ECE496 Project Proposal

Project Name: Remote-Controlled Robot

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Executive Summary

Delivering items across campus or within an office building can be a tiring and time-consuming task for people and staff to do it manually. The challenge of such a process can be significantly mitigated if there exists a robotic delivering system that can fulfill the delivery needs. In this document, the context of the delivery problem will be analyzed, and a potential solution will be proposed to replace the human labor in this process. The scope of the proposed design will be set, together with metrics to measure its ability to solve the problem.

Motivation

The UofT campus is large, and it can take tens of minutes to travel from one building to another. To deliver items across such a span of area can be difficult, especially for elder people or during winter times. As robotic technology and internet-of-things becomes more popular these days, there still lacks an effective solution to automate payload delivery within a confined area. Currently, off-the-shelf affordable robotic vehicles are either incapable of carrying significant amount of cargo over a long distance, or cannot be remotely controlled [1][2]. Products that satisfy both of our needs, on the other hand, are way too expensive to be economically viable for mass implementation (typically priced around $170,000 by 2021, Nov.) [3]. Therefore, we would like to design a capable and affordable solution to tackle the delivery problem ourselves.

Problem Statement

Delivering items and files indoors in an office environment or inside campus buildings would be a time-consuming task. For maximizing productivity, it would be helpful if an automated robotic system can fetch documents, coffee, and snacks from the counter, and directly deliver them to employees' tables.

Project Goal

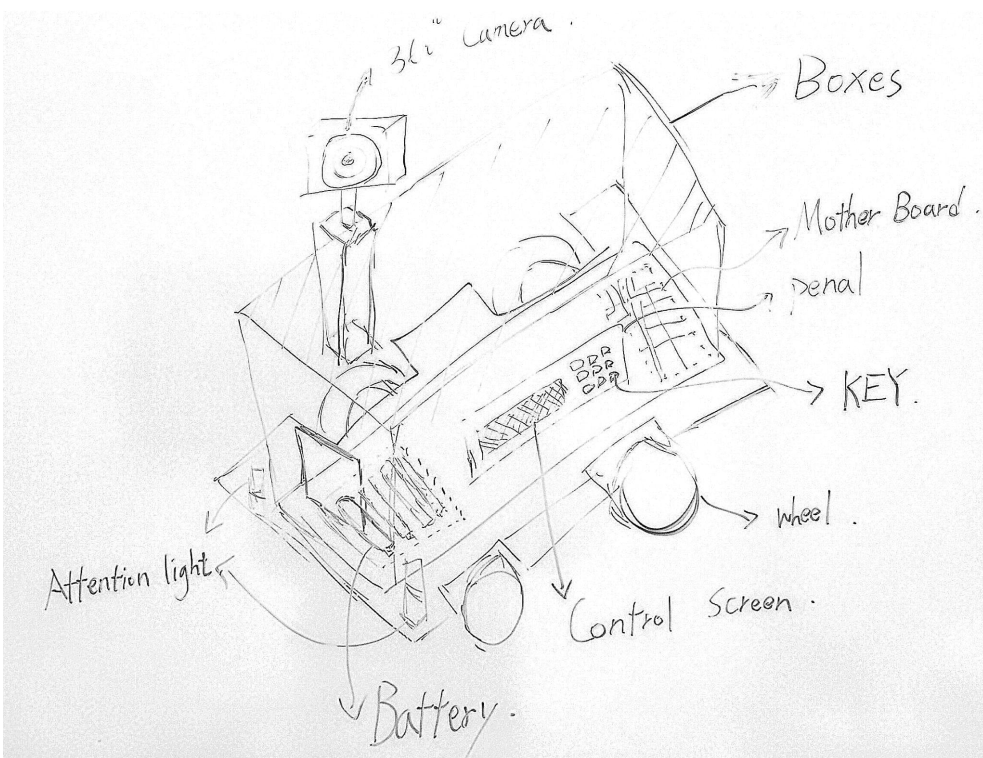
Our project is aimed to build such a robotic vehicle to help reduce the amount of human effort required to transfer small items inside a building. The goal of this project is to construct a means of remote-controlled robotic transportation, in which items can be delivered from one place to another autonomously in an indoor environment, without the need for users to physically travel to their destinations.

Scope of Work

In this project, our team is aiming to construct a remote-controlled robotic vehicle that enables the user to drive inside a building to deliver items. The car needs to be controllable from afar, uploading video streams from its onboard camera to allow the user to control it without a line of sight.

The key objectives and challenges involved in this project include:

- Design and construct a robotic vehicle, from scratch, using raw materials (like wood pieces), purchasing off-shelf parts, and 3D printing.
- Design and Assemble a digital control and electric motor system (using purchased parts) to enable driving and turning off the vehicle for an adequate amount of time after being charged.
- Make the vehicle remote controllable by either a phone or a computer, without needing a direct line of sight, possibly via Wi-Fi or cellular network.
- Ensure the vehicle is safe to drive indoors, even when not under direct human supervision.
- Design a medium that allows the vehicle to safely store and transport small items onboard.
- The delivery process should be convenient and user-friendly. It also needs to be completed in a timely manner where it should drive at least as fast as human walking speed or faster.



