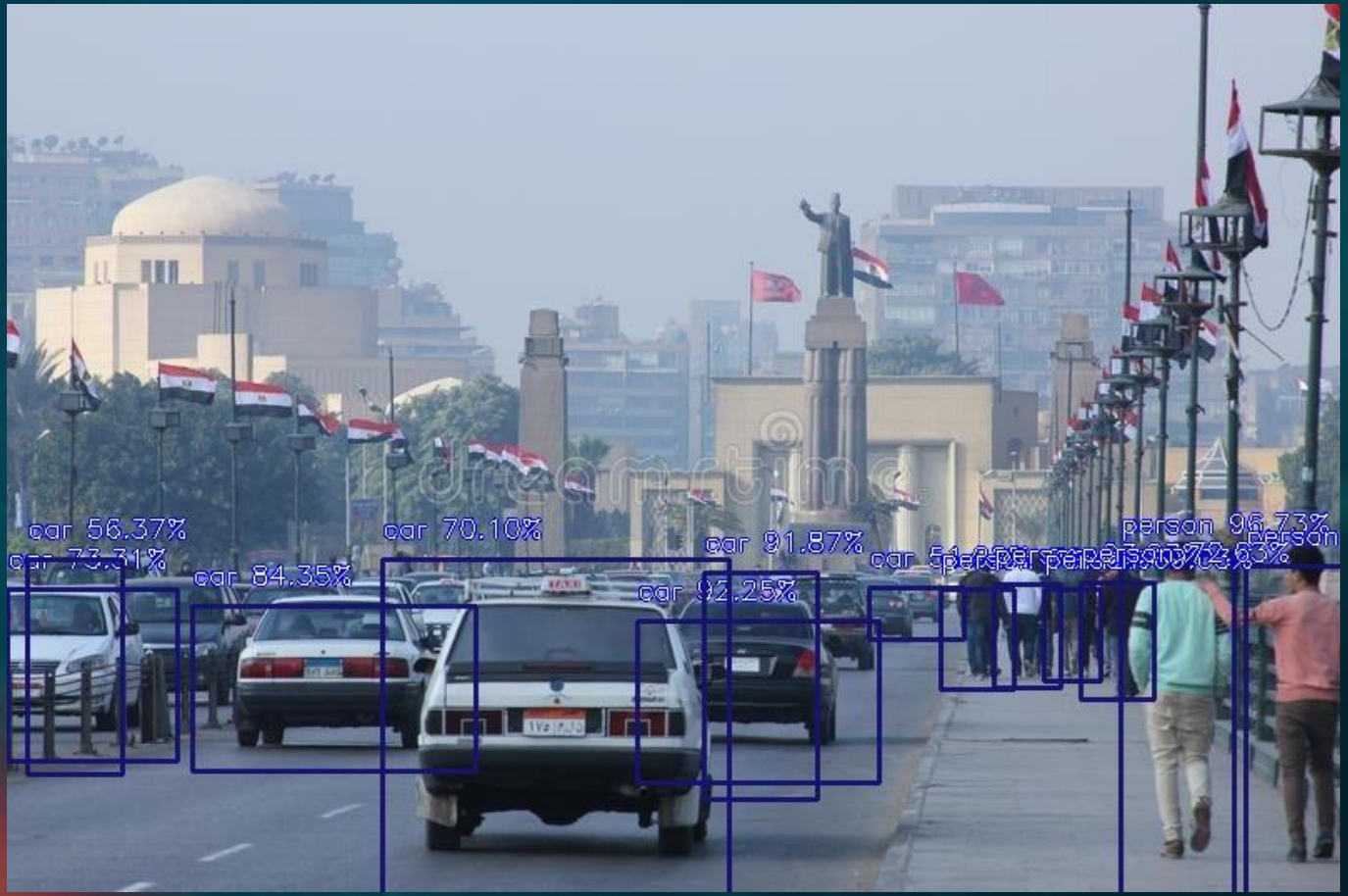


Traffic light

Street View 1

Street View 1

Street View 2



Street View 2

Distance Measurements

01.4

LI-DAR

Very Expensive
Setup is complex
Affected with Street dust
No color information

RADAR

Low Resolution
No color information

Ultrasonic

Low Resolution
No color information
Limited range

RGBD Cameras

Kinect V1 Cannot work in outdoors.
Kinect V1 & V2 affected by the color of objects
Limited Range

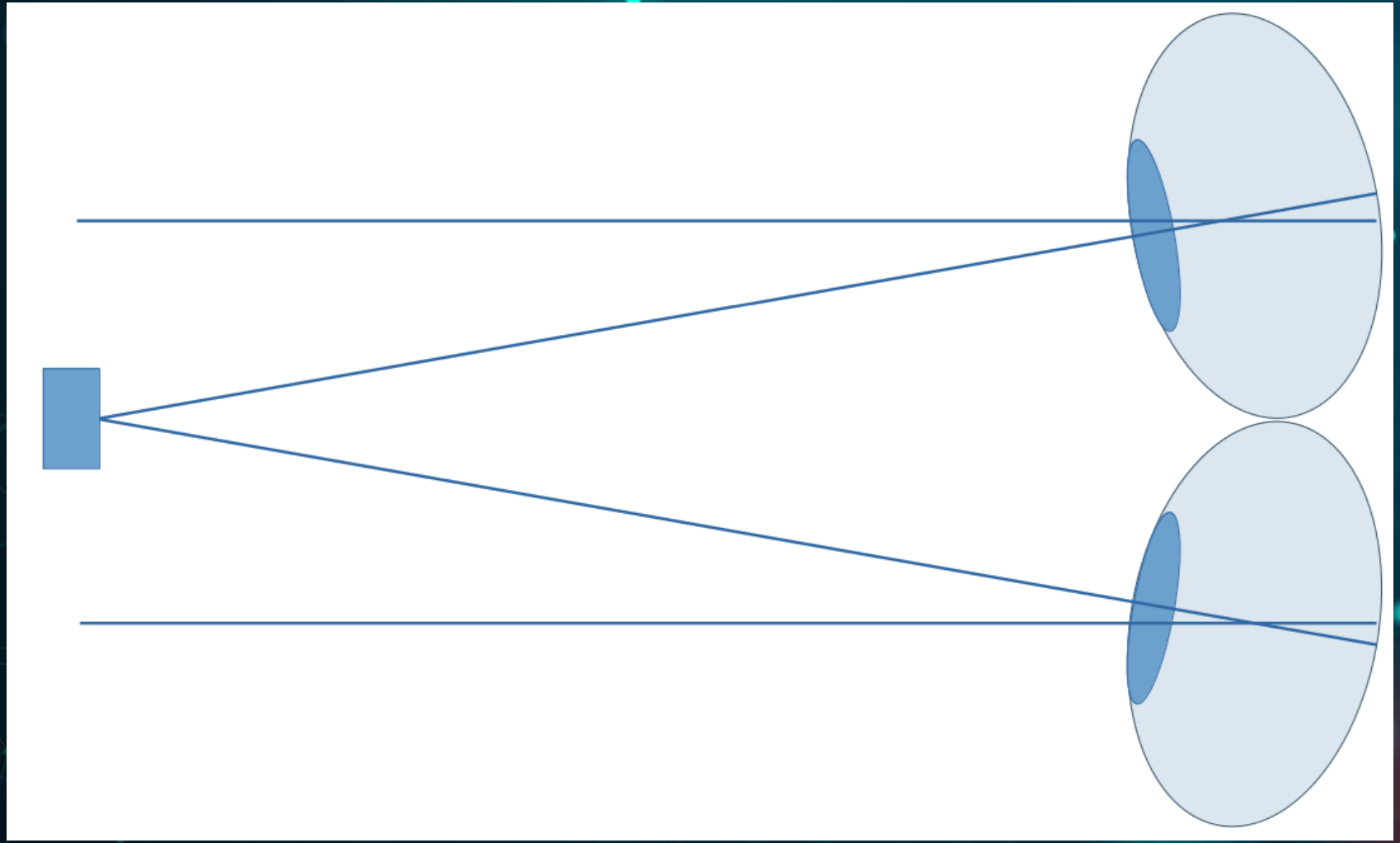
Another Way of distance measurement

01.5

You could enter a subtitle here if you need it

RGB Camera

How can human see?



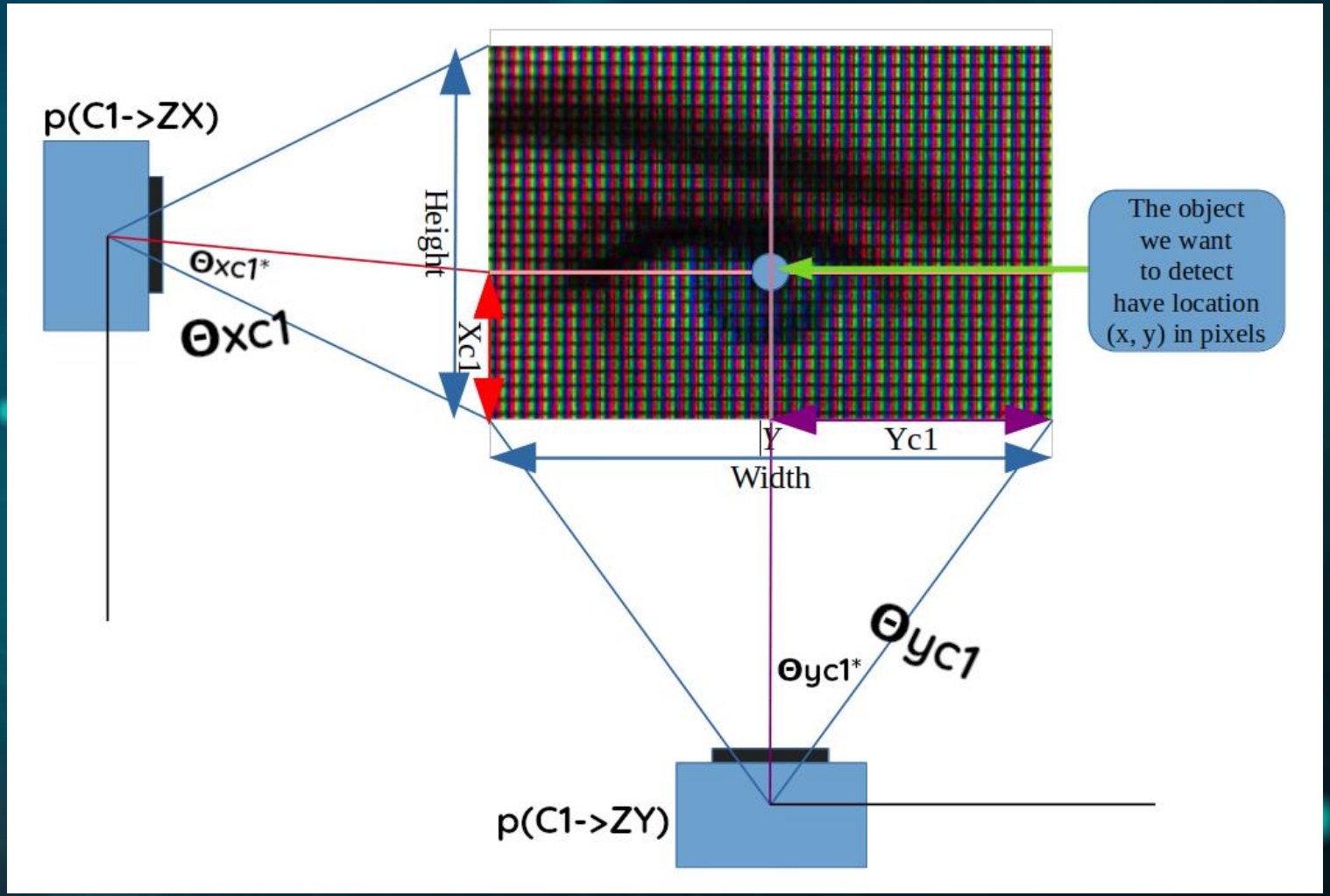

p(C1->ZX)
Height
Θxc1*
Θxc1
Xc1
The object
we want
to detect
have location
(x, y) in pixels
Y
Yc1
Width
Θyc1
Θyc1*
p(C1->ZY)

Figure 5

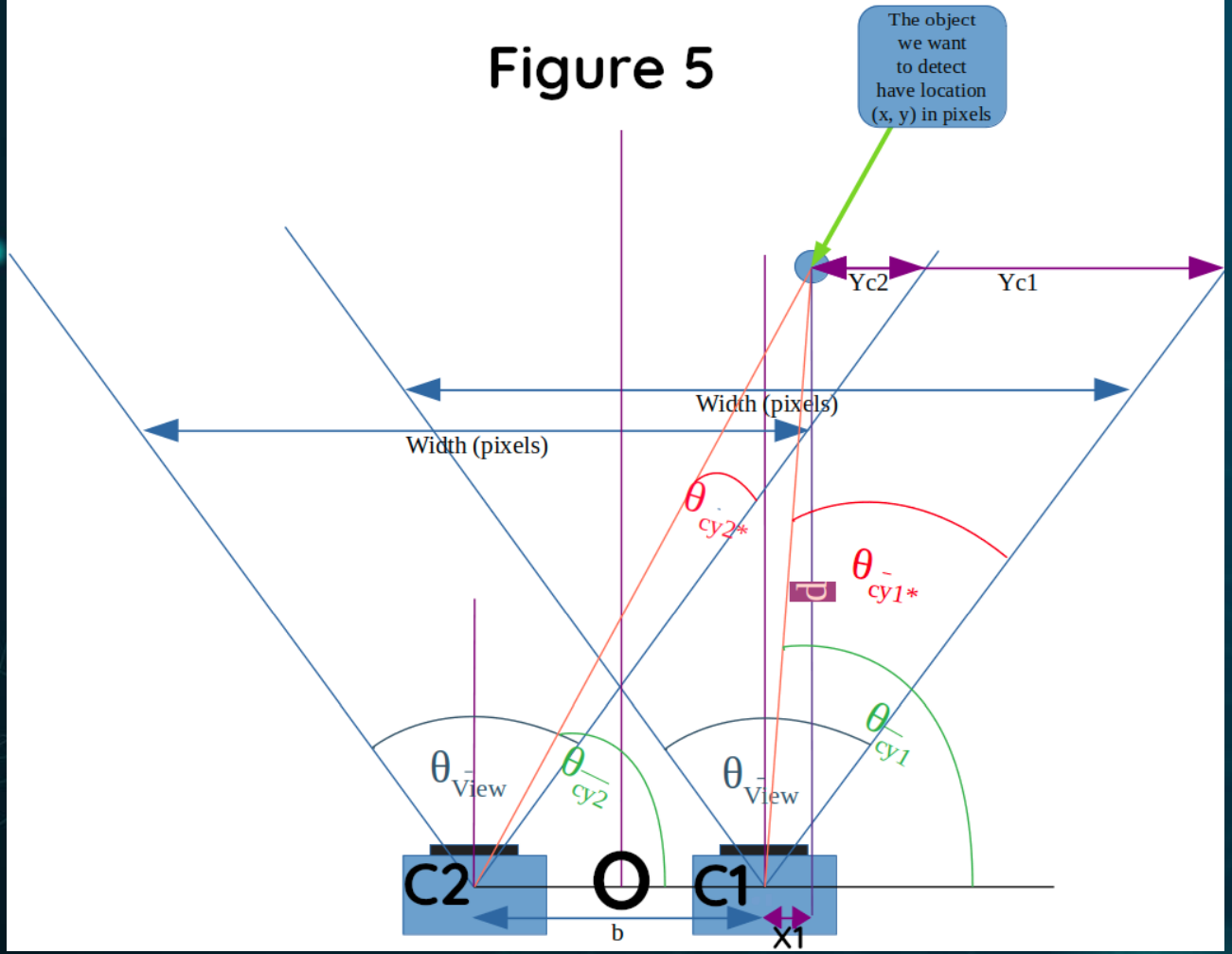
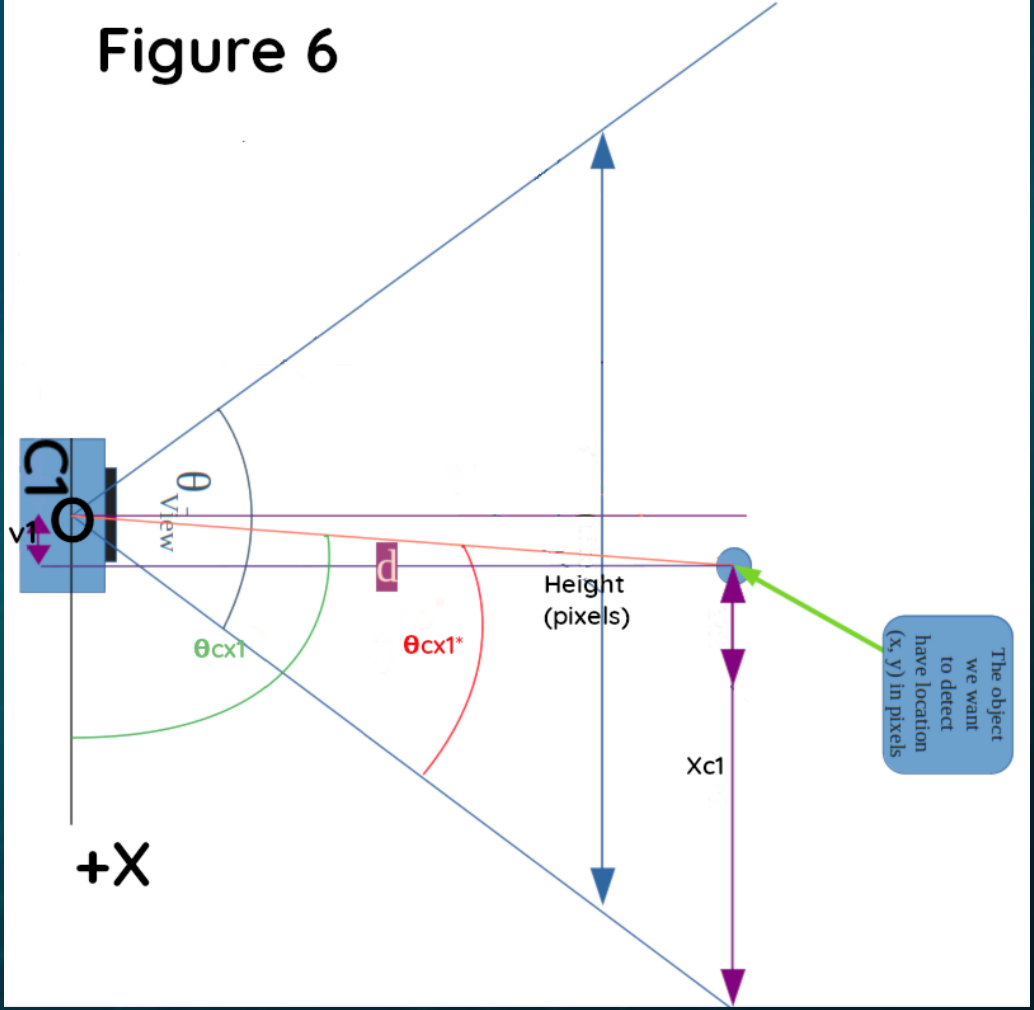
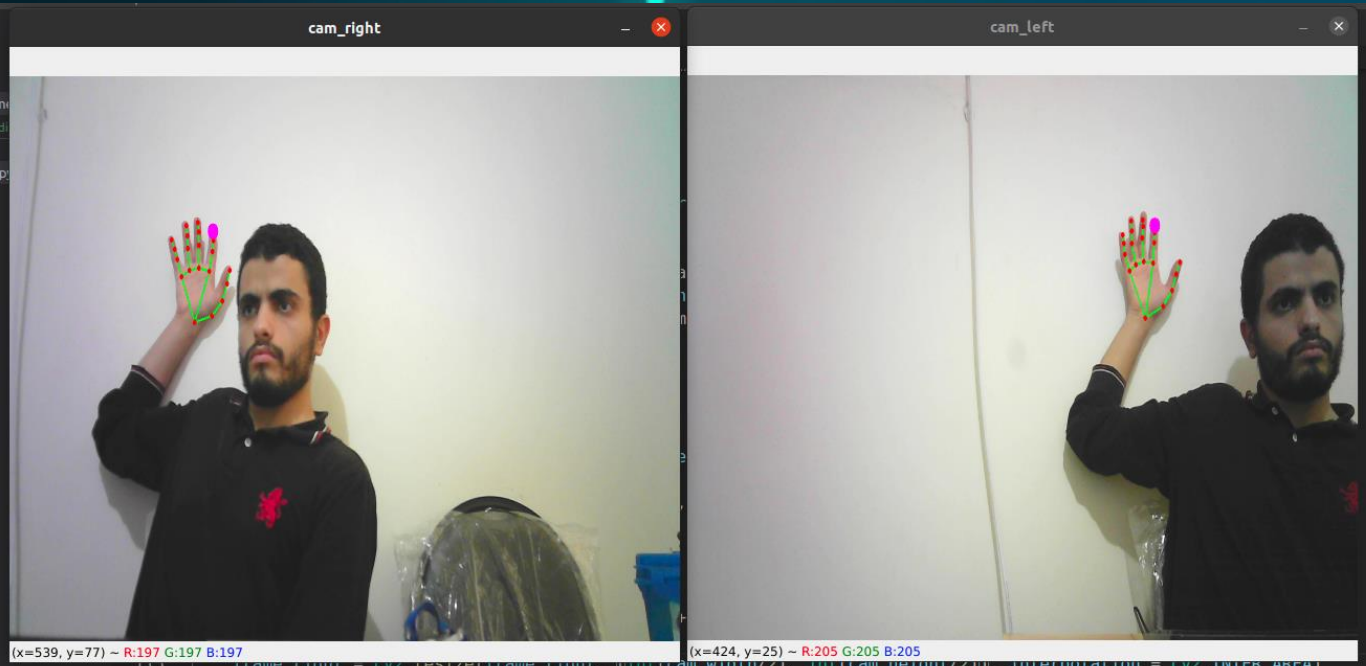

