DEVELOPMENT OF A ROBOTIC ORTHO-PROSTHESIS FOR TRANS-HUMERAL AMPUTEES

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Degree of Master of Science

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Thesis submitted in partial fulfillment of the requirements for the degree Master of Science by research in Biomedical Engineering

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement 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.

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

Signature of the Supervisor(s): Date:

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Abstract

Over the years trans-humeral prostheses have been developed as a remedy for trans-humeral amputation: the amputation occurs between shoulder and elbow. For the best usage of the trans-humeral prostheses, amputee should have a strong residual arm (stump arm) after the amputation. Furthermore, the ranges of motions and also the full functionality of the prosthesis will be limited if the amputee has a weak stump arm. Moreover, prolonged applying of the loads on the stump arm can cause musculo-skeletal disorders.

In order to improve the dexterity of the prosthesis, they are developed with more joints and actuators. Hence, the weight of the prosthesis increases. There is a need for power assisting the weak stump arm while the prosthesis is at work. Trans-humeral ortho-prosthesis is a device which assists the power of stump arm from an orthosis while replacing the missing upper limb with trans-humeral prosthesis. This research is carried to develop a 9 Degrees of Freedom trans-humeral ortho-prosthesis. It consists of 4 DoF motions: shoulder horizontal flexion/extension, shoulder vertical flexion/extension, shoulder abduction/adduction and shoulder internal/external rotation, at the orthosis and 5 DoF motions: elbow flexion/extension, forearm supination/pronation, wrist ulnar/radial deviation, wrist flexion/extension and compound motion of thumb and index finger, at the prosthesis. Moreover, shoulder abduction/adduction is supported as a passive DoF in order to compensate the misalignments of the joints caused by the motions of clavicle and the scapula in the sagittal plane while enabling shoulder abduction/adduction . Even though the orthosis is designed to achieve 4 DoF motions, it contains 6 DoF motions. Therefore, the whole ortho-prosthesis becomes a redundant manipulator.

Simulation experiments have been carried out to determine the workspace of the hand of the ortho-prosthesis and to determine the manipulability of the ortho-prosthesis. Workspace plots show that it can reach the workspace of a human hand. Manipulability measures: manipulability index, minimum singular values, condition number and manipulability ellipsoids verify that the trans-humeral ortho-prosthesis would not reach singular configurations. Furthermore, it is confirmed that the ortho-prosthesis is capable of performing dexterous motions due to its high manipulability after carrying out experiments with the fabricated prototype of the trans-humeral ortho-prosthesis.

***Keywords*-Trans-humeral, ortho-prosthesis, manipulability measures, singular configurations, musculo-skeletal disorders, linear velocity jacobian**

DEDICATION

To my loving family

who keeps lifting me up with unconditional love,

every time I fall down ...

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LIST OF ABBREVIATIONS

ADL	Activities of Daily Living
DoF	Degrees of Freedom
U/R	Ulnar/ Radial
F/E	Flexion/ Extension
ROM	Range of Motions
Abd/Add	Abduction/Adduction
S/P	Supination/ Pronation
I/E	Internal/ External
DH	Denevit-Hartenberg
HRI	Human Robot Interaction
N/A	Not Applicable