# Title page

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***THESIS SUBMISSION***

**DR PAUL POUNDS**

**Fucking kill me already**

# Abstract

200-300 words written last

# Executive summary

1 page

# Contents

[1 Title page 1](#_Toc514613197)

[2 Abstract 2](#_Toc514613198)

[3 Executive summary 2](#_Toc514613199)

[4 Contents 2](#_Toc514613200)

[5 Introduction 2](#_Toc514613201)

[6 Problem breakdown 2](#_Toc514613202)

[6.1 Limitations on all exoskeletons – power, power to weight ratio 2](#_Toc514613203)

[6.2 Previous solutions – force mechanisms 2](#_Toc514613204)

[6.3 Proximity as a solution 2](#_Toc514613205)

[6.3.1 Less exhausting 2](#_Toc514613206)

[6.3.2 Intuitive 2](#_Toc514613207)

[6.3.3 Won’t flail out of control and be unstable 2](#_Toc514613208)

[6.4 Cases for use 2](#_Toc514613209)

[6.4.1 Justification of capabilities (tested movements) 2](#_Toc514613210)

[6.4.2 Stand still under standard conditions 2](#_Toc514613211)

[6.4.3 Actuation of movement 2](#_Toc514613212)

[6.4.4 Walking 2](#_Toc514613213)

[6.4.5 Up stairs 3](#_Toc514613214)

[6.4.6 Sitting 3](#_Toc514613215)

[6.5 Justification of demo scope (lower body only) 3](#_Toc514613216)

[6.6 Task division between participants 3](#_Toc514613217)

[6.7 Justification of controls and perception systems required 3](#_Toc514613218)

[6.7.1 Detecting the pilot’s proximity 3](#_Toc514613219)

[6.7.2 Detecting the suit’s position 3](#_Toc514613220)

[6.7.3 Force application of the system by the pilot to the environment 3](#_Toc514613221)

[6.7.4 Control system for decision making 3](#_Toc514613222)

[6.7.5 System communication from control & perception software to actuation system 3](#_Toc514613223)

[7 Scope 3](#_Toc514613224)

[7.1 Assumptions 3](#_Toc514613225)

[7.2 Equipment 3](#_Toc514613226)

[7.3 Demonstrable capabilities 3](#_Toc514613227)

[7.4 Stuff out of scope 4](#_Toc514613228)

[7.5 Variation on original scope 4](#_Toc514613229)

[8 Pilot’s proximity 4](#_Toc514613230)

[8.1 Requirements 4](#_Toc514613231)

[8.2 Possible solutions 4](#_Toc514613232)

[8.3 Justification of chosen solution 4](#_Toc514613233)

[8.4 Components list of chosen solution 4](#_Toc514613234)

[8.5 Performance 4](#_Toc514613235)

[9 Force application from pilot to system to environment 4](#_Toc514613236)

[9.1 Requirements 4](#_Toc514613237)

[9.2 Possible solutions 4](#_Toc514613238)

[9.3 Justification of chosen solution 4](#_Toc514613239)

[9.4 Components list of chosen solution 4](#_Toc514613240)

[9.5 Performance 4](#_Toc514613241)

[10 Control system for decision making 4](#_Toc514613242)

[10.1 Requirements 4](#_Toc514613243)

[10.2 Possible solutions 4](#_Toc514613244)

[10.3 Justification of chosen solution 4](#_Toc514613245)

[10.4 Components list of chosen solution 4](#_Toc514613246)

[10.5 Performance 4](#_Toc514613247)

[11 Communications 4](#_Toc514613248)

[11.1 Requirements 4](#_Toc514613249)

[11.2 Possible solutions 4](#_Toc514613250)

[11.3 Justification of chosen solution 4](#_Toc514613251)

[11.4 Components list of chosen solution 4](#_Toc514613252)

[11.5 Performance 4](#_Toc514613253)

[12 Holistic integration of requirements 5](#_Toc514613254)

[13 Demo 5](#_Toc514613255)

[14 Recommendations and further research 5](#_Toc514613256)

[15 Conclusion 5](#_Toc514613257)

[16 References 5](#_Toc514613258)

[17 Appendices 5](#_Toc514613259)

[17.1 Code 5](#_Toc514613260)

[17.2 PCBs 5](#_Toc514613261)

[17.3 CAD drawings 5](#_Toc514613262)

# Introduction

A powered exoskeleton, or exoskeleton, is wearable technology the amplifies and augments the pilot’s physicality. Through direct mechanical assistance via actuators, the pilot’s effective strength may be increased. By supplementing the strength required to complete a task the energy requirements of the task may be reduced; effectively increasing the pilot’s endurance. Possible applications for exoskeletons include: military operations, emergency & rescue, physical/manual labour, and medical applications.

