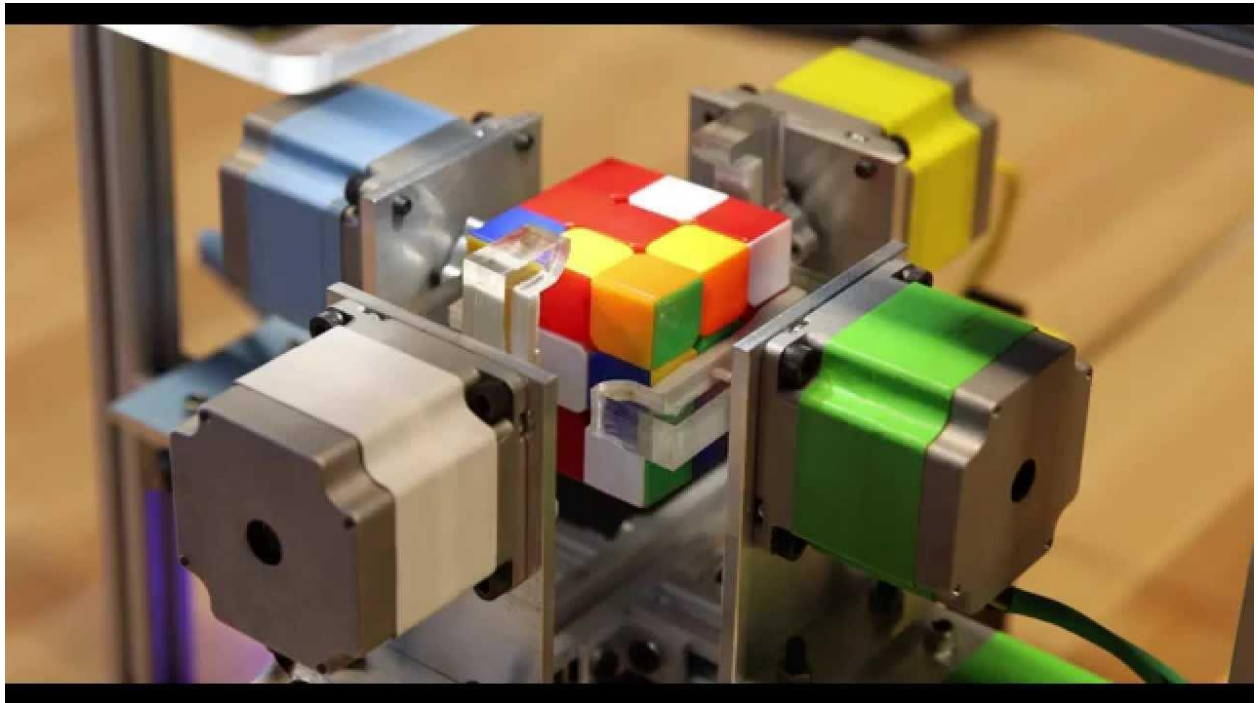
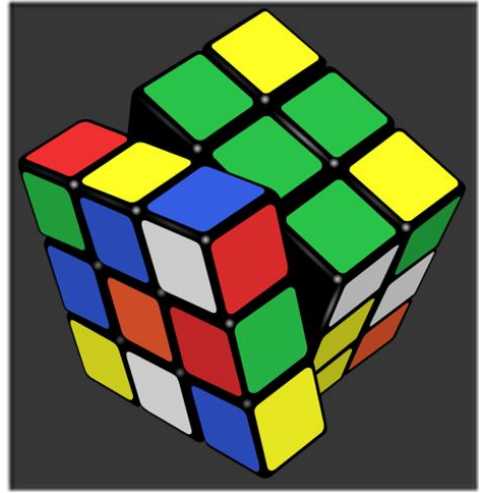


