University of British Columbia
Electrical and Computer Engineering
ELEC 291/292

Coin Picking Robot

Introduction

For the second project of ELEC291/ELEC292, you will design, build, program, and test robot that detects and picks coins. The robot has two modes of operation: Automatic and Manual. In automatic mode the robot must operate within a predefined perimeter defined by a wire carrying an AC current and detect and pick the coins automatically. In manual mode, the robot is remote controlled by an external operator.

Project Requirements

The project **<u>must</u>** include the following components and/or functionality:

1. **Two different microcontroller Systems:** For this project you'll need at least two microcontroller systems: one microcontroller is used in the robot while the other microcontroller is used in the remote controller. The microcontrollers used for the robot controller and remote controller must be from different families. Parts to assemble microcontroller systems based on these popular microcontrollers are included in the parts of project 2 kit:

Maker	Family	Microcontroller
ST Microelectronics	ARM	STM32L051
Microchip	PIC32	MX130F064B
Microchip	AVR	ATMEGA328P
Texas Instruments	MSP430	MSP430F2553
NXP	ARM	LPC824

Examples and information on how to use these microcontrollers is available on Canvas. Additionally you can use one of the microcontrollers used in previous labs or projects:

Maker	Family	Microcontroller
Nuvoton	8051	N76E003
Silicon Labs	8051	EFM8LB1

For your project select one of each family from the tables above. An example of a <u>valid</u> combination: the transmitter using the EFM8LB12 (8051 family) and the robot using the PIC32MX130 microcontroller (MIPS family). An example of an **<u>invalid</u>** combination: the transmitter using the LPC824 (ARM Cortex M0 family) and the robot using the STM32L051 (ARM Cortex M0 family) since both microcontrollers belong to the same family. You may as well use any other microcontrollers not included in the lists above provided that you acquire both the IC and developing system.

2. **Battery Operated:** The robot and the controller must be battery operated. Batteries are neither provided in any of the kits nor will be provided to you at any moment because they are very expensive. You need to buy your own batteries. Both an AA battery holder and a 9V battery clip are included in the project kit.

3. **Metal Detection:** Coins must be detected using a metal detector. To assemble the metal detector you can use one of the inductors provided in the project 2 kit as part of a Colpitts oscillator. Your robot must be able to detect all the current Canadian coins in circulation (0.05$, 0.1$, 0.25$, 1$, and 2$).

4. **Coin picker mechanism and electromagnet:** A coin picker mechanism consisting of two micro servo motors and an electromagnet kit is provided with the project 2 kit. Your coin picker must be capable of picking any of the current Canadian coins in circulation (0.05$, 0.1$, 0.25$, 1$, and 2$; provided that they can be attracted by a magnet) and carefully deposit them in a container carried by the robot.

5. **Robot construction:** You can use any material you find available for the chassis of the robot (paper, cardboard, wood, plastic, metal, etc.). The parts listed below have been used successfully in similar projects in the past and are included in the project 2 kit.

Part #	**Description**
2 x Solarbotics GM4	Gear Motor 4 - Clear Servo
2 x Servo Wheel	2.63" x 0.35" (pair)
Tamiya 70144	Ball Caster
4 x AA	Battery holder
1 x 9V cable	9V battery clip
2 x KY61 or equivalent	Metal gear micro servo motor
1 x Coin picker assembly kit	Several parts to assemble the coin picker.
1 x Electromagnet kit	Bolt, washers, nut, and magnet wire to make and electromagnet to pick coins.
Folded Chassis	Aluminum robot chassis made using the water jet cutter.

You can buy the project 2 kit for 80$ from:

https://eng-services.ece.ubc.ca/course-support/2024-winter-term-2/elec291/

and pick it up in MCLD1032.

6. **C programming:** The code for this project must be completed using the C programming language.

7. **MOSFET drivers:** To drive and control the motors of your robot you must use MOSFETs (Metal Oxide Semiconductor Field Effect Transistors). You should have both NMOS and PMOS in the ELEC201/CPEN211 parts kit you bought last term. If you find the motors are too noisy (electronically noisy, that is) you may want to consider isolating the microcontroller from the motors using opto-isolators to control the MOSFETs. The LTV847 optoisolator is included in the ELEC291 microcontroller parts

kit. Obviously, the robot should be able to move forward and backward as well as turn left or right.

8. **Perimeter Wire Generator and Detection:** Your robot must be able to detect a perimeter wire carrying an AC current and remain inside such perimeter. To generate the field you can use either the function generator in the laboratories or build your own perimeter AC source using an oscillator such as the LM555 timer. The minimum perimeter area should be 0.5 m^2. The recommended perimeter surface consists of a rectangle 1 m x 0.5 m as it easily fits on the laboratory benches.

