**CPEN 291   
Project 1 Report**

**A. Group info**

Lab section: L2A (*L2A or L2B)*                   Group #: A-G4    (*Example: A-G1*)   
Group’s Lab Bench #s: 9   and 4 (*Example: 1 and 2*)            
Student names:

|  |  |
| --- | --- |
| Andrea Shao | Matthew Chow |
| Brielle Law | Matthew Stefansson |
| Sebastian Gonzalez | Matthew Yen |

**B. Technical documentation for the main functionality**

1. Hardware

We considered three configurations for the reflective optical sensors:

* **Option A**: Three reflective optical sensors aligned side-by-side, locataed on the lower platform at the front of the robot. The two outer sensors are separated by the distance of the black electrical tape (approx. 2cm) and the third sensor is centered in between.
* **Option B**: Five reflective optical sensors aligned side-by-side, located on the lower platform at the front of the robot. Each sensor is separated evenly by half of the distance of the electrical tape (approx. 1cm). The two additional sensors were considered to maximize the smoothness.
* **Option C:** Four reflective optical sensors aligned in a triangular formation. A single sensor is placed 3cm in front of the remaining three sensors aligned side-by-side separated by the distance of the black electrical tape (approx. 2cm). The positional offset of the sensor is to account for the expected 3cm gaps in the track. This would prevent us from having to track the time required to travel 3cm.

We initially decided to implement Option B, making use of the 5 reflective optical sensors. We made this decision to maximize accuracy and to allow for greater error when searching for the black line. We were concerned that using only 3 sensors would result in continuous back and forth swerving.

Challenges:

After implementing Option B, we were challenged by inconsistencies of one of the optical sensors. This single sensor would unreliably return the expected value (1 for black and 0 for white). Thus, to ensure we could achieve the main functionality of following the line, we decided to simplify our design to Option A. We concluded that this was the optimal decision, because the implementation of the PID controller would provide the same performance as if

1. Line Following Algorithm

When considering which hardware configuration to choose, we also took into account their corresponding line following algorithms.

* **Option A:** (Corresponding to 3 Reflective Optical Sensors) If the middle sensor reads 1, the robot should continue on a forward path. If the left sensor reads 1, the robot needs to correct its path by veering left.  If the right sensor reads 1, the robot needs to correct its path by veering right.
* **Option B:** (Corresponding to 5 Reflective Optical Sensors) If the middle sensor reads 1, the robot should continue on a forward path. If the two center right sensors read 1, the robot needs to correct its path by veering a *slight* left. If the outer left sensors read 1, the robot needs to correct its path with a larger left turn. The equivalent conditions for the right sensors hold true.

Implementation of the PID controller

* Both Option A and Option B require similar PID controller implementations. Each possible combination of triggered sensors correlate to an error value. If only the middle sensor reads 1, the robot is travelling on the desired path, and hence has an error of 0.

PID = (Kp \* error) + (Kd \* (error - prevError)) + (Ki \* integral)

1. Headless Pi
2. Battery-operated Robot Implementation and Challenges

**C. Technical documentation for the additional functionality**

Fully document your design and implementation for the additional functionality. In particular explain:

1. PiCamera
2. Android Application
   1. Sending
      1. Mode

The application determines what kind of mode the robot is in. It can be in autonomous or remote control mode. With remote control mode, the application can send various commands to the

* 1. Receiving
* What the additional functionalities are
* Include the list of the additional components you used
* How camera is used as a part of an additional feature
* The hardware implementation
* The software implementation

**D. Test and evaluations**

Explain your evaluation and testing procedures for hardware and software. Please demonstrate systematic testing, debugging and continuous integration. Include the problems you have encountered and how you resolve them, as well as best practices you have incorporated.

**E. Conclusions and Reflections**

Reflect and conclude on the lessons, tricks or interesting concepts you have learned during the project.

Also reflect on other aspects such as team work, project management, time management, ...