The object we want to detect have location (x, y) in pixels
Yc2
Yc1
Width (pixels)
Width (pixels)
θ cy2*
θ cy1*
θ View
θ cy2
θ View
θ cy1
C2
O
C1
b
X1

Figure 6


The object
we want
to detect
have location
(x, y) in pixels
Xc1
Height
(pixels)
θcx1*
θcx1
d
θ
View
C1
v1
+X




```
    frame_right = cv2.resize(frame_right, (int(cam_width/2), int(cam_height/2)), interpolation = cv2.INTER_AREA)
    frame_left = cv2.resize(frame_left, (int(cam_width/2), int(cam_height/2)), interpolation = cv2.INTER_AREA)
    cv2.imshow(camRight_winname, frame_right)
    cv2.imshow(camLeft_winname, frame_left)

    key = cv2.waitKey(1)
    if(key == ord('q')):
        cv2.destroyAllWindows()
```

PROBLEMS OUTPUT TERMINAL DEBUG CONSOLE

```
X: -48.7689607110814    Y: -0.07240403995605504 Z: 169.61195596011422   D: 176.48408533292664
X: -48.794578975513666  Y: 1.4210854715202004e-14       Z: 169.95957629777462   D: 176.82524851591955
X: -48.52137284465133   Y: 2.842170943040401e-14        Z: 169.26575470399035   D: 176.08298991737135
X: -48.62061418414758   Y: 0.07240403995609057  Z: 169.6119559601141    D: 176.44314940117232
X: -48.669416575985075  Y: 2.842170943040401e-14        Z: 169.26575470399035   D: 176.1238422967152
X: -48.42250205115689   Y: -0.07213369870862607 Z: 168.9208460895409    D: 175.7242047976634
X: -48.595386124541214  Y: 2.842170943040401e-14        Z: 169.26575470399035   D: 176.1033993655565
```

Advantages of measurements with RGB Cameras

Accurate color information

High resolution

High Accuracy

Accuracy Improvement

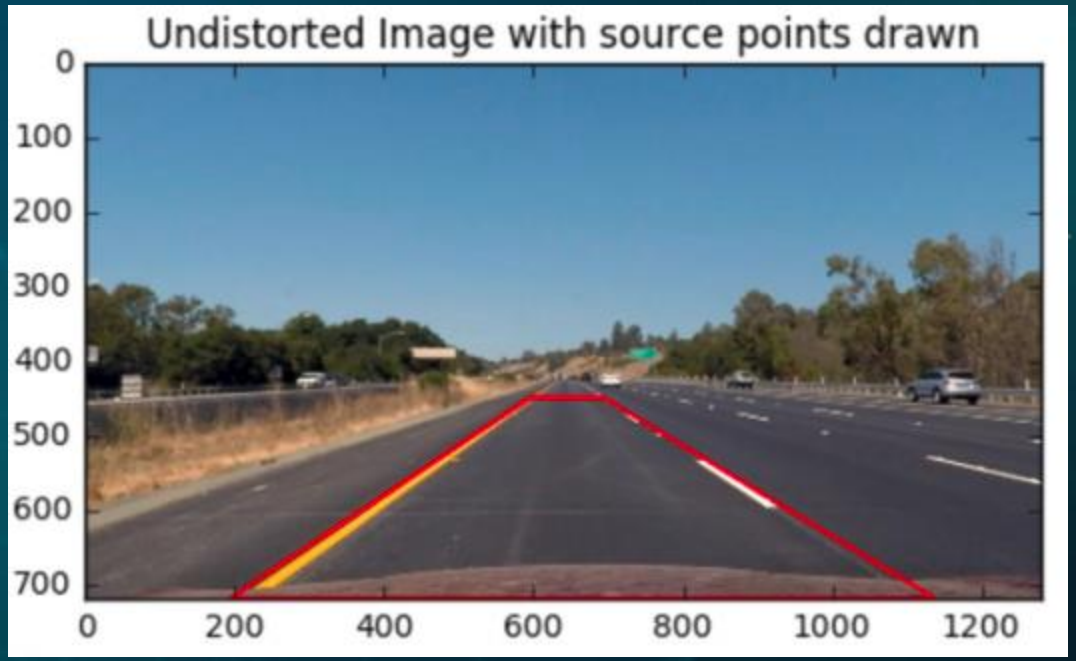
Easy setup

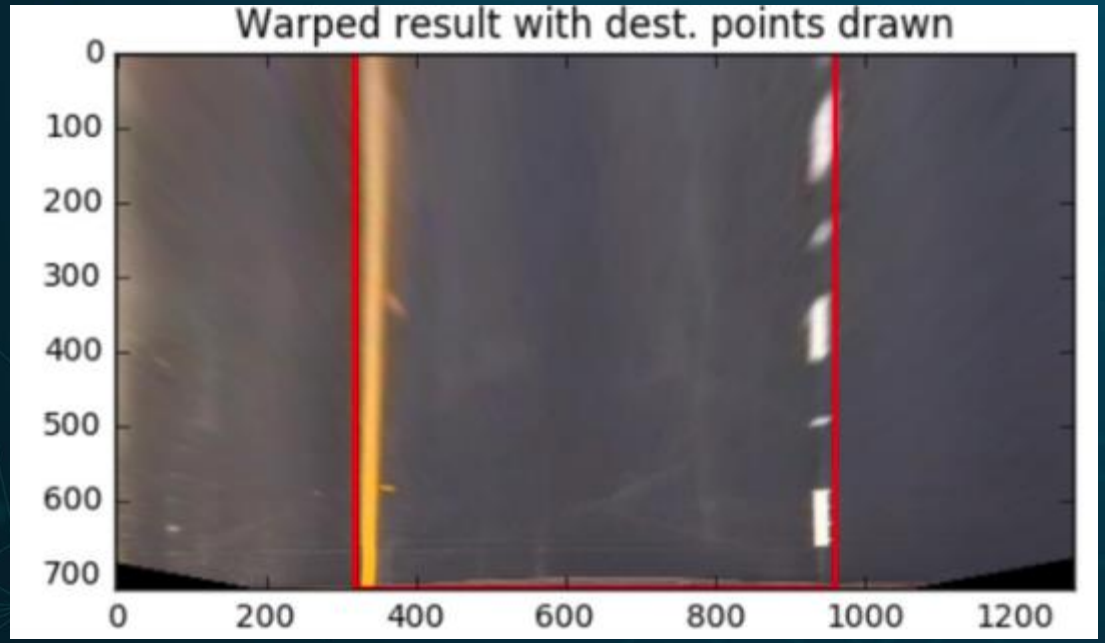
Low cost

Lane detection

01.6

You could enter a subtitle here if you need it


Undistorted Image with source points drawn
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200


Warped result with dest. points drawn
0
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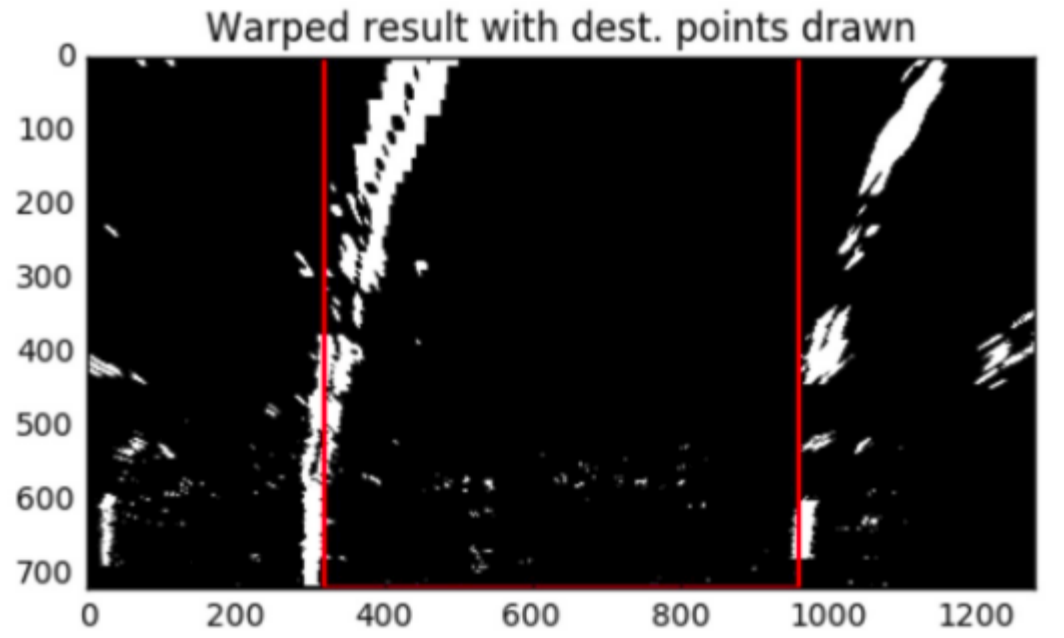
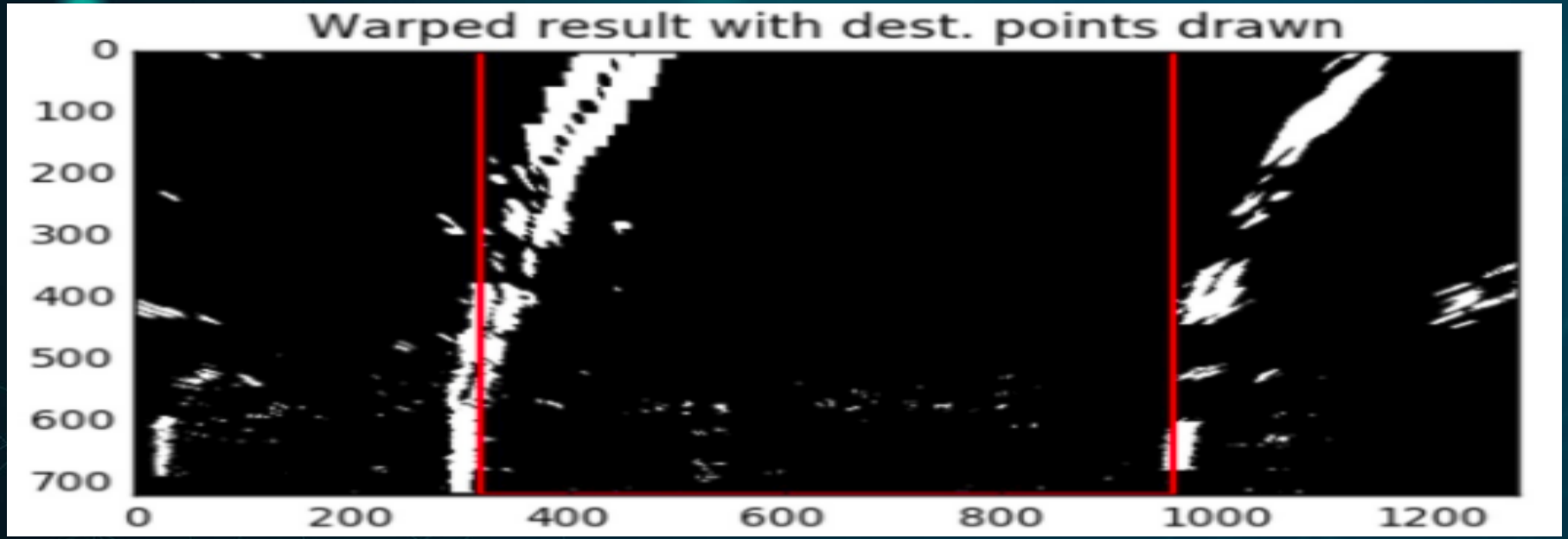
200
300
400
500
600
700
0
200
400
600
800
1000
1200


Warped result with dest. points drawn
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200


