THE UNIVERSITY OF QUEENSLAND

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CONNECTING VIRTUAL ROBOTICS TO AN EXPERIMENTAL PLATFORM

by
Callum Rohweder

School of Information Technology and Electrical Engineering,
The University of Queensland.

Submitted for the degree of
Bachelor of Engineering
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52 KENNIGO STREET
SPRING HILL, QLD, 4000
Tel. 0404 639 174

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Professor Shazia Sadiq
Head of School
School of Information Technology and Electrical Engineering
The University of Queensland
St Lucia, Q 4072

Dear Professor Sadiq,

In accordance with the requirements of the degree of Bachelor of Engineering in the division of Mechatronic Engineering, I present the following thesis entitled 'Connecting Virtual Robotics To An Experimental Platform'. This work was performed under the supervision of Dr Surya Singh.

I declare that the work submitted in this thesis is my own, except as acknowledged in the text and footnotes, and has not been previously submitted for a degree at The University of Queensland or any other institution.

Yours sincerely,

Callum Rohweder.

Acknowledgments

I specifically would like to thank my fellow students in the school of ITEE for assisting me during this project; for listening to the software issues I faced and giving useful insight and direction.

The product of this thesis was created in complete self-sufficiency, with functionality specified by my supervisor.

Acknowledge your supervisor, preferably with a few short and specific statements about his/her contribution to the content and direction of the project. If you collaborated with another student, acknowledge your partner's contribution, including any parts of the thesis of which s/he was the principal author or co-author; this information can be duplicated in footnotes to the chapters or sections to which your partner has contributed. Briefly describe any assistance that you received from technical or administrative staff. Support of family and friends may also be acknowledged, but avoid sentimentality—or hide it in the dedication.

Abstract

This document is a skeleton thesis for 4th-year students. The printable versions (`skel.dvi, skel.ps, skel.pdf`) show the structure of a typical thesis with some notes on the content and purpose of each part. The notes are meant to be informative but not necessarily illustrative; for example, this paragraph is not really an abstract, because it contains information not found elsewhere in the document. The LaTeX 2_ε source file (`skel.tex`) contains some non-printing comments giving additional information for students who wish to typeset their theses in LaTeX. You can download the source, edit out the unwanted material, insert your own frontmatter and bibliographic entries, and in-line or `\include{}` your own chapter files. Of course the content of a particular thesis will influence the form to a large extent. Hence this document should not be seen as an attempt to force every thesis into the same mold. If in doubt about the structure of your thesis, seek advice from your supervisor.

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Chapter 1

Introduction

Remotely controlling a robot or robotic manipulator is a desirable objective with large complications to still be overcome. It is proposed that doing this through a virtual environment can eliminate collisions or undesirable actions that may incidentally occur due to the nature of long distance control, whilst providing the benefits of virtual simulations. Specifically, this thesis focuses on the development a remote interface to a 'Virtual Robotics Environment Platform', VREP. VREP can be used to simulate robotic arms and processes, and includes the commonly used wheel-chair based Kinova Jaco arm which is available at the University of Queensland. The remote interface, otherwise known as the 'client program' (given that it treats VREP as the server), was designed to take input from a user by either keyboard or joystick, and have the motion played out in VREP, corrected for any obstructions, and then control the movement of the Jaco arm through the Kinova Software Development Kit.

In all engineering disciplines, virtual simulations allow one to view and interact with an environment or process in a non-destructive manner. Simulations can provide a realistic rendering of an event, whilst providing further detail into physical phenomena that establish design constraints, and optimization techniques. Robotics makes use of lumped electromechanical components to interact with an environment in a desirable manner. Thus, virtual robotics is a necessary field for growth in engineering, as it allows the testing of interactions with an environment whilst giving unforeseen insight.

Companies such as those in manufacturing, technical experts in the fields of medicine and surgery, and persons with disabilities all benefit from the capability of robotic manipulators. In most circumstances it is expected that these manipulators can be controlled by a user in real time, however this ability is restricted by inherent delay in the process of receiving an input, calculating an action, and actuating. Further expectations of robotics include optimality and customisation; where it may be desirable for movements of a robot to minimize the energy used in a given

process or a robotic arm to pick up a glass a in a certain manner. This provides interconnected layers of desired functionality for a robot; a layer dedicated to moving the manipulator, a layer designed to create movements that meet the user's needs whilst minimizing design criteria, and a monitoring layer that focuses on aspects such as physical constraints and robotic learning.

With the invention of the internet to provide long range data-resourcing, came a desire to move the control of manipulators and processes to a remote location. The concept of remote robotics is no different to the typical method of controlling manipulators, an input has a desired output, however at some time in between, data is processed and sent through the internet. Given factors such as time to send, packet loss, processing time, and internet traffic, a significant amount of undesirable delay is added and decreases the satisfaction of real-time control. This produces large complications in areas such as remote robotic surgery, where reaction delay may have harmful effects.

