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School of Engineering

Contents

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Abstract

This is abstract text.

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Declaration of originality

I hereby confirm that no portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright statement

Acknowledgments

Acknowledgments go here.

1 Introduction

The goal of this project is to create a system for controlling and teleoperating a robot arm with a human arm. In order to maintain simplicity in the project scope, the robot arm is assumed to be shoulder-mounted and has the seven degrees of freedom (DoF) [1], matching that of a healthy human arm.

1.1 Background and motivation

The motivation for this project comes from articles within the books: "Human–robot teleoperation based on Imus" [2] and "Whole-body human-motion based robot teleoperation" [3], which both describe research into remote teleoperation of shoulder-mounted robot arms. Both articles describe the use of an inertial measurement unit (IMU) based solution to obtain data from the human operator. The limitation in both of these articles is that they only map the end effector position of the robot arm to the wrist position. Because the human arm has redundancy in the number of joints available [4], a robot arm only mapping the end effector position could end up with its forearm or upper arm in a position that causes collisions, even though the end effector is in the target position. This ambiguity could lead to collisions with obstacles in the environment, and lack of safety for people within the envelope of the robot arm.

Whilst not necessarily critical in the use cases that Zhou et al. and Lyu et al. describe - remote welding inspection and simple delivery and manipulation tasks for an elderly patient - a scenario that is obstacle rich would require precise control of the robot arm. One such scenario is an underwater environment where a telescopic robot arm is attempting to collect a sample. Whilst Jin et al. describes a potential autonomous solution [5], this method is comparatively slow to the prospect of remote teleoperation: ranging from five to nine seconds in the simple case where the target object and origin of the robot arm is stationary. Consequently, the complexity increase for the case where nothing is stationary, a more realistic use case, would mean that this method would be inefficient compared to the intuition of a trained operator.

Other potential areas of application of full arm tracking could be in the medical industry and with surgical robots, where collisions with patients is unwanted. Likewise, nuclear decommissioning robots where absolute accuracy of matching an operator's intentions is critical.

These limitations suggest the need for a more comprehensive tracking and mapping approach that uses the full kinematic data available from the operator.

1.2 Aims and objectives

The overall aim is to create a system for mapping the joint angles of a human arm to a shoulder-mounted robot arm.

To achieve this goal, there will be an evaluation of available arm tracking methods. Many methods currently exist for tracking the joint angles of robot arms, including: IMU based solutions discussed earlier, attitude and heading reference systems [6], computer vision based systems [7], and flex sensor based systems [8], among others. A rigorous examination of these methods will be conducted as a prerequisite to the final implementation, to understand the applicability and feasibility of each tracking system. Relevant tracking metrics will be discussed in the methodology section, but include cost, accuracy, engineering complexity, etc.

Finally, it is acknowledged that the procurement of a seven DoF robot arm is unlikely for a Bachelor's thesis. Hence, the final implementation of the tracking method will be created in the form of a simulation in CoppeliaSim. This has the advantage of being able to set up precise scenes for the evaluation of the final tracking method chosen, as well as comparison with baseline methods such as joysticks or pure end effector mapping. Likewise, the robot could be customised to match the proportions of the operator's arm perfectly, which would increase ease of use for the operator.

2 Literature review

2.1 Introduction

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2.2 Example display items

This is an example of providing a cross-reference to Section 3. Similarly, this is an example cross-reference to a sub-subsection, Section 3.2.

This is an example of adding references [9], [10], [11]. If you want the author name, or similar, you can use: Casson et al. in 2009 introduced a really good idea. (This is for when you primarily use numbered citations, but occasionally need an author's name. If using author names as the reference everywhere, change style=ieee in the biblatex setup above to whatever reference style you want, and then just use the cite command.)

Table 1. Example table. Full caption goes here. Often a short caption in [] is used as well as the main caption to keep the list of figures tidy; it gets messy if there are long captions going over more than one line.

Participant	Number / %		Duration / %	
	Prime dresses	Non-prime dresses	Prime dresses	Non-prime dresses
1	33.33	33.91	20.83	18.42
2	13.04	17.50	04.93	07.62
3	22.73	20.10	13.00	08.20
4	31.34	21.88	10.57	11.09
5	08.47	19.32	03.04	09.73
Mean	16.4	16.5	07.8	07.5
Standard deviation	09.7	06.6	05.4	03.3

Table 2. Example table. Full caption goes here. Often a short caption in [] is used as well as the main caption to keep the list of figures tidy; it gets messy if there are long captions going over more than one line.

Participant	Number / %		Duration / %	
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Mean	16.4	16.5	07.8	07.5
Standard deviation	09.7	06.6	05.4	03.3

For adding *emphasis* use the emph command. In general, try to avoid texttt, textit, textbf and similar commands — these don't tell the document *why* the style is being changed, and this information is needed for screen readers. In contrast, emph gives meaning to the change in format. By default it uses italics, but you can change the style if you want to.

Here are two example tables. Table 1 is an example using tabularx to fix the size of the table to be the same width as the page, with columns that auto-wrap if the text is too long. Table 2 is an example using tabular where the width of the table is set by its contents. It may go beyond the width of the page.

This is an example equation in text $2 \sin \omega t$. Below is an example of a displayed equation. See (1) for info.

$$a^2 + b^2 = c^2 \tag{1}$$

Note that numbers are displayed differently in the text depending on how they are entered. Compare for example 123456 vs. 123456 vs. $123\,456$. Entering numbers directly, such as 1955, should be used for *text mode* numbers. That is, those representing text (dates, page numbers, and similar). Numbers representing maths, or variables or similar, should be entered inside \(\) or `\num` so they are typeset in the same way as they appear in an equation. (This requires a bit of discipline, but helps ensure consistent use of number styles throughout.) `\num` is provided by the `siunitx` package. The display it provides can be customised if wanted.

Fig. 1. Example figure. Full caption goes here. Often a short caption in [] is used as well as the main caption to keep the list of figures tidy; it gets messy if there are long captions going over more than one line.

(a) **(b)** **(c)**

Fig. 2. Three copies of the University logo. (a) Copy one. (b) Copy two. (c) Copy three.

Documentation is at `https://texdoc.org/serve/siunitx/0`.

This is an example of a quote in text "*The electroencephalogram (EEG) is a classic noninvasive method for measuring a person's brainwaves*" [11]. Below is an example of a displayed quote. Both are using the csquotes package.

> "*Electrodes are placed on the scalp to detect the microvolt-sized signals that result from synchronized neuronal activity within the brain.*" [11]

This is an example figure. See Fig. 1 for more details. Alternatively, can put multiple figures into a subfigure environment, for example Fig. 2, or Fig. 2b to cite a particular sub-figure.

An example code listing is given in Listing 1. See `https://www.overleaf.com/learn/latex/Code_listing` for more examples of how to display code. Code in the body of the text can be included as `for` or `while` or `main`.

Listing 1. My code example

```
import numpy as np

def my_filter(in,f_obj):
    y = filter(f_obj,in)

    return y

```

2.3 Summary

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3 Methods

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4 Results and discussion

4.1 Introduction

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4.2.3 More detail

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5 Conclusions and future work

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Appendices

A Project outline

Project outline as submitted at the start of the project is a required appendix. Put here.

B Risk assessment

Risk assessment is a required appendix. Put here.