Warped result with dest. points drawn
0
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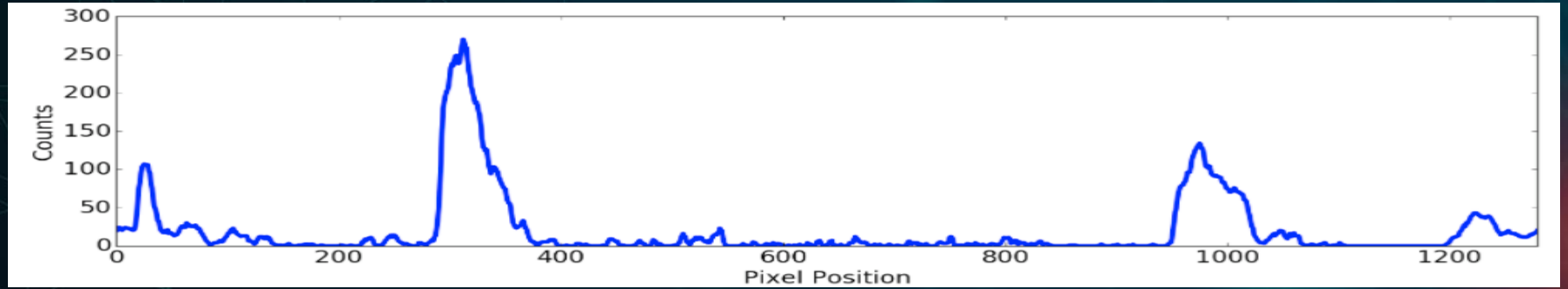
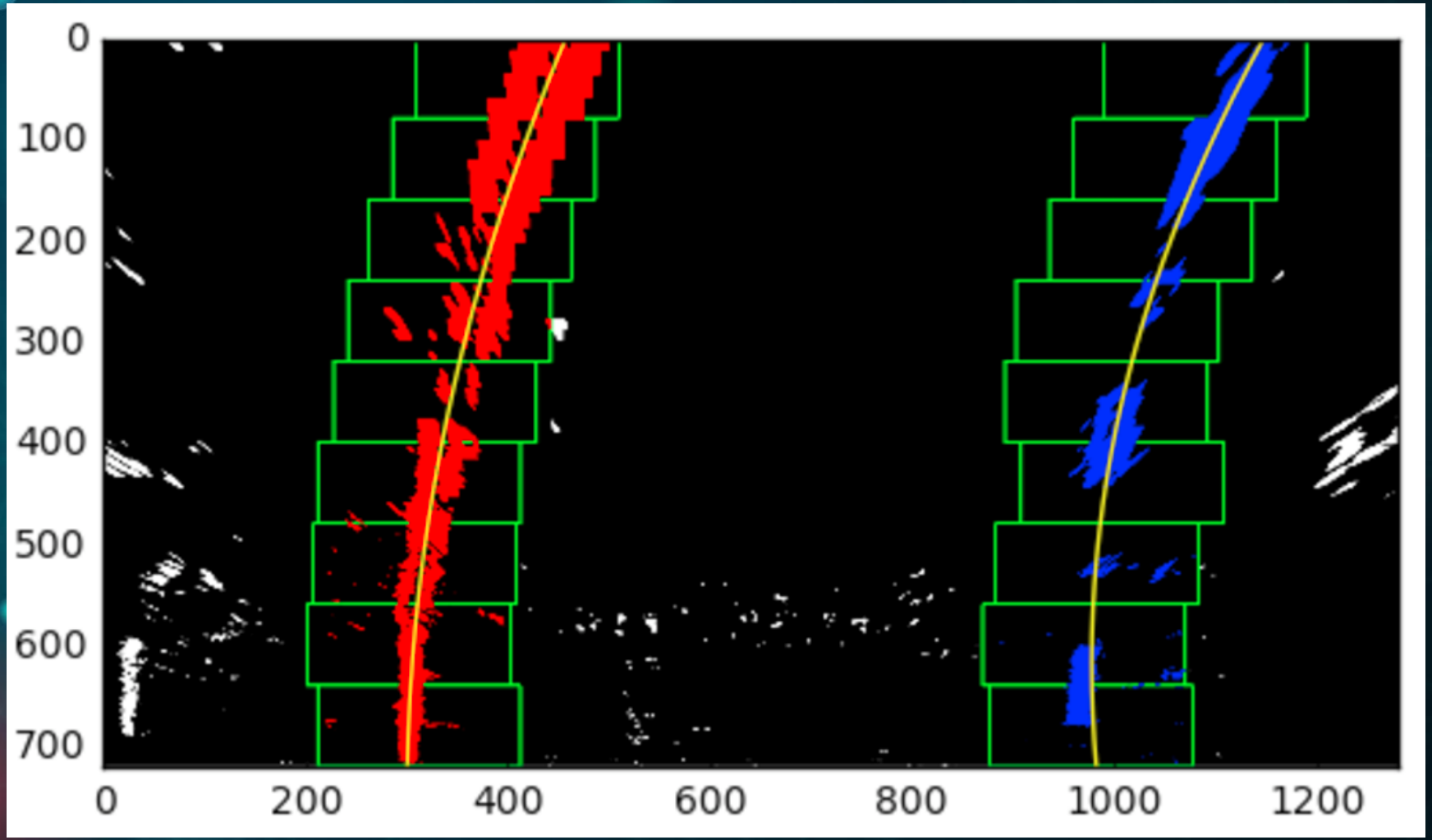
200
300
400
500
600
700
0
200
400
600
800
1000
1200


Counts
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
Pixel Position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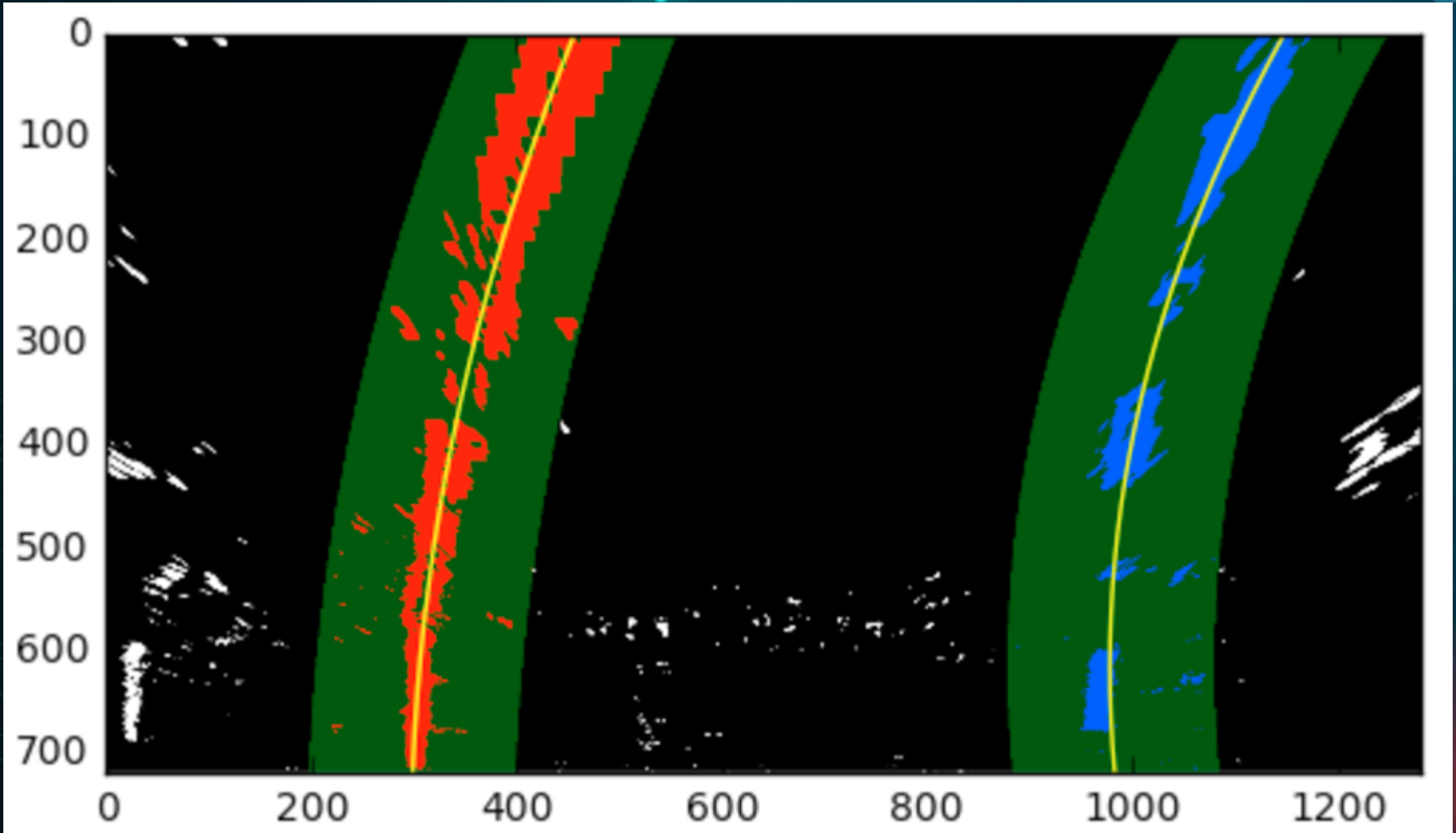
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200


0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200

Radius of curvature (533.72m, 625.44m)
Offset right (0.33m)
Farm
Hill Blvd

Electrical Car

02

Why Electrical Car?

Electrical Car Advantages

Electric cars are energy efficient

Electric cars require lower maintenance

Very Safe in comparsion with ICE cars

Environment Frindly

Electrical Car Advantages

Electric cars are energy efficient

Electric cars require lower maintenance

Very Safe in comparsion with ICE cars

Environment Frindly

Safety of Tesla

Safety of Tesla

TESLA

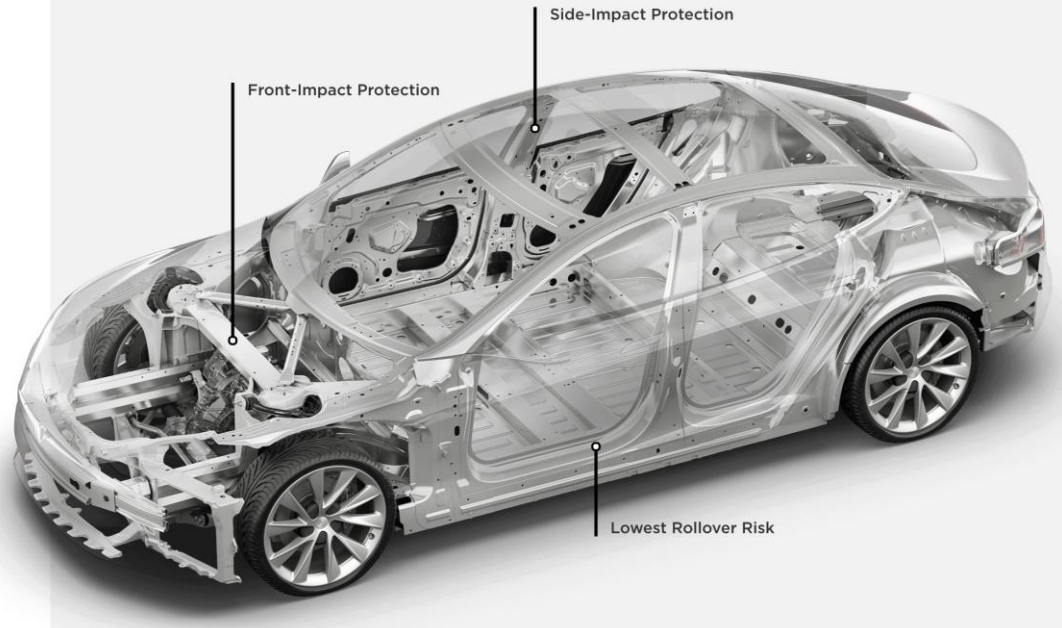
Safety

The Safest Car

Model S achieved the highest safety rating of any car ever tested, and set a record for the lowest probability of occupant injury—from front, side, rear and rollover accidents.

5-Star Overall Rating

Front	★★★★★
Side MDB	★★★★★
Side Pole	★★★★★
Driver Overall	★★★★★
Side Overall	★★★★★



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EV implementation Layers

1

Hardware Foucsed Layer

Motor -Inverter and Battery
Mangament System

2

Software Foucsed Layer

Collect Sensors Data , Process it
and control the prototype

EV implementation Layers

1

Hardware Foucsed Layer

Motor -Inverter and Battery
Mangament System

2

Software Foucsed Layer

Collect Sensors Data , Process it
and control the prototype

HOW DO WE DO IT?