Virtual robotic environments can simulate the true movements of a manipulator given its physical attributes. VREP in particular can calculate the joint angles required to be able to move the hand from one position to another using a physics engine and accuracy of choice. It is believed that allowing a virtual environment to compute the movements required by a remote user will increase the accuracy in movement and decrease the chance of collision of the physical robot.

Although this thesis does not go into large detail on the testing of the complete product, remote user to physical robotic arm movement, it does go through the design of the remote interface. The problems faced in controlling a robotic arm, design strategies tested, and the future improvements of the client program are presented. This interface was crucial to the success of the whole system, and it was important to refine before interfacing with a physical arm.

The introductory chapter describes the importance of the field and the scope and significance of your project. It usually ends with an overview of the remainder of the thesis.

Notice that Arabic page numbering begins with Chapter 1. Preceding pages (known as "frontmatter") have Roman numbering. The `book` document class in LaTeX follows this numbering convention by default (see Lamport [1], p. 80).

Chapter 2

Literature review / prior art

You will need to review previous work in the field, which may include books and papers ("literature"), patents and commercial products ("prior art"), and earlier work in your Department. This information is usually (but not always) collected in a single chapter, whose title should preferably be more specific and interesting than the one above.

Chapter 3

Theory

A scientific paper is likely to be read by people who are not specialists in the same field as the author(s), but who nevertheless may need to use the results of the paper in their own fields. Similarly, the examiners of your thesis will probably include at least one academic who does not teach or conduct research in the subject area of your thesis. In an early chapter of your thesis, therefore, you should quote any theoretical results which are necessary for the understanding of later chapters. Examiners who are not specialists in your area will know whether you have given sufficient theoretical information. They will also know whether you have insulted their status by presenting material which is familiar to every half-competent graduate in every field of ECE.

Chapter 4

Methodology, procedure, design, etc.

This may be one chapter or several. Again, titles should be more informative than the above.

You will almost certainly need diagrams to clarify your meaning. The LaTeX 2_ε `graphics` package allows the inclusion of PostScript graphics, as in Fig. **??**. The inclusion of LaTeX `picture` graphics, as in Fig. **??**, requires no auxiliary packages and allows the mathematical formatting features of LaTeX to be used in diagrams; but the `picture` files, unlike PostScript files, usually require manual editing.

Chapter 5

Results and discussion ...

... or perhaps the discussion should be a separate chapter.

In any case, you will probably need to include tabulated results. Table 5.1 illustrates the use of various LaTeX environments to include a computer printout (plain text file) in a document. The `verbatim` environment, which encloses the formatted text, is also useful for program listings.

Table 5.1: *Fraction of air volume involved in heat exchange for second mode (right column) vs. filling factor (left column). The plain-text headings represent f, m, μ_2 and f_2.*

f(%)	m	mu2	f2(%)
0.016	80.00	0.05400	4.874
0.031	56.57	0.07732	5.438
0.062	40.00	0.11103	6.125
0.125	28.28	0.16001	6.970
0.250	20.00	0.23175	8.020
0.500	14.14	0.33799	9.329
1.000	10.00	0.49789	10.967
2.000	7.07	0.74444	13.008
4.000	5.00	1.13919	15.525
8.000	3.54	1.81095	18.568
19.237	2.28	3.61958	23.174
37.180	1.64	7.28635	27.094
57.392	1.32	14.63631	29.813
74.316	1.16	29.35160	31.453
85.734	1.08	58.79364	32.360

Chapter 6

Conclusions

6.1 Summary and conclusions

6.2 Possible future work

Appendix A

Dummy appendix

Appendices are useful for supplying necessary details or explanations which do not seem to fit into the main text, perhaps because they are too long and would distract the reader from the central argument. Appendices are also used for program listings.

Notice that appendices are "numbered" with capital letters, not numerals. When the `\appendix` command in LaTeX [1, p. 175] is used with the `book` document class, it causes subsequent chapters to be treated as appendices.

Appendix B

Program listings

B.1 First program

Some initial explanatory notes may precede the listing.

B.2 Second program

B.3 Etc.

Appendix C

Companion disk

If you wish to make some computer files available to your examiners, you can list and describe the files here. The files can be supplied on a disk and inserted in a pocket fixed to the inside back cover.

The disk will not be needed if you can specify a URL from which the files can be downloaded.

Bibliography

[1] L. Lamport, *LaTeX: A Document Preparation System*, 2nd ed. (Addison-Wesley, 1994).

[2] REFERENCE 2

[3] Etc.