THE UNIVERSITY of EDINBURGH

Robotics: Science and Systems

Practicals - Final Report

Design, mechanics, and logic of an autonomous robot made out of LEGO parts

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Abstract

You MUST preface the report with a 100-200 word summary of what it contains. This is usually easier to write when you have finished the report. It should briefly explain the task, the approach used, the results and the conclusions drawn. Avoid making entirely generic statements that could apply to almost anything, e.g., (BAD) "This report describes the construction of a robot to perform a task. We describe the design decisions and outline the control program, then explain the results and possible improvements". Instead make it specific to what you have done, e.g., (GOOD) "We have built a robot capable of searching for and recognising special locations in a lab environment. It uses two IR sensors to avoid obstacles, and a low cost camera to recognise resources and target locations, as well as a sonar sensor for navigation. We implement a subsumption control architecture. The robot was tested in five time trials and was able to locate an average of 4 resources and 3 target locations within that time. The main limitation was that our robot was unable to reliably plan its route to the next location but relied on random search".

Contents

1 Introduction

The presented task was to build a robot capable of autonomously navigating through an arena, avoiding obstacles and walls, looking for three unique textured cardboard cubes, and delivering each cube to its respective base - each of them belonging to one and only one base. The entire task should be fulfilled in under 5 minutes.
The arena layout was static, and contained two bases marked with a black rectangle on the floor. The assignment of each cube resource to its base should be easily configured in the robot's source code, since such assignment would be changed just before the final practical demonstrations.

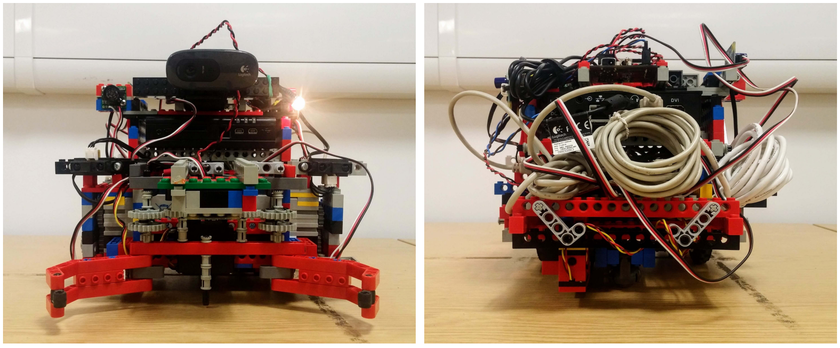
The task was approached by dividing it into other small sub-tasks. Each sub-task was then completed in a sequential manner, from the most simple to the most daunting.
The entire project was divided into two major milestones. The sub-tasks required for the first major milestone had a bigger priority, and thus were approached first.

The task was not approached by building the robot first, and only then programming it. The robot was built iteratively: the physical layout got slightly tweaked each time a sub-task required it. The final physical layout of the robot still used some elements of the initial design, but overall it changed completely.
The same thing can be said about the source code: the architecture was iteratively adapted to integrate new modules. Each module was separately tested before being integrated into the main program.
There were times when the source started to have code smells which required a minor (and some times a major) refactoring. Close to the end of the project a major refactoring had to be done in order to implement a proper State Machine. In retrospective, the State Machine should have been one of the first things to have been outlined and implemented - it would have saved a considerable amount of time throughout all the development process.

2 Methods

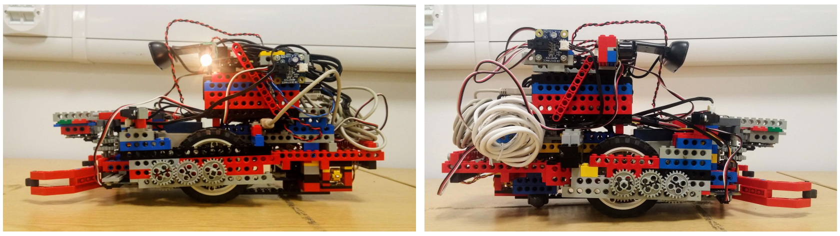
A good rule of thumb here is that someone reading your report should be able to replicate your approach. So you need to provide a good description of the physical architecture, particularly the type, number and position of sensors and actuators. Include labelled photographs or diagrams, and make sure the dimensions are clear. Comment on factors that led to the design, explaining the decisions you made.