Two major factors impact the viability of exoskeleton technology: power supply, and control. This thesis shall address one facet of the difficulties or exoskeleton control. Current exoskeleton control methods are inadequate due to mechanical constraints and the limitations of the control methods. Imperfections in mechanical design may result in a limited range of movement affecting the suits utility (e.g. A rigid spine in a confined space). Current methods of control use either force-based sensors or preprogramed movements. Finite sets of preprogramed movements are insufficient for dynamic environments and are only suitable for applications where the pilot is incapable of properly piloting the system kt. Force based methods encounter stability problems and may increase the exertion required to complete a task kt.

Instead this thesis will focus on the development of a novel power exoskeleton control method based on detecting the pilot’s position relative to the suit to maintain a constant offset; specifically focusing on the development of the controls and perception systems required to direct an exoskeleton.

Why good for offset system

# Problem breakdown

## Existing Technologies and limitations

Exoskeleton technology began in 1890 kt, with Nicholas Yagin, with the development of a passive device that used compressed gas to assist in human movement. However, it was not until the 1960s that the first attempt at a practical power exoskeleton was developed. The Hardiman kt, created by General Electric, was ground-breaking but non-viable due to its extreme weight (double its maximum load) and control problems. The suit, when used as a complete system instead of in parts, was subject to dangerous violent uncontrolled movements and the master-slave control system suffered debilitating lag.

Since the Hardiman, exoskeletons have been plagued by the same two major problems: power to weight ratio (and power supply) and control. The following outlines current developments in exoskeleton technologies.

### HULC

### EskoGT

### Raytheon XOS Exoskeleton

### Warrior Web

### Hybrid Assistive Limb (HAL)

## Force Based Mechanicsms

## Proximity as a solution

### Less exhausting

### Intuitive

### Won’t flail out of control and be unstable

## Cases for use

### Justification of capabilities (tested movements)

### Stand still under standard conditions

Steady state

Info required by system

* Pilot location
* Suit location
* Force applied by pilot to suit
* Force applied by suit to environment

### Actuation of movement

Movement

Info required by system

* Pilot location
* Suit location
* Force applied by pilot to suit
* Force applied by suit to environment

### Walking

Real time movement

Info required by system

* Pilot location
* Suit location
* Force applied by pilot to suit
* Force applied by suit to environment

### Up stairs

Force application

Info required by system

* Pilot location
* Suit location
* Force applied by pilot to suit
* Force applied by suit to environment

### Sitting

Regulated force application

Info required by system

* Pilot location
* Suit location
* Force applied by pilot to suit
* Force applied by suit to environment

## Justification of demo scope (lower body only)

## Task division between participants

## Justification of controls and perception systems required

### Detecting the pilot’s proximity

### Detecting the suit’s position

### Force application of the system by the pilot to the environment

### Control system for decision making

### System communication from control & perception software to actuation system

# Scope

## Assumptions

## Equipment

## Demonstrable capabilities

How to demonstrate on the demo rig the capacity to complete the below activities:

* Standing still
* Walking
* Stairs
* Sitting

## Stuff out of scope

## Variation on original scope

# Pilot’s proximity

## Requirements

## Possible solutions

## Justification of chosen solution

## Components list of chosen solution

## Performance

# Force application from pilot to system to environment

## Requirements

## Possible solutions

## Justification of chosen solution

## Components list of chosen solution

## Performance

# Control system for decision making

## Requirements

## Possible solutions

## Justification of chosen solution

## Components list of chosen solution

## Performance

# Communications

## Requirements

## Possible solutions

## Justification of chosen solution

## Components list of chosen solution

## Performance

# Holistic integration of requirements

# Demo

# Recommendations and further research

# Conclusion

# References

# Appendices

## Code

* Firmware in C
* Matlab

## PCBs

## CAD drawings