RUBIK'S CUBE SOLVING ROBOT





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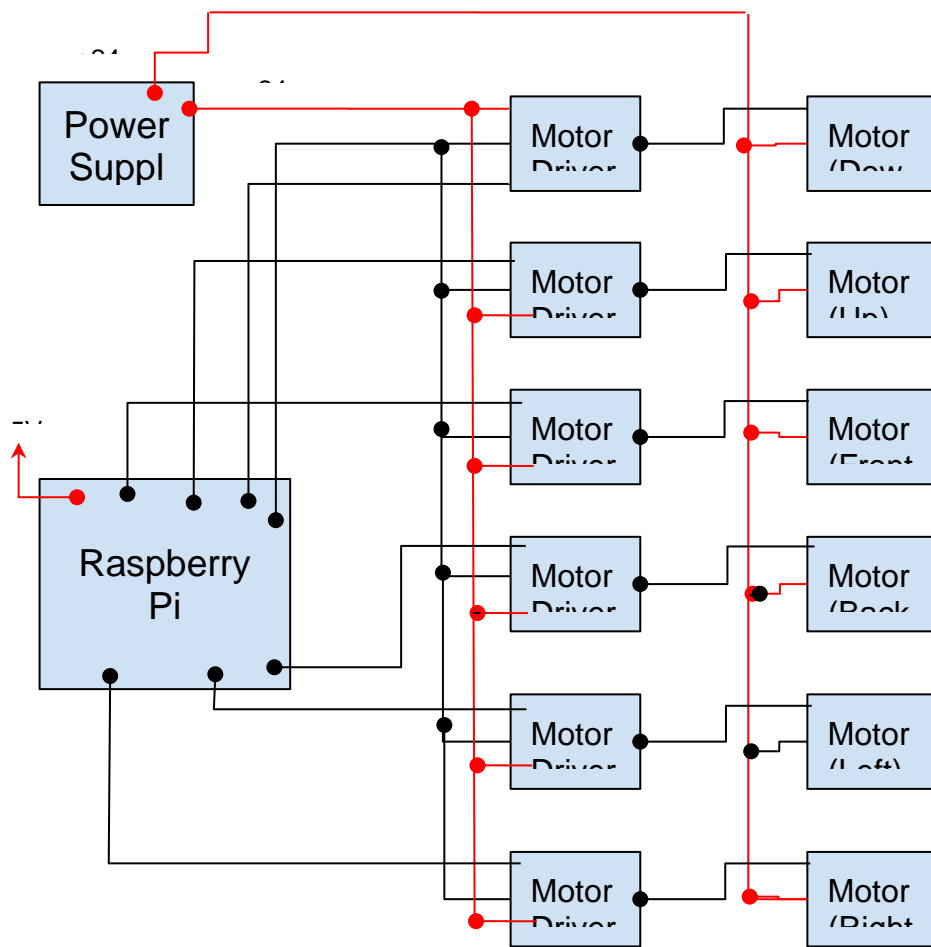
Introduction

There are many approaches on how to solve the Rubik's Cube. All these methods have different levels of difficulties, for speedcubers or beginners, even for solving the cube blindfolded. People usually get stuck solving the cube after completing the first face, after that they need some help.

So we implemented a robot who can solve this rubik's cube easily.

Plan

For the final result, we wanted to make a robot which can shuffle the cube randomly and read each color of the cube with the camera attached on it. From the data, the robot can automatically solve the rubik's cube.