2.1 Physical architecture



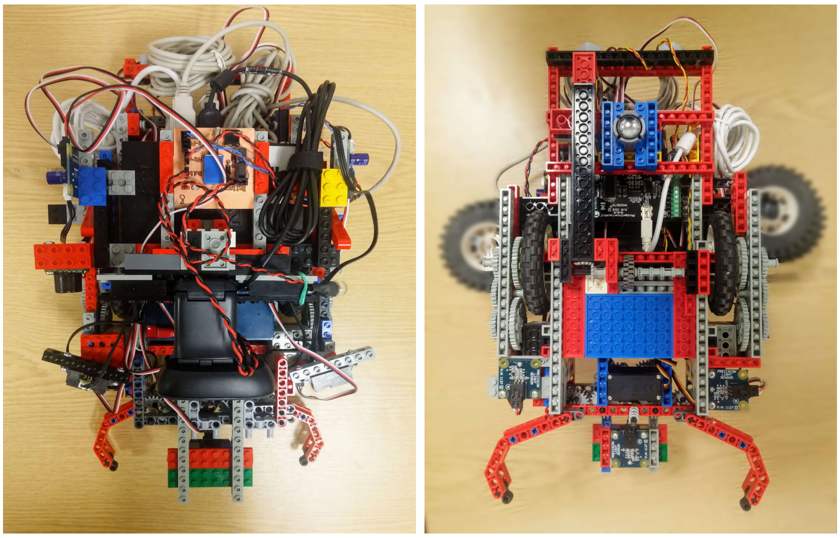
(a) (b)

Figure 1



(a) (b)

Figure 2



(a) (b)

Figure 3

2.2 Base detector and gripper

2.3 Actuators and gearing

2.4 Sensing

2.4.1 IR and Sonar

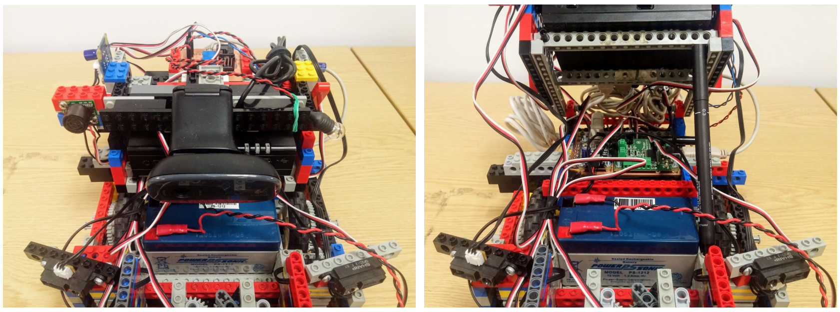
2.4.2 Camera

2.4.3 Hall effect sensor

For the control program you should provide a flow diagram or pseudo-code description, and again explain the reasoning that led to this solution.

This is likely to be the longest section of the report. Do not include code except for short snippets that help explain a crucial part of the program you created.

Avoid repetition and refer to other peoples' work instead of describing well known algorithms. (1400 words)



(a) Hop on (b) Hop off

Figure 4: Lifting the hop reveals the Phidgets boards and enables easy access to the battery slot.

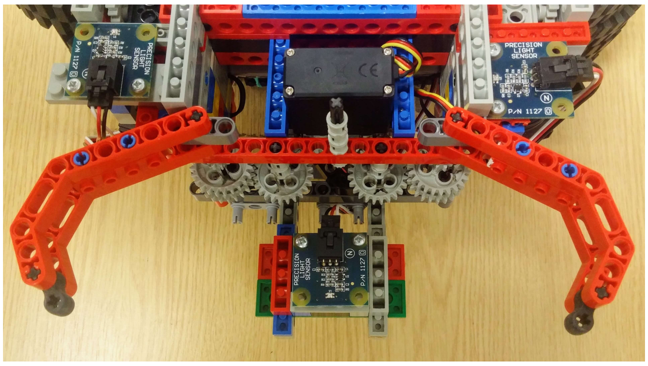


Figure 5

3 Results

3.1

This should contain some quantitative evaluation of the robot performance. For example: that it can find a resource site from a disance of x metres, and recognise and leave within t seconds; etc.

