DEVELOPMENT OF AN UPPER-LIMB POWER-ASSIST 
EXOSKELETON ROBOT TO GENERATE HUMAN LIKE MOTION

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Degree of Master of Philosophy

Department of Mechanical Engineering

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Thesis submitted in partial fulfillment of the requirements for the degree of
Master of Philosophy

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July 2014
DECLARATION

I declare that this is my own work and this thesis 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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ACKNOWLEDGEMENTS

An achievement of a success after hard work and commitment is always accompanied with the support of many individuals. I would like to take this opportunity to thank them all who were with me during last three years and share all moments throughout this journey.

My first responsibility is to thank my thesis supervisor, Dr. Ruwan Gopura to giving all the guidance and support throughout the research work as well as encouraging for good research work. He also provided many research opportunities for me to expand my experience in this area and I must thank it too. Further, my co-supervisor, Dr. Sanath Jayawardena also gave valuable suggestions, comments, and ideas to improve the content of my research work. Moreover, I got an opportunity to get their expertise knowledge to improve the content of my thesis, research work, publications, and presentations in different ways and I honestly thank them for their cooperative support.

Also, I should thank my progress review panel members, Dr. Koliya Pulasinghe (chairman) and Dr. Palitha Dasanayake (member) for their valuable suggestions and comments to improve the content of my research work. Despite to the busy schedule, I am appreciating the commitment given by Dr. Koliya Pulasinghe to conduct my progress reviews in planned time schedule.

I started my research work during last three years of my probationary period. Therefore, my head of division, Mr. K.M Ranasiri, Directress (ITUM), Mrs. Priyangani Samarasekara they all encouraged me and supported in many ways to complete the research work prior to end of probationary period. Also my colleague staff members gave free time for me to concentrate to research work. I must thank them all for their support.

During this research work, I got an opportunity to make close contacts with researches in ResearchGate too. Even though they are not physically present, I
gained contribution from them to improve my research work. It is my duty to mention their support at this moment.

Also I would like to extend my appreciation to my co-authors, Prof. Mann, Mr. Sanjaya, and Mr. Thilina for their suggestions to improve the research content of my work. Further, Prof. Mann gave his knowledge to improve the research content of my work. He also helped me to find valuable research papers to my studies too. I am appreciating his support at this moment.

Without any doubt, I must thank my wife, Vinidu, for her endless dedication to allowing free time for me to concentrate on my research activities. She provided all software requirements as well as printed materials for my research. During most difficult situations, I got mental relax from my little one. His smile and loving words really help me to keep research stuff away from me for a while.

Last but not least, my warm thank is given to my loving mother and father, for all their love and encouragement, and supported me in all my pursuits.

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ABSTRACT

Weakness is inherently associated with ageing society. In fact, Exoskeleton robotic technology can be used to provide assistance for age society to perform activities of daily living (ADL) without depending on others.

Upper limb exoskeleton robots are much suitable to perform ADL. Typically, upper limb exoskeleton robot consists of number of joints and links which are corresponding to joints and limbs of human upper limb. Further, exoskeleton robots differ from other conventional robots due to present of close interaction with wearer. In general, two types of interaction can be seen in exoskeleton robots: physical human robot interaction (pHRI) and cognitive human robot interaction (cHRI). Strengthening features of cHRI can be seen on recent developments of upper limb exoskeleton robots. However, there exists a vacuum to identify aspects of pHRI relating to performance of exoskeleton robots.

The research work of this thesis is focused to design an upper limb exoskeleton robot for motion assist taking effect of kinematic redundancy. The proposed exoskeleton robot (6-REXOS) has four active degree of freedom (DOF) and two passive DOF in its kinematic chain. Two passive DOF are provided to 6-REXOS by means of flexible bellow coupling and those are positioned at wrist and elbow joint of the 6-REXOS to keep their axes parallel to each other. This configuration enhances kinematic redundancy in 6-REXOS. The effect of redundancy is verified with respect to dexterity measures, such as manipulability index, minimum singular value, and condition number. Further, manipulation of end-effector of 6-REXOS due to kinematic redundancy in operational space is presented base on manipulability ellipsoids.

4DOF kinematic model for human lower arm is proposed in thesis. Manipulability measure of human kinematic model is used to benchmark the performance of 6-REXOS. Different measures are taken into account in design of 6-REXOS to ensure smooth pHRI. Passive compliance of bellow coupling in order to reduce kinematic discrepancy as well as improve the manipulation of 6-REXOS is highlighted in this thesis.

Key words: Exoskeleton robot, Redundancy, Compliance, Manipulability index, Minimum singular value.
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<td>Physical Human Robot Interaction</td>
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<td>DOF</td>
<td>Degree of Freedom</td>
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<td>eHRI</td>
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