

## Rubik's Cube Subsets

Subsets is a derived game from Rubik's cube. Regardless of display method the cube remains confusing to many players. Subsets aims to ease this confusion by using only two surfaces of the cube. Moves are also restricted so that exchange only occurs between two surfaces by 180 degree rotations, or within a single surface by 90 degree rotations.

## Search Methods

Permutations are searched using sequential commands, which can be converted to integer numbers. Base value is  $2N+3$ ,  $N$  being the size of the cube. Zero is assigned to "Null Command" or "No-Move", and remaining commands are assigned to positive integers  $\{1, 2, 3, \dots\}$ . Moves are divided into X, Y, Z categories, each rotating around an axis.

$$Com \rightarrow integer = \{X_k \rightarrow k, Y_k \rightarrow N+k, Z_1 \rightarrow 2N+1, (for N>1) Z_N \rightarrow 2N+2\}$$

Inverse commands are not defined for Z axis and as for X and Y they are not necessary. Despite the restriction, Subsets achieves symmetry by other set of command sequences. In other words "solver" and "reacher" sequences are of same length, hence the symmetry. In my opinion math part is more interesting than the game.

## Solving A Permutation

### **Approach 1**

Iterate integer values  $\{0, 1, 2, 3, \dots, S\}$ , generate sequence for each value, apply sequence to permutation, and check whether permutation is solved.  $S$  is the smallest integer whose sequence solves the permutation, and is called minimum solver sequence. Approach-One is guaranteed to solve any permutation that is in Rubik Permutation Space, and sequence is guaranteed to be shortest length. However if  $S$  is a large number, computer may not solve in a reasonable amount of time, and if  $S$  is bigger than Integer.MAX value algorithm will simply fail.

### **Approach 2**

Build partial Rubik-Permutation-Space, and save this data for later use. If a permutation is an element of calculated data iteration can be skipped, or iteration can be narrowed by checking if a sequence can reach built data. Once a match is found sequences can be appended for a solution. Solution sequence is guaranteed to be shortest length, however sequence's integer value may not be the smallest. This approach too may not solve in a reasonable amount of time, or may fail if  $S$  is too large to handle.

With these methods, Scout(Approach-1) and Cx00(Approach-2), size 2 and 3, can be solved. Scout and Cx00 will most likely fail for  $N > 3$ .

For  $N=4$ , an algorithm was implemented which uses calculated sequences for the final step(s). (Sides and mid-squares are same as  $N=2$ ). A solution sequence can be generated, however it is no longer shortest.