Rubik's Cube Solver

6.111 Final Project
Fall 2013

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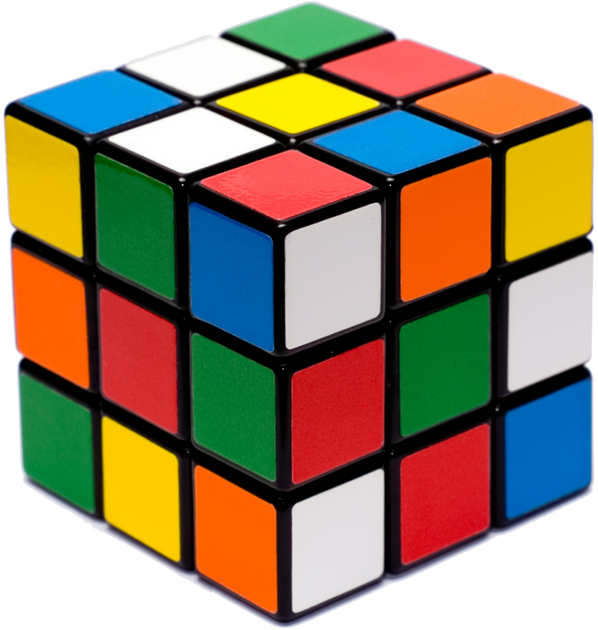
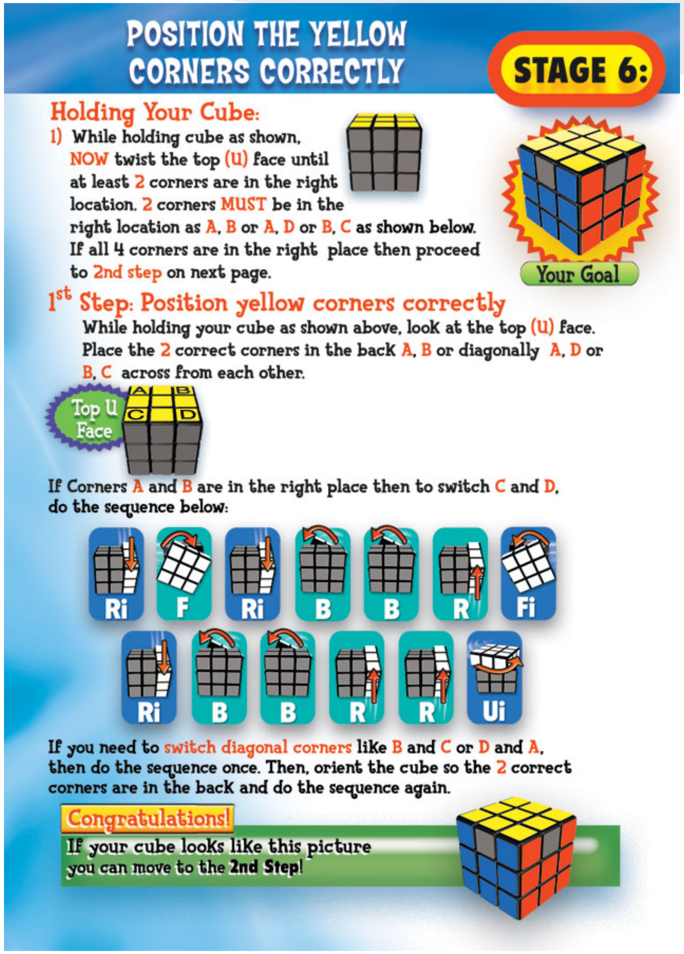
Rubik's Cubes are difficult to solve





POSITION THE YELLOW CORNERS CORRECTLY

STAGE 6:

Holding Your Cube:

1) While holding cube as shown, NOW twist the top (U) face until at least 2 corners are in the right location. 2 corners MUST be in the right location as A, B or A, D or B, C as shown below. If all 4 corners are in the right place then proceed to 2nd step on next page.

1st Step: Position yellow corners correctly

While holding your cube as shown above, look at the top (U) face. Place the 2 correct corners in the back A, B or diagonally A, D or B, C across from each other.

