ECSE 211
FINAL REPORT
Team 01 - RobotExpress

Angelina Duan - 260835863
Shichang Zhang - 260890019
Junjian Chen - 260909101
Lide Cui - 260852913
Yutong Wang - 260839723
Dominic Chan - 260904794

McGill University
Department of Electrical and Computer Engineering
Winter 2021

1. Introduction
   a) *What was the main reason(s) for doing the project?*
      The main goal of this project was to **learn and develop our engineering design skills**, as well as to **gain hands-on experience** with project management and documentation . Specifically, we learned how to professionally conduct and manage an engineering project with regards to a clientele, including the need for a schedule and budget-based plan as well as the need to properly document and keep track of our **design processes.** This project provided us a great opportunity to learn how to **use effective tools to help our team management**. All the aspects that we learned from the project will be important to our future engineering careers.

   b) *What was the main learning outcome of the project?*
      - We learned how a project is organized and how to conduct a project step by step.
      - We learned how to **analyze a design problem** from a system's perspective.
      - We learned how to use different tools such as GitHub, MS Teams, WeChat, Zoom, and Google Drive to help us **communicate and work collaboratively.**
      - We learned how to use effective tools to **maintain good documentation traceability** like Gantt chart and Spreadsheet.
      - We learned how to properly do **documentation.**
      - We learned how to effectively **work as a team with our different roles,** as well as how to **manage the team budget**.
      - We learned how to **test robots using the v-model** and how to link tests to software and hardware designs.
      -

2. Team organization - the startup of the project

   a) *How were tasks allocated?*
      We prepared a capability document at the start of the project. Each team member wrote down their own strength and weakness as we have completed 5 labs beforehand. We split our team into software, hardware, and testing sub-teams as some of us are good at coding while others are good at hardware design or documentation writing. Each sub-team had meetings to split tasks based on its members' interests and abilities. We had a sub-team leader record the team's progress and reported it to the project manager.
   b) *How was the initial Gantt chart designed?*
      The purpose of the Gantt chart is to form a timeline and break down the general project requirements into realizable tasks. So we first analyzed the client's needs document and the timetable for meeting with the professor. Then from the requirements document we wrote, we determined the tasks and their dependencies. So we formed the critical path based on timeline and

dependencies. Lastly, for individuals that are responsible for each task, we split the tasks based on their interests and abilities. We also considered the time constraints and we distributed the work evenly.

c) *What information was used to estimate the initial task breakdown?*
   - The meeting document and the project description (client needs' document) that released on mycourses
   - The requirement document, where we analyze the tasks
   - The interests and abilities of each team member

d) *Were any guidelines followed in developing the first version of the chart?*
   The guideline that we followed was the requirement document, which specified the requirements of the project and the tasks to be completed. We also followed the meeting document which gives the schedule of the meeting with professor Moon and the main tasks to be accomplished every week. Lastly, we had a meeting with TA every week to give suggestions and improve our chart.

3. Issues encountered in the progress of the project

a) *Were all the dependencies correctly identified at the start of the project? What dependencies contributed to the critical path of the project?*
   The overall dependencies were correct as the general project timeline was given. However, as time moved on, more tasks were added and some tasks were completed beforehand or completed before their normal schedules. Because of the reasons above, the dependencies needed to be changed.

   Here is the critical path with major tasks and dependencies:
   Project Kickoff -> Initial documentations->Mechanical design proposal -> Webot model design -> Complete mechanical design -> Complete testing of mechanical design -> Software document version 1 with system model document -> coding -> unit test -> integration test -> pre-beta demo test-> beta demo test-> fix bugs from beta demo -> pre-complete system test -> complete test -> final demo and presentation ->final document submission

   During each testing period, testing documents were updated. And during each coding part and when a new design appeared, the associated documents were updated. See Gantt chart for detailed information.

b) *What initial ideas turned out either not to work or be based on wrong assumptions?*
   - We updated our initial ideas of the hardware design several times. Because our robot could not go over the overpass or sometimes it rolled down from the overpass.
   - At first, the passing-bridge solution was determined by the relative location between the robot and the midpoints of the bridge. However, after the beta demo, we found that we don't need such complicated algorithms, so we used a new algorithm that calculates the points to cross the bridge by the direction of the bridge.

c) *What other issues/factors had an impact on the project? And how did these affect the project progress?*
    - Unclear user requirements had the most significant impact on the project. Many times, we were unable to predict the actual conditions of the environment from the given materials. We may work on some complicated and useless cases but ignore other possibilities.
    - Also, work division and integration were great challenges to us. Compared to individual work, teamwork made individual workload smaller, but understanding others' work consumes a lot of energy and attention.

