TIME OPTIMIZED SMOOTH TRAJECTORY GENERATION FOR 2DOF AND 3DOF REDUNDANTLY ACTUATED CABLE SUSPENDED PARALLEL ROBOTS

Mudduwa Bathubaralage Lahiru Chaaminda Boralugoda

138533D

Degree of Master of Science

Department of Electronic and Telecommunication Engineering

University of Moratuwa
Sri Lanka

October 2019

TIME OPTIMIZED SMOOTH TRAJECTORY GENERATION FOR 2DOF AND 3DOF REDUNDANTLY ACTUATED CABLE SUSPENDED PARALLEL ROBOTS

Mudduwa Bathubaralage Lahiru Chaaminda Boralugoda

138533D

Thesis submitted in partial fulfillment of the requirements for the degree Master of Science in Electronics and Automation

Department of Electronic and Telecommunication Engineering

University of Moratuwa
Sri Lanka

October 2019

Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgment any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part, in print, in electronic or other medium. I retain the right to use this content in whole or in part in future works (such as articles or books).

Signature : Date:

The above candidate has carried out research for the Masters thesis under my supervision.

Name of the supervisor: Prof. Rohan Munasinghe

Signature of the supervisor: Date:

Abstract

Cable Suspended Parallel Robots (CSPR) are a type of cable driven parallel manipulators (CDPR) that has recently become popular for large workspace operations. They possess many advantages over common parallel robot architectures. They also possess the disadvantage of limited dynamics in motion due to the inability to exert compression and the constant limited downward force, gravity. Further, the redundancy in actuation in planar and spatial robots of certain footprints makes it challenging to determine the cable tensions and suitable dynamics for trajectories.

This thesis introduces an analytical model to circumvent the cable tension determination problem using a concept termed as ‘Feasible Acceleration Diagram’. It then designs a novel methodology to generate time optimized point to point straight line trajectories with smooth dynamics for redundantly actuated 2DOF and 3DOF point-mass cable suspended parallel robots while ensuring positive cable tensions. The procedure of determination of kinematics for the trajectory is explained in detail with a test case for the 3DOF 4 cable scenario. Finally, the results obtained are verified by a simulation followed by a numerical method.

Acknowledgements

With immense gratitude I would like to acknowledge the support of the research supervisor Prof. Rohan Munasinghe, and course coordinator Dr. Chamira Edussooriya to make this research a success. I would also like to thank the academic staff of the Electronic and Telecommunication department for the guidance given throughout the academic period.

Finally, I want to thank my beloved wife for the encouragement and the support.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CSPR	:	Cable Suspended parallel Robot
CDPR	:	Cable Driven Parallel Robot
DBCDPR	:	Dual Base Cable Driven Parallel Robot
DOF	:	Degrees of Freedom
EE	:	End Effector
FAD	:	Feasible Acceleration Diagram