If your robot is not capable of doing the final task, you should evaluate what it does do correctly, and try to analyse what it does wrong.

The reader should be left with an accurate understanding of exactly what your robot is capable of, even if this is not as good as you hoped. Bad results are results too. You get marked based on how you approached the problem and how you evaluated the results. (800 words)

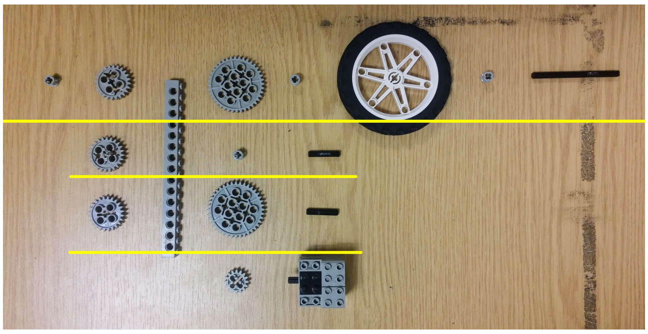


Figure 6

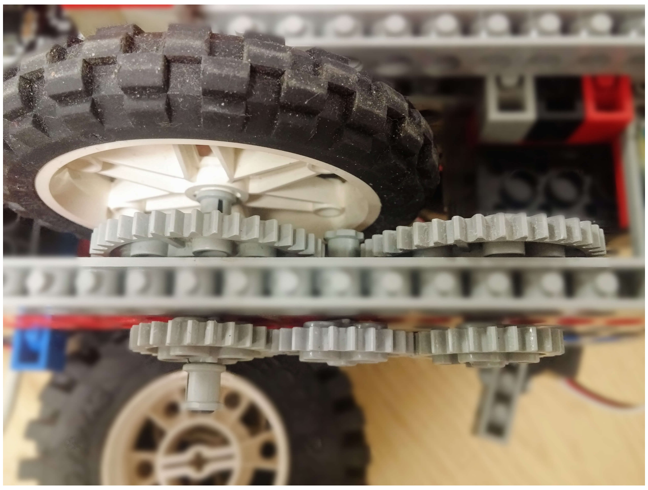


Figure 7

4 Discussion

4.1

Start by summarising the results, and giving your evaluation of how well it works. Explain what you think were the most successful elements of your approach, and what was less successful. Include ideas about how the system could be improved. (200 words)

4.2

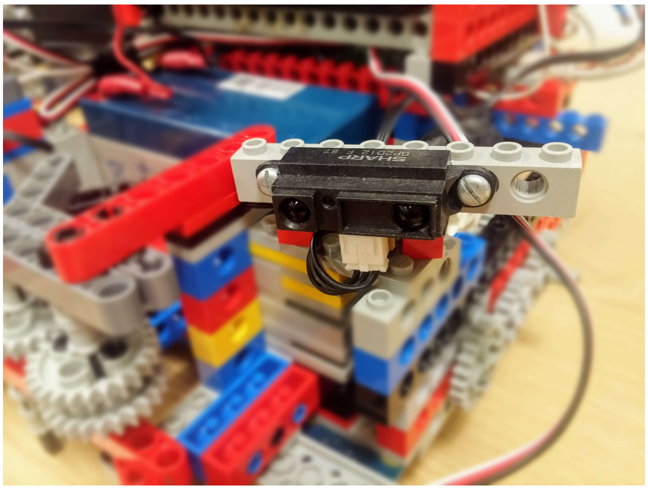


Figure 8

5 Sources

Python 2.7 Docs
https://docs.python.org/2.7/

OpenCV 3.0.0 Docs
http://docs.opencv.org/3.0.0/index.html

The Art of LEGO Design
http://www.cs.tufts.edu/comp/150IR/artoflego.pdf

LEGO Design
https://www.clear.rice.edu/elec201/Book/legos.html

Gears, Pulleys, Wheels, and Tires
http://www.ecst.csuchico.edu/~juliano/csci224/Slides/03%20-%20Gears%20Pulleys%20Wheels%20Tires.pdf