Requirement Specifications

This section will include how the function and success of the project will be quantified in a systematic way. The proposed design and its alternatives will be measured against these requirements in the future.

3.1 Functions

The functions described in Table 1 are the proposed tasks that the design will meet. The main purpose of the design is detailed in the "Primary Functions" category and the "Secondary Functions" illustrate our

Table 1: Functions

Primary Functions	**Secondary Functions**
Able to be controlled and driven around	Makes an electric robotic vehicle that drives on level ground
	Possesses enough battery charge for it to function for a prolonged period between recharge
Be controlled remotely from afar	Receive motor commands from the user via a long-range remote communication interface
	Transmit camera vision to the user for controlling
	Operate safely without human supervision
Delivers items to destinations indoors	Store and transport items securely without damaging them
	Be convenient and fast to use

3.2 Objectives

The following objectives describe what the design aims to achieve, in measurable terms. The objectives in this section are ranked by their priority. Regarding trade-offs and compromises involved between the functions, the proposed design will always try to meet the top objectives first.

Table 2: Objectives

Objectives	**Metric**	**Goal**
Cheap to build and manufacture	Cost of parts and manufacturing	Less than 400$ for a prototype [Appendix A]
Easy to control, responsive to user commands	End-to-end latency from vehicle to control platform and back [?]	Up to 200ms
Drive fast with payload onboard	Vehicle speed at full battery	At least 5 km/h [Appendix B]
Clear and real-time video feedback	Video quality and latency	1280x720p@30Hz or better Latency up to 100ms
Last long after battery charge	Distance and time covered for one charge	Run at least 5km per charge (or lasts 1hrs at 5 km/h) [Appendix A]
Have adequate payload capacity	Onboard item dimensions and weight	210x297mm or more [4] Able to carry 1kg
Be safe to drive	Collision avoidance ability	Automatically stop upon barrier when cruising at full speed
Operate quietly indoors	Noise level during operation	Up to 45dB at all times [5]

3.3 Constraints

The constraints section lists all the absolute requirements for the project which it has to satisfy.

- Costs no more than 600$ CAD [Appendix A].
- Latency for controlling the vehicle and video feedback is no more than 500ms.
- Able to reach a speed of at least 2.5 km/h with payload onboard [6].
- Video feedback quality of at least 640x480p@30Hz.
- Run at least 2.5km per battery charge (or lasts 30min at 5 km/h).
- Be able to carry a minimum of 500g of payload (at least 200x200mm in dimension).
- Noise level during operation does not exceed 55dB [7].

Conclusion

In this document, we explored the difficulties for people to travel across campus to deliver trivial items and proposed a solution to it. We plan to build a remote-controlled robot that can be controlled to deliver items across the U of T campus without the controller physically moving. We introduced the problem, explained the background, set the scope of the project, and finally described the detailed requirements of the robot.

Reference:

[1] GreenCo Robots, “Greenco Robots,” *GreenCo Robots*. [Online]. Available: https://greencorobots.com/. [Accessed: 23-Sep-2022].

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[3] Mark Fairchild Freelance Technical Copywriter and F. T. Copywriter, “Delivery robots: The cost-saving future of last mile shipping,” *#HowToRobot*, 12-Nov-2021. [Online]. Available: https://www.howtorobot.com/expert-insight/delivery-robots. [Accessed: 23-Sep-2022].

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[6] L. V. Zyl, “**fit & proper:** what is the ideal walking speed for you?,” *Business Standard News*, 08-Oct-2015. [Online]. Available: https://www.business-standard.com/article/current-affairs/fit-proper-what-is-the-ideal-walking-speed-for-you-115100900029_1.html. [Accessed: 23-Sep-2022].

[7] M. D. Giv, K. G. Sani, M. Alizadeh, A. Valinejadi, and H. A. Majdabadi, “Evaluation of noise pollution level in the Operating Rooms of hospitals: A study in Iran,” *Interventional medicine & applied science*, Jun-2017. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5598129/. [Accessed: 23-Sep-2022].

Appendix A: Fee less than $320

Tools or Material for making carts	Fee
Computer system	$189
3d Model Printing Room Access Fee	$1.5 / 30 min
3d Model material Filament Glutter	$26.99
Electronical Equipment Component (led, electric wire, board etc)	$59.95
Electronical Camera	$18.99
	Total: 320

Appendix B: Calculation for robot speed at least 10 km/h

Mechanical and Electronic Components	Wheel Specification: 6V, 280 RMP, 10cm diameters, 4W Camera Specification: 6V, 3W Battery : 15000mAh (3A, 5V) SBC Power usage 7W
Total Power	Total Power = Camera Power + Motor Power + MotherBoard Power =(3W + 4W * 4 + 7V) * 2h = 52 Wh
Operating Time	Battery Power = 15Ah * 5V = 75wh 15000 Battery is sufficient to support the motor within 2h.
Speed	Car Speed（theoretical）:280RPM * 2 * PI * 0.1 cm ≈ 56 m / min = 3.6 km/h Add gear in order to double the speed. So the speed in theory over than 7.2 km/h.