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New State Based Algorithm For Rubik's Cube

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Abstract— Rubik's cube is a 3-dimensional mechanical puzzle. The aim of this research paper is to describe a new algorithm which is state based to solve the Rubik's cube. There 40 quintillion possibilities to solve this problem. Hence without knowing the principles behind cube it is nearly impossible to solve in proper manner. It will take you through everything in order to solve the Rubik's cube. It is really simple, you just need to follow the algorithm and you will be solving Rubik's cube in less than two minutes. This paper on how to do the Rubik's Cube will take about 45 minutes to understand, but once you get, you can impress all your friends with how you can solve one of life's great mysteries: how to do a Rubik's Cube**.**

Keywords— Flowchart, Algorithm of Rubik's Cube, Artificial Intelligence, Group theory.

I. INTRODUCTION

The Rubik's cube is a 3-D combination puzzle invented in 1974 by Erno Rubik.The motivation for developing the cube was that he wanted to create a model that explains the 3-D geometry. Rubik's cube is also known as "MAGIC CUBE". This cube has become a hit worldwide for nearly a generation.

I strongly believe that many people continue to practice to gain an algorithm for solving Rubik's cube. After several days or by several months, some of them have been solved Rubik's cube and others may have been given up with it. As a result, over 340 billion Rubik's cubes have been sold worldwide.

I propose an algorithm or I should say this research paper is intended for helping people those who are keep trying or who have failed in solving Rubik's cube in state based manner. First of all to accomplish the task, we should be well known with the basics of theory of Rubik's cube. The most amazing factor is that Rubik's cube have a great bond with the Group theory in discrete mathematics and the algorithms (BFS, DFS) which are majorly associated with Artificial Intelligence (Present and the Future of computer science).This algorithm is designed to transform each faces correctly without interfering with the other parts. For better understanding, I will be denoting some specific variables for the faces or sides. As we know an algorithm is a step by step procedure to solve a particular task in particular time.

I am forced to mention that, I can give one hundred percent assurance in solving the Rubik's cube with the algorithm which I propose but the time taken to solve t will be depending upon each individual and their practice.

1.1 Problem statement:

This paper is intended to generate a new algorithm to solve Rubik's cube in state based manner.

1.2 Motivation:

Varieties of possible cube configurations have inspired different sessions like computer science and mathematics. Several professors and scientists around the world have often used Rubik's cube as a case of studying optimal solutions, creating new algorithms.

The reason for choosing Rubik's cube as my platform is because it has a relevant and significant importance in computer science research field. It serves as an example for the study of permutations and data structure. The Rubik's cube has also been a tool to test for the Artificial intelligence to learn, develop new algorithms and solve other problems as well.

1.3 Purpose:

• My first goal is to propose a new algorithm state based which is simple and understandable for a common man to solve Rubik's cube in few steps.

• My second goal is to motivate friends to seek out, try to analyse different methods of solving Rubik's cube and to understand the magic in Rubik's cube and the bond between cube and computer science.

II. RELATED WORK

As a classic brain-training toy well known to the public, Rubik's Cube was used for scientific research and technology development by many scholars. The previous related work provides a basic understanding of the Rubik's Cube and shows its mechanical art from the aspects of origin and development, characteristics, research status and especially its mechanical engineering design, as well as making a vision for the application in mechanism.

III. METHODOLOGY

3.1 Basis of Rubik's cube:

1) There are six faces with six colors in each cube.
2) Rubik's cube is a cube with edges of 56 mm long.
3) There are nine small cubes(cubers) for each face.
4) The center cuber on each face can only be seated in centers of any face.
5) There are four wing cubers [edge] for each face and they can be only seated in edge positions (four for one face).
6) The middle cubers can only be placed in middle positions in any sort of rotations.
7) The centers are connected to the cross by means of screws causing cubers to hold tightly together.
8) When you rotate a side,you rotate one third of the cube,this is layer

3.2 Terminology:

Having a cube in front of you, the individual layers are rotated as follows:

1) The layer facing towards you is the front layer and is denoted as **F**[Front]
2) The layer facing awayfrom you is the back layer, denoted as **B**[Back].
3) The layer which on the top is the upper layer and denoted as **U** [Up].
4) The layer which is at bottom is the down layer and is denoted as **D** [Down].
5) The layer which is on your right is the right layer denoted as **R**[Right].
6) The layer which is on your left is the left layer denoted as **L**[Left].
7) The layer which is in between left and right layers is denoted as **M**[Middle].
8) The layer which is in between up and down layer is denoted as **E**[Equator].
9) The layer which is in between front &back layers is denoted as **S**[Standing].

