DESIGN OF BIPED ROBOT MODEL CONTROLLER

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Computer Engineering) with Honours.

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

May 2008

REKABENTUK PENGAWAL MODEL BIPED ROBOT

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Laporan ini dikemukakan untuk memenuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Elektronik (Kejuruteraan Komputer) dengan Kepujian

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

Mei 2008

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

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Sesi Pengajian	:	2007/2008

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DEDICATION

For my beloved mother and father also to my family who always give me support.

ACKNOWLEDGEMENTS

By the Grace of Al-Mighty, finally I have completed my project based on the knowledge and experience that I got during my entire first half of my project flow. Here I would like to take this opportunity to thank the people for their utmost help and guidance given to me. I sincerely appreciate the following people for their utmost cooperation to me during my project flow. To Universiti Teknikal Malaysia Melaka (UTeM), Dean, Head of Department and Lecturers of Faculty of Electronic and Computer Engineering who had always given me their undivided guidance and corrected my mistakes during doing my PSM. I extend my appreciation to the respective Pn. Sharatul Izah Binti Samsudin, my project supervisor who has shared her working experience as well as give me information and also given me full support and guidance in order to build my confidence and ability while doing my project. My panel lecturers who conduct the secondary evaluation for my PSM, En. Mohd Shakir Bin Md Saat and Pn. Siti Huzaimah Binti Husin. Last but not least, my respective parents and my beloved friends who were always keep in touch and guide me during the project. This project is dedicated to everyone who was involved while I am doing the project because without his or her help and support, I would not have been able to create this project successfully.

ABSTRACT

In this project, a controller for a biped robot model is designed. The biped structure modeled is a five link, two dimensional walking robot with a torso and knees but no ankles. The simulation environment contains simulation block for the biped model and a PD controller block for controlling the model. This project covers the modeling and simulation of a biped robot and will be implemented using Matlab/Simulink software. As a basic for the robotics industry, designing model controllers for robots are the most crucial area. We will be able to build a robot in the future by designing a robot model controller. My project is based on the usage of Matlab/Simulink as the software for simulation instead of Solidworks for better performance. The mathematical models used easily appear to be highly nonlinear and high-dimensional preventing the effective use of traditional modeling and control methods. Matlab/Simulink will be used as the software to design the biped robot model controller since Solidwoks software is quite sensitive towards disturbance. Matlab/Simulink software also offers greater performance besides it is easier to control. Other than that, the stability of the biped robot can be improved by using the Matlab/Simulink since biped robot involves gate control and kinematics. There are five main objectives of designing the biped robot model controller. Firstly, to formulate the exact mathematical model of the biped robot. Next, to build biped robot model in Matlab/Simulink and to design model controller of the biped robot. Finally, the objectives are also to analyze controlled biped robot model and to develop graphical user interface, GUI for simulation and biped motion animation. In order to complete my design on the biped robot, I have used a few methods in gaining information. To conclude the work done in this thesis, it can be stated that all of the goals mentioned will be achieved. Where, the simulation of controlled biped robot model will be succeeded and working simulator environment will be developed.

ABSTRAK

Dalam projek ini, sebuah sistem kawalan untuk model robot biped telah direka. Model struktur kawalan biped ini mempunyai 5 rangkaian, gerakan robot dua dimensi dengan torso dan lutut tetapi tiada buku lali. Projek ini merangkumi pemodelan dan simulasi sebuah robot biped dan akan dilaksanakan dengan menggunakan perisian Matlab/Simulink. Simulasi yang dijalankan melibatkan gambarajah blok bagi model biped dan pengawal terbitan seimbang. Sebagai asas kepada industri robot, merekabentuk model kawalan adalah bahagian yang sangat penting. Kita akan dapat membina sebuah robot pada masa hadapan dengan merekabentuk model kawalan robot. Bagi meningkatkan kecekapan projek ini melibatkan penggunaan perisianMatlab/Simulink digunakan dan tidak menggunakan perisian Solidworks. Model matematik yang digunakan adalah tidak linear dan berdimensi tinggi. Matlab/Simulink digunakan sebagai perisian untuk merekabentuk model kawalan robot biped kerana perisian Solidworks adalah sensitif terhadap gangguan. Matlab/Simulink juga menawarkan pretasi yang lebih baik di samping lebih mudah untuk dikawal. Selain itu, tahap kestabilan robot biped juga boleh dipertingkatkan kerana biped robot melibatkan kawalan get dan kinematik. Terdapat lima objektif utama dalam mereka bentuk model kawalan robot biped ini. Antaranya adalah untuk menerbitkan formula matematik bagi model robot biped. Selain itu, ia adalah untuk membina model robot biped ini dalam Matlab/Simulink dan merekabentuk model kawalan robot biped. Objektif yang terakhir adalah untuk menganalisa model kawalan robot biped dan menerbitkan paparan grafik pegguna (GUI), untuk simulasi dan gerakan animasi biped. Pada akhir projek ini, sebuah model kawalan robot biped akan dibina sebagai permulaan untuk pemodelan dan kawalan berasaskan data. Selain itu, satu alat simulasi Matlab/Simulink. akan diwujudkan untuk memudahkan pengumpulan data dan simulasi model. Sebagai kesimpulan, semua matlamat yang telah dinyatakan dapat dicapai. Di mana, simulasi

bagi model kawalan robot biped dapat dijayakan dan persekitaran kerja simulasi akan diwujudkan.

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LIST OF SYMBOLS / SHORT FORMS

M	**-**	**Momentum**
F	**-**	**Forces**
PD	**-**	**Proportional-derivative**
DSP	**-**	**Double support phase**
SSP	**-**	**Single supportphase**
GUI	**-**	**Graphical user interface**
SP	**-**	**Setpoint**
PV	**-**	**Process variable**
MV	**-**	**Manipulated variable**
PID	**-**	**Proportional-integral-derivative**

APPENDIX

CHAPTER I

INTRODUCTION

In this chapter the introduction of project, objectives of project, problem statement, scope of project, brief of metadology and structure of report are presented.

1.1 Introduction

This document describes the biped robot simulation tool for Matlab/Simulink. The tool enables the simulation of the exact dynamics of a two-dimensional biped robot model on a walking surface. The simulation environment contains a simulation block for the biped model, PD controller block for controlling the model and data-based controller block which implements the so-called clustered regression control. A graphical user interface for simulation and biped motion animation is also included. The biped structure modeled is a five-link, two-dimensional walking robot with a torso and knees but no ankles. The walking surface can be defined as a sequence of points connected with straight lines. The interaction between the biped and the ground is modeled using external forces acting on each leg tip when the leg touches the ground. This enables the use of one seven degrees of freedom dynamic model to describe the dynamics of the system in all situations. The ground contact forces are calculated by

separate PD controllers. The PD control method presented for controlling the gate is quite cumbersome, its main purpose being only to enable data collection from the walking biped system. Using this data, the clustered regression model structure is applied to the biped control.

1.2 Objectives of project

This thesis work handled the modeling and controlling of a simple biped walking robot. There are five main goals of designing the biped robot model controller:

a) To formulate the exact mathematical model of the biped robot. The walking surface is modeled by the external forces (collected in vector F), which are calculated using PD controllers when the leg is touching the ground. The actual control of the biped is done with the moments (in vector M) applied to the joints of the robot.

b) To build biped robot model in Matlab/Simulink. The structure of the two dimensional model is designed. Then, the momentum (M), forces (F) and the coordinates (q) is determined. The mathematical formula is formulated according to the momentum, coordinates and the forces acting on it and it is then applied in Matlab in the form of coding to determine the motion of the biped robot.

c) To design model PD controller of the biped robot. To enable the data collection from the biped walking movement, a PD control scheme for the system was developed. The controller contains four independent SISO PD controllers, which follow continuously updated reference signals.

d) To analyze controlled biped robot model. The animation shows the resulting gait, which is by no means optimal as the parameters of the controllers were tuned by hand. The input and output data of the system can be collected.

e) To develop graphical user interface, GUI for simulation and biped motion animation. Graphical user interface (GUI) was created for simulating a Simulink model including the biped model block and an arbitrary controller. The GUI enables the biped model simulation with specified parameters and the animating of the system behavior. It is also possible to save all the simulation data or only one state of the system to the Matlab workspace.

1.3 Problem Statement

Robotic field is very important in this new millennium. This field is growing widely all over the world. In the growth of this field, Malaysia also has its own robotic based industries. As a basic for the robotics industry, designing model controllers for robots are the most crucial area. We are able to build a robot in the future by designing a robot model controller. My project is based on the usage of Matlab/Simulink as the software for simulation instead of Solidworks for better performance.

Walking robots offer challenging problems in the field of system modeling and control. The mechanical structures of the walkers are usually complex, being composed of many joint-connected parts which impact also with the surrounding environment. We only consider only the input and output data of the system, that is, with the help of data-based techniques. If the relation between the control values given and the resulting state of the robot could somehow been captured, the actual internal structure of the system could be forgotten. Therefore the mathematical models easily appear to be highly nonlinear and high-dimensional preventing the effective use of traditional modeling and control methods.

Here Matlab/Simulink will be used as the software to design the biped robot model controller since Solidwoks quite sensitive towards disturbance. I propose to use the Matlab/Simulink because it offers greater performance besides easy to control. Other than that, the stability of the biped robot can be improved by using the Matlab/Simulink since biped robot involves gate control and kinematics.