4. The budget
    a) *What constraints did the budget place on your team?*
    We had a limited budget that our team had to distribute work based on each team member's **best strengths and skills**. Furthermore, we had to **plan ahead** to ensure we met all the requirements within the limited budget. Lastly, the limited budget forced us to **set feasible goals**.
    b) *How did initial planning for available resources and budget spending affect the development of the timeline?*
        - The Gantt chart helped us progress well and make our work more organized
        - Knowing available resources(budget, availability, capability, and tools) made our timeline progress smart
    c) *Did you allocate resources to all the project tasks, at the start of the project and use this to estimate the budget? If not, explain why not.*
    We allocated resources to each task at the start of the project to **help us understand our milestones and important design tasks**, such that we could have a realistic timeline. Throughout the project, our allocated resources have changed based on the actual budget we used.
    d) *In what aspect of the project and its management did you lack resources?*
    We had a set limit of budget per person available each week. This first led to a lack of documentation update, especially in **testing**. If we had more budget, we could consider more cases to test which might lead to better performance during the final competition. Another one is **lacking time for meetings**. The meeting time was scheduled beforehand which took away a large proportion of our budget.
5. *How the process has contributed to the final outcome of the project?*
    a) *Do you think the process was useful in reaching the final design?*
        - Yes, the process ensured that we all had an understanding of the design problem and the requirements that we analyzed were useful for forming the solution
        - Understanding how the overall system accomplished the outlined tasks helped us to better determine how to define our subsystems.

- This process also assigned every team member a role so that everyone could focus on their responsibility.
- Lastly, the process guided us to finish this relatively large project step by step.

b) *Which parts of the process were the most difficult to implement and why?*
   - Coding and tests are the most difficult parts. It is hard to design tests for all possibilities. And make solutions that are suitable for every scenario.
   - Also, constructing a mechanical model that could successfully get on the overpass is also difficult.

c) *How much time has been devoted to testing?*
   - For the software team and testing team, about 60% of the time is used to design and run tests.
   - According to our overall budget calculation, we spent 81.5 hours on testing which was 23.4% of our total budget for the project.

d) *When in the process did you implement testing?*
   - Testing was implemented throughout the entire process
   - The sensor characterization test was implemented when implementing the mechanical design model. We used the code from lab 4 and 5 to test the sensor's position and functionality.
   - The component unit tests were done after the completion of each component and updated after modifications
   - The implementation tests were implemented when its corresponding component unit tests were passed
   - Pre-beta demo and pre-final demo tests were implemented before the bata demo and final demo
   - Beta demo tests and final demo tests were implemented when all the above tests were done which is our complete system test

e) *If you were to implement your robot with a physical LEGO Mindstorms kit. How much time do you estimate the full prototype would take to build? Explain how you have reached the estimate.*
   - If we were to implement our robot with a physical LEGO Mindstorm kit, we expect to spend more time building our hardware model in comparison to building it with LeoCAD. This is because in LeoCAD, we don't have to physically connect all the sensors and motors with the EV3 brick. However, in reality, the sensors and motors must be connected with a wire and plugged into the Ev3 brick, this means we have less free space around the EV3 brick to place other LEGO pieces. Besides that, if our robot were implemented with a physical LEGO kit, the position of the ultrasonic sensor must be redesigned,

because its current position covers the screen of the EV3 brick. Therefore, building robots with a physical LEGO kit increases the complexity of hardware design.

