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Design, model and build a USAR robot platform

Mechatronic Project 478
Final Report

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Executive summary

Title of Project
Design, model and build a USAR robot platform
Objectives
Create a model to describe the kinematics of a Load Intuitive Module (LIM). Build a prototype Urban Search and Rescue (USAR) device which uses LIMs to climb stairs. Validate the model using the prototype.
What is current practice and what are its limitations?
The current practice for USAR platform ranges widely, but the most successful platforms use tracks with paddles for locomotion. These devices are effective but very expensive, there is a need for low cost expendable USAR robots.
What is new in this project?
This project will introduce a model to describe a cheaper stair climbing robot platform using LIMs.
If the project is successful, how will it make a difference?
The model developed in this project can be used to inform future USAR designs.
What are the risks to the project being a success? Why is it expected to be successful?
...
What contributions have/will other students made/make?
In 2013, Matthew Wilson developed the LIM system as a masters project at the University of Cape Town (UCT). Further development on the system was done in final year projects at UCT by students Jordan Haskel, Murray Buchanan, and Richard Daniel Powrie in 2017, 2018, and 2019 respectively.
Which aspects of the project will carry on after completion and why?

USAR devices using LIMs as a platform can be designed, built and tested.
What arrangements have been/will be made to expedite continuation?
...

Table of contents

List of figures

List of tables

Chapter 1

Introduction

1.1 Background

During disasters such as earthquakes, Urban Search And Rescue (USAR) robots are used to detect victims in hazardous environments where first responders would otherwise be put at risk. More advanced USAR robots can explore and map the environment while overcoming obstacles, and deliver supplies to victims who cannot be immediately evacuated. USAR robots were first used in the aftermath of the September 11 attacks on the World Trade Centre, where they had limited success as they would frequently get stuck or broken. Since then, designs for USAR robots with many different locomotion methods have been considered and compared in competitions such as the RoboCup Rescue Robot League and the DARPA Robotics Challenge. At present USAR robots are typically only successful at surveillance, due to the extreme conditions in disaster zones and the urgency of rescue operations, first responders will rarely consider using USAR robots.

Another problem limiting the use of USAR robots is cost, USAR robots are prohibitively expensive so rescue organisations use them sparingly. There is a need for low cost, expendable USAR robots. In 2013, Matthew Wilson proposed an automatically-shape-shifting platform that uses a Load Intuitive Module (LIM) in the place of regular wheels, shown in Figure 1.1 (Wilson, 2013). The LIM system uses a two outer "minor wheels" placed on a central hub that can be rotated as a "major wheel". The minor wheels are geared to the central hub such that the they drive the vehicle, however if they experiences high resistance, for example from hitting an obstacle, the torque will cause the major wheel to rotate instead, flipping one of the minor wheels over the obstacle to automat-

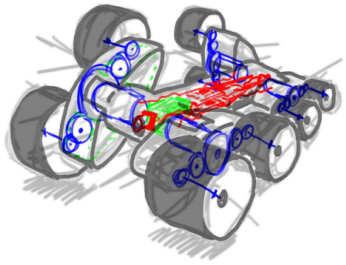

Figure 1.1: Systems layout of Wilson's LIM device (Wilson, 2013)

ically climb it. This is an adaptation of a similar system that uses three minor wheels called a "Tri-star" developed for Lockheed in 1967 (Forsyth and Forsyth, 1965). Using only two wheels gives the system a lower profile for exploring disaster environments while maintaining the ability to climb obstacles. This is a strong concept for a cheap stair climbing robot as it only uses a single motor for both normal driving and climbing obstacles.

LIMed robot platforms were built individually by four final year students at UCT (Wilson, 2013), (Haskel, 2017), (Buchanan, 2018), and (Powrie, 2019), one of these robots is shown in Figure 1.2. These platforms show some success in climbing a single step, albeit inconsistently. Powrie noted that a mathematical model that accurately describes the kinematics of the system could be developed to optimise the design of LIMed robots. This project is a continuation of these students' work.

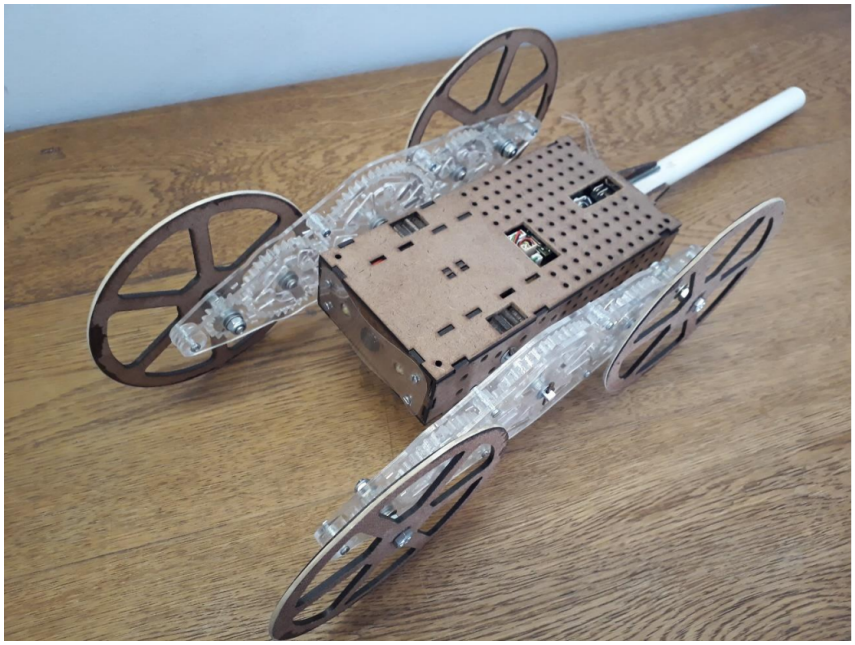

Figure 1.2: Powrie's "Di-Wheel" robot (Powrie, 2019)

1.2 Objectives

The aim of this project is to create a model that can be used to inform future USAR designs. The following objectives were identified to meet this aim:

1. Create a model to describe the kinematics of a LIM.
2. Build a prototype USAR device which uses LIMs to climb stairs.
3. Validate the model using the prototype.

This project does not intend to create a fully functioning USAR robot, but rather a prototype of the platform that a USAR robot may use.

1.3 Motivation

Future designers can use the model produced in this report to design and optimise LIMed USAR robots. These robots use fewer actuators so could be cheaper than existing USAR robots. Lowering the cost of USAR robots is a priority as it makes them more accessible to rescue organisations.

List of references

Buchanan, M. (2018). Ascender.

Forsyth, R. and Forsyth, J. (1965). Amphibious star-wheeled vehicle.

Haskel, J. (2017). A cost effective, tele-operated observation search and rescue robot.

Powrie, R. (2019). Di-wheel robot.

Wilson, M. (2013). Development of a low-cost, mid-sized, tele-operated, wheeled robot for rescue reconnaissance.