01

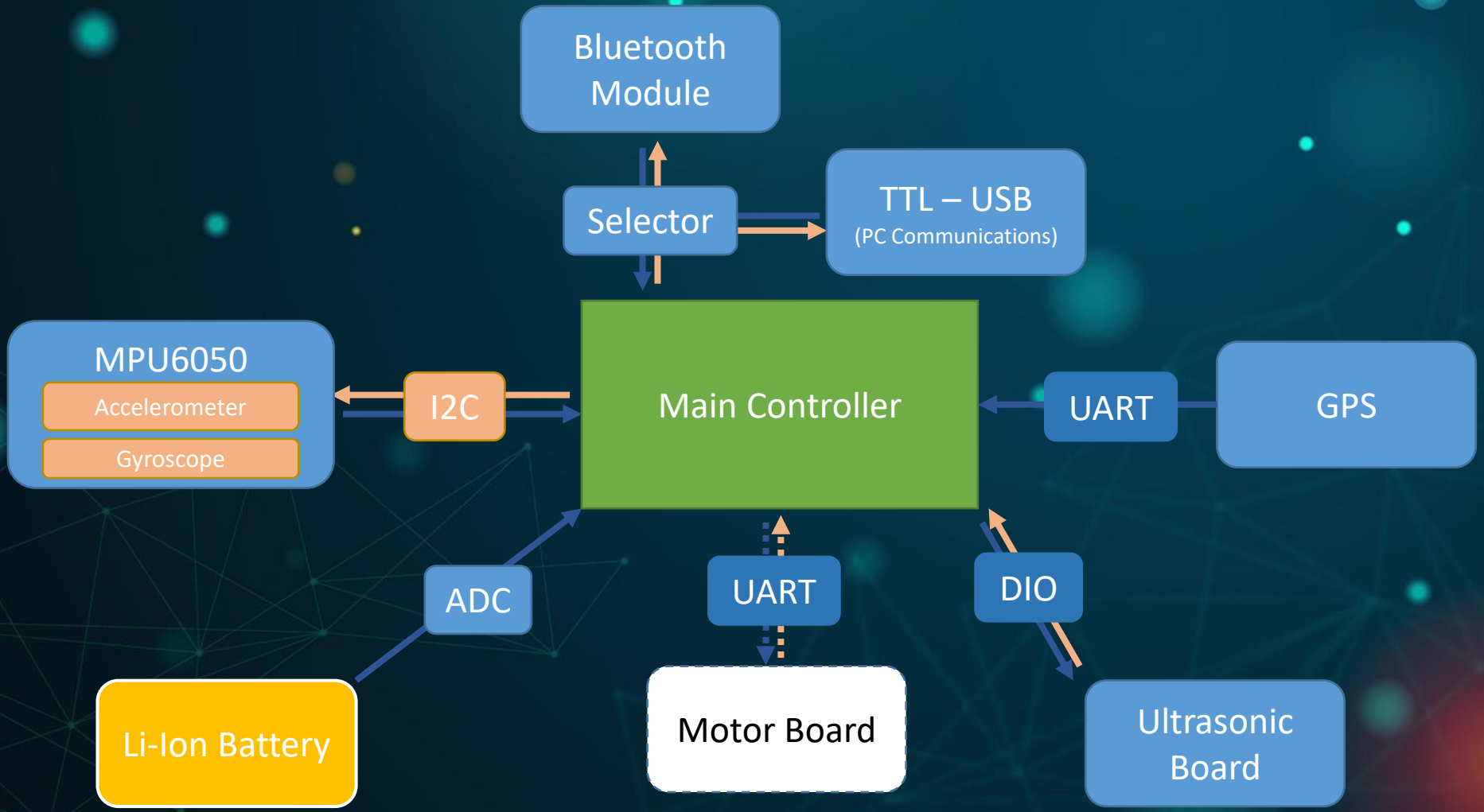
Main ECU

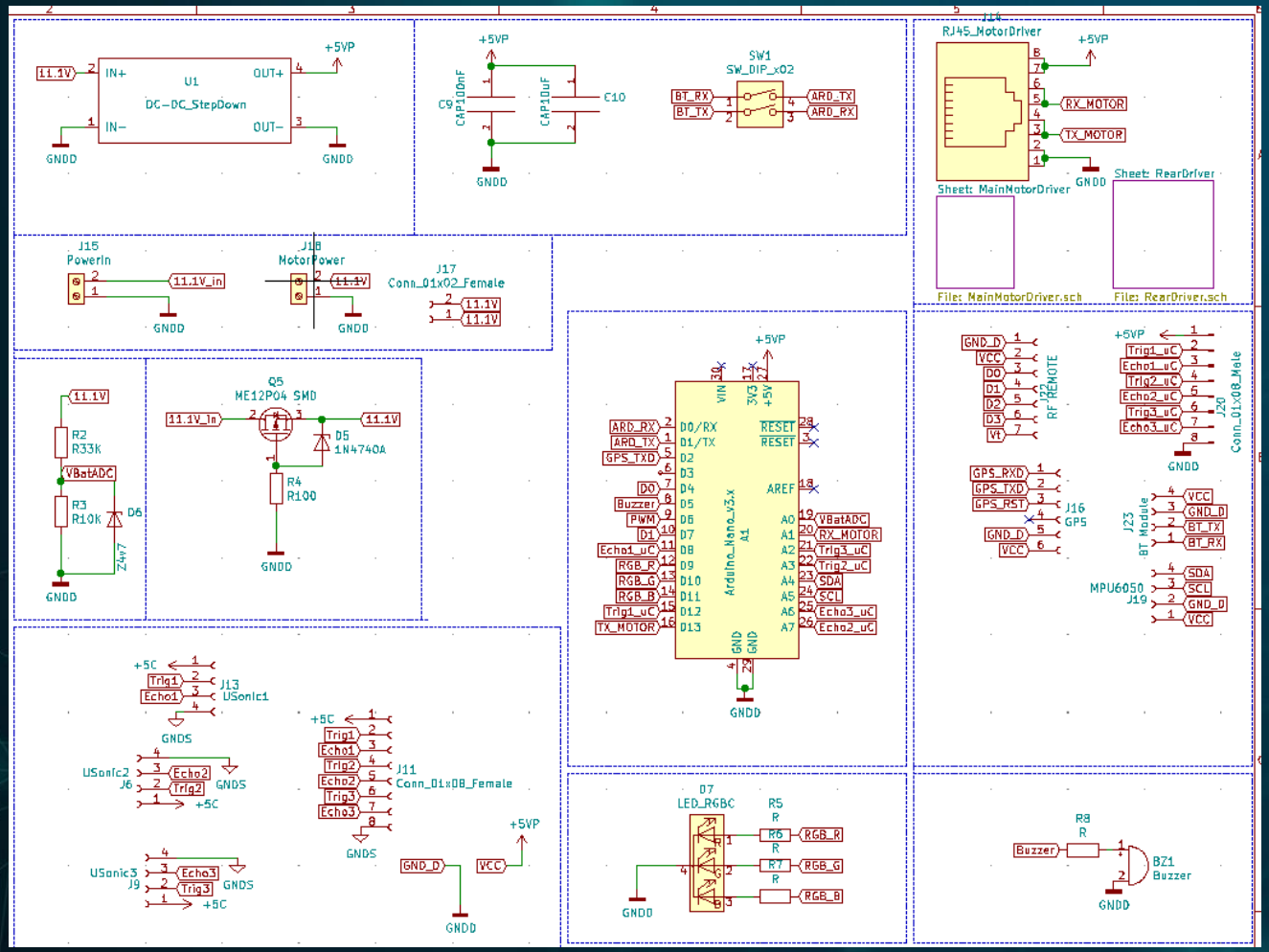
Collect Sensor Data , Forward Commands

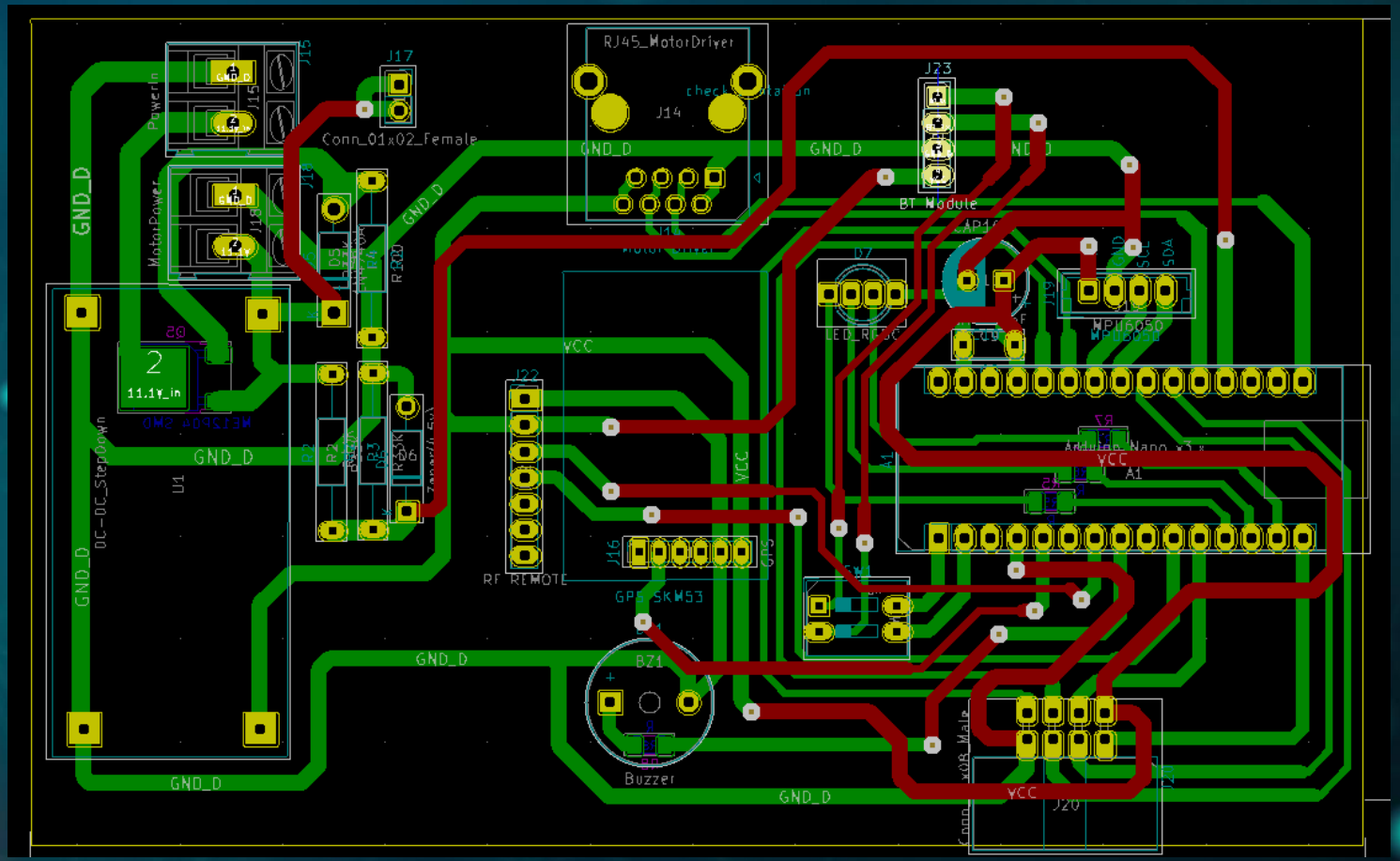
02

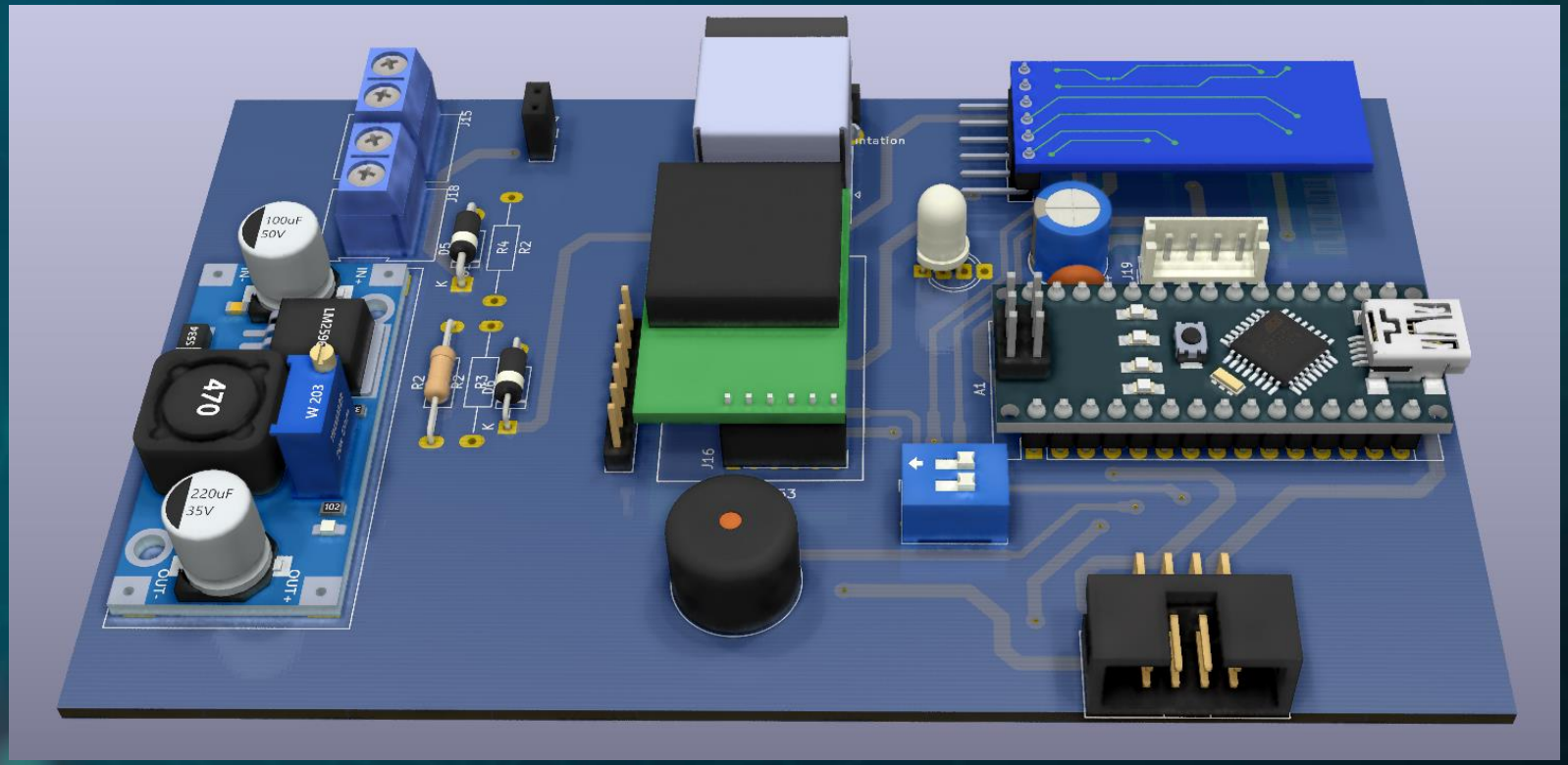
Motor & Lights ECU

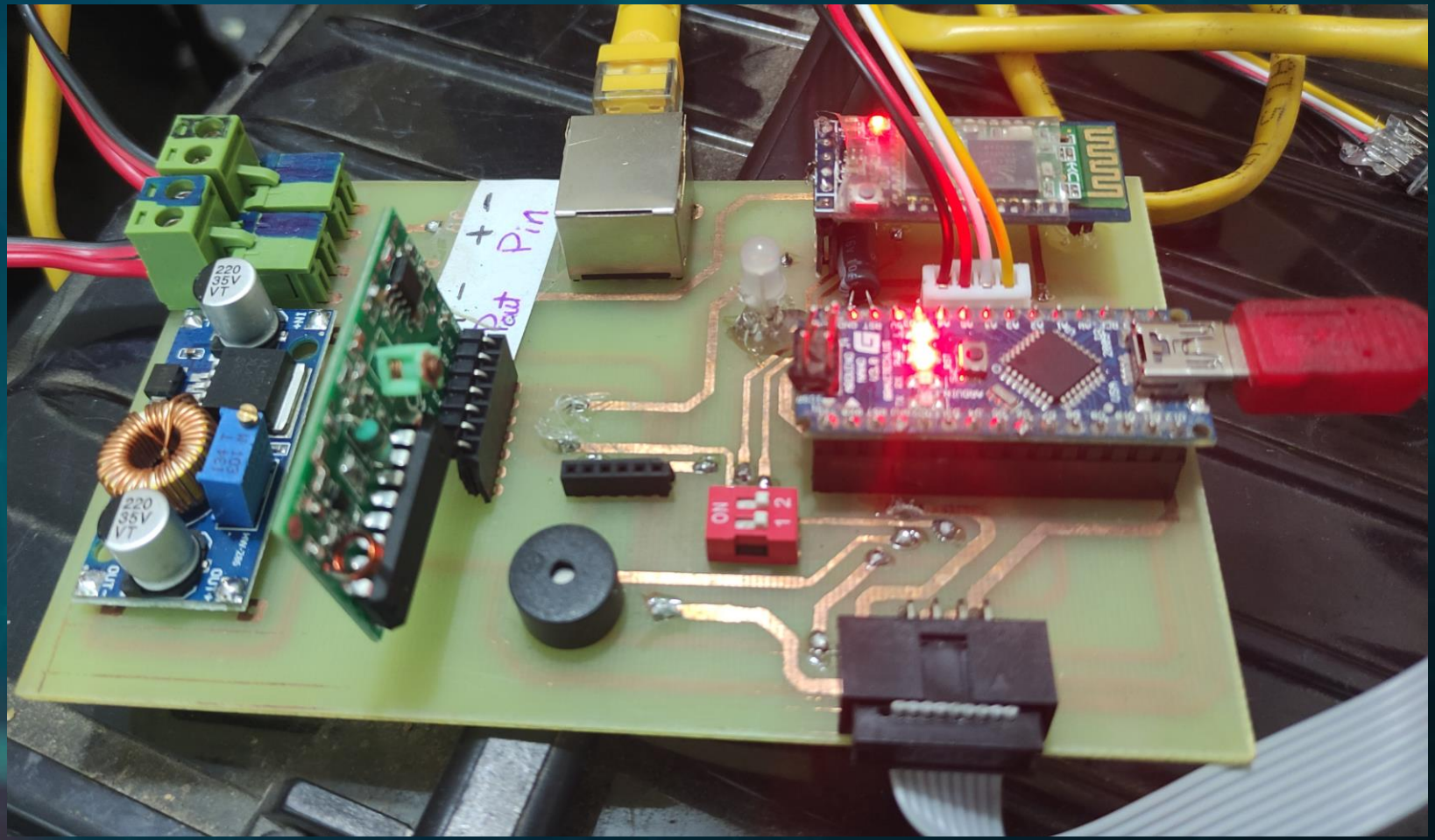
Control Steering and Drive Motors in addition to Lights


Bluetooth Module
Selector
TTL – USB
(PC Communications)
MPU6050
Accelerometer
Gyroscope
I2C
Main Controller
UART
GPS
ADC
UART
DIO
Li-Ion Battery
Motor Board
Ultrasonic Board

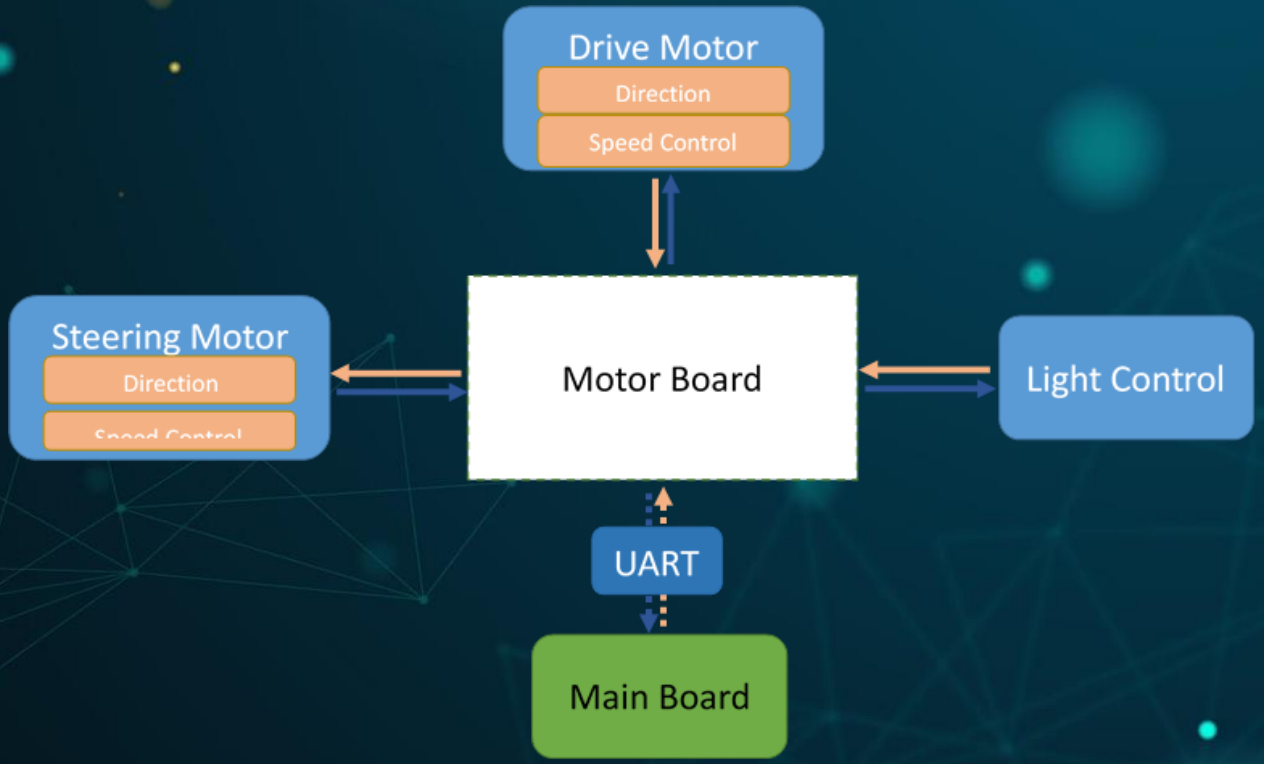

U1
DC-DC_StepDown
IN+
IN-
OUT+
OUT-
11.1V
+5VP
GNDD
C9
CAP10nF
C10
CAP10uF
SW1
SW_DIP_x02
BT_RX
BT_TX
ARD_TX
ARD_RX
J14
RJ45_MotorDriver
RX_MOTOR
TX_MOTOR
Sheet: MainMotorDriver
Sheet: RearDriver
File: MainMotorDriver.sch
File: RearDriver.sch
J15
PowerIn
11.1V_in
J16
MotorPower
J17
Conn_01x02_Female
R2
R33k
VBatADC
R3
R10k
D6
Z4v7
Q5
ME12P04 SMD
D5
1N4740A
R4
R100
Arduino_Nano_v3.x
A1
D0/RX
D1/TX
GPS_TXD
D0
Buzzer
PWM
D1
Echo1_uC
RGB_R
RGB_G
RGB_B
Trig1_uC
TX_MOTOR
RESET
AREF
A0
A1
A2
A3
A4
A5
A6
A7
Trig3_uC
Trig2_uC
SDA
SCL
Echo3_uC
Echo2_uC
J12
RF_REMOTE
GND_D
VCC
D0
D1
D2
D3
Vt
J20
Conn_01x08_Male
Trig1_uC
Echo1_uC
Trig2_uC
Echo2_uC
Trig3_uC
Echo3_uC
J16
GPS
GPS_RXD
GPS_TXD
GPS_RST
J23
BT Module
BT_TX
BT_RX
MPU6050
J19
SDA
SCL
J13
USonic1
Trig1
Echo1
GNDS
USonic2
J6
Echo2
Trig2
+5C
J11
Conn_01x08_Female
USonic3
J9
Echo3
Trig3
D7
LED_RGBC
R5
R6
R7
R8
R
Buzzer
BZ1
Buzzer