Table 1

Rotating Notation	Description
R,L,U,D,F,B,S,M,E	Rotate to the right of layer.
R',L',U',F',B',S',M',E'	Rotate to the left of layer.
DOUBLE''	Rotate to the left two times.
2R,2D,.....	Rotate to the right two times.

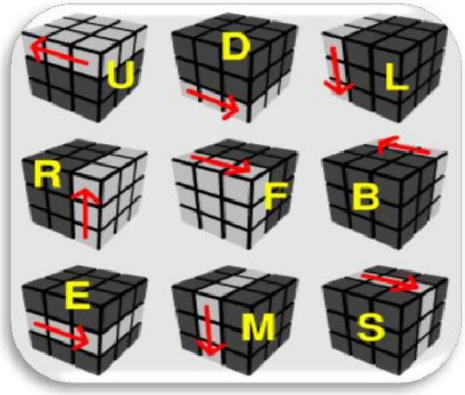


Fig. 1

3.3 Group Theory and Rubik's cube:

3.3.1 Definition :

By definition, a group G consists of a set of objects and a binary operator, *, on those objects satisfying the following four conditions:[4]

• The operation * is closed, so for any group elements h and in G, h∗g is also in G.[4]
• The operation * is associative, so for any elements f,g, and h, (f ∗g)∗ h = f ∗ (g ∗ h).[4]
• There is an identity element e ∈ G such that e ∗ g = g ∗ e = g.[4]
• Every element in G has an inverse g−1 relative to the operation * such that g ∗ g−1 = g−1 ∗ g = e.[4]

Note that one of the requirements is not commutative, and it will soon become clear why this is not included.[4]

3.3.2 Theorems About Groups:

Keep in mind the following basic theorems about groups:

• The identity element, e, is unique.[4]
• If a ∗ b = e, then a = b−1[4]
• If a ∗ e = b ∗ e, then a = b[4]
• The inverse of (ab) is b−1a−1[4]
• (a−1)−1 = e[4]

3.3.3 Examples of Groups:

The following are some of the many examples:

• The integers form a group under addition. The identity element is 0, and the inverse of any integer a is its negative, −a[4].
• The nonzero rational numbers form a group under multiplication. The identity element is 1, and the inverse of any x is 1 x [4].
• The set of n × n non-singular matrices form a group under multiplication.This is an example of a non-commutative group, or non-abelian group, as will be the Rubik group.[4]

3.3.4 Rubik's Cube Moves as Group Elements:

We can conveniently represent cube permutations as group

elements.
The Binary Operator for the Rubik Group:
Our binary operator, *, will be a concatenation of sequences of cube moves, or rotations of a face of the cube. We will almost always omit the * symbol, and interpret fg as f ∗g. This operation is clearly closed, since any face rotation still leaves us with a permutation of the cube, which is in R. Rotations are said to be always associative: it is not a matter how we group them, as long as the order in which operations are performed is conserved. The identity element e corresponds to not changing the cube at all.[4]

The inverse of a group element g is usually written as g−1. We saw above that if g and h are two elements of a group, then (hg)−1 = g−1h−1. If we think of multiplying something by a group element as an operation on that thing, then the reversed order of the elements in the inverse should make sense.
Let F be the cube move that rotates the front face clockwise. Then f, the inverse of F, moves the front face counterclockwise.[4]

3.4 Artificial Intelligence and Rubik's cube:
The Artificial intelligence research community had made various donation for knowledge of mankind. Finding a solution to a constraint search problem is thought to be a proof of intelligence can be assumed to be intelligent.
Artificial intelligence ia a study of how to make computers to do things which at the moment people do better. Artificial intelligence is the developing of computer programs to solve complex problems by application of process that are analogers.