- In addition, if our robot were made with a physical LEGO kit, it is very likely to damage during the testing trials. In the testing trials, our robot fell off the overpass and ran into the wall many times. So more time will be spent fixing our robot after it failed the testing trials.
- Therefore, we expect to spend about 50% more time every week on implementing our robot with a physical LEGO Mindstorm kit. We are currently spending 8.6% of our total budget on hardware implementing, which is around 5 hours per week. In this case, we expect to spend 7.5 hours every week on implementing our robot with a physical LEGO kit.

f) *<u>How would you change the process for designing tests to make it more effective?</u>*

- We will make a more thorough and detailed test plan before implementation. Since the cost of changing existing solutions is very high. Also, we will divide our work into different modules, since the division of work is a little unorganized.
- We will design more edge cases to test the performance of the robot. In our final demo, the robot fails because the map is out of our expectations.
- Our integration test is not effective as we concentrate too much on the unit test. We will spend more time performing the integration test before moving into the complete system test. Lack of integration tests is also a reason for the failure of our complete system test.
- We will subdivide the unit test of a specific function. A problem with the testing document is that, in one single unit test document, there exist many procedures to test. Actually, it is misleading for both the testing team and others who look at our document. So we will subdivide the unit tests to make the tests more clear hence more effective.

6. *Remote team dynamics*

a) *<u>What was the most challenging aspect of working as a remote team? How did you overcome this?</u>*

- First, we were in different time zones and five of us were in China, so there was always a delay to solve problems. Also, Our version control tool was not very clever, but we were getting more used to it by using GitHub to control different versions.
- Also, communication was a huge challenge to conquer. As all the work was done remotely, it was hard for team members to understand others' work especially in the Software team that they needed to spend time understanding others' code.

b) *How has your team's way of communicating, sharing of work, or managing of the project tasks with each other change over time?*
    - We communicated using **WeChat**, a popular social media application in China. We shared and edited our document through **Google Drive**. For the robot version control, we use **GitHub**. Finally, for formal meetings with TA and professor, we use **Microsoft Teams**.

7. Conclusions

a) *What did you learn from this course?*
    - How to work in a team environment with predefined roles while following the engineering design process on a schedule
    - How to show the work with documentation and charts
    - How to present in the context of engineering
    - The importance of team management and defining constraints
    - Technical knowledge related to LeoCAD, multi-thread software development, and robotics.

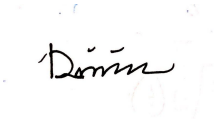
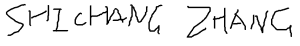
b) *Explain why a clear, effective, and controlled process is necessary when working in a team and what it helped you achieve.*
    Before this course, most of the team members only took courses that contained coding skills only or required individual work. It was the first time that required teamwork skills and cooperation.
    - Team members had time difference: that we defined time availability and organized the meeting schedules which allowed all the team members to take part in the meeting
    - The difference in capabilities among team members: each team member had different skills. So we defined tasks and separated them based on member's abilities which boost our efficiency.
    - Resource constraints: the time budget is limited to 58.5 hours per person so we separated tasks evenly to ensure everyone learned something.
    - What we achieved: Complete the course is a huge achievement to us and we learned how to be a team!

c) *Is any of it applicable to other courses you might take? If so, what and why?*
    - Yes. It is applicable for ECSE 458(Capstone Design Project). Because it requires interdisciplinary group work, provides resource constraints, demands progress updates, and needs team management skills.

d) *What would you change in what you did if you were doing it over?*
    - About the team management: we spent a lot of time on coding and debugging in the first few weeks. If we can do it over, we will spend more time on testing and writing testing documents. After the final demo, we found out we haven't thought about the map like the one in the competition before which is caused by the lack of testing.

- About software development: For coding, we will make our codes more neat. As different members have their coding styles and the imperfect cooperation makes it hard to understand others' codes, it lowers the efficiency of coding. We will concentrate more on coding readability and comment, to make it easier for us to cooperate in software development.

The undersigned members of team 01 agree that the contents of both this report and the information handed in on MS Teams, provide an accurate representation of the work done on this course and the contributions of each team member.

Angelina Duan	**Junjian Chen**	**Yutong Wang**
		
Dominic Chan	**Shichang Zhang**	**Lide Cui**
		

15 April 2021