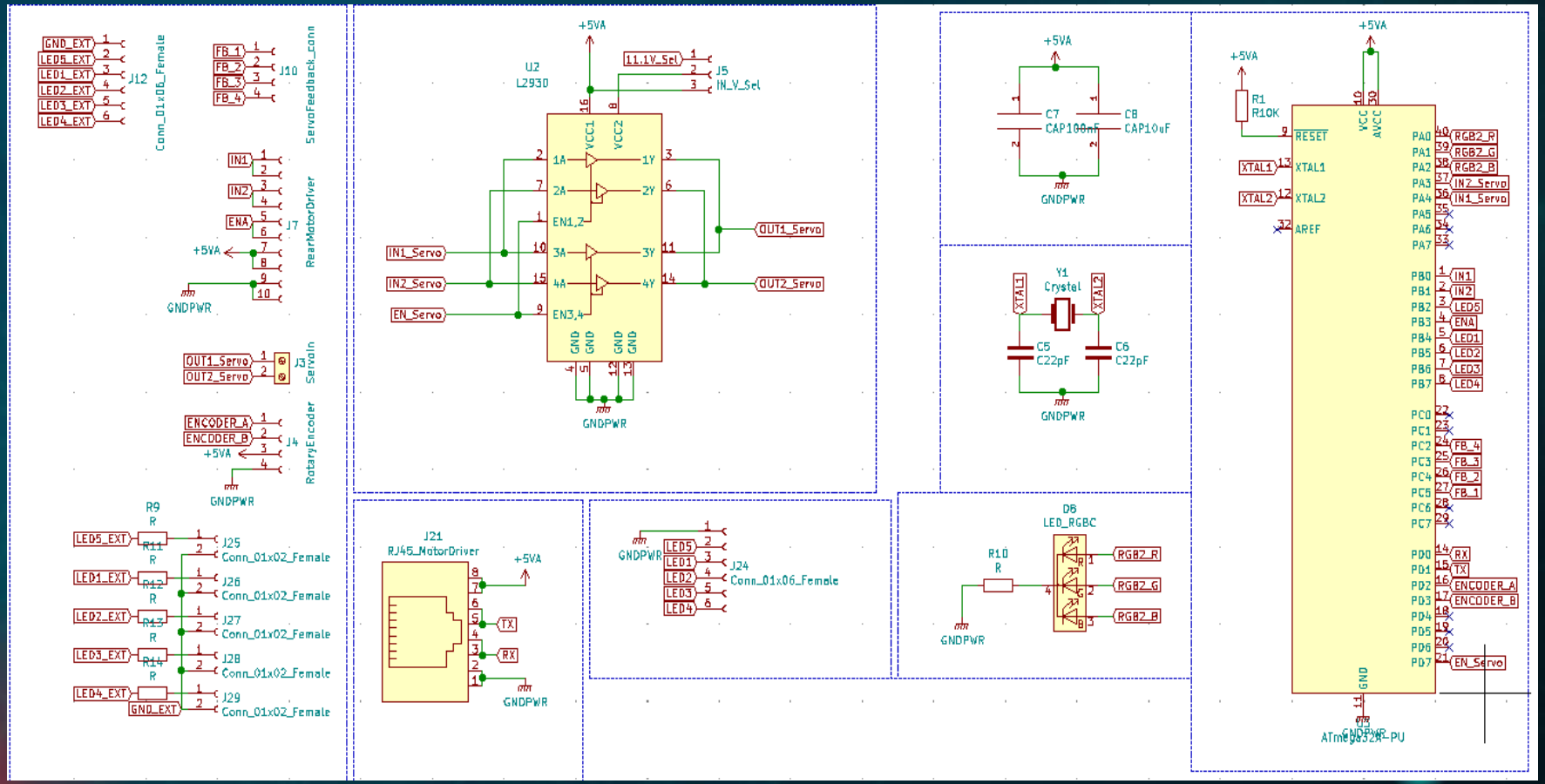

RJ45_MotorDriver
J14
J17
Conn_01x02_Female
J15
Power in
MotorPower
GND_D
J23
BT_Module
D7
LED_RGB
WPU6050
J22
RF_REMOTE
J16
GPS_SKW53
BZ1
Buzzer
VCC
Arduino_Nano_v3.x
A1
U1
DC-DC_StepDown
11.1V_in
J20
x08_Male

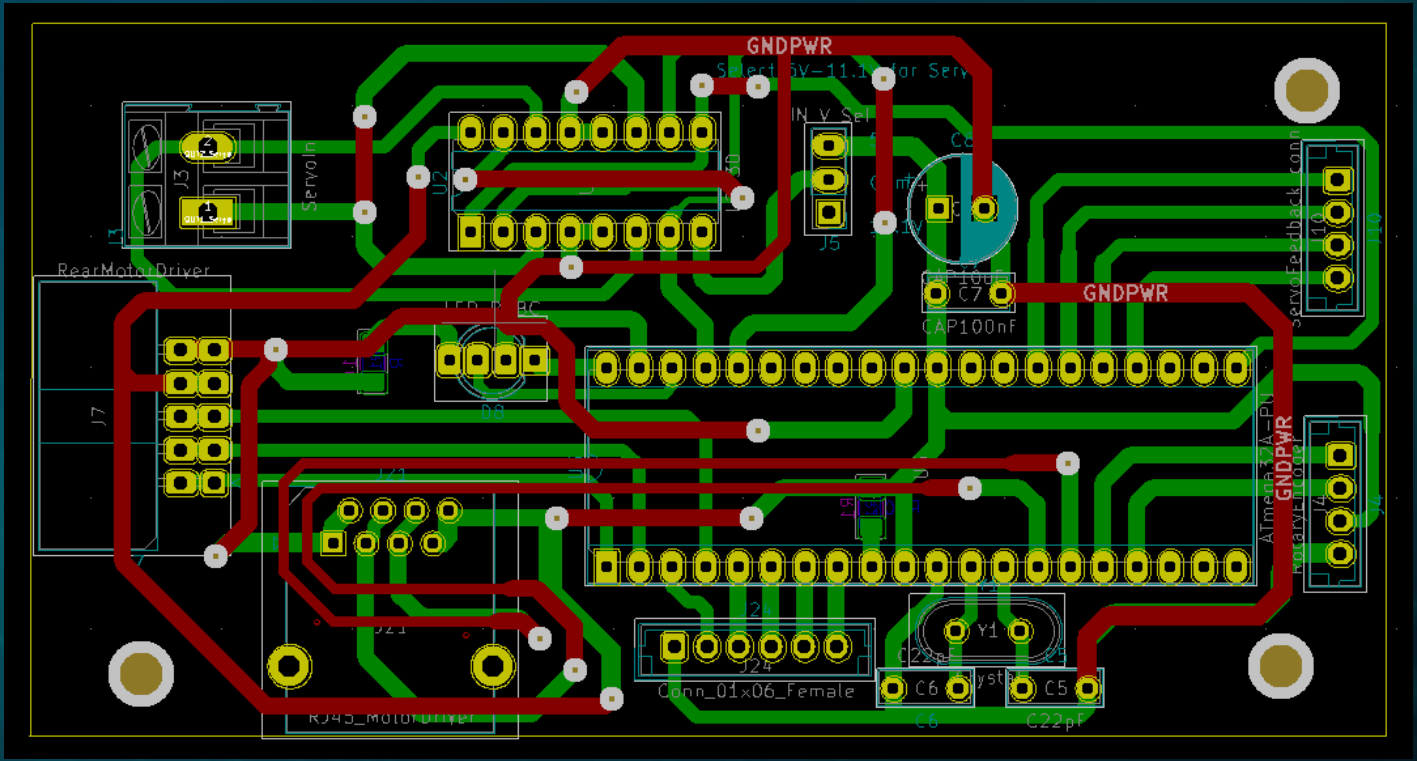

100uF
50V
470
220uF
35V
OUT-
OUT+
IN-
IN+
LM2596
W 203
J15
J18
D5
R4
R2
R3
D6
J16
J19
A1

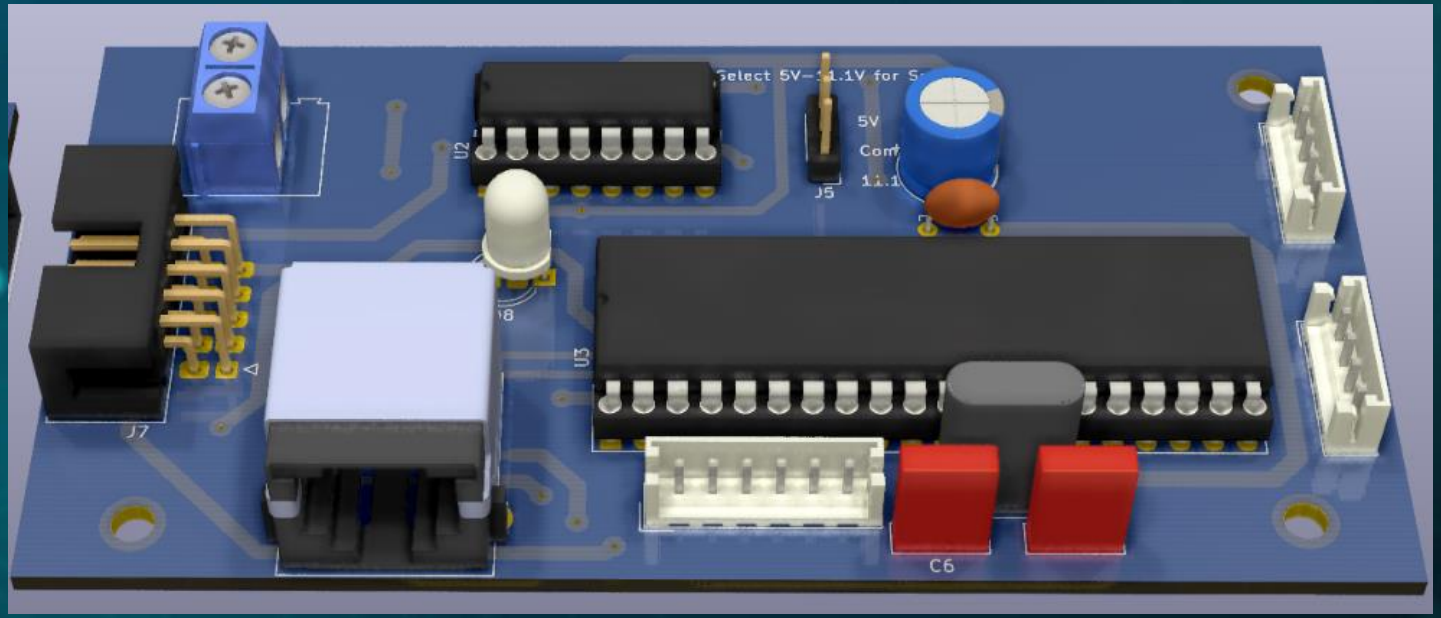

220
35V
VT
220
35V
VT
Pin
Pat
ON
1 2

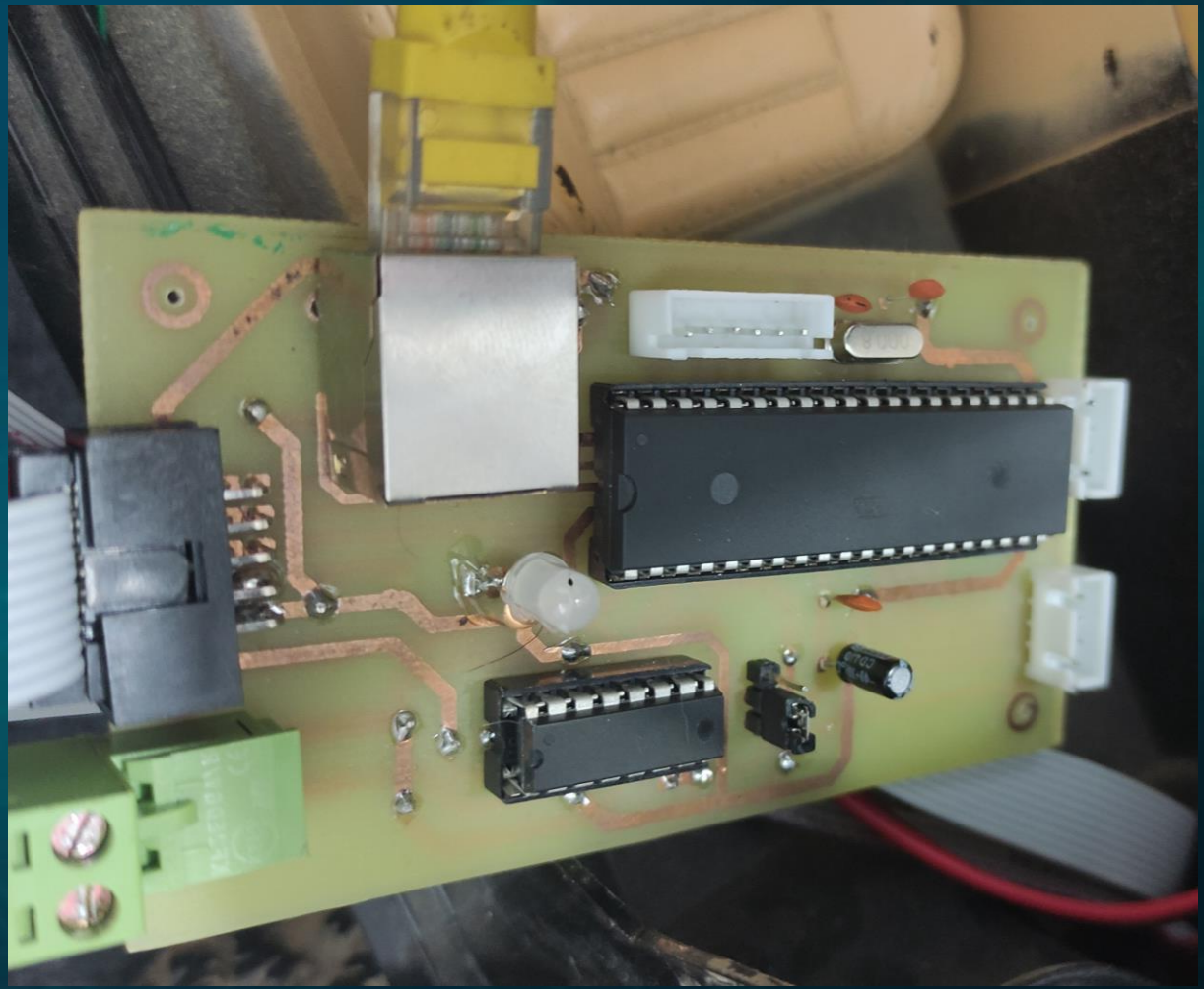
Motor Control Board (2nd ECU)