9. **Automatic Robot Task:** The robot should individually pick 20 coins (four of each type) placed randomly in the area defined by the perimeter wire, without completely leaving the perimeter at any time[1]. After the robot finishes picking the 20 coins, it stops and waits for commands from the remote controller.

10. **Manual Robot Tasks:** In manual mode the robot is controlled using a remote of your own design. The basic manual tasks are: move forward or backward, turn left or right, stop, and pick a coin. To communicate with the robot a couple of serially controlled radios JDY-40 are included in project 2 kit. Examples and information on how to use these radios are freely available on the internet; for example:

    https://benjemmett.com/archives/790

    Please be aware that the JDY-40 radios use the ISM frequency band which is shared with WIFI internet and many other wireless devices. Make sure you change both the 'transmit' and 'receive' device IDs from the defaults included in the examples to avoid interfering with other group communications. Examples on how to configure and used the JDY-40 as both a master and slave are available on Canvas for all the supported microcontrollers.

11. **Remote:** While one microcontroller system is used to control the robot, another microcontroller system is used to transmit commands to the robot and display data returned by the robot. The remote should include a LCD to display the "strength" of the signal of the metal detector in the robot, as well as a speaker that beeps whenever metal is detected. The frequency of the beep should increase with increase strength of metal detection by the robot. Use a joystick or another suitable method to control movement of the robot. You can use the "PS2" joystick included in the project #2 kit to control the movement of the robot.

[1] Parts of the robot may temporarily be outside the defined perimeter. For example, if the robot is turning and one of the wheels comes out of the perimeter it is still acceptable.

Project Evaluation

The evaluation of this project consists of a demonstration (worth 30% of the final mark), a written project report (worth 5% of the final mark), and a video recording presentation (worth 5% of the final mark). In the project demonstration, your design is evaluated using the following criteria:

Mark	The project:
9.0-10	Is exceptional, did everything it was supposed to do well plus lots of additional functionality.
8.0-9.0	Did everything required, circuitry / project well designed / some additional functionality.
7.5	Did everything required. The project lacks originality, innovation, or extra functionality.
7.0-8.0	Mostly worked, not entirely, not the greatest design.
6.0-7.0	Didn't really work, ok design but didn't really come together.
5.0-6.0	Didn't work, not very good design.
0.5-5.0	Didn't work, poor design. (Pile of parts!)
0	No project demonstrated.

The project demonstration evaluation will be carried out by the course instructor and/or one or more laboratory TA(s) on April 4, 2017. This demonstration should not take more than 4 or 5 minutes, if everything is working reasonably well. The project report is due by April 7, 2017. You need to submit the project report using the format described in the following section.

Project Report Format

The project report should be written for a reasonably expert reader such as a project manager (an engineer) in a company for whom you might have designed this prototype product. The project report should have sufficient detail that someone skilled in the art could reproduce or improve upon your results. The number of pages for the report should be ≤ 20 (not including the title page and appendices, double spaced, 'Arial' or 'Times New Roman' font size 12 for text, and 'Courier New' font size 8 or 10 for the source code, approximately one inch margin for the top, bottom, left, and right margins) and include the following sections:

1. **Title Page –** It should include the course name and number, instructor name, section, project name, <u>group number</u>, names and student number of the students in the group, and the date of submission.

2. **Table of Contents**

3. **Introduction** – Design objective and specifications. Overview of the overall design approach including **system block diagrams for both the hardware and software designs**.

4. **Investigation –** This section must include the following subsections:

A. **Idea Generation** – Describe how your group generated ideas and working hypotheses.
B. **Investigation Design** – Describe how you group perform the design investigations involving information and data gathering, analysis, and/or experimentation.
C. **Data Collection** – Describe how your group used appropriate procedures, tools, and techniques to collect and analyze data.
D. **Data Synthesis** – Describe how your group synthesized data and information to reach appropriate conclusions.
E. **Analysis of Results** – Describe how your group appraised the validity of conclusions relative to the degrees of error and limitations of theory and measurement.

5. **Design** – This section must include the following subsections:

A. **Use of Process** – Describe how your group adapted and applied general design processes, accesses to design systems and components, or processes to solve open-ended complex problems as relevant for this project.

B. **Need and Constraint Identification** – Describe how your group identified customer, user, and enterprise needs, and applicable constraints.

C. **Problem Specification** – Describe how your group specified additional design requirements based on needs and constraints presented in the point above.