If Corners A and B are in the right place then to switch C and D, do the sequence below:

Ri F Ri B B R Fi

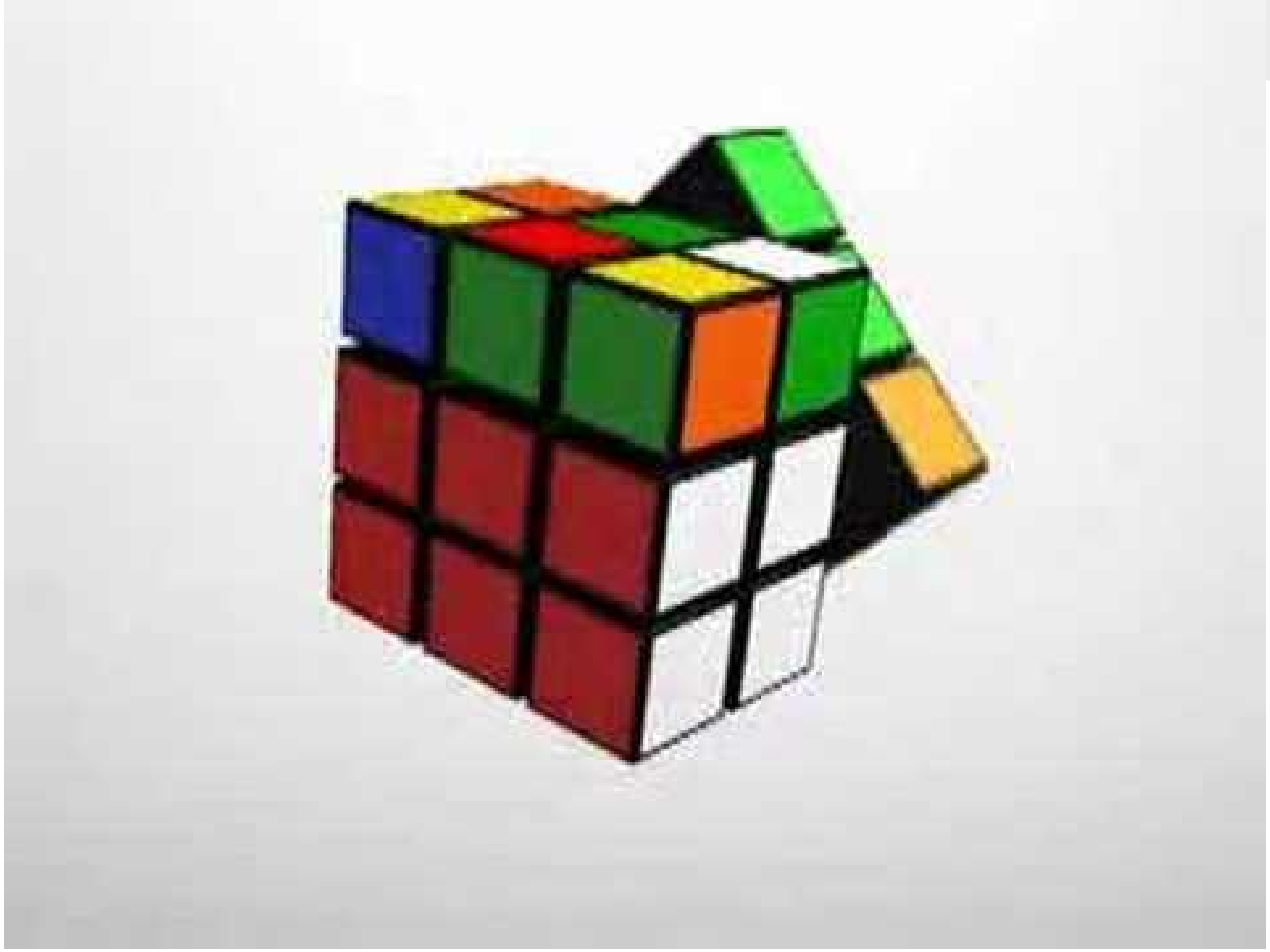
Ri B B R R Ui

If you need to switch diagonal corners like B and C or D and A, then do the sequence once. Then, orient the cube so the 2 correct corners are in the back and do the sequence again.

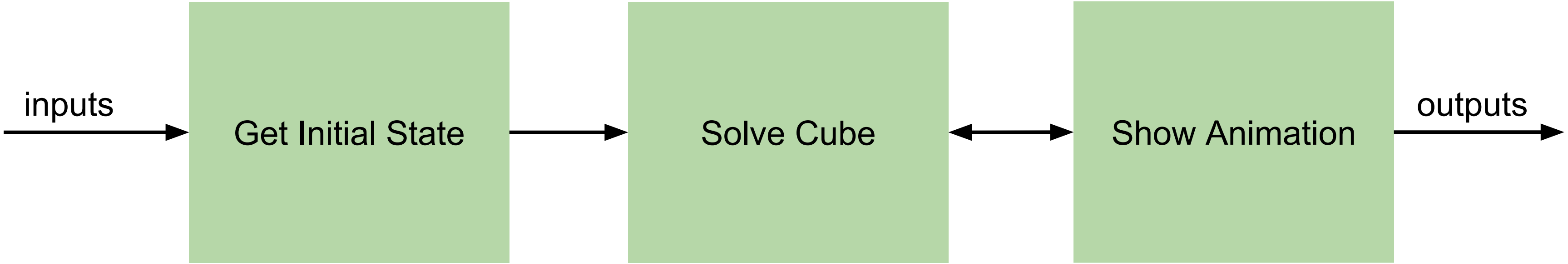
Congratulations!

If your cube looks like this picture you can move to the **2nd Step**!

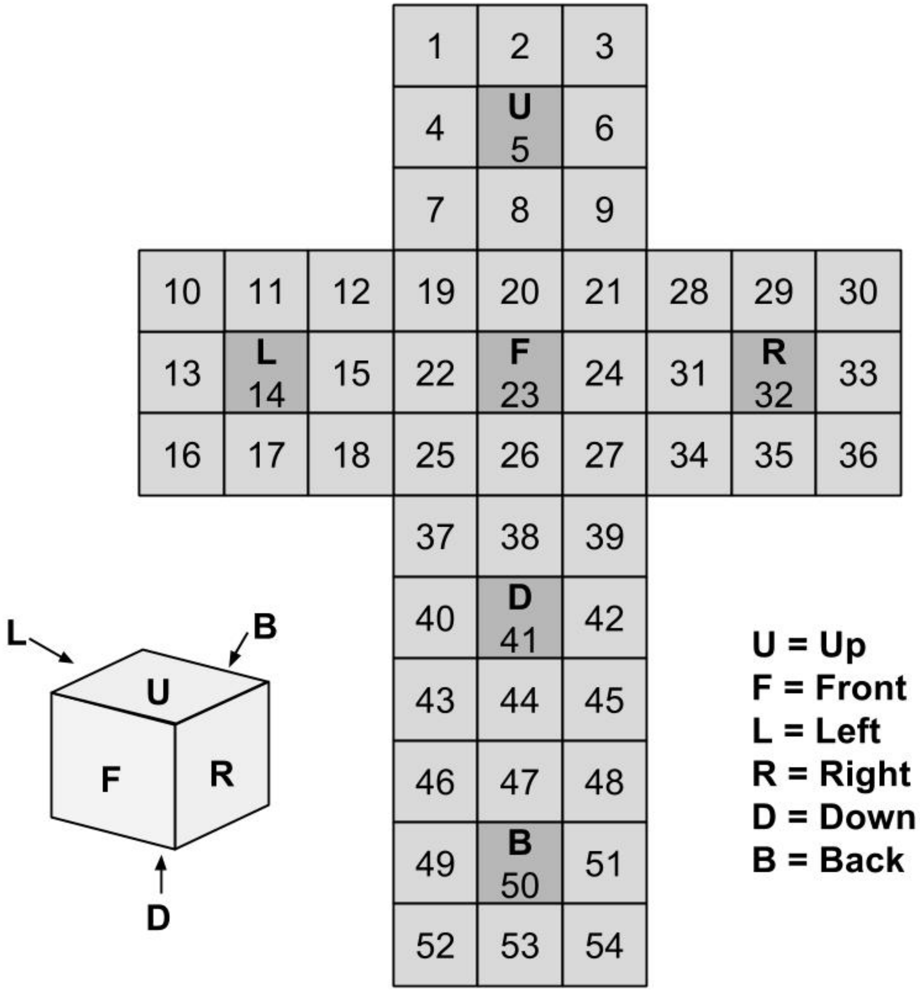
An animated solution would be helpful



The solution is divided into three parts



The cube configuration must be represented consistently

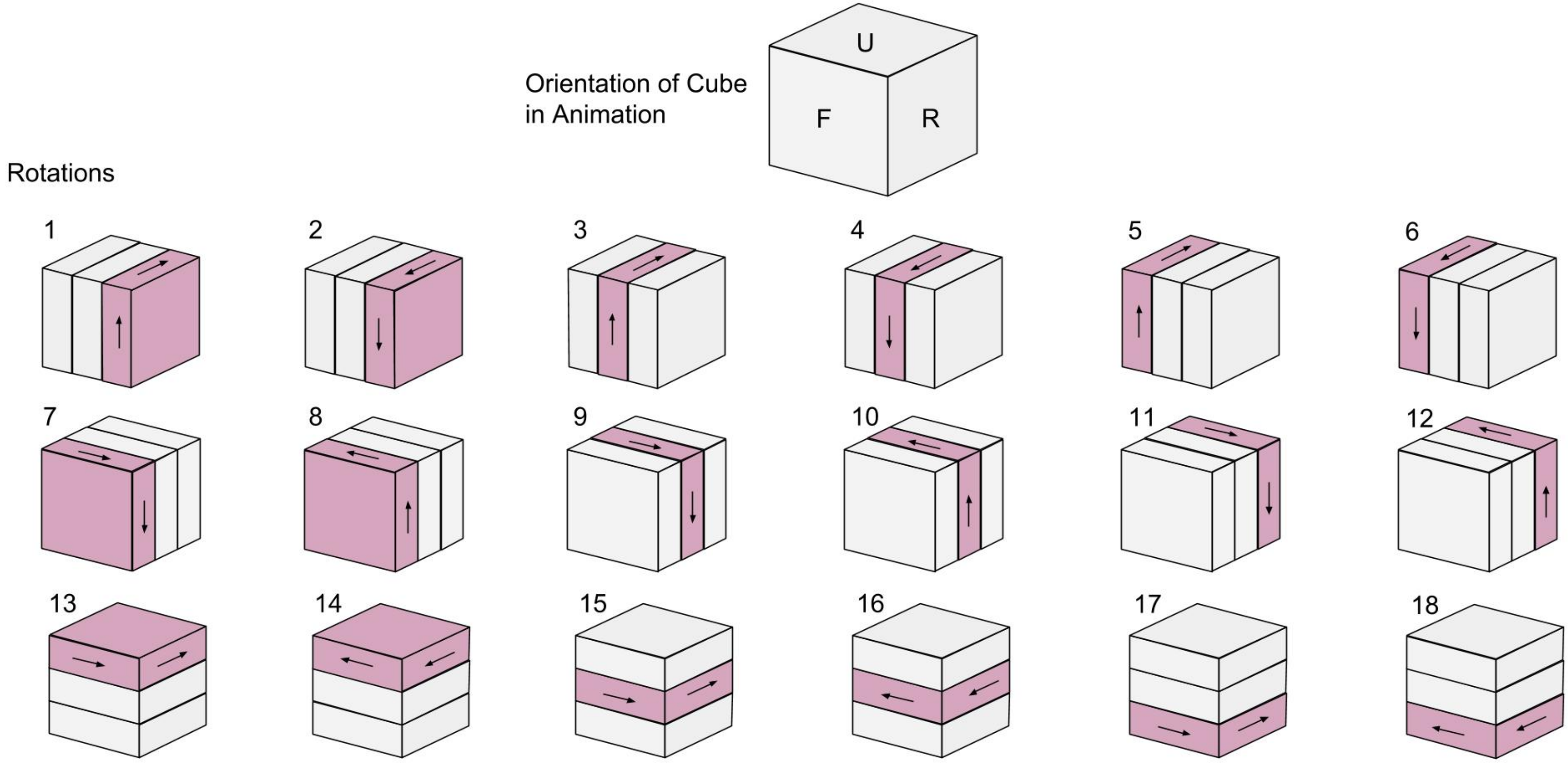


U = Up
F = Front
L = Left
R = Right
D = Down
B = Back

- 6 colors -> 3 bits
- 54 cubelet faces

- 3(54) = 162 bit representation

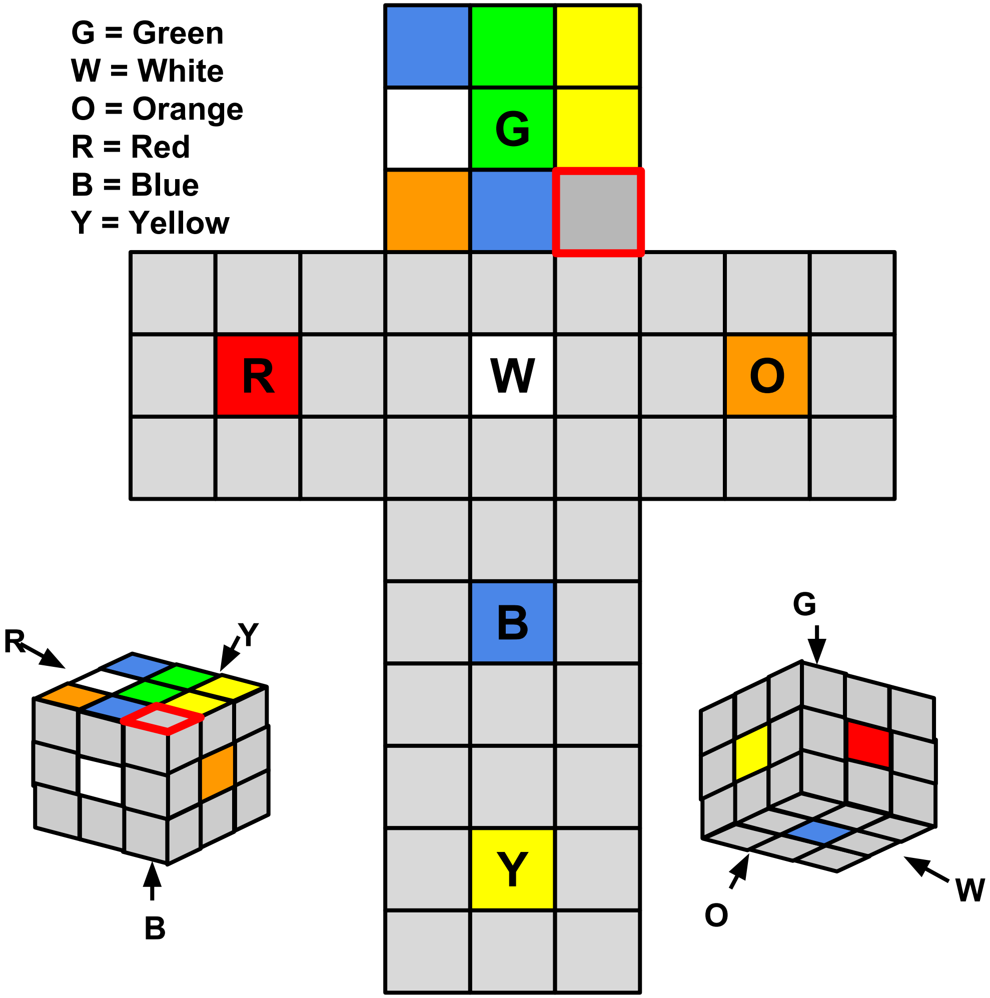
The rotations must be specified consistently



- 18 rotations -> 5 bits

Step 1: Gather the starting configuration

G = Green
W = White
O = Orange
R = Red
B = Blue
Y = Yellow



- Cross image (opposite) displayed on-screen.
- Scroll through cubelet faces using arrow buttons.
- Input colour with correct button.
- When complete system checks to ensure configuration is valid

Step 2: Choose an algorithm

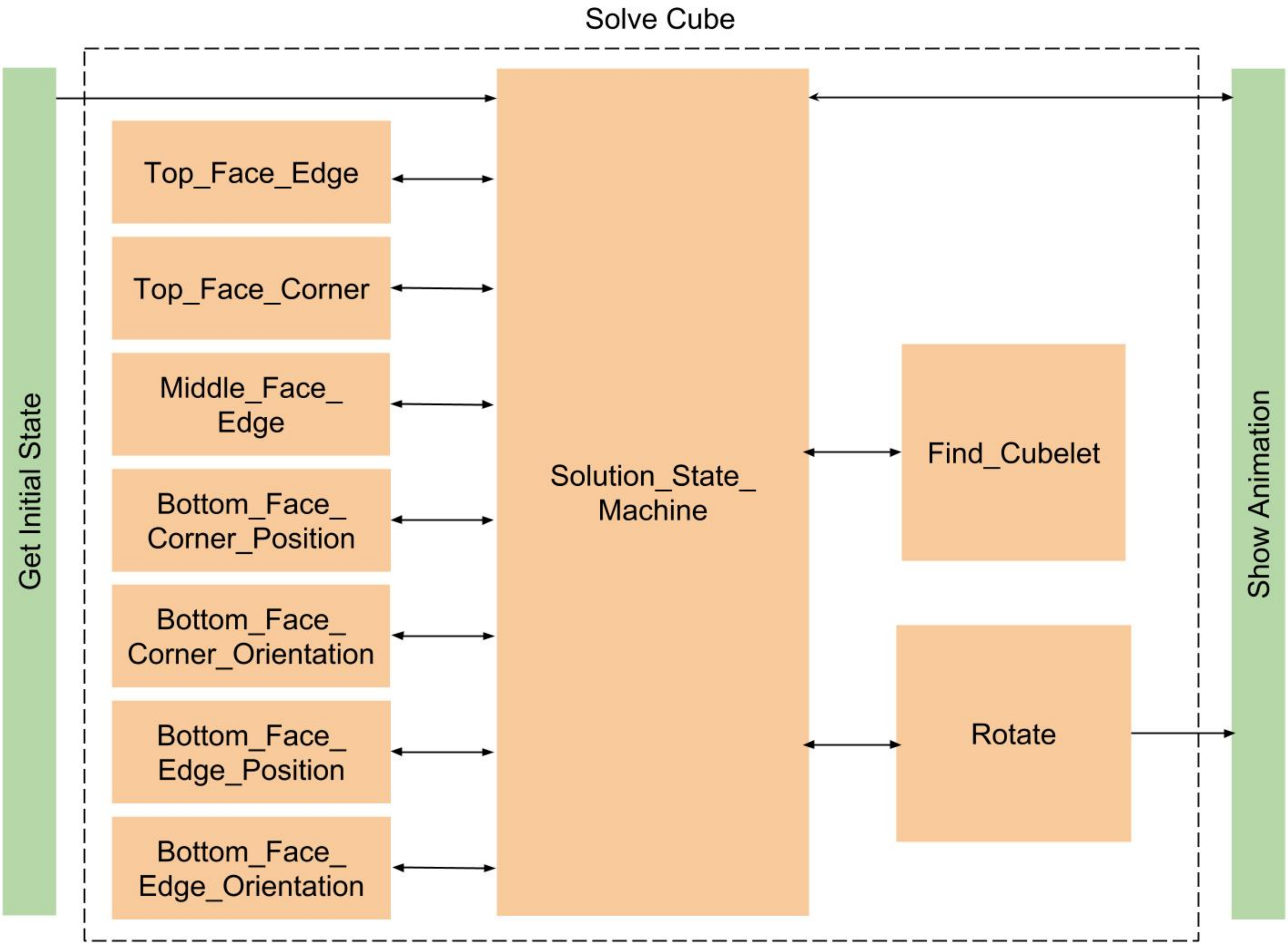
Algorithm Tradeoffs:

- Number of rotations vs. Memory required
- More than 4.3 x 10^{19} starting configurations

Decision:

- 7 step solution
- Solve top, then middle, then bottom layer

Step 2: Use a state machine



Step 3: Animate solution

- Display cube in 3D on screen
- Use matrix multiplication to rotate image

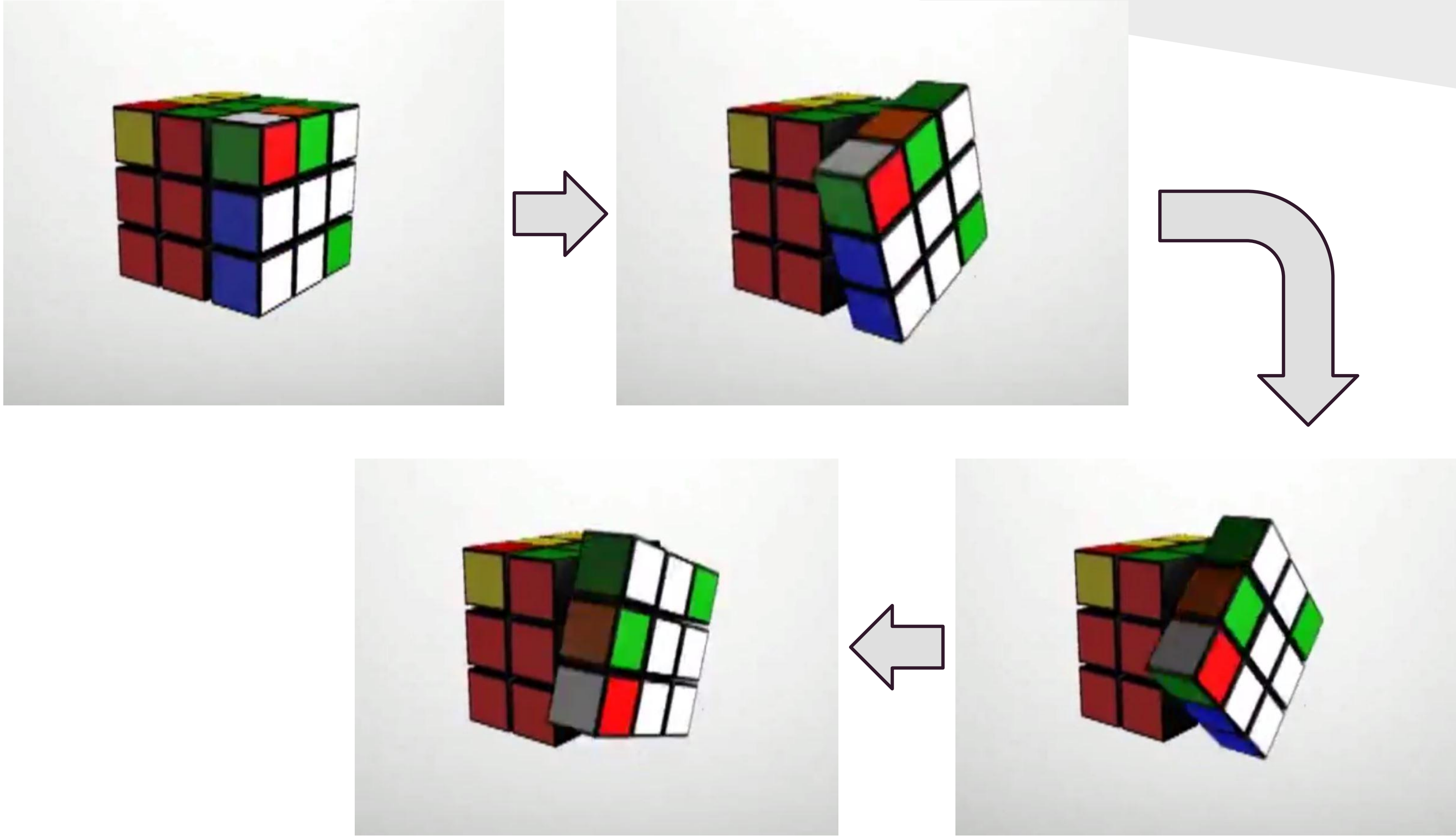
$$R_x(\theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

- Rotator sub-module to carry out animation
  - sends rotation matrix values to 3D renderer
- 2 buffers - one to store calculation results

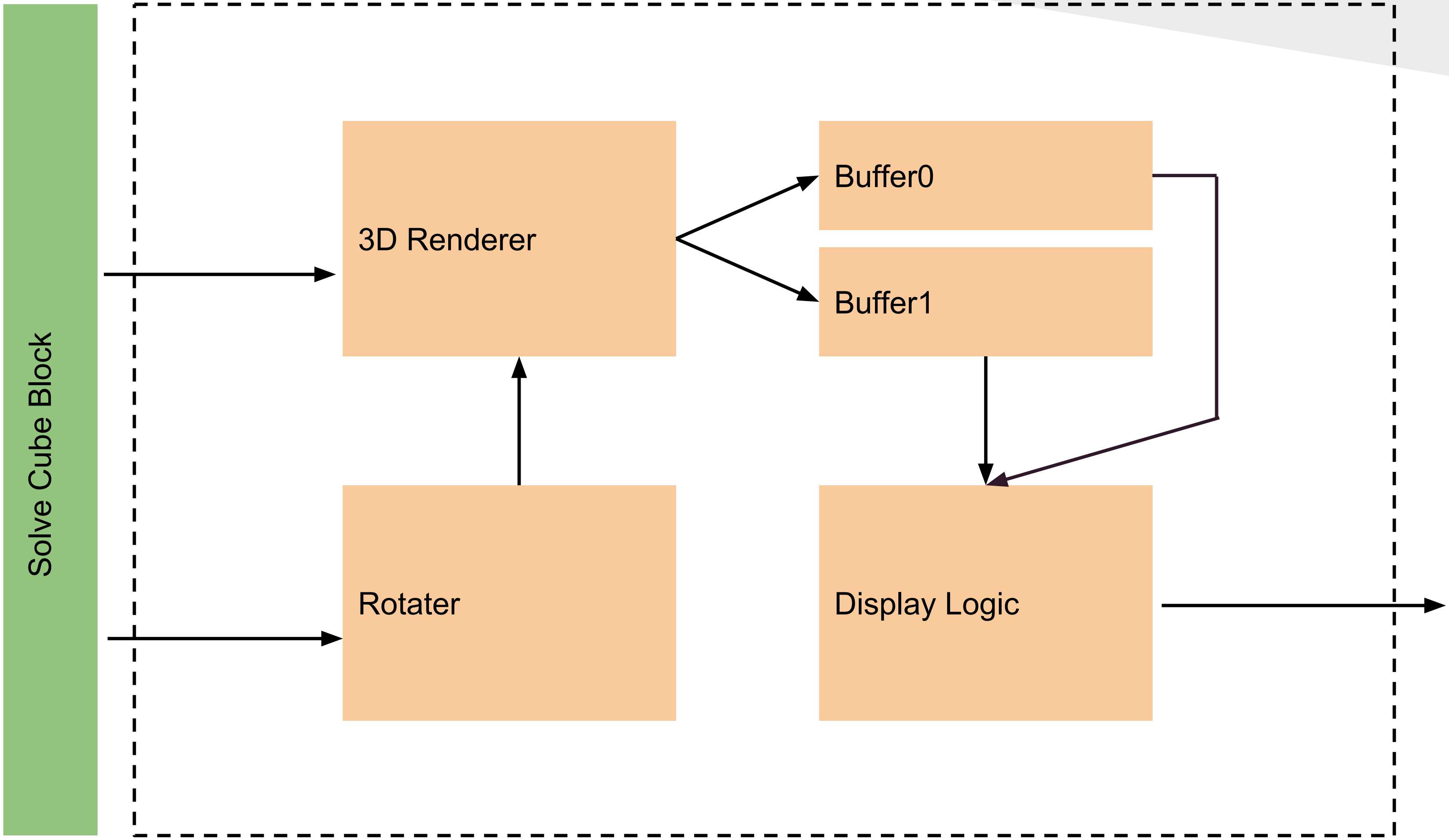
  - one to display cube

  - switch every frame

Step 3: Rotation Sequence



Step 3: Animation Block Diagram



Timeline

Week of 11/11:

Katharine: Solve top layer of cube

Jack: Complete basic animation module

Week of 11/18:

Katharine: Solve entire cube

Jack: Complete Get_initial_state module

Week of 11/25:

Katharine: Debug cube solving

Jack: Improve animation module & debug

Week of 12/2: Debug