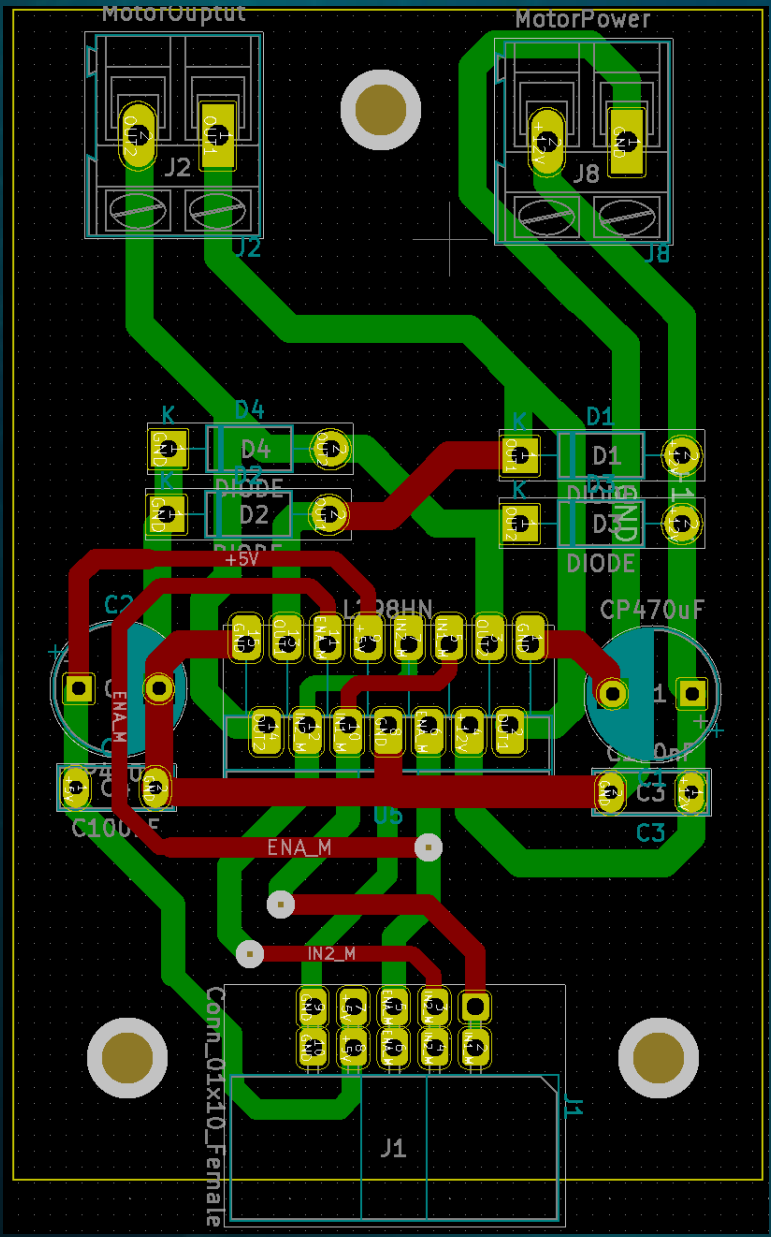


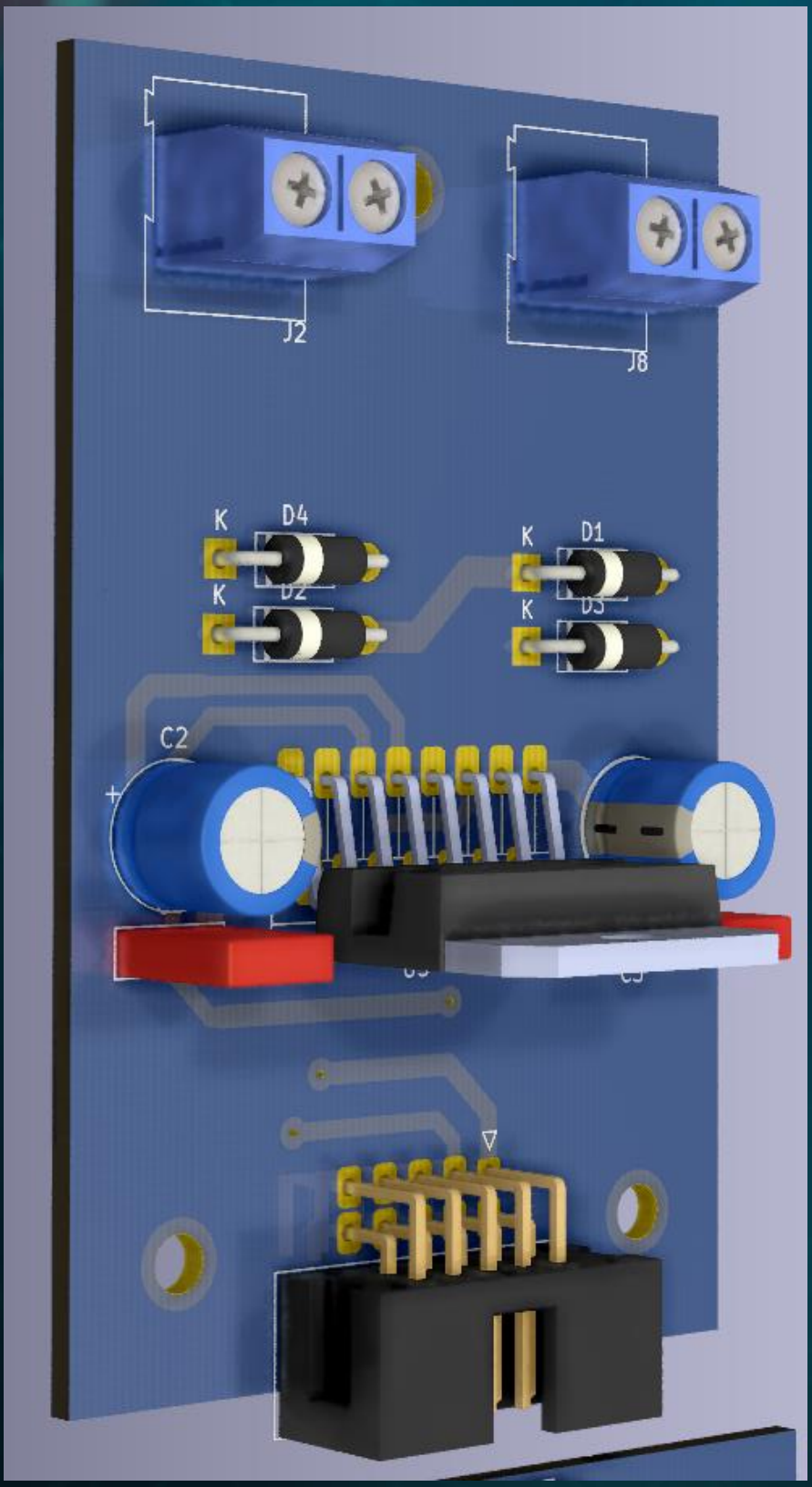

GND_EXT
LED5_EXT
LED1_EXT
LED2_EXT
LED3_EXT
LED4_EXT
J12
Conn_01x06_Female
FB_1
FB_2
FB_3
FB_4
J10
ServoFeedback_conn
IN1
IN2
ENA
J7
RearMotorDriver
+5VA
GNDPWR
OUT1_Servo
OUT2_Servo
J3
ServoIn
ENCODER_A
ENCODER_B
J4
RotaryEncoder
R9
R
R11
R12
R13
R14
J25
J26
J27
J28
J29
Conn_01x02_Female
U2
L293D
11.1V_Sel
J5
IN_V_Sel
VCC1
VCC2
1A
2A
EN1,2
3A
4A
EN3,4
1Y
2Y
3Y
4Y
GND
IN1_Servo
IN2_Servo
EN_Servo
C7
CAP100nF
C8
CAP10uF
Y1
Crystal
XTAL1
XTAL2
C5
C22pF
C6
C22pF
R1
R10K
RESET
XTAL1
XTAL2
AREF
VCC
AVCC
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
PC0
PC1
PC2
PC3
PC4
PC5
PC6
PC7
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
RGB2_R
RGB2_G
RGB2_B
IN2_Servo
IN1_Servo
LED5
ENA
LED1
LED2
LED3
LED4
FB_4
FB_3
FB_2
FB_1
RX
TX
ENCODER_A
ENCODER_B
EN_Servo
ATmega32M1-PU
J21
RJ45_MotorDriver
J24
Conn_01x06_Female
D6
LED_RGBC
R10
R

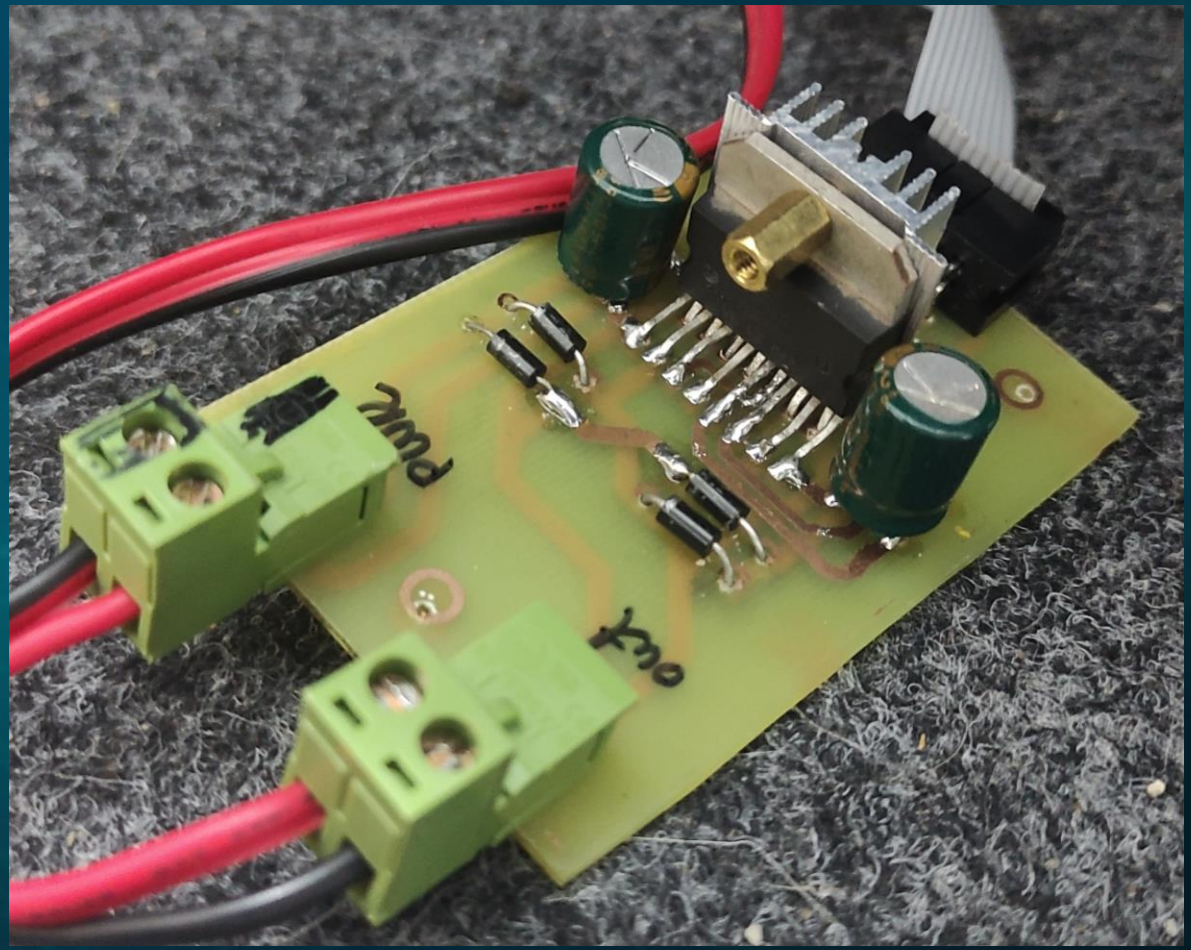

GNDPWR
Select 5V-11.1V for Serv
IN V Sel
J5
C8
CAP100uF
C7
CAP100nF
GNDPWR
ServoFeedback_Conn
J10
J3
Servo1n
RearMotorDriver
J7
U2
LED_R_RC
D8
J21
RJ45_MotorDriver
J24
Conn_01x06_Female
Y1
C22pF
C6
C5
C22pF
Atmega32A-PU
GNDPWR
RotaryEncoder
J4