Hardware

For our robot we used,

Raspberry pi

Stepper motors

Motor drivers

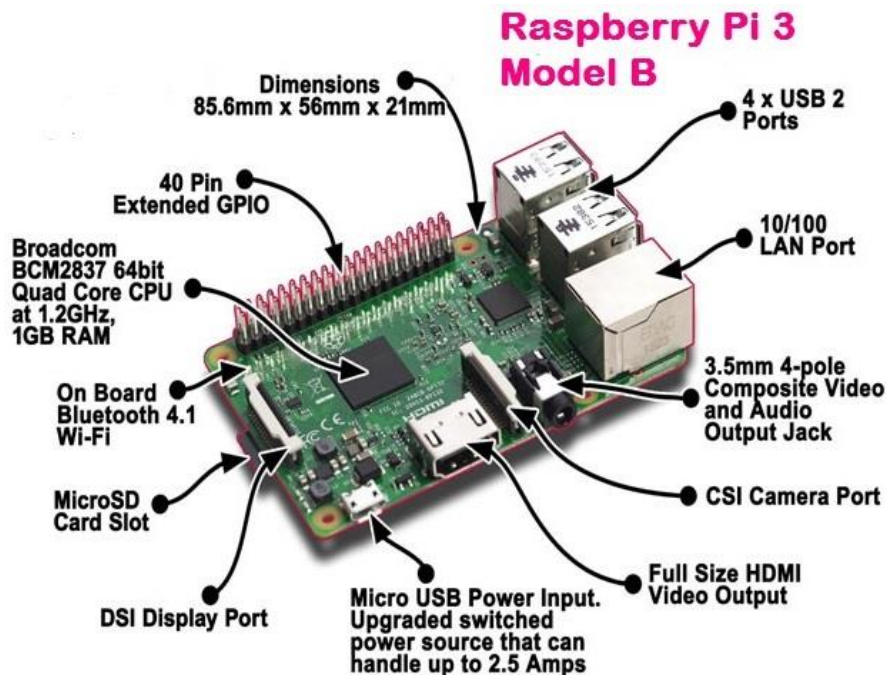
Web Camera

Rubik's Cube

LED (for lightning)

Raspberry pi

I would like to introduce Raspberry Pi as a world's most inexpensive and powerful Single Board Computer. We have used raspberry Pi 3 Model B for our robot.



02

Raspberry Pi 3 Model B Features

CPU: Raspberry Pi 3 uses Broadcom BCM2837 SOC 64-bit quad-core ARM Cortex A53 (ARMv8 CPU) with 512KB shared L2 cache.

Memory: Provided with 1 GB of RAM

Wi-Fi Support: 802.11n Wireless LAN

Bluetooth: Supports Bluetooth 4.1 Bluetooth Low Energy (BLE)

USB Ports: 4-USB ports which allow attaching four different USB devices like keyboard, mouse, etc.

Ethernet Port: Standard Ethernet port to quickly setup and access internet. This can be very useful when we want to setup raspberry pi for the first time without a monitor.

GPIO Pins: Raspberry Pi 3 supports 40 GPIO Pins General Purpose Input Output. These digital input/output pins can be used to drive LED, Switches, and Sensors etc.

Full HDMI Port: Support HDMI port (High-Definition Multimedia Interface) which can be used to quickly connect raspberry pi to HDMI Monitor. With HDMI Cable and Monitor we can add Screen to Raspberry Pi.

Micro SD card slot: The Micro SD Card will hold the operating system which will boot while we power on Raspberry Pi 3. In next tutorial, we will learn how to setup and prepare SD card with Raspbian OS.

Audio/Video: Combined 3.5mm audio jack and composite video

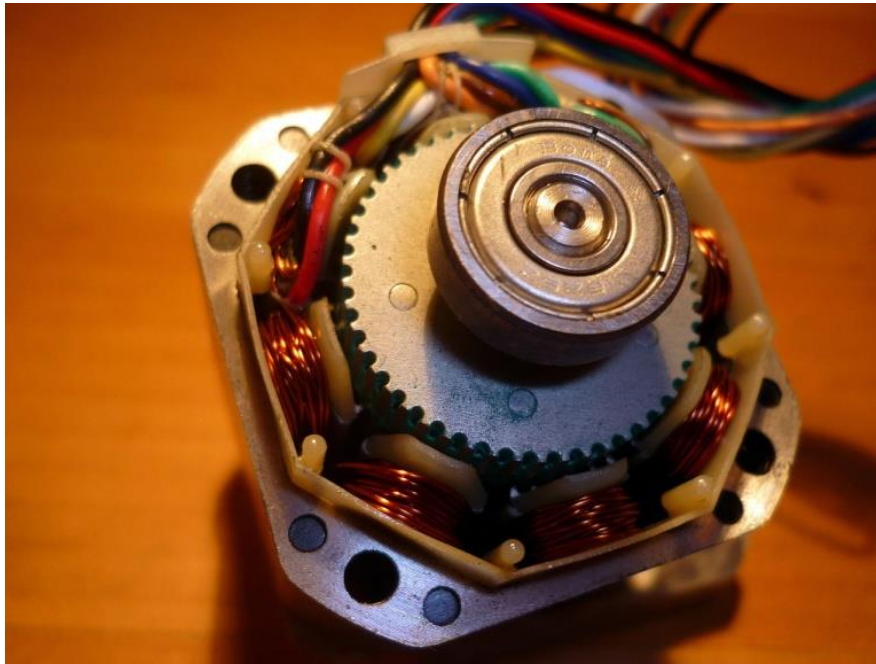
Display interface (DSI): enable us to interface Display Module

Camera interface (CSI): enable us to interface Camera Module

Graphics Support: VideoCore IV 3D graphics core for advance graphics capabilities.