D. **Solution Generation** – Briefly describe potential design solutions suited to meet functional specifications. If possible, include even those that didn't work!

E. **Solution Evaluation** - Perform systematic evaluations of the degree to which several design concept options meet project criteria. Clearly explain why you choose the final design.

F. **Detailed Design** – Explain how you applied appropriate engineering knowledge, judgment, and tools, in creating and analyzing design solutions. This has to be one of biggest parts of the report. In this section you must include the description and evaluation of each block (e.g. "A-stable Circuit", or "Counter Initialization"): Describe the approach taken to design each block. For circuits, include a detailed circuit diagram and describe how it works. For programs, include the source code in the appendices, and refer to it while you describe it.

G. **Solution Assessment** – Describe how you assessed the design performance based on requirements, needs, and constraints. This section must include an **evaluation of the complete system** by mean of tests you carried out including plots of performance, reproducibility numbers, tables, etc. as judged appropriate for this project. Describe how each relevant part of your design was tested and the testing results. Also in this section, the strengths and weaknesses of the design must be pointed out.

6. Live-Long Learning – Identify a specific learning need or knowledge gap. For example, did your learn something new by yourself? You didn't take a course that would have helped with the project? You found that one of the courses you took was particularly useful for the project?

7. Conclusions – Summarize the design and functionality of your project. Summarize also the problems you encounter, and how many hours of work the project took.

8. References – A specific book, paper, datasheet, or website is referred to in the **body** of the report at the point at which you say something about it, by a numerically-ordered, square-bracketed number, the first one being [1]. Then, at the end of the Report in a section called **REFERENCES** located just before the **Appendices** section**,** the same square-bracketed number is followed by the Author List, Article Title, Journal or Book Title, Volume, Number, Pages, ISBN Number, Publisher, Date of Publication. Although the Reference list can be listed alphabetically by author, instead we do not recommend this for an Engineering Report. With an alphabetical listing, the location in the body where any particular reference is discussed is then hard to find, since the references are no longer in order of appearance. Examples of references are [1] and [2] (note that the numbers in the square brackets here refer to the appropriate numbers in the Reference list). The Reference list itself might look like:

> **REFERENCES**
> [1] Smith, J, and F. Jones, "Designing an universal logic circuit", Journal of Impossibly Wonderful Electronic Circuits, v.3, n.1, pp. 21-35, March, 1910.
> [2] Jones, F and J. Smith, "Why universal logic circuits are impractical" , …

9. Bibliography – Items in a section at the end of a report called **BIBLIOGRAPHY** are NOT referred to in the body of the report. It is a list of appropriate background or additional reading and is located after the **References** section and before the **Appendices** section. The items in the Bibliography are usually ordered by last name of the first author. It is sometimes appropriate to have BOTH a Reference list and a Bibliography list. An example Bibliography looks like:

> **BIBLIOGRAPHY**
> • Sedra, A., and K.C. Smith, Microelectronic Circuits, 4th Edition, Oxford University Press, 1998.

10. Appendices – Supporting documents such as extensive theoretical analyses, mechanical drawings, and source code. Your source code should be properly documented and indented. Do not append datasheets, compiler manuals, or other already published material to the report.

Project Report Marking Rubric.

Report Content	**Worth**	
Title page (all information present including student names/numbers/section?)	0.2	
Table of contents	0.25	
Introduction	0.3	
Investigation		
Idea Generation	0.2	
Investigation Design	0.2	
Data Collection	0.2	
Data Synthesis	0.2	
Analysis of Results	0.25	
Design		
Use of Process	0.25	
Need and Constraint Identification	0.25	
Problem Specification	0.25	
Solution Generation	0.35	
Solution Evaluation	0.2	
Safety/Professionalism	0.2	
Detailed Design		
Hardware block diagram?	0.5	
Circuit explained?	1.0	
Software block diagram?	0.5	
Software explained?	1.0	
Solution Assessment		
Tests include data/plots?	0.5	
Life Long Learning	0.2	
Conclusions	0.5	
References (present and used correctly?)	0.25	
Bibliography (present and used correctly?)	0.25	
Appendices (if present, used correctly?)	0.25	
Report Format		
Double space?	0.25	
Correct Fonts?	0.25	
Margins?	0.25	
Number of pages? (<20 not including appendices)	0.25	
Clear & clean figures? (Bad scans of poorly hand drawn figures are not acceptable)	0.25	
Page numbers.	0.25	
Clean presentation.	0.25	
Weeks late (-2 points per week)		
GRADE (out of 10)		