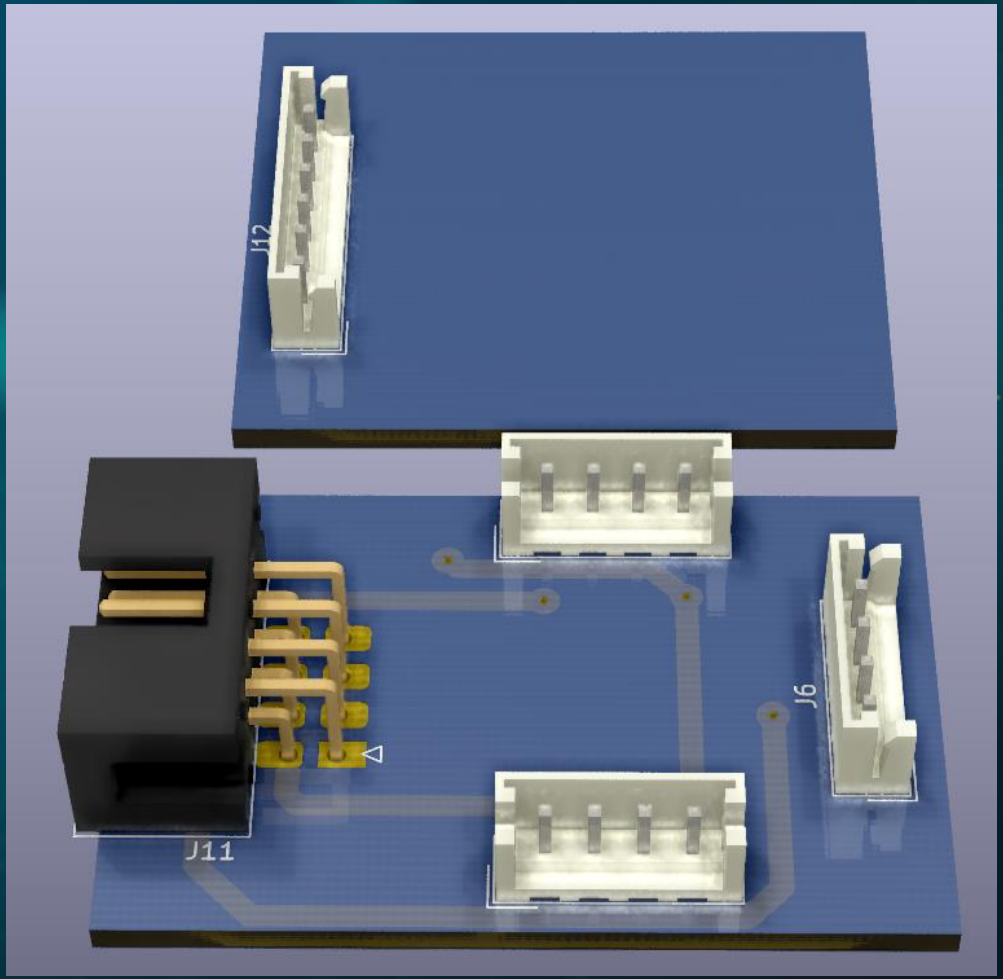

U2
J5
5V
U3
J7
C6

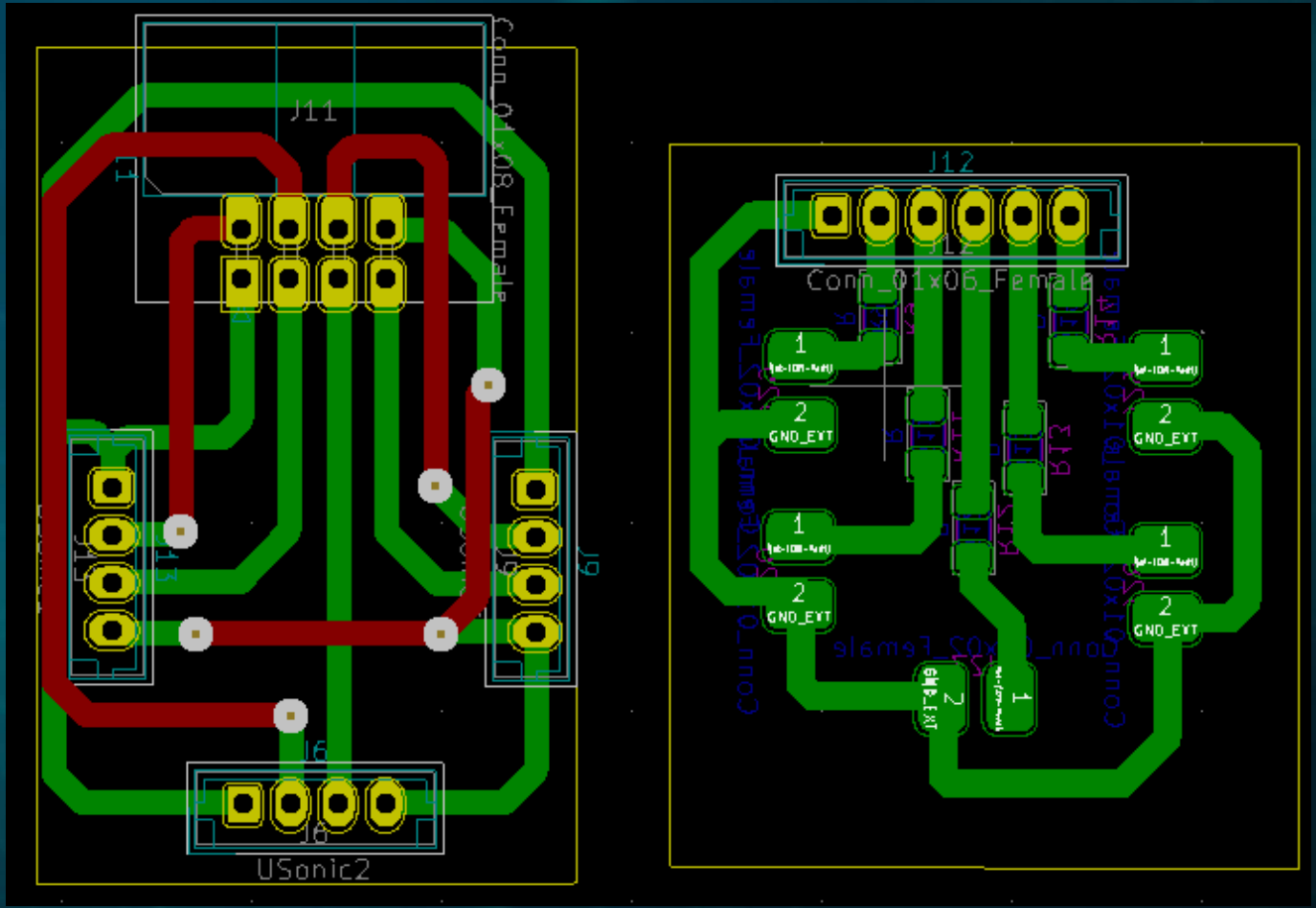


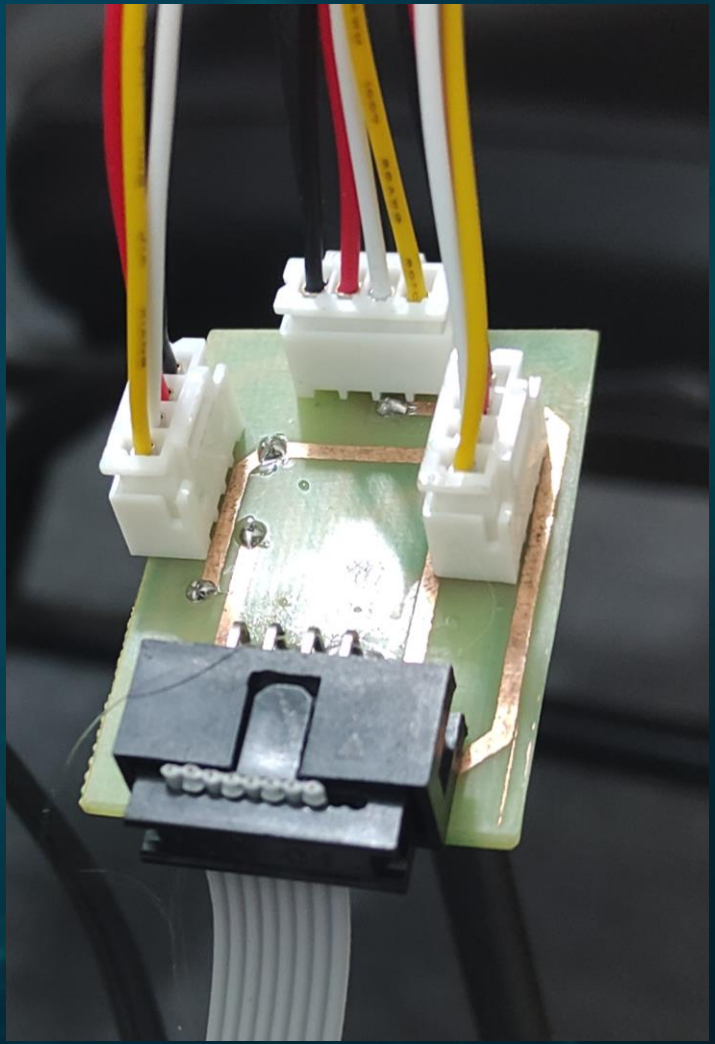

MotorOuptut
MotorPower
J2
J8
D4
D1
D2
D3
DIODE
+5V
C2
CP470uF
C3
ENA_M
IN2_M
Conn_01x10_Female
J1


J2
J8
K
D4
K
D2
K
D1
K
D3
C2
+


PWR
out


J12
J11
J6


J11
Conn_01x08_Female
J12
Conn_01x06_Female
GND_EXT
USonic2



Data Visualization

Acceleration

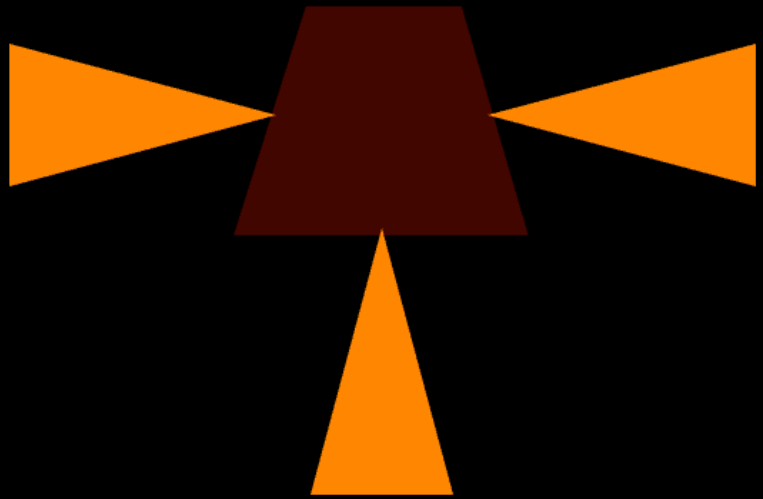
X: −7.450
Y: −1.390
Z: −0.030

Battery & GPS

Battery : 43 % (Discharging)
GPS (Latitude) : 1.258
GPS (Longitude) :−1.558

Gyroscope

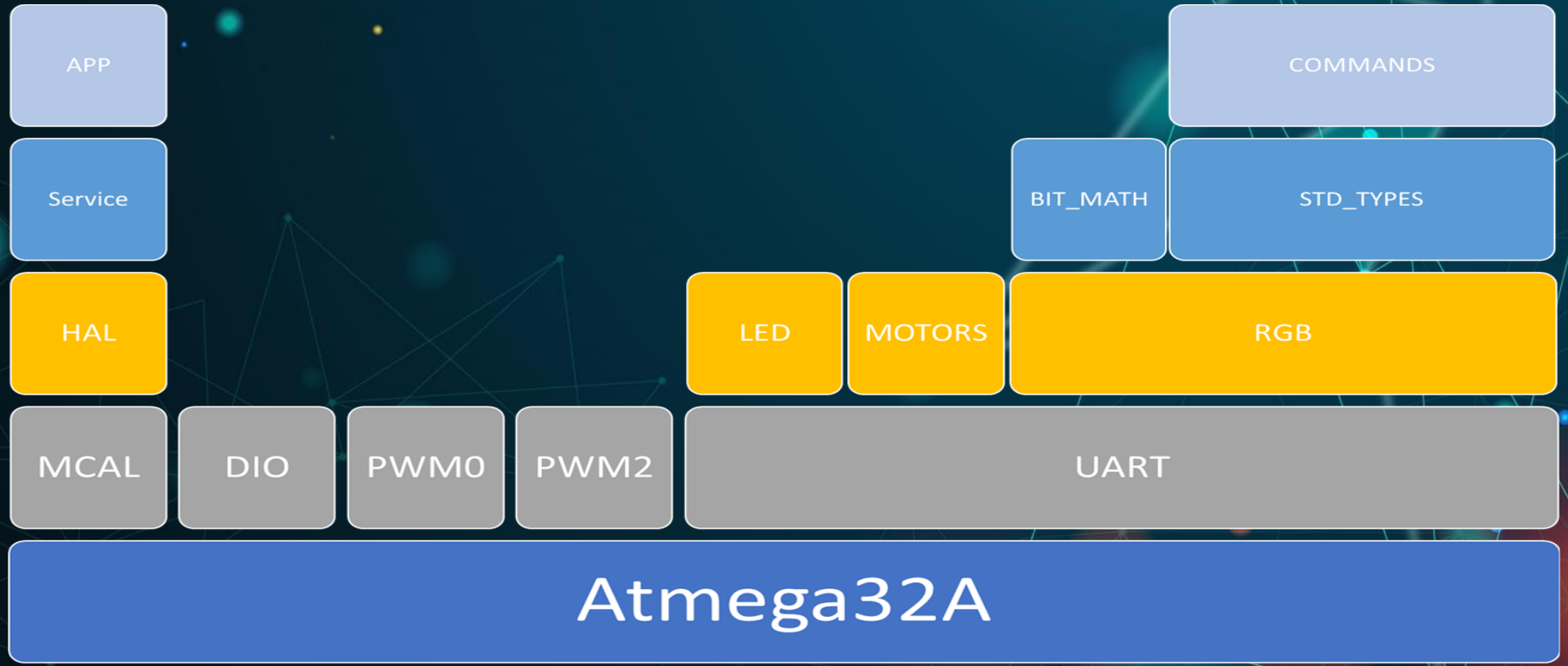
X: 1.110
Y: 0.200
Z: 0.110



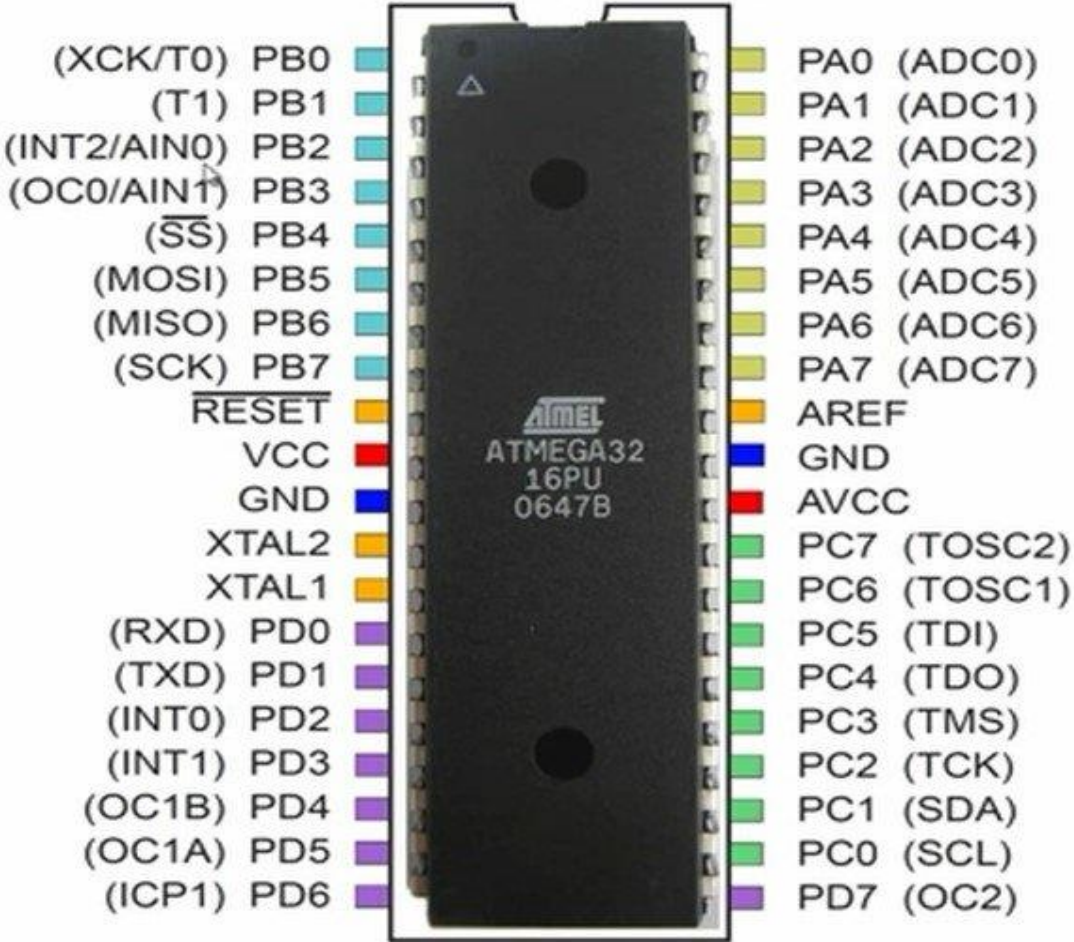
DEMO!

Embedded Software

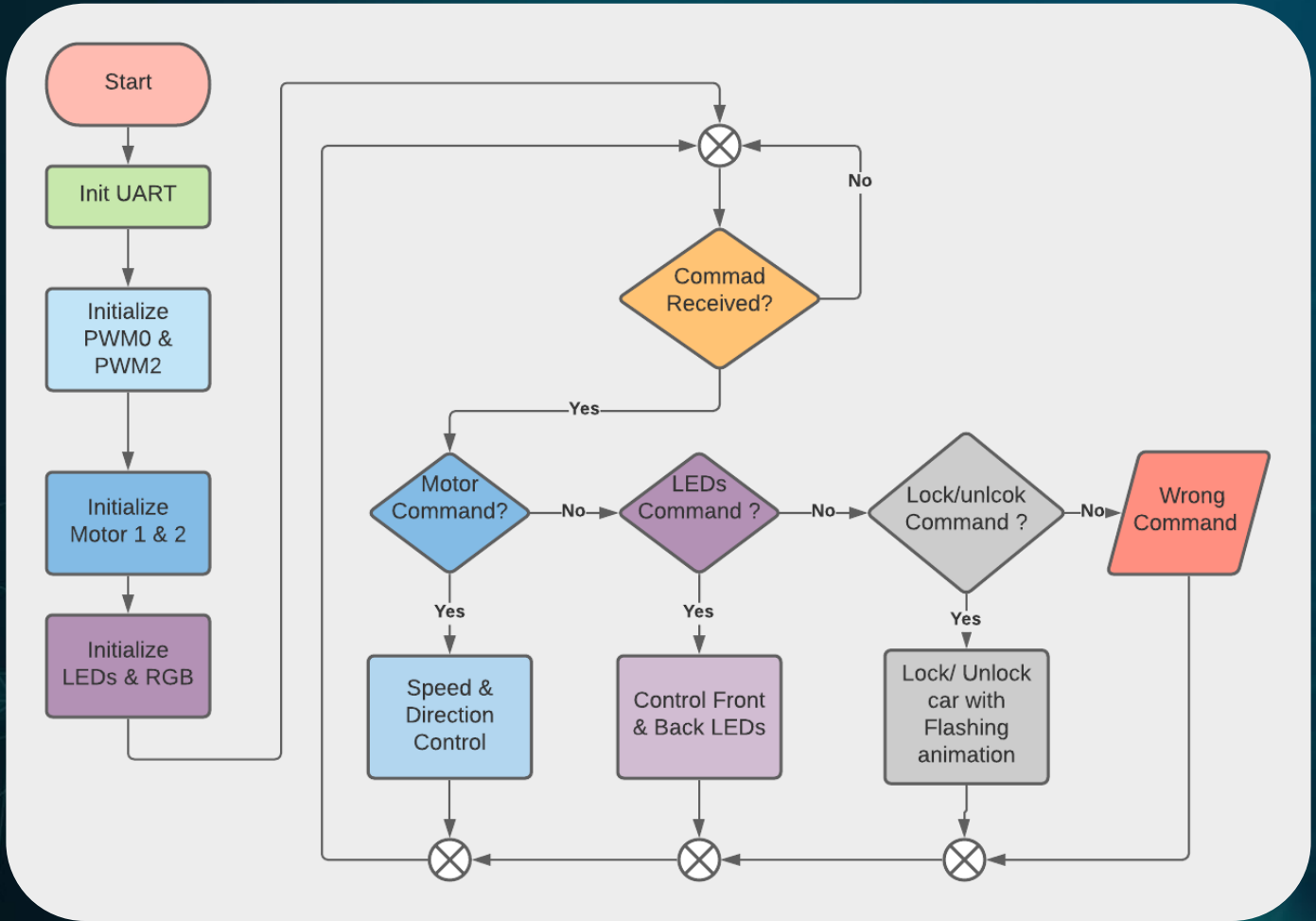
Layer Architecture

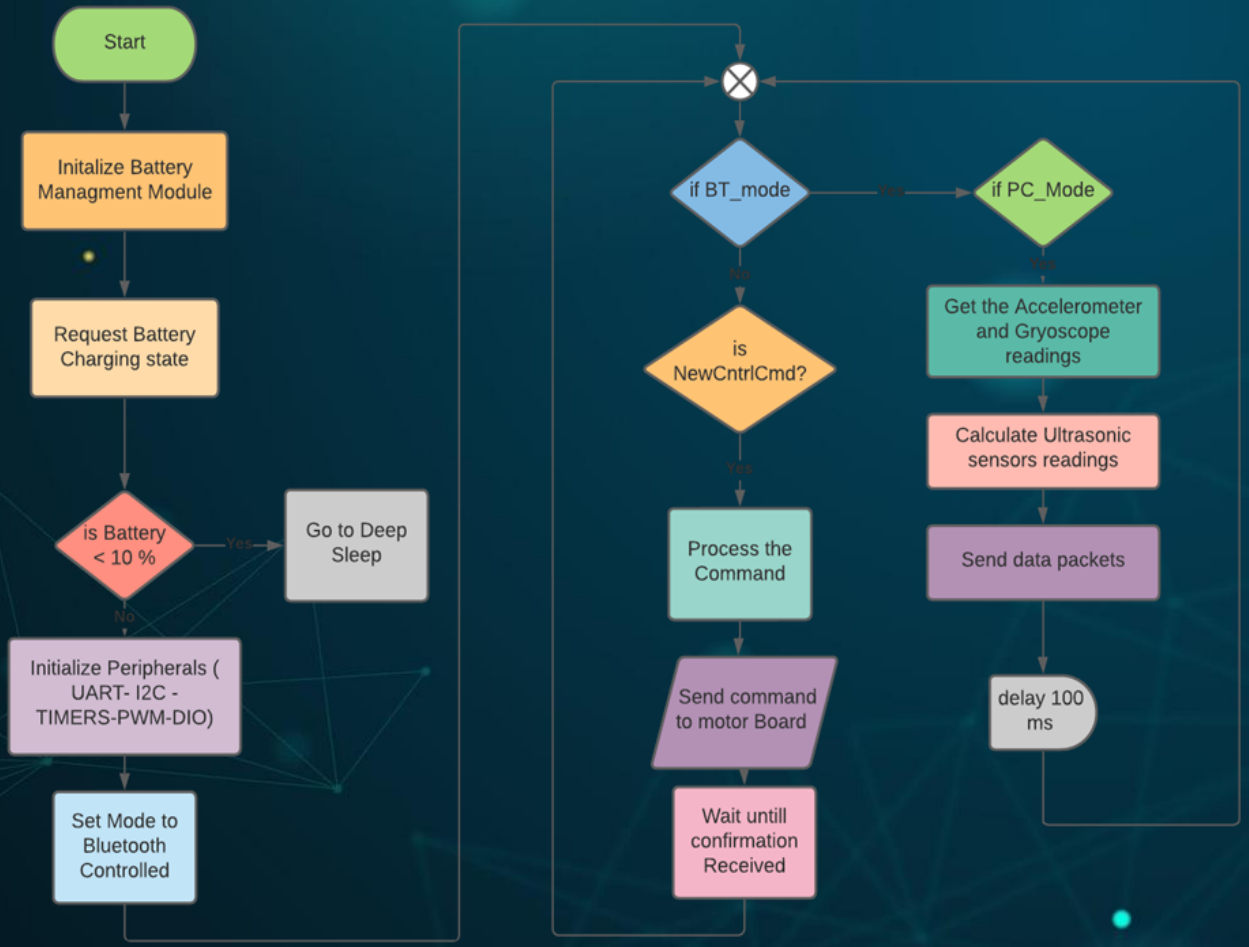


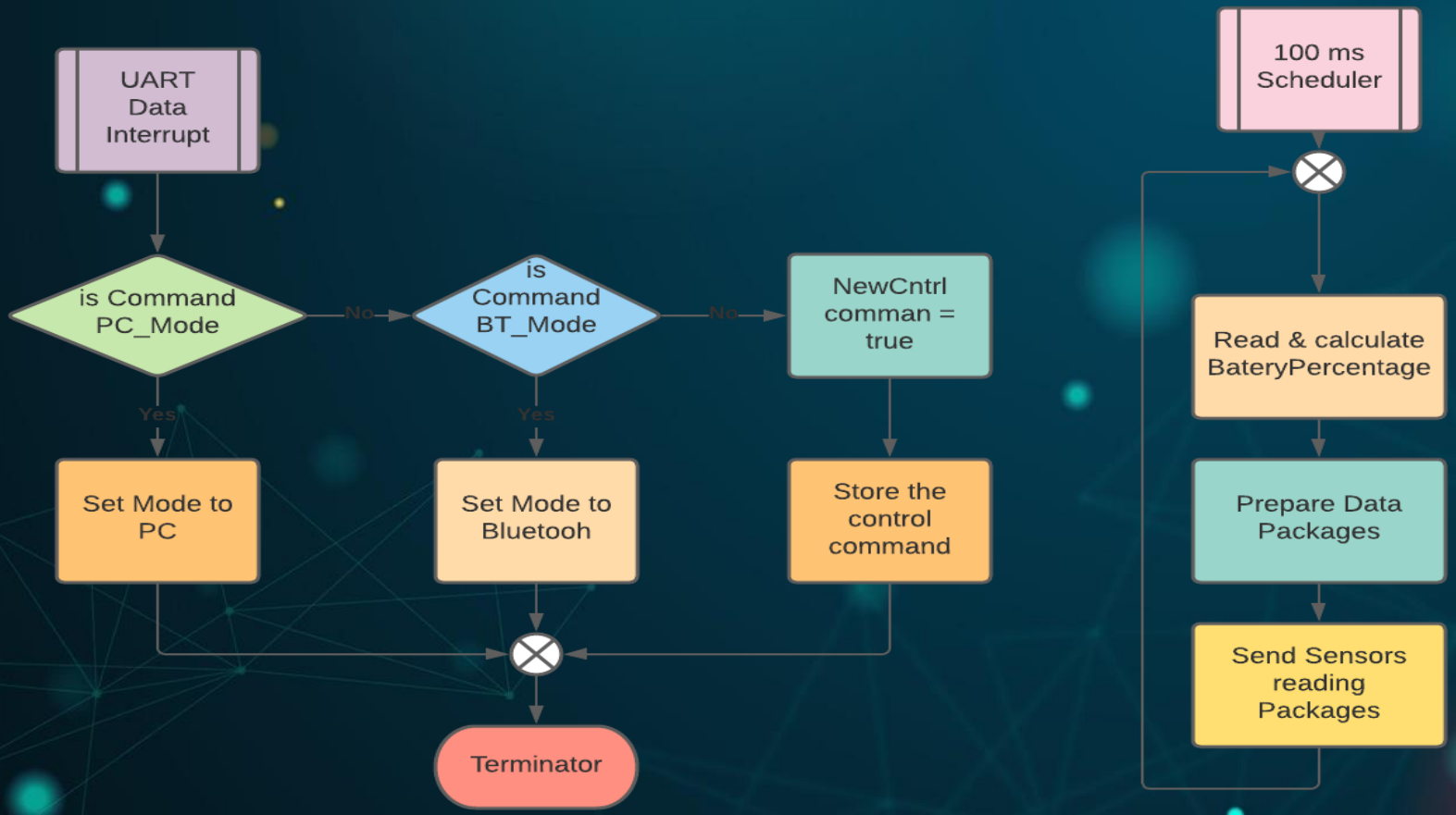
Microcontroller



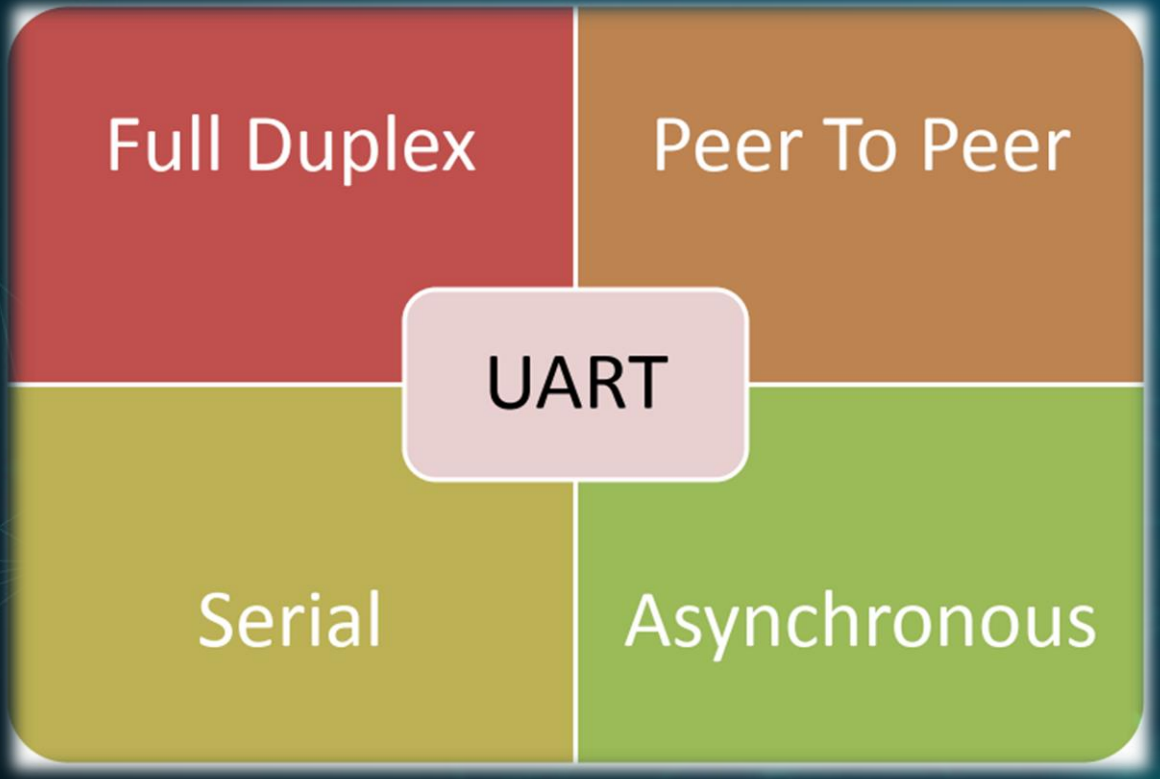
Code


Start
Init UART
Initialize PWM0 & PWM2
Initialize Motor 1 & 2
Initialize LEDs & RGB
Commad Received?
No
Yes
Motor Command?
No
LEDs Command ?
No
Lock/unlcok Command ?
No
Wrong Command
Yes
Yes
Yes
Speed & Direction Control
Control Front & Back LEDs
Lock/ Unlock car with Flashing animation

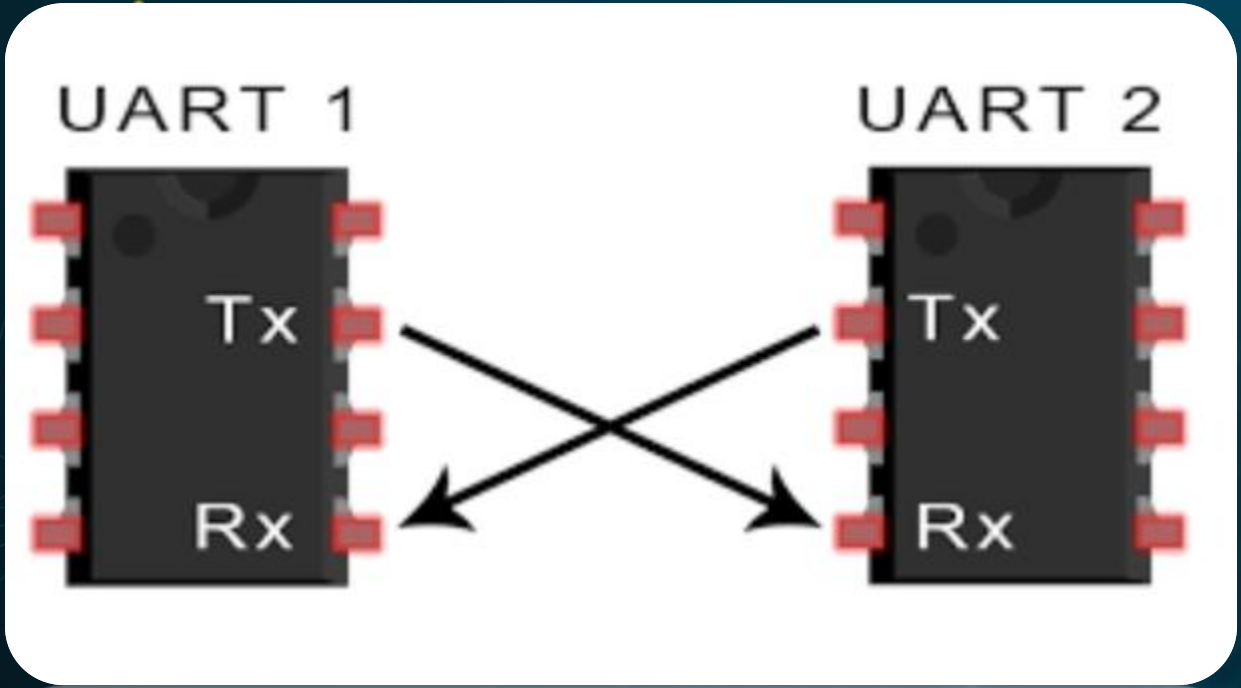

Start
Initalize Battery Managment Module
Request Battery Charging state
is Battery < 10 %
Yes
Go to Deep Sleep
No
Initialize Peripherals (UART- I2C - TIMERS-PWM-DIO)
Set Mode to Bluetooth Controlled
if BT_mode
Yes
if PC_Mode
No
is NewCntrlCmd?
Yes
Process the Command
Send command to motor Board
Wait untill confirmation Received
Yes
Get the Accelerometer and Gryoscope readings
Calculate Ultrasonic sensors readings
Send data packets
delay 100 ms


UART Data Interrupt
is Command PC_Mode
No
is Command BT_Mode
No
NewCntrl comman = true
Yes
Yes
Set Mode to PC
Set Mode to Bluetooh
Store the control command
Terminator
100 ms Scheduler
Read & calculate BateryPercentage
Prepare Data Packages
Send Sensors reading Packages

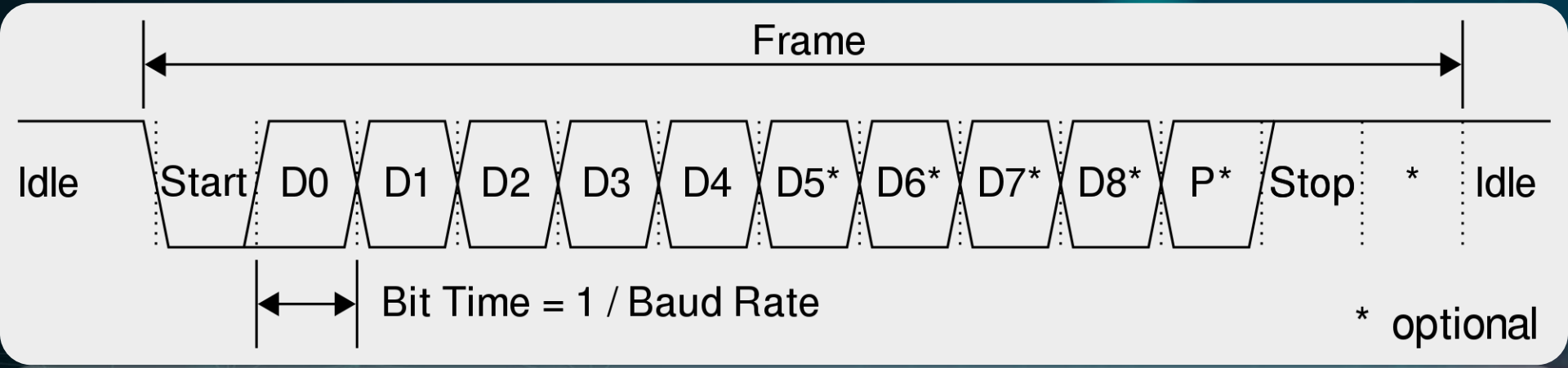
Serial Communication
UART



Communication Connection



UART Frame


Frame
Idle
Start
D0
D1
D2
D3
D4
D5*
D6*
D7*
D8*
P*
Stop
*
Idle
Bit Time = 1 / Baud Rate
* optional

Commands

M2F	Set Back Motor Forward
M2B	Set Back Motor Back
M2S	Set Back Motor Stop
M2X	Set Back Motor Break
M2V	Set New Speed for Back Motor
M1R	Set Front Motor Right
M1L	Set Front Motor Left
M1S	Set Front Motor Stop
M1X	Set Front Motor Break
M1D?	Asking for Direction (R or L)
COF	Lock Car Off (Car OFF)
CON	Unlock Car (Car ON)
LFOR	Turn ON Light of Front Right
LFOL	Turn ON Light of Front Left
LFFR	Turn OFF Light of Front Right
LFFL	Turn OFF Light of Front Left
LBOR	Turn ON Light Of Back Right
LBOL	Turn ON Light Of Back Left
LBFR	Turn OFF Light Of Back Right
LBFL	Turn OFF Light Of Back Left

THANKS!