Stepper motors

A stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.



The stepper motor is known by its property to convert a train of input pulses (typically square wave pulses) into a precisely defined increment in the shaft position. Each pulse moves the shaft through a fixed angle.

There 2 main types of stepper motors,

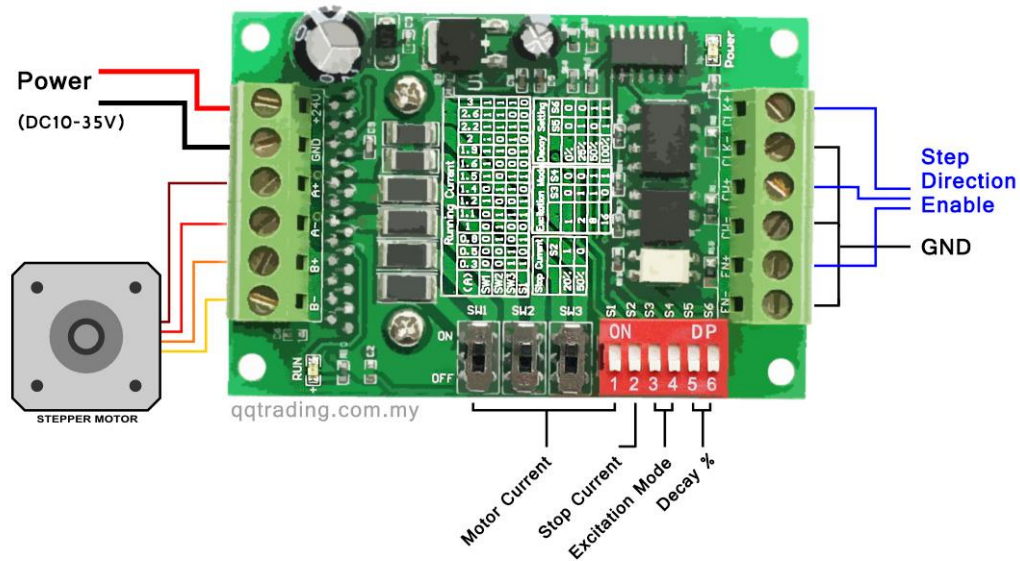
- Unipolar Stepper motor
- Bipolar Stepper motor

We have used unipolar stepper motor for our robot.

Motor drivers

The drive (or amplifier) converts the indexer command signals into the power necessary to energize the motor windings. There are numerous types of drives, with different

voltage and current ratings and construction technology. We used TB6560 motor driver for our robot.



Web Camera

We need to identify the colors of the shuffled cube for that we used a web camera.



LED bulb

We used a LED bulb for lightning purposes.

Software

Python

- Kociemba
- OpenCV

Python

Python is an interpreted high-level programming language for general-purpose programming. For program raspberry pi we used python language. We mainly used two libraries for our programming purpose.

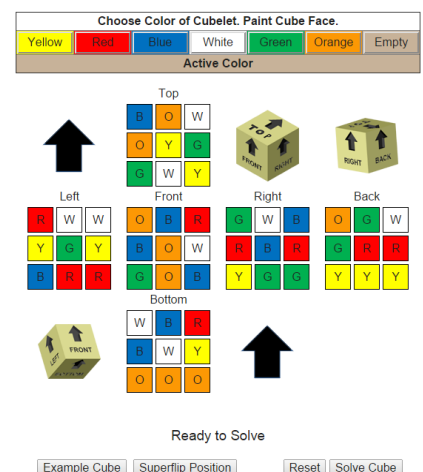
They are,

- **Kociemba**
- **OpenCV**

Kociemba

We used this library to solve the rubik's cube. It's a computer algorithm for solving the 3x3x3 cube, created by Herbert Kociemba. It is similar to the Thistlethwaite's algorithm though with fewer steps.

The package exposes just one function `solve()`, which accepts a cube definition string and returns a solution string in standard notation (see below). Optional second argument allows solving to a specific pattern.



```
>>> import kociemba
```

```
>>>
```

```
kociemba.solve('DRLUUBFBRBLURRLRUBLRDDFDLFUFUFFDBRDUBRUFLLFDDBF  
LUBLRBD')
```

```
u"D2 R' D' F2 B D R2 D2 R' F2 D' F2 U' B2 L2 U2 D R2 U"
```

```
>>>
```

```
kociemba.solve('FLBUULFFLFDURRDBUBUUDDFBRRDDBLRDRFLLRLRULFUDRRB  
DBBBUFL',
```

```
'BBURUDBFUFFFFRRFUUFLULUFUDLRRDBBDBDBLUDDFLLRRBRLLLBRDDF')
```

```
u"R' D2 R' U2 R F2 D B2 U' R F' U R2 D L2 D' B2 R2 B2 U' B2"
```

When installing with pip, kociemba will also register a command line tool with the same name. So you can also use it like this:

```
$ kociemba <cubestring>
```

The names of the facelet positions of the cube (letters stand for Up, Left, Front, Right, Back, and Down):

	*U1**U2**U3*	

	*U4**U5**U6*	

	*U7**U8**U9*	

*****	*****	*****
*L1**L2**L3*	*F1**F2**F3*	*R1**R2**R3* *B1**B2**B3*
*****	*****	*****
*L4**L5**L6*	*F4**F5**F6*	*R4**R5**R6* *B4**B5**B6*
*****	*****	*****
*L7**L8**L9*	*F7**F8**F9*	*R7**R8**R9* *B7**B8**B9*
*****	*****	*****

	*D1**D2**D3*	

	*D4**D5**D6*	

	*D7**D8**D9*	

A cube definition string "UBL..." means that in position U1 we have the U-color, in position U2 we have the B-color, in position U3 we have the L color etc. according to the order U1, U2, U3, U4, U5, U6, U7, U8, U9, R1, R2, R3, R4, R5, R6, R7, R8, R9, F1, F2,

F3, F4, F5, F6, F7, F8, F9, D1, D2, D3, D4, D5, D6, D7, D8, D9, L1, L2, L3, L4, L5, L6, L7, L8, L9, B1, B2, B3, B4, B5, B6, B7, B8, B9.

So, for example, a definition of a solved cube would be

UUUUUUUUUURRRRRRRRRRFFFFFFFFFDDDDDDDDDDLLLLLLLLLLBBBBBBBBB

Solution string consists of space-separated parts, each of them represents a single move:

- A single letter by itself means to turn that face clockwise 90 degrees.
- A letter followed by an apostrophe means to turn that face counterclockwise 90 degrees.
- A letter with the number 2 after it means to turn that face 180 degrees.

e.g. R U R' U R U2 R' U

OpenCV

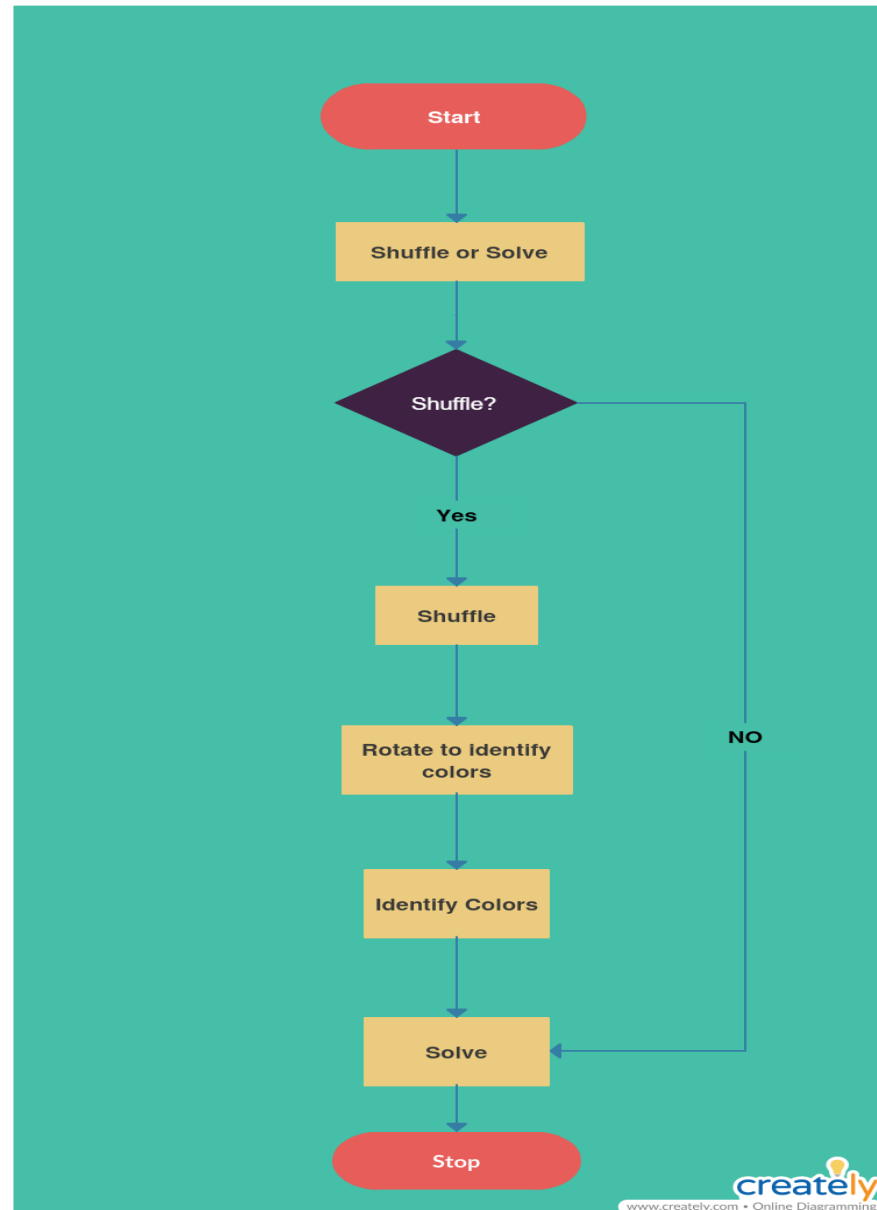
OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library.

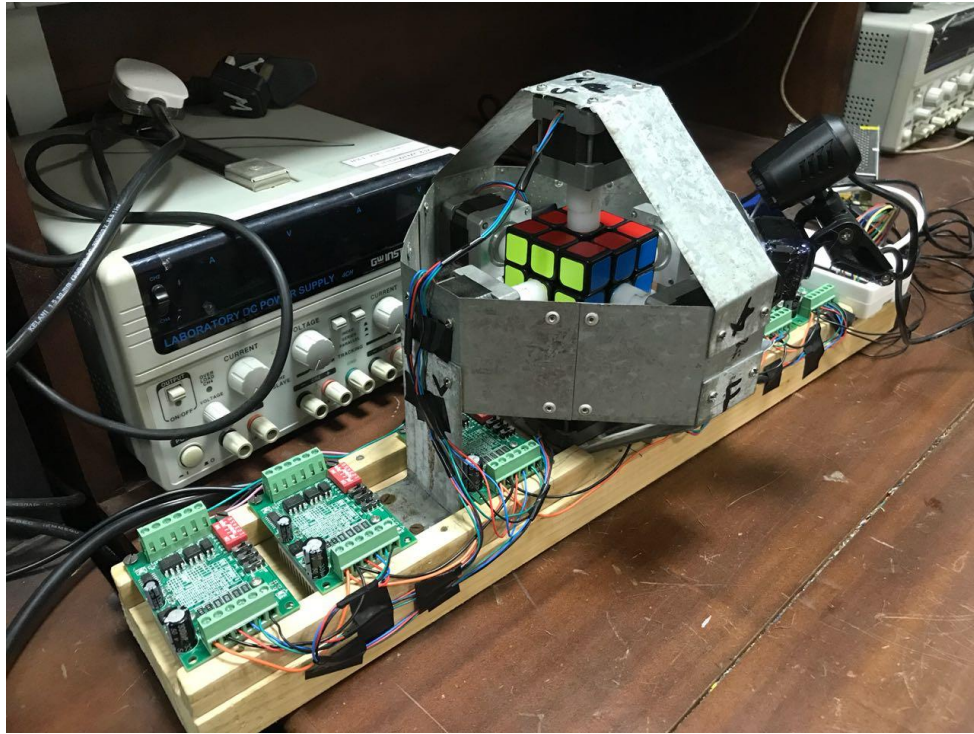
The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to do image processing and machine learning in various streams.



In our project we had to identify six colors in our rubik's cube, it needs image processing. To do that image processing we used openCV.

Process





Final

Output

Future Improvements

We hope to improve this robot to solve any given rubik's cube rather than fixing a specific cube to the robot.(cube can be remove not fix to the robot)