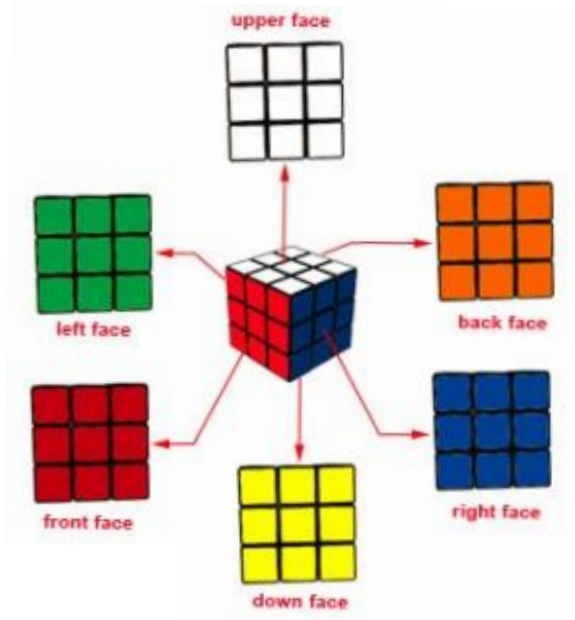
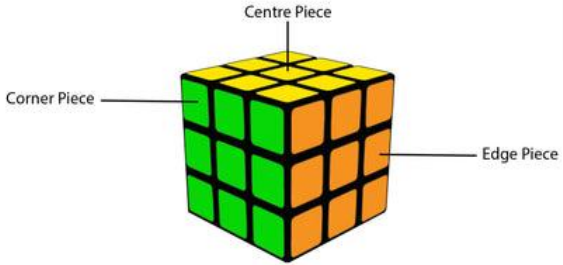
Solving the Rubik's Cube with Computer Vision

Pedro Lopes 97827
Computer Vision - MECT

Introduction

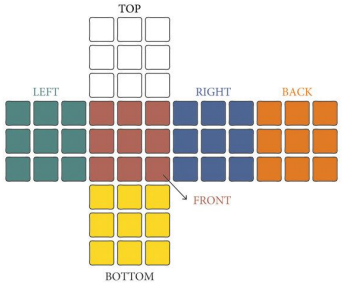
- 3D colorful puzzle;
- Different color schemes, but one notation;
- Each piece has at least 1 color;
- Standard Rubik's cube have a specific configuration;





Goals

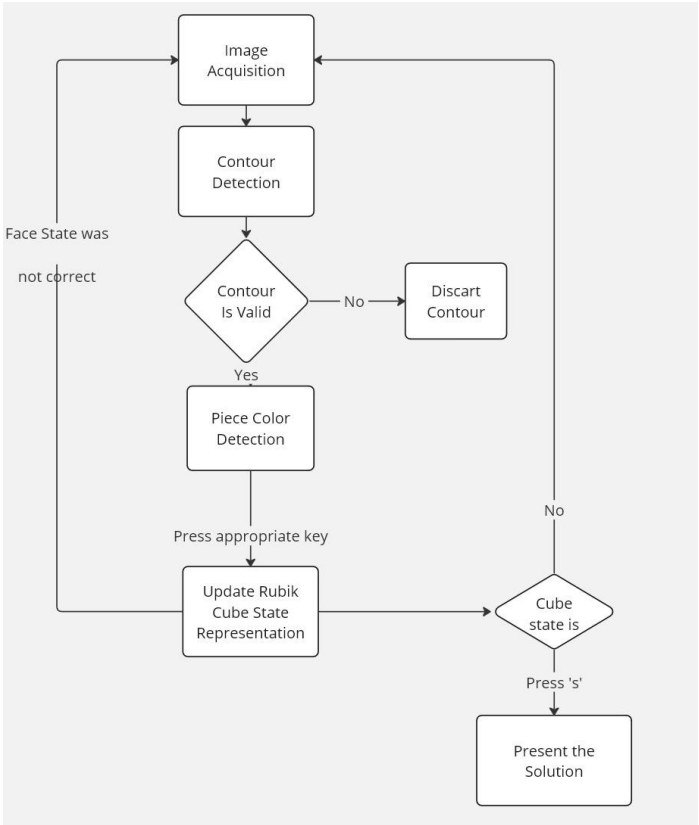
- Identify cube faces;
- Identify facelet color;
- Represent the cube state;
- Orient the user to solve the puzzle;



Workflow

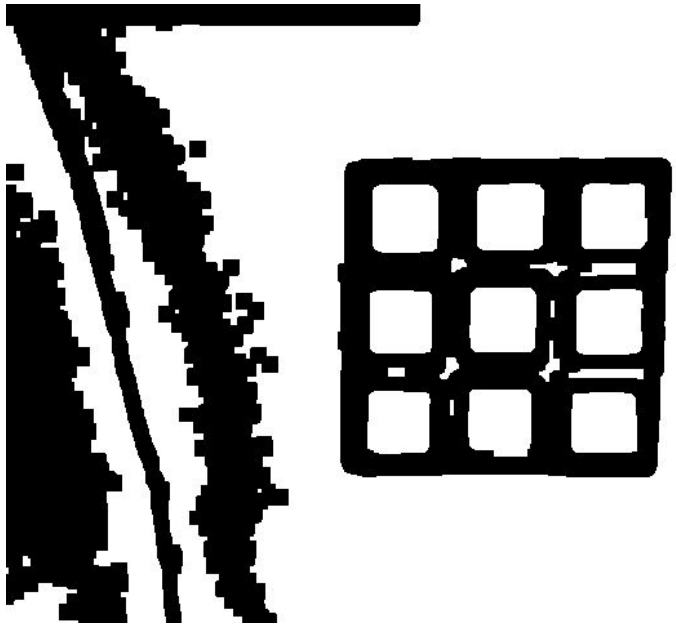
Six stages:

- Image acquisition
- Contour detection
- Contour selection
- Piece color detection
- Rubik cube state representation
- Present the solution



Contour Detection

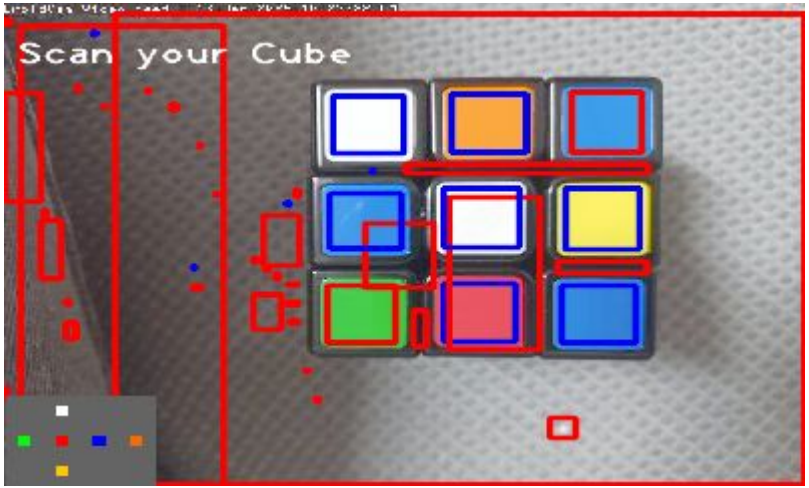
- Gaussian blur
- Thresholding to zero
- Canny



Contour selection

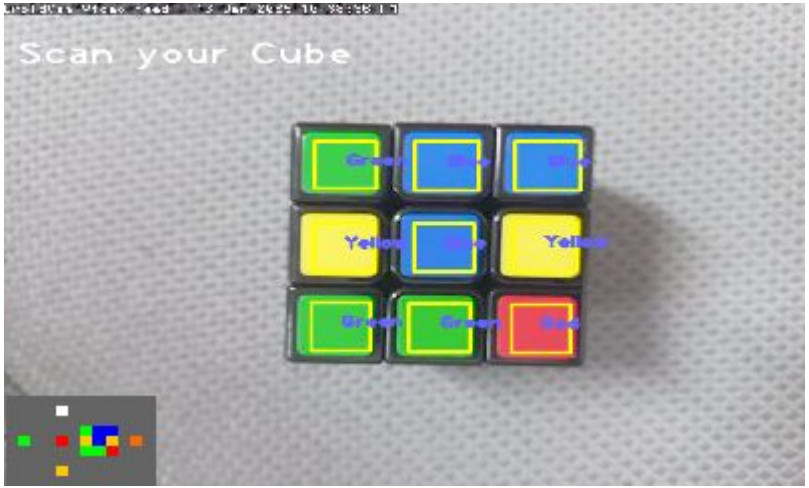
Base rules:

- Contours need to be composed of 4 points
- Each angle must be somewhere between 85 degrees and 95
- The length of every side is approximately the same length as the biggest side



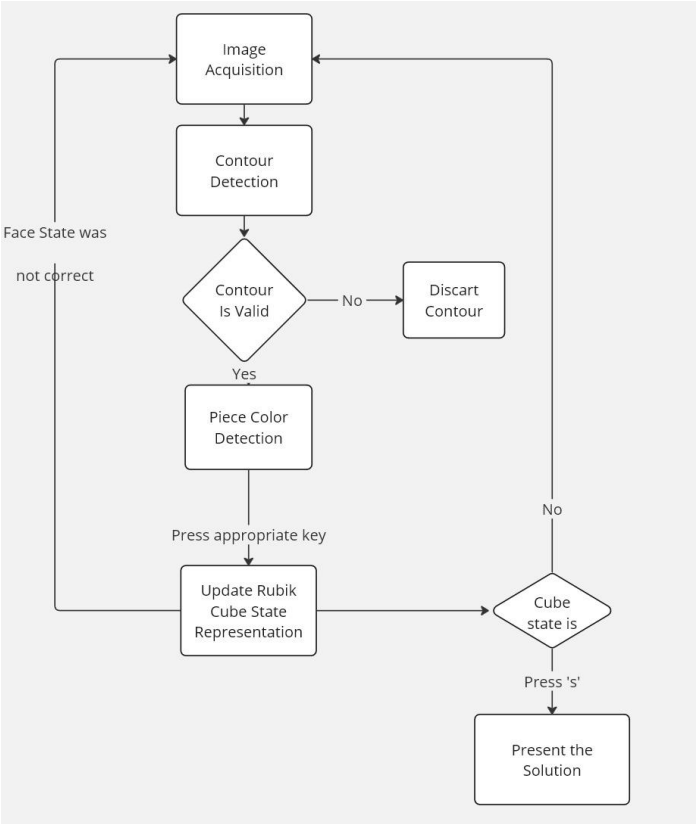
Piece color detection

- Transform BGR Image to HSV
- Use previous defined thresholds to determine pixel color



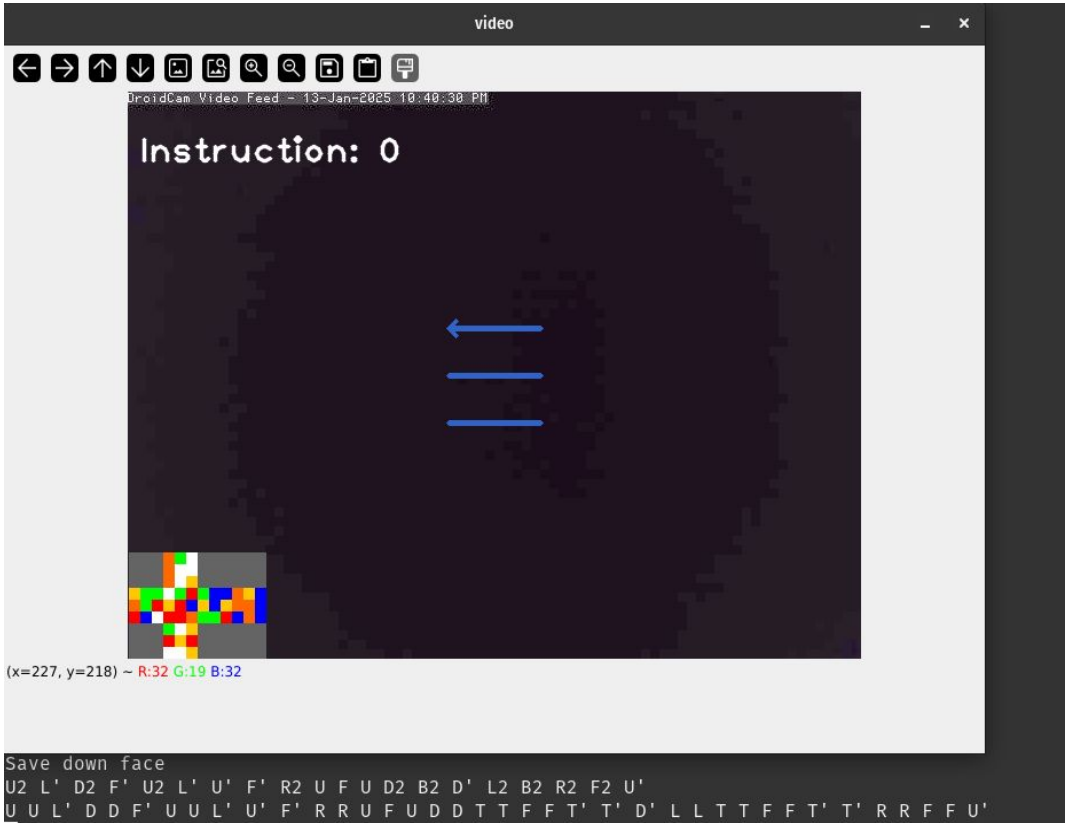
User Interaction

- Scan each face by pressing corresponding letter (F for Front, U for Upper …)
- Check cube state for errors
- Press S for solutions



Kociemba Solutions

- Non trivial
- New users struggle to understand what to do
- Arrowed Lines help to understand what move to make



Limitations

- Only 9 valid contours must appear on the screen
- Lighting conditions affect drastically the outcome
- The official logo needed to be covered
- Too much noise in contour detection
- Python is slow
- Facelets positions are hard to sort

Conclusion

- It was the first time I solved the rubik cube
- Combining different techniques it was possible to determine the cube state
- Using the cube state, a step-by-step guide with simple instructions is presented helping the user solve the cube

Webgrafia

http://programmablebrick.blogspot.com/2017/02/rubiks-cube-tracker-using-opencv.html

https://kociemba.org/math/twophase.htm

https://github.com/muodov/kociemba