

DESIGN AND ANALYSIS OF A ROