Twisty Puzzle Masterz 2.0

(Project Notes)

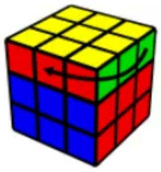
Idea Conceived: 05/05/2023

Terms

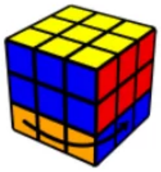
- ➢ Location:
  - ○ All intersecting layer names for the given cubie
- ➢ Orientation
  - ○ Placement of the stickers on the given cubie with respect to their correct center piece colors.
- ➢ Incorrectly Slotted
  - ○ An edge cubie is in the wrong edge location
  - ○ A corner cubie is in the wrong corner location
- ➢ Cubie
  - ○ An individual piece on the cube.

Notations

Layer Latter	**Layer Name**
U	Up
D	Down
R	Right
L	Left
F	Front
B	Back



U



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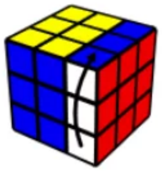

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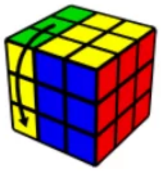

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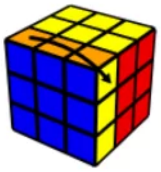

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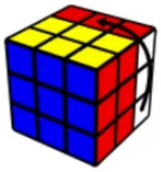

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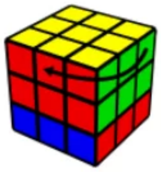
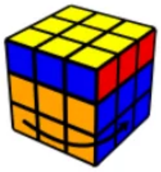
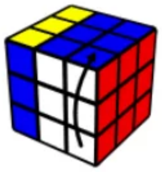


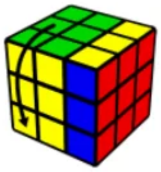
Uw / u



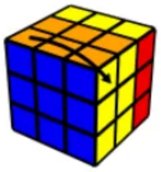
Dw / d



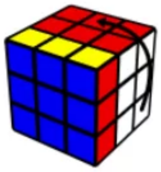
Rw / r



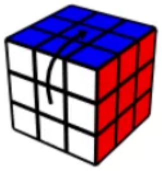
Lw / l



Fw / f



Bw / b



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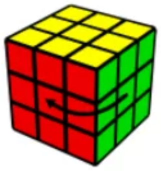
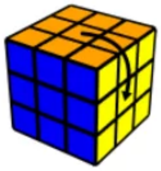
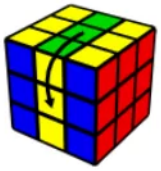


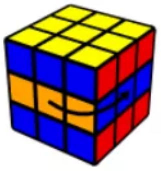
y



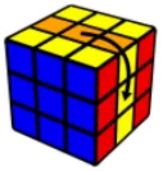
z



M



E



S

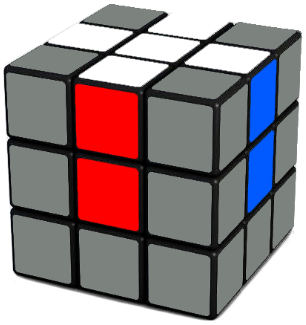
Substitute Notations

- x = Rw L’ x’ = Rw’ L
- y = Uw D’ y’ = Uw’ D
- z = Bw’ F z’ = Bw F’
- s = Bw’ B s’ = Bw B’

How “*Twisty Puzzle Masterz*” solves the 3x3x3 Rubik’s Cube

1. Cross

a. The method listed below actually solves the cross on the bottom. (i.e, D layer)



b. Solve Order

i. Cubies to solve

{
[WHITE, GREEN] , [WHITE, BLUE] , [WHITE, ORANGE] , [WHITE, RED]
}

c. Steps

i. Get all cross pieces on down layer
ii. Rotate bottom layer until at least 2 pieces are in correct location
iii. Set the cubies that are in the correct locations to their correct orientation
iv. Iff 2 cubies are in incorrect locations then swap them
   1. Set those 2 cubies to correct orientation Iff need to.

d. Step 1

i. Get all cross pieces on down layer

e. Avoidance Maneuver

This is done by rotating the down layer such that there is no white cubie on the spot that itersets with the down and chosen layer to move.

```
// Chosen layer to move
n = [L or  R]
```

- Rotate D (until no white edge cubie interests [n,D])
- n or n'

- ***IMPROVEMENT 1:*** *At this point you already know which white edges have been solved so you don't need to (do while) rotate the down layer until you are above an unsolved piece.*
- *Instead, you can just keep track of those 4 pieces and which ones are solved and unsolved. That way you can know exactly what movements are needed to put the unsolved white edge piece under your solving cubie.*

- ***IMPROVEMENT 2:*** *If you have to do D D D then undo those steps and do a D'*

f. If cubie on up layer

Location = {U, R}	Execute => R2
Location = {U,F}	Execute => F2
Location = {U,L}	Execute => L2
Location = {U,B}	Execute => B2

If there is a white edge cubie already located at [n, D] then use the **avoidance maneuver** to solve the cubie in the up layer.

g. **If cubie on middle layer**

Location = {L,F}	Execute => L or F’
Location = {R, F}	Execute => R’ or F
Location = {L, B}	Execute => L’ or B
Location = {R, B}	Execute => R or B’

Prefer the move that puts the cubie in the correct location.

(or)

Move that wont kick out an already positioned white cubie on the down layer.

h. **If cubie on down layer**

i. Go to the next white edge cubie to solve. This one is already on the desired layer.

ii. Maintain location on down layer while putting other cubies on down layer using the **avoidance maneuver**.

i. Step 2

i. Rotate bottom layer until at least 2 pieces are in correct location

j. Step 3

1. Set all cubies to their correct orientations.
2. If solving cubie is on **Right**
    a. R2 U F R’ F’
3. If solving cubie is on **Front**
    a. F2 U L F’ L’

4. If solving cubie is on **Left**
    a. L2 U B L’ B’
5. If solving cubie is on **Back**
    a. B2 U R B’ R’

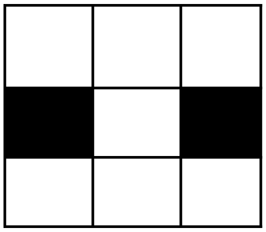
6. ***IMPROVEMENT 3:*** Add Xw and Xw’ to data structure possible rotations
    - If solving cubie is on **Right**
        - Execute: R Uw’ R Uw
    - If solving cubie is on **Front**
        - Execute: F Uw’ F Uw
    - If solving cubie is on **Left**
        - Execute: L Uw’ L Uw
    - If solving cubie is on **Back**
        - Execute: B Uw’ B Uw

k. Step 4

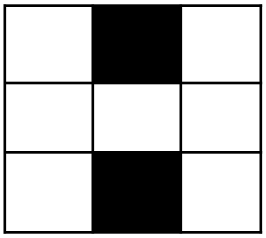
i. Iff 2 cubies are in incorrect locations then swap them

NOTE: Black squares on the below diagrams represents a white cubie on the down layer.

1.



2.



ii. Case 1:

R2 L2 U2 R2 L2

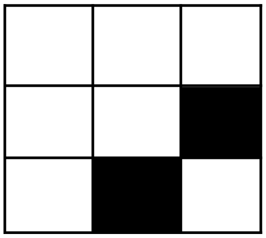
iii. Case 2:

F2 B2 U2 F2 B2

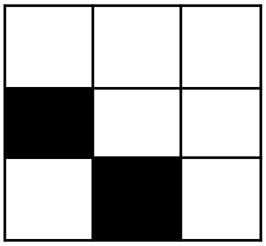
1. ***IMPROVEMENT 4***: The above two cases can be swapped by rotating the up layer to match the alignment of 2, then executing the following:

    - M2, U2, M2

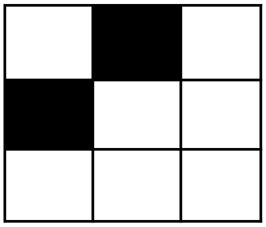
2.



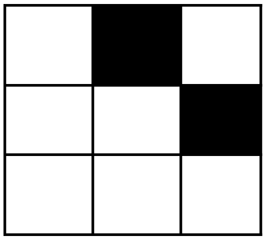
3.



4.



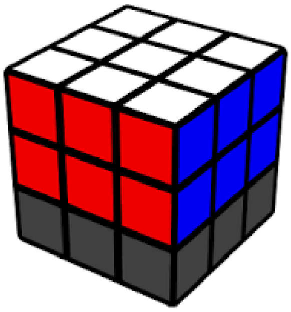
5.



6. To swap the white cubies in cases 3-6 above, use these four algorithms respectively:
    a. R2 U F2 U’ R2 //initial location [[D,F] , [D,R]]
    b. F2 U L2 U’ F2 //initial location [[D,F] , [D,L]]
    c. L2 U B2 U’ L2 //initial location [[B,D] , [D,L]]
    d. B2 U R2 U’ B2 //initial location [[B,D] , [D,R]]

iv. ***IMPROVEMENT 5***:If you have setup 3 above and they both need to be swapped and oriented, then you can use a single algorithm:
    1. F’ R F R2

2. F2L



a. **F2L Configuration Format:**

General

```
      “Case Number”: {
                    <Cubie1>
                  , <Cubie2>
                  , <Solution Algorithm>
        }
```

Specific

```
{
        "Case": 1,
        "Cubie1": {
                "Orientation": {
                  "STICKER_COLOR_1": "SIDE_COLOR_1",
                  "STICKER_COLOR_2": "SIDE_COLOR_2",
                  "STICKER_COLOR_3": "SIDE_COLOR_3"
                }
        },
        "Cubie2": {
                "Orientation": {
                  "STICKER_COLOR_3": "SIDE_COLOR_2",
                  "STICKER_COLOR_2": "SIDE_COLOR_3"
                }
        },
        "SolutionAlgorithm": "F' U F' U2 R' F2 R U2 F2"
}
```

b. Removal Maneuver

1. Determine which case needs to be executed
    a. Case 1: Corner Cubie being removed
        `R U R'`
    b. Case 2: Edge Cubie being removed
        `U R U' R' U' F' U F`

2. Based on location of the cubie to remove, use the corresponding mapping in the **orientation transform** algorithm.

c. **Orientation Transform**

3. The purpose of the orientation transform algorithm is to be able to easily modify/transform an existing algorithm to a format that can be executed from a different angle.

```
//   EXPECTED      -> [F, R, B, L] [F, R, B, L] [F, R, B, L] [F, R, B, L]
//   REPLACEMENT   -> [F, R, B, L] [R, B, L, F] [B, L, F, R] [L, F, R, B]
//                     _  _         _  _         _  _         _  _
```

4. Using the above side mappings, this function will be able to convert any algorithm to a new orientation that can be executed.

d. **F2L Edge Cases** (that require a specific correction algorithm)

   i. White stickered Cubie is in the D layer in the wrong location.
   ii. White stickered Cubie is in the D layer in the correct location with wrong orientation.
   iii. White stickered Cubie is in the D layer in the correct location and correct orientation.
   iv. F2L edge cubie is in the wrong location in the middle layer.

e. **F2L Solution Steps:**

   i. Locate both cubies
   ii. If one or both of the F2L cubies are slotted in the wrong corner, then remove them from that corner. (***removal maneuver***)
   iii. Rotate the top layer to correctly align the F2L pair iff:
      1. Both of the F2L cubies are in the U layer.
      2. One F2L cubie is in the U layer and the other is in the correct location.

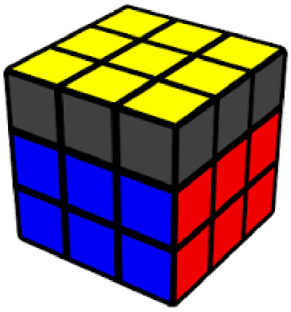
   iv. Execute the corresponding algorithm using the (***orientation transform***) function.

3. Pseudo-Code:

```
                // Pairs to solve, in order
                { [ORANGE, WHITE, BLUE], [ORANGE, BLUE] }
                { [RED, WHITE, BLUE], [RED, BLUE] }
                { [RED, WHITE, GREEN], [RED, GREEN] }
                { [ORANGE, WHITE, GREEN], [ORANGE, GREEN] }


      List<SurfaceName> locationOfCubie1 = findLocationOfCubie( cubie1 );
      List<SurfaceName> locationOfCubie2 = findLocationOfCubie( cubie2 );

List<SurfaceName> correctLocation1 = getCubieAtLocation( String[] {“F R”} );
List<SurfaceName> correctLocation2 = getCubieAtLocation( String[] {“F R D”});


            if( locationOfCubie1 != correctLocation1
                                    && locationOfCubie2 != correctLocation2
                              ){
                  if( isInWrongEdge( cubie1  ) ){
                        // Removal maneuver       (for edges)
                  }
                  if( isInWrongCorner( cubie2 )){
                        // Removal maneuver        (for corners)
                  }

                  // Loop through all F2L Cases to find the one that matches.
                  String correctF2LCase = {};
                  for(String case : F2L_JSON ){
                        // Check orientation and location of cubie1 and 2
                  with that of the current
                        //      F2L case.

                        if( foundMatchingCase ){
                              break;
                        }
                  }

                  String algorithm = correctF2LCase [“SolutionAlgorithm”];
```

```
        String algorithmTransform = orientationTransform( algorithm
        );

    }
```

4. OLL



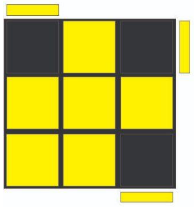
1. Now that you have solved the cross, and the first 2 layers (F2L), the next step is to solve the orientation of the last layer (OLL)

a. **OLL Configuration Format:**

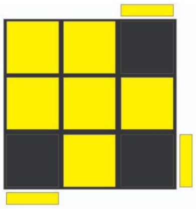
This is the format that the **OLL_algorithms.json** file is expected to use.

```
{
  “Case”: 1,
       “YellowMap_TopSurface”:[
             "" , "Y" , "",

       "" ,  "Y", "" , "Y",   "",
       "Y",  "" , "Y", "Y",   "",
       "" ,  "Y", "Y", "Y",   "",

             "" , "" , ""
       ],

       “SolutionAlgorithm” = “R U R’ U R U2 R”
```

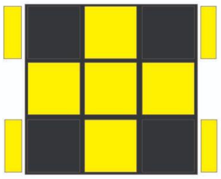
```
    }
```



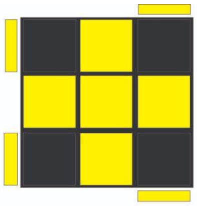
Caso OLL-1
R U R' U R U2 R



Caso OLL-2
R' U' R U' R' U2 R



Caso OLL-3
R U R' U R U' R' U
R U2 R'



Caso OLL-4
R U2 R2 U' R2 U' R2
U2 R

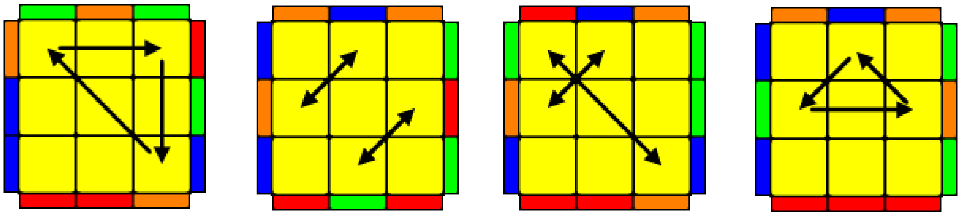
b. **OLL Solution Steps:**

1. Proper Orientation:
    a. Loop through each of the 57 cases to check if you have any of them
    b. If not, then perform a U rotation and check all 57 again
    c. Once you've found a case that matches, with the correct orientation, then execute the associated algorithm

        i. ***IMPROVEMENT 6***:
            1. Instead of checking for each of the 57 cases and doing a U rotation until the correct alignment is made, you could just create a kind of transformOrientation() for OLL to execute a transformed version of the solution algorithm, despite the current orientation.

c. **<u>OLL Pseudo-Code</u>**

5. PLL



a. OLL Configuration Format:

```
“Case 1” : {
        “MoveTo”:
                        [ “U R B”,    self ,   “U R F” ,
                          self     ,   self ,   self     ,
                          self     ,   self ,   “U L B” ]

        “SolutionAlgorithm” : “x R’ U R’ D2 R U’ R’ D2 R2”
}
```

Case 1 format description:

Cubie at location “U L B” is moving to location “U R B”,
Cubie at location “U R B” is moving to location “U R F”,
Cubie at location “U R F” is moving to location “U L B”

<u>Set Locations On Up Layer</u>

```
[
        “U L B” ,  “U B”,  “U R B”,
        “U L”    ,  “U”   ,  “U R”    ,
        "U L F"  , "U F" , "U R F"
]
```

b. **OLL Solution Steps:**

   i. First, check if PLL is already solved. If so, then do nothing.

   ii. Loop through each of the 21 cases to check if you have a correct alignment for any of them. If you do then execute that algorithm associated with the case.

   iii. If you've searched all 21 cases and haven't found an alignment, perform the alignment adjustment maneuver on each case until you've found the matching one.

```
for(i < 4){
     for(j < 4){
          Perform a U rotation
     }
     Perform a Uw D'  rotation
}
```

c. <u>**Known Improvements**</u>

   i. PLL skip that still requires a single **U** rotation to fully solve.

      1. Scramble:
         F B' U B R' U2 L' R' F' R' D' R F'
         B' D' L2 U2 D2

         a. Put that scramble algorithm in the reset button to see what the generated solution steps are. It will solve 99% but won't figure out that it still needs a final U rotation.

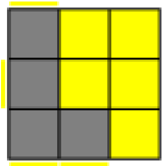
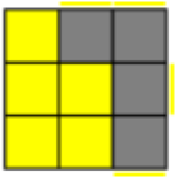
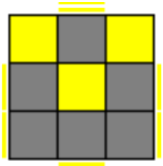
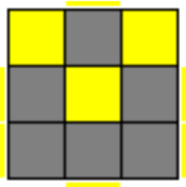
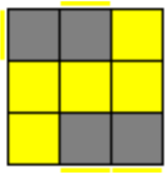
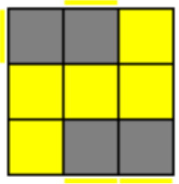
      2. You really should fix this because it will make the incomplete solves look off during the solving animation on **ruwix.com**

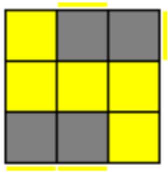
d. <u>**OLL Pseudo-Code**</u>

6. Algorithm Errors

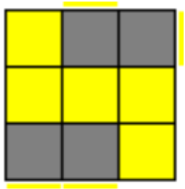
i. All of the algorithms listed in this section on the left are used in the oll.pdf document in the **/notes** directory of this android project. After testing all F2L, OLL, and PLL algorithms, I found these to be incorrect. Their correct replacements are listed on the right.

OLL

Wrong			**Correct Replacement**
31		(R' U') F (U R U' R') F R	 (same case, different orientation) **L' Dw' R Dw L U' Rw' U' Rw**
19		Rw' (R U) (R U R' U' Rw) x (R2' U) (R U')	 **R’ U2 F R U R’ U’ Uw’ D R2’ U2 R B**
39		(L F') (L' U' L U) F U' L'	 **R B’ R’ U’ R U Uw D’ R U’ F’**

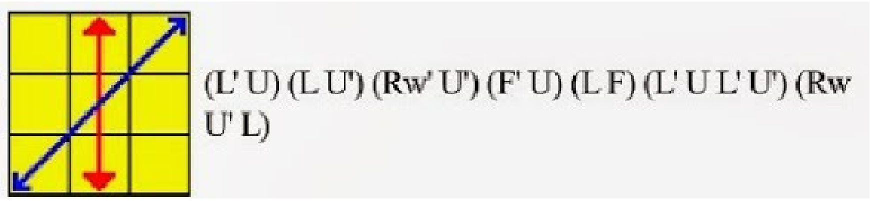
40 

(R' F) (R U R' U') F' U R

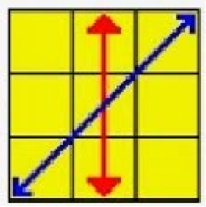


L’ B L U L’ U’ Uw’ D L’ U F

PLL



(L' U) (L U') (Rw' U') (F' U) (L F) (L' U L' U') (Rw U' L)



R’ U L’ U2 R U’ L R’ U L’ U2 R U’ L U’

7. Test Cases

a. Test the following initial Rubik’s Cube rotations on a solved cube to ensure that:

   i. **‘w’** rotations are working correctly.

      1. Rw
      2. Rw’
      3. Lw
      4. Lw’

5. Uw
6. Uw’
7. Dw
8. Dw’
9. Fw
10. Fw’
11. Bw
12. Bw’
13. Fw R U R’ U’ Fw’
14. Fw Rw’

ii. **‘M’** rotations are working correctly

1. M
2. M’
3. M2
4. M2’
5. M’ U M U2 M’ U M
6. F’ U’ R’ M U R B’
7.

b.

- □ **Add detailed comments**
    - explain all magic numbers and algorithms.
- □ **Update variable and method names**
- □ **Add transformOrientation() to the Cross solution instead of an algorithm map.**
- □ Use proper code style guide for java (reference software engineering document)

- □ Document all design decisions related to conventions that you follow for configuring the cube and its algorithms.
- □ **Static code analysis tool for Java android in VC Code to generate code diagrams instead of having to make these by hand.**

Working Java Android Cube Solver and OpenCV

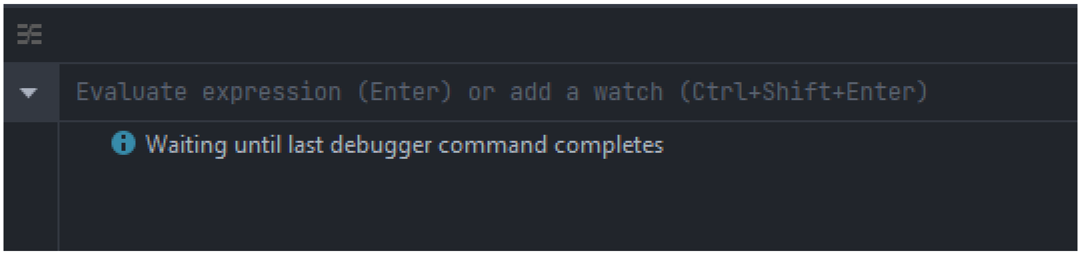
https://github.com/ucchiee/AndroidRubikCubeSolver

How to add OpenCV to android:

- https://www.youtube.com/watch?v=oIk2hTPxFqs&t=255s
    - At 6:28 whatever you name that module, open that folder in file explorer and paste everything from C:\Users\downs\Desktop\OpenCV-android-sdk**\sdk into it**
    - **Update build.gradle for (:opencv)** add this line
        - `android {`
        - `    namespace 'org.opencv'`
    - **Update build.gradle for (:opencv)** with 4 fields to match your project build.gradle
        - a) compileSdkVersion
        - b) buildToolsVersion
        - c) minSdkVersion and
        - d) targetSdkVersion.
    - Comment out each line that is throwing an error inside of **AsyncServiceHelper.java** (I don't use that anywhere)
- https://www.youtube.com/watch?v=bR7IL886-uc&t=221s
- Also helpful
    - https://stackoverflow.com/questions/63254458/could-not-import-the-opencv-library-in-android-studio (last post in this stackoverflow thread)
    - https://www.geeksforgeeks.org/how-to-add-opencv-library-into-android-application-using-android-studio/
    - https://www.geeksforgeeks.org/different-ways-to-delete-a-module-in-android-studio/

Video Format Inspiration:

https://www.youtube.com/watch?v=fAX27_FyU9g



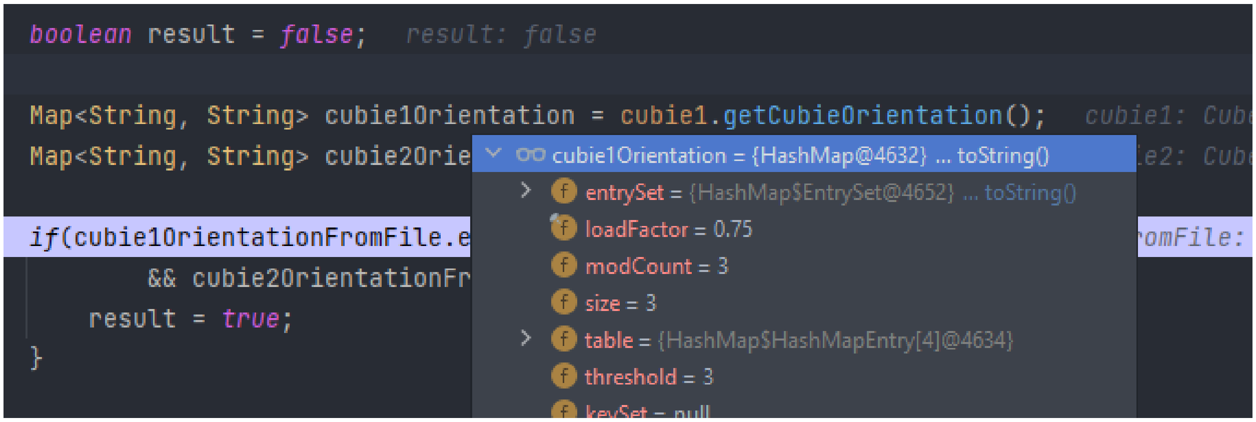
Evaluate expression (Enter) or add a watch (Ctrl+Shift+Enter)

Waiting until last debugger command completes

Debugging Error:

How to solve "Waiting until last debugger command completes"

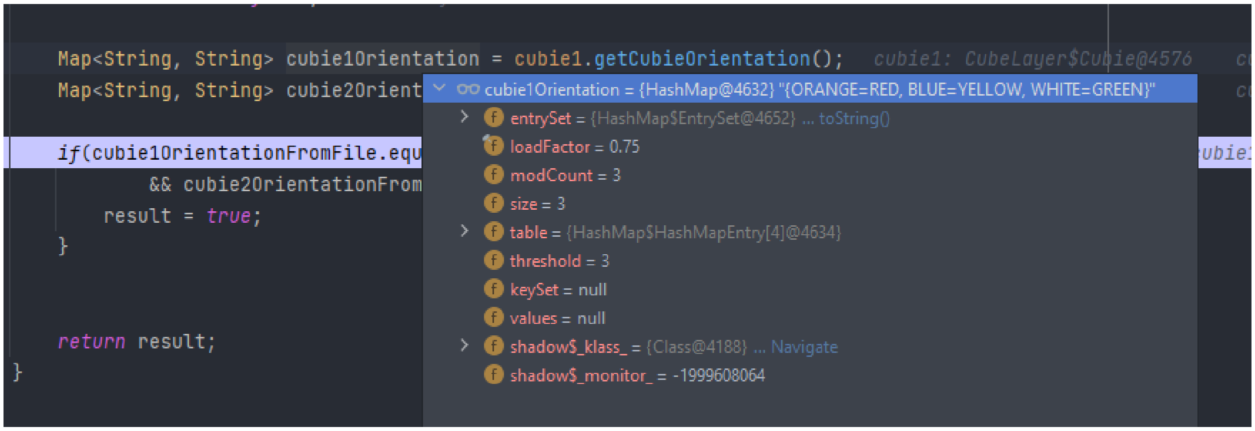
- Fix 1
  https://stackoverflow.com/questions/63290304/how-to-solve-waiting-until-last-debugger-command-completes-stuck-in-android-st
- Fix 2
  - Open Task Manager -> Terminate all processes under Android Studio that are not Console Window Host



```
boolean result = false;   result: false

Map<String, String> cubie1Orientation = cubie1.getCubieOrientation();   cubie1: Cube
Map<String, String> cubie2Orie                                                          e2: Cube

if(cubie1OrientationFromFile.e                                                          omFile:
        && cubie2OrientationFr
    result = true;
}
```

```
cubie1Orientation = {HashMap@4632} ... toString()
  entrySet = {HashMap$EntrySet@4652} ... toString()
  loadFactor = 0.75
  modCount = 3
  size = 3
  table = {HashMap$HashMapEntry[4]@4634}
  threshold = 3
  keySet = null
```

After turning off toString() object view to fix the above issue you'll need to select the toString() option from the drop down after hovering over a variable to see it's string value.



```
Map<String, String> cubie1Orientation = cubie1.getCubieOrientation();   cubie1: CubeLayer$Cubie@4576   c
Map<String, String> cubie2Orient                                                                         c

if(cubie1OrientationFromFile.equ                                                                         ubie1
        && cubie2OrientationFrom
    result = true;
}


return result;
}
```

```
cubie1Orientation = {HashMap@4632} "{ORANGE=RED, BLUE=YELLOW, WHITE=GREEN}"
  entrySet = {HashMap$EntrySet@4652} ... toString()
  loadFactor = 0.75
  modCount = 3
  size = 3
  table = {HashMap$HashMapEntry[4]@4634}
  threshold = 3
  keySet = null
  values = null
  shadow$_klass_ = {Class@4188} ... Navigate
  shadow$_monitor_ = -1999608064
```

Other Helpful Resources

1. You can use this website to generate an animation of the execution of the solution algorithm for those who don't know the rubik's cube notations:
   a. https://ruwix.com/widget/3d/? [solution algorithm]
   b. This is helpful if my solution algorithm ends up being 80-100 movements

2. Working python OpenCV (using open source solver)
   a. https://github.com/nicpatel963/CubeSolvingScript/blob/master/cubenew.py

3. Working Android OpenCV and Solver (But using USB cameras?)
   a. https://github.com/geoffreywwang/CubeBot

4. https://www.youtube.com/watch?v=afAGtExoiLQ
5. https://www.youtube.com/watch?v=RMo_CLi1Z5g
6. https://www.youtube.com/watch?v=CWmKHcx1X6A
7. https://www.youtube.com/watch?v=3pqo6SMmtS4
8. Project is 9 years old. Can't build into Android Project without Gradle.
   a. https://sgelb.github.io/projects/arcs
9. 3D cube animation
   a. https://github.com/cjurjiu/AnimCubeAndroid
   b.