**F. References and bibliography**

Provide any relevant references.

Also include the list and description of the files submitted for this lab (including code and Fritzing breadboard view)

Submission:

* 291 Project Report (this file)
* Fritzing file (RPi, LCD, both breadboards)
* Python file (main functionality)
* Java file (additional app functionality)

**Appendix A – Robot pictures**

Include pictures of your robot here. The pictures should clearly show the robot as a whole, as well as all electronics, wiring and parts. Include photos taken from the top, and from the sides. Show the location/installation of circuits and components as clearly as possible.

**Appendix B - Code**

Include the complete Python code with comment statements. This code must be the same code as the files you demo and submit. Clearly identify the portion of the code for the main functionality and the Additional functionality.

The code must be readable, with proper indentation, syntax highlighting (that is, copy with colour coding), and on white background. The code must be in text (that is, absolutely no snapshots of the code).

**Appendix C - Fritzing**

Include the snapshot of your fritzing breadboard view. Include as many as you have, but clearly describe which is which. This is in addition to the fritzing file that you submit to the Canvas.

**Appendix D - GitHub**

Every group member must have reasonably and equally contributed tow the project github repository. If that is not the case for any member and there is a valid reason as to why, please include an explanation here.

**Appendix E – Complete Component list**

* 1 Raspberry Pi 4 Model B
* 1 Adafruit 1.44 inch TFT LCD
* 1 Robot kit
  + Fuselage upper and lower plate
  + 2 Geared DC motors
  + Multiple screws, washers, spring washers, nuts
  + 2 wheels
  + 1 Caster
  + 1 Sensor mounting grill
  + 1 Battery holder
  + Power switch and jack
  + 1 IR sensor mounting bracket
* 4 AA batteries
* 1 Motor hat
* 3 TCRT5000 reflective optical sensors
* 1 Raspberry Pi Camera Module V2
* 1 Android phone (Used for app for additional functionality)
* 2 small breadboards
* 1 large breakboard
* Multiple wires
* Electrical tape

**Appendix F – Answer the following questions:**

Q1 – Teamwork: Explain in details the methods your group has used to communicate effectively among team members.

After the last mini project, we found that a Facebook chat proved to be useful in connecting with one another while not at lab. We continued using the same chat for this project as well. It allowed us to easily ask questions, send links to google docs, and keep progress regularly updated.

On top of this, we also had a short team meeting at the beginning of the first lab. We broke our project into smaller modules and assigned one or two people to be the leaders of each section. This allowed us to avoid an error we ran into in the last project where different portions of the project would be almost done, but nothing was ever fully complete. By assigning leaders to each section, there was always someone continuously checking and ensuring each portion was up to date. This being said, each group member still worked on all parts of the project to ensure maximum exposure and experience. The leaders per section was just a strategy to keep progress flowing.

Additionally, our team also implemented a lot more partner programming in this project. As our main components were the app and additional functionalities, sensor and PID controls, and actual movement of the robot, there were always around 2 people working on a portion of the project at a time. We were able to continuously rotate between one person coding and another reviewing. This allowed us to catch subtle bugs that may have taken hours to find as the person coding was able to talk through their thought process with their partner. This also eased us into an environment that welcomed constructive criticism and overall allowed for more effective communication and collaboration.

Q2 – Design Process for the additional functionalities: Describe clearly the process you used for the following design aspects of your own additional functionalities. Please spend time to carefully answer each of them.

1. **Use of process**: Describe your approach to adapt and apply a general design process for any additional feature. What was your approach?
2. **Constraint identification**: Explain the constraints that you must consider in the design of the additional functionalities.
3. **Solution generation**: Explain at least two possible alternative additional features that your group rejected due to technical reasons and explain why.
4. **Solution Assessment**: Explain how you tested and assessed the viability and then correctness of your group’s additional features.

**Appendix G - Other**

Below we have included photos of the interface for our app (additional functionality):