LEGO Gear Ratio Calculator
http://gears.sariel.pl/

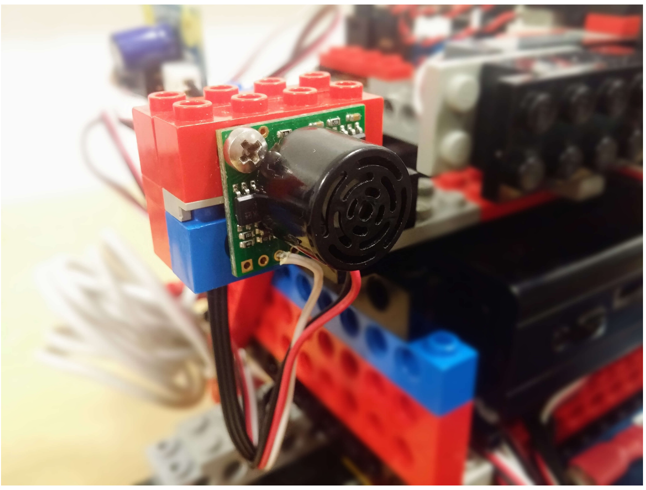


Figure 9

A Appendix

A.1 Extra images

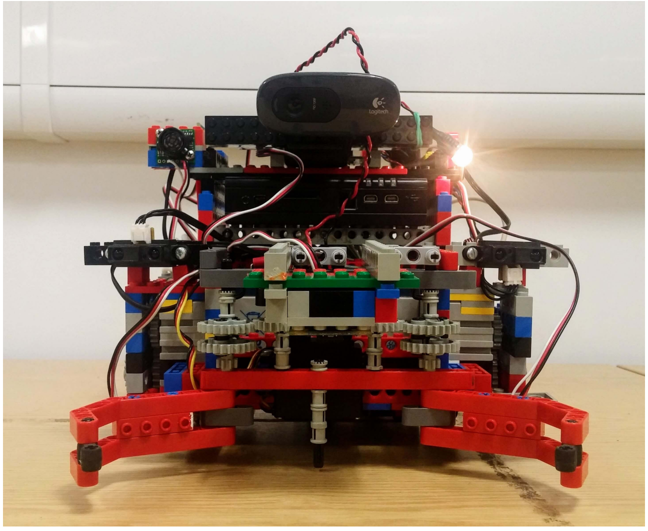


Figure 10

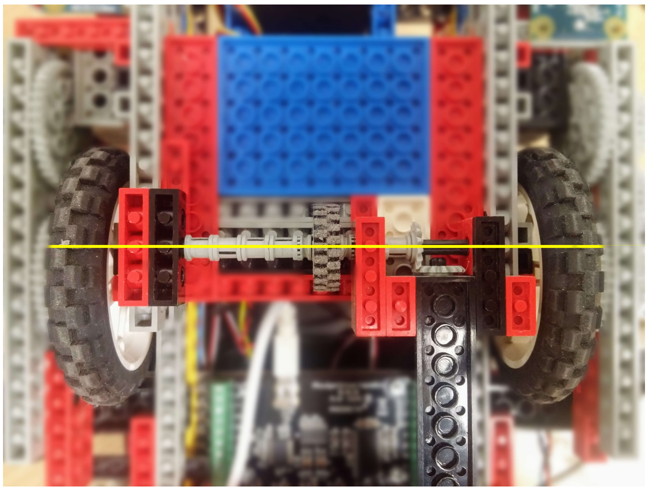


Figure 11

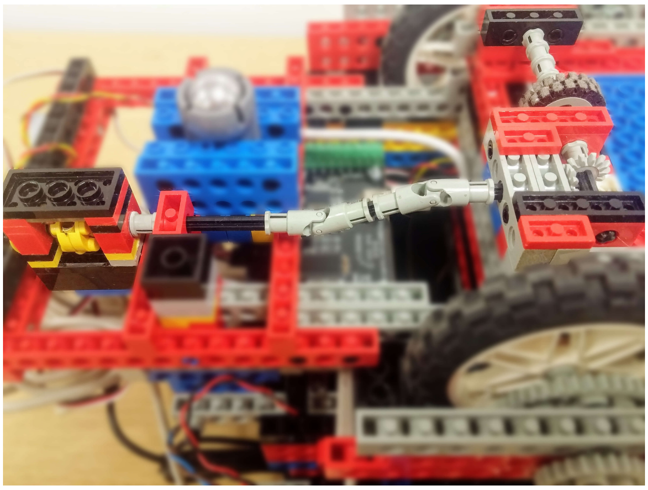


Figure 12

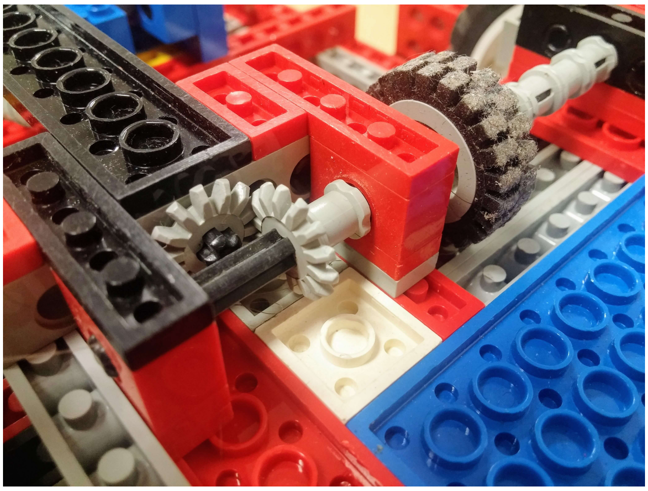


Figure 13

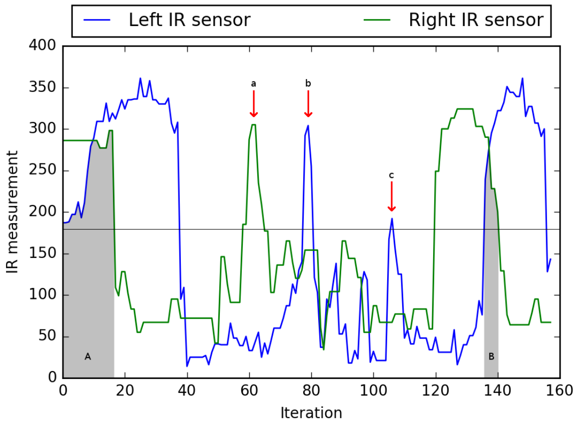


Figure 14

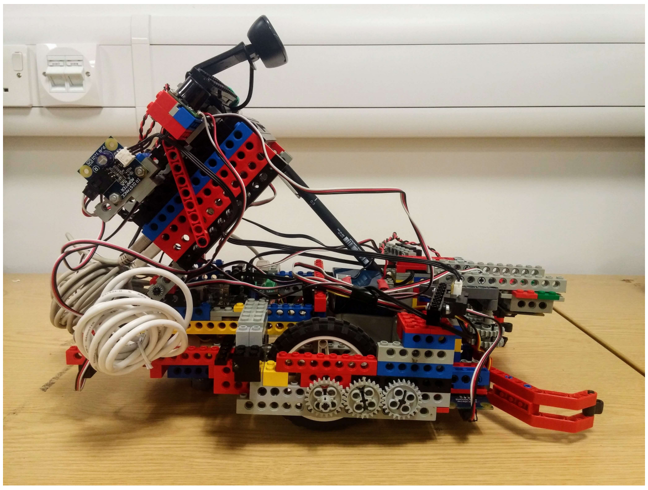


Figure 15: Hop off, side view.

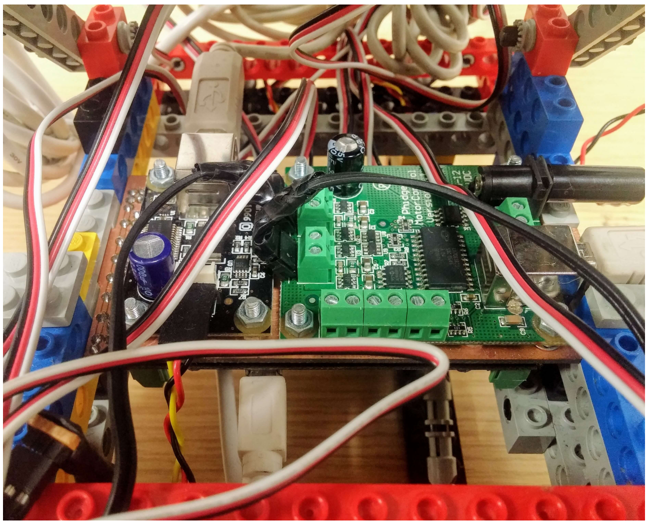


Figure 16

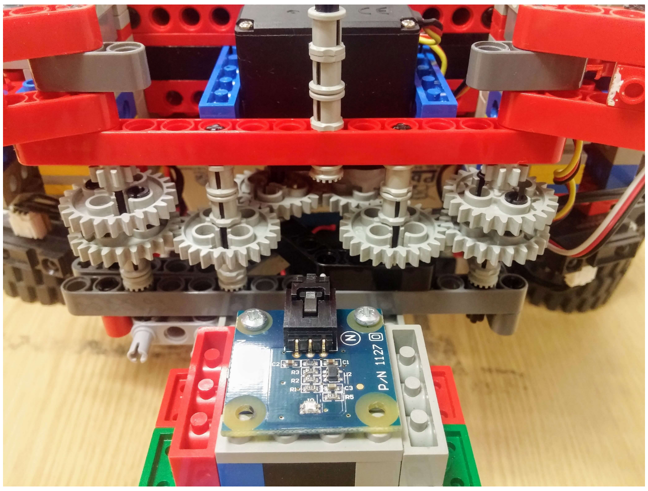


Figure 17

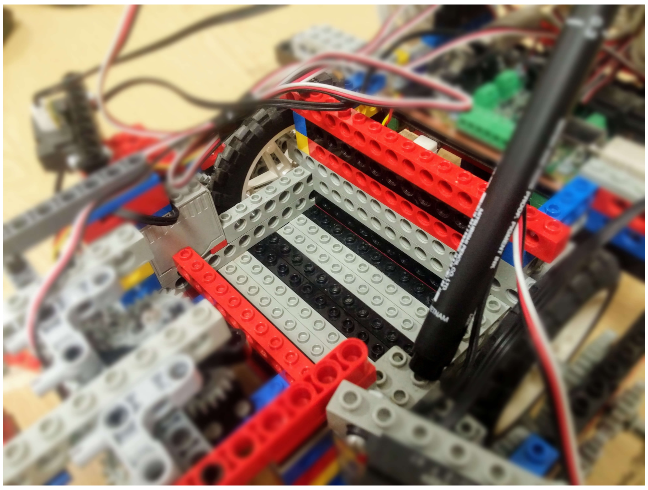


Figure 18

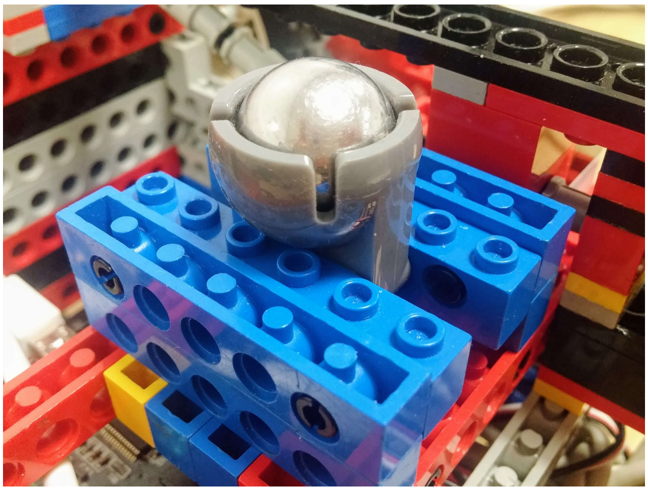


Figure 19