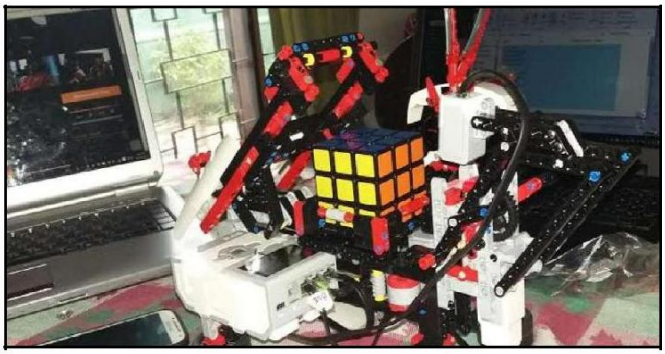
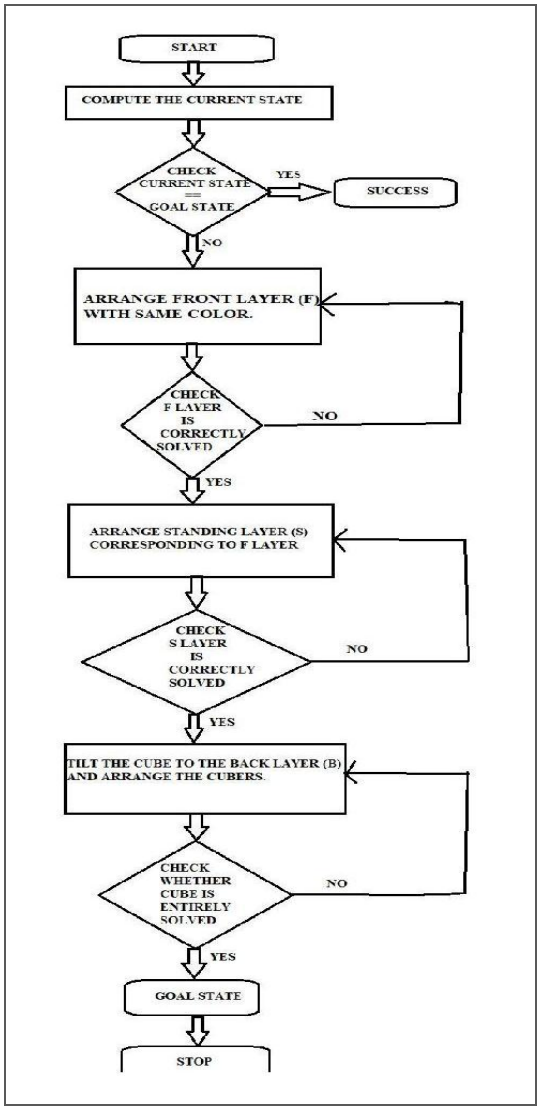


Fig.2
For researches all around the world, the following problems are challenges:
• The Rubik's cube contains 4.352x10'9 states, making it impossible to store in the memory. This is equal to the number of states reachable from any given state.
• The minimum number of moves required to solve a Rubik's cube. It is not possible for any human being to physically count each permutations and solving problems such as finding optimal solutions cannot be solved only by humans.Therefore, computers act as a utilitarian tool to solve problems such a Rubik's cube puzzle, since computers are good at numeric calculations, memorising large set of data and can search quickly. However, human are really good at generalizing and using knowledge, something that computers are primitive in comparison. Because their method of analysis characterizes the cases in which multiple squares can be moved into place simultaneously, it provides a way to recognize those cases, and thus an algorithm for solving a disordered cube. The algorithm isn't quite optimal: It always requires a few extra moves. But as the number of squares per face increases, those moves dwindle in significance.

IV. RESULTS AND DISCUSSION

4.1 Flowchart for algorithm:



4.2 New Algorithm:

PART 1 [FIRST LAYER]

Step 1:The first thing you have to do is to determine first layer, like so

A) It is also important to remember that the center cuber color and identify the corresponding cubers which are at different layers with same color.

Fig.3

B) It is also important to remember that the edge and middle cubers have to be aligned with the centres like this:
Algorithm:

FDF' R'D'R F'RF FRU FD'F'

Fig.4

C) Repeat the algorithm mentioned above until the desired goal state is obtained.

D) Goal state of step 1**.**

Fig.5

Point to remember:
After completing first layer you have to check whether the middle cuber of second layer is having same colour corresponding to the first layer.

Part 2 [Second Layer]

Step 2: The next step is to put the four second layer pieces in the right place.
A) Find the piece that you need to put in the correct set that cuber in left corner [Bottom layer].
Algorithm: R' D' R D F D F'

B) Repeat the algorithm until desired goal is obtained.

Fig.6

Part 3 [Third Layer]
Step 3: The first thing to do is to turn the cube upside-down.
A) Here we have to arrange the layer without making changes
in other layers.
Algorithm: R B' U' B U R'
The possible movements are shown below and the starred figure is the goal state.

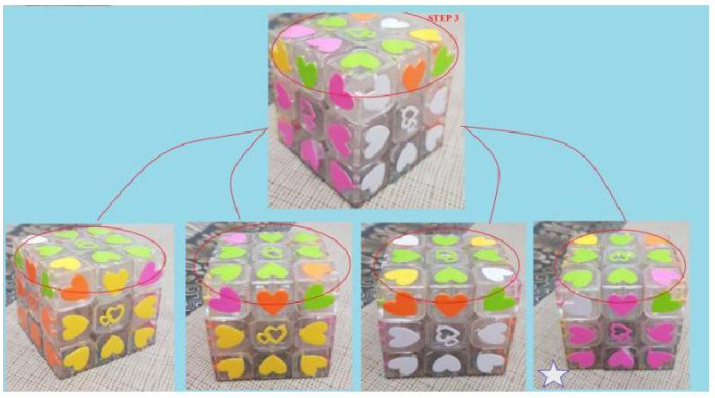


Fig.7

B) Make sure that the cube has gained a L shape in the top level, like STARRED in above image.

Fig.8

C)To complete the bottom layer do the following algorithm

Algorithm: R D' R' D' R D''

Fig.9

Now you can see that the bottom layer is perfect but whole cube is not perfect, there are some more cubers to be placed in their on place to make cube correct.

D)At this step we are exchanging the corner cubers to this proper destination

Algorithm: R U R' U R' F 2R U R' U R' U' R' F'

Fig.10

E) We have to exchange the middle cubers to its respective places.

Algorithm: 2R U R' U R' F R U' R' U R'

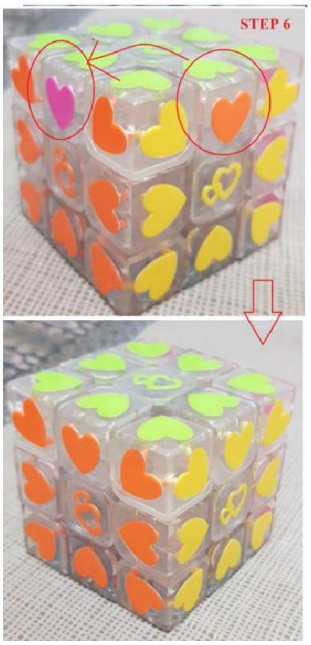


Fig.11

THE CUBE IS AT GOAL STATE.

V. CONCLUSION AND FUTURE SCOPE

There are several ways to measure the performance of an algorithm. An algorithm that is complete will always guarantee to find one solution in particular problem. In this paper we can give a definite solution to the problem in Rubik's cube.

The time complexity of an algorithm quantifies the amount of the space taken by the algorithm to complete as an arbitrary number/length of the steps to perform. The space complexity of an algorithm quantifies the amount of space taken by the algorithm in order to successfully complete the algorithm. Therefore time,space,completeness will also determine which the proposed algorithm is how much efficient while solving the Rubik's cube.

Future research in this field could investigate which algorithm is better or which is efficient and give more valid results with proof. And as I mentioned Rubik's cube as a great significant bond between computer science field as well as the mathematics. Artificial intelligence is considered to be the present and the future of digital world. So why can't we think about of making a solution to Rubik's cube with respect to the concepts of artificial intelligence. In collaboration with

Artificial Intelligence why we can't invent a **mini robot.**

Significant part of designing such a robot is some basic computer vision: the robot must correctly recognize the colors on the cube in order to be able to solve it.This can be able with python I believe.

The actual sequence of rotations used by the robot is almost certainly computed by assembling a sequence of hard-wired patterns that transpose small subsets of positions -just like a human solver would solve the cube.
And also, we could generate a new **Android application** to Solve Rubik Cube, that helps you to learn how to solve a Rubik s cube. In which we focus on solving Rubik's cube 3x3x3 by showing our step by step tutorials. Suitable for beginners and it is very easy to follow. Using this algorithm we generate a new **program** using any simple programming languages like java,python,MATLAB
To conclude,

Research is a process to discover new knowledge. I believe that contributing a new algorithm in Rubik's cube is considered to be a great thing. Even though there are many other algorithms for solving Rubik's cube and the specialty in my algorithm is that it is simple to understand and it ensures a proper solution. The time taken to solve the Rubik's cube is depending up on the practice of each individual. Research is different than other forms of discovering knowledge. The very next step which I have planned is to implement this algorithm using MATLAB version 2017 using the image processing technique.So that this can be considered as the live project.Each six sides can be given as the input to the system using webcamera and the solution can be shown in a 3D movement which is state based BY THE NEW ALGORITHM.

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