Initial Plan: Rubik's cube solver

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Project Description

A device that uses Lego Mindstorms alongside a camera to solve a Rubik's cube. The device will take pictures of the six faces of the cube and then calculate the colours and locations of the parts of the cube so that it can check that the configuration of the cube is valid before trying to solve it. The physical part of the system uses a cradle to hold onto the cube and an arm to rotate the cube. As the device involves a mechanical part it is reasonable to assume that the cube may not be placed correctly into the cradle and so the camera should be used to monitor the condition of the cube so that it can tell if it has been correctly placed into the cradle. If the device notices that the cube is not sitting correctly in the cradle action to try to resolve the problem is required. It should be noted that is is not about the cube being incorrectly modified but about the cube being correctly held by the machine. Due to the limitations of the Lego Mindstorms and the amount of Lego that I own it may not always be possible to manipulate every part of the cube before rotating it to an appropriate position beforehand. Movement of the cube to the appropriate position should be considered to try to optimise the time taken by the physical part of the system.

A Rubik's cube is a twenty six piece puzzle which involves two ways of rotating the cube in each of the three planes into four different positions. If you do not include rotating the cube into its original position then there are eighteen different ways of changing the cube. If a brute force method was used to try to solve the problem then the computational complexity of the problem would be 18^n where n is the number of moves made. Research on the mathematics behind the Rubik's cube and computations by Google have proved that the maximum number rotations required to solve the cube which is also known as God's number is twenty. This means that the solution could take up 18^{20} which is simply not reasonable to try with a standard computer.

Projects Aims and Objectives

The program can calculate the colours on the sides of the scrabbled cube so that locations of the parts can be used to find the solution

The program can identify when the parts of the cube have been incorrectly put back together so that it does not try to solve an unsolvable cube

The program should be able to solve the Rubik's cube within 80 moves. This is due to estimations of the current number of moves that I require to resolve the cube using human methods to be approximately 100.

The program should optimise the way the Rubik's cube is moved to position between the modification moves calculated by the program the program in the first step. With approximate calculations of the time taken to do a single move and the aim for the number of moves to solve the problem I should aim for the overall time taken to solve the cube to be less than 5 minutes.

The program should be able to report the condition of the cube if it is not correctly inside the holder.

The program should be able to calculate the correct way to act if the cube is not correctly placed within the holder.

Work Plan

Week 3 15/10/12

Research on mathematical methods for solving Rubik's cube and finish initial plan
MILESTONE 19/10/12 – Initial Plan

Week 4 22/10/12

Continue research on mathematical methods for solving Rubik's cube

Week 5 29/10/12

Research on mathematical methods and begin to implement methods for solving the cube

Week 6 05/11/12

Implement methods for solving the cube and research when required

Week 7 12/11/12

Begin using image processing to identify the colours on the sides of the cube and continue with solving of main cube

Week 8 19/11/12

Continue with analysis of the images of the sides of the cube
MILESTONE 16/11/12 – Program can solve the cube, will need to be optimised

Week 9 26/11/12

Implement methods which calculate whether the cube is valid from the images imputed into the system. Fix any bugs that are occurring and spend time on Interim Report. It is likely that I will be busy this week with hand other coursework.
MILESTONE 23/11/12 – Program can identify the parts of the cube from images of the faces

Week 10 03/12/12

Fix any bugs that are occurring and spend time on Interim Report. It is likely that I will be busy this week with hand other coursework.

Week 11 10/12/12

Spend time on Interim Report. It is likely that I will be busy this week with hand other coursework.
MILESTONE 14/12/12 – Interim Report

Winter Break and Exam Period 15/12/12 – 27/1/13

I should be very busy during this period as I have a lot of exams in January and so it is unlikely that I will be able to do large amounts of the project. It is currently unclear how much time I will have depending on when my exams finish

Week 1 28/01/13

Research and implement linking the Lego Mindstorms with Java programs running on the computer and be able to manipulate the cube

Week 2 4/02/13

Research and implement linking the Lego Mindstorms with Java programs running on the computer and be able to manipulate the cube

Week 3 11/02/13

Implement movement of the cube into positions so that it can be manipulated by the Lego Mindstorms

Week 4 18/02/13
Implement movement of the cube into positions so that it can be manipulated by the Lego Mindstorms
MILESTONE 22/02/13 – Cube can be solved and manipulated by the Mindstorms, number of moves will not be optimised, orientation of cube between manipulation will need to be optimised.

Week 5 25/02/13
Research and Implement methods for using images to check the status of the cube so that it can be placed back into the cradle if there is a problem

Week 6 04/03/13
Research and Implement methods for using images to check the status of the cube so that it can be placed back into the cradle if there is a problem

Week 7 11/03/13
Begin optimisation of method for solving the Rubik's cube and orientation the cube between manipulation. Research and Implement methods for using images to check the status of the cube so that it can be placed back into the cradle if there is a problem.
MILESTONE 15/02/13 – Cube will be pushed back into cradle if it is does not sit correctly

Week 8 18/03/13
May be more busy due to other courseworks. Continue optimisation of the methods used, start write up of Final Report and add any addition features that may be required

Spring Break 31/3/13 – 14/04/13
Continue optimisation of the methods used, start write up of Final Report and add any addition features that may be required

Last Weeks of Spring Semester 15/04/13-03/05/13
May be more busy due to revision and other courseworks. Continue optimisation of the methods used, start write up of Final Report and add any addition features that may be required

MILESTONE 03/05/13 – Final Report