TUTUS: Track Utilizing Transport for User Safety

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Abstract

In this paper, we discuss our solution towards social issues such as theft, sexual assault, and work-related stress in the context of delivery in densely populated urban areas, especially with the rising concerns for covid-19 (Muschert & Budd, 2020). In doing so, we will address our robot, TUTUS' design, social relevance, and practicality, and how it can be implemented in real situations. We aim to achieve this by having our robot capable of efficiently navigating through apartment complexes, carrying parcels of varying sizes and shapes while keeping cost low and practicality high.

1. Introduction

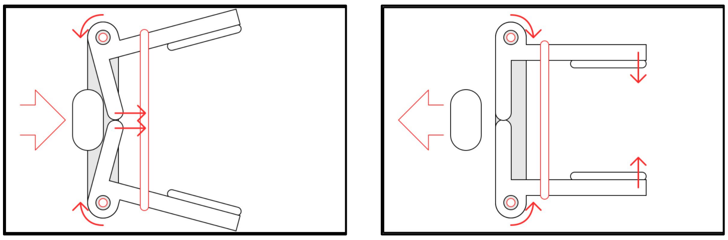
During the Covid epidemic, quarantine has brought about an influx of online consumers to the delivery industry (Naterattner, 2020). As a consequence of this sudden rise in online shopping interest, the average delivery person's expected workload has increased drastically. Workers are expected to work up to 15 hours shifts while delivering up to 300 packages a day and are denied basic human rights such as toilet privileges and rest time (Seoul Labor Center, 2019). There have also been cases of delivery people committing crimes such as sexual assault and theft, building further concerns towards the trust in their workers' reliability. We propose the partial automation of the delivery process by targeting apartment complexes in densely populated urban environments by removing the need for door-to-door delivery. This has the potential to alleviate the workload and, as a result, the stress induced by it while easing the public's concerns over their health and safety.

2. Robot design

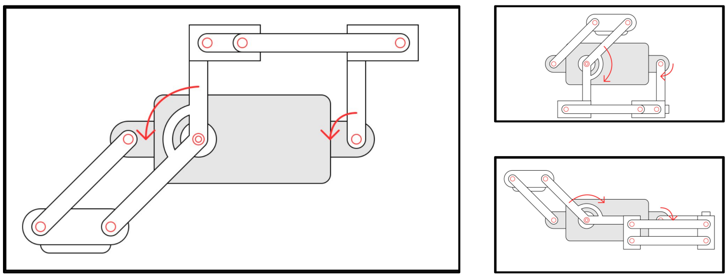
When it came to the robot's design, we wanted to minimise cost and increase the versatility of its design so that it could be better implemented in a variety of different apartment environments. In this section, we explore the design decisions made towards achieving these goals while discussing the practical use.

2.1 Cost Efficiency

To create a cost-efficient design, we had to maximize the use of mechanisms and fully take advantage of the limited degrees of freedom (Hesselbach et al., 2004). We created a multi-joint system and mechanisms that took advantage of neighboring moving parts, eventually decreasing the number of motors while achieving equal results. We have used a joint, which allows for the adjacent mechanisms to move in opposing directions while only requiring one motor. Consequently, we lose the ability to control parts of the robot independently; however, this also reduces the cost of maintenance and repair, making it a more viable option for apartment owners.



Above is a diagram of the claw mechanism. The two L-shaped claws allows us to control the grabbing with a simple horizontal movement. This intuitive design is not only easy to construct, but also cheap to maintain.



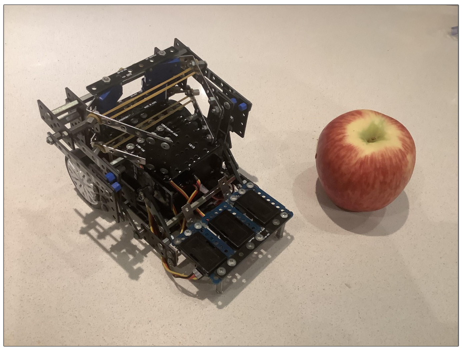
Above is a diagram of TUTUS' central mechanism which articulates the 2 main components (Line tracer and Claw) in relation with each other. This mechanism, although not limited, can switch between three modes for variety of situation and needs. Numerous multi joint systems were applicated to fully utilize the single servo motor being used. This helps greatly to lower the price.

2.2 Versatility

Our approach to versatility consisted of designing hardware that allowed for a wide range of apartment types while also having software that would allow the robot to quickly adapt to differently arranged apartment buildings (Wolf et al., 2005). Specifically, we have implemented a line tracing algorithm which helps in autonomously pathfinding in all different kinds of apartment layouts. This line tracing algorithms can also detect certain “detection regions”, which should be placed in front of package pick up area, and in front of each door, helping the robot to identify where it is and be able to drop off the package at the correct door without having to hard code the distances and angles that are only applicable to a single building.

3. Hardware specifics

TUTUS was designed focusing specifically on being compact and low price. As shown on the image below, the current model is a scaled down build of the actual robot, constructed to serve as a prototype and proof of concept.

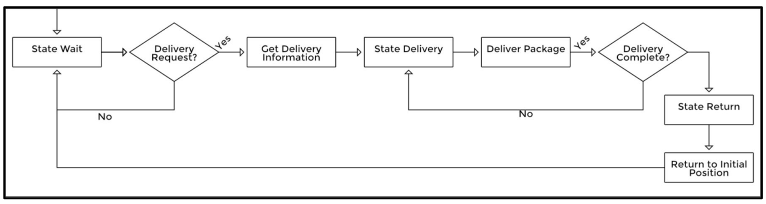


Design Specifications

Section	Component	Specification
Robot dimensions		Height: 13.0cm Width: 14.0cm Extended Length: 20.7 cm Retracted Length: 20.7 cm
Controlling system		Autonomous
Processor/ Operating Systems		AVR core CPU Arduino C lang.
Sensors	Line Tracer	3 IR Sensors
DoF (Degrees of Freedom)	Body Body	1 servo 2 130 rpm motors total: 3 DoF

4. Robot Operation

TUTUS is programmed using C language because of its utility and flexibility (Simmons & Apfelbaum, 1998). TUTUS' multi-functional servo movements are sequentially programmed, allowing for more stable and smooth movement. However, majority of TUTUS' functions are performed autonomously via Machine States and pathfinding algorithms. Below is a flowchart describing the structure of its algorithm.



The algorithm is divided into three sections, where the robot will cycle through state wait, state delivery and state return for optimized performance.

5. Future Improvement

As this robot is a miniature representation of TUTUS, it inevitably lacks few features which would otherwise be included. Such features mainly include a camera and stronger motors. In future builds where TUTUS is to scale (Current model is an approx. 1:10 scale) we ought to make the following improvements.

5.1 Image Recognition

This function, along with a camera, was excluded due to insufficient processing power of our CPU. Addition of Image recognition will be used to ensure that the parcel has been properly delivered.

5.2 Stronger motor

Higher motor output will greatly enhance the general performance of the robot, since all of the mechanisms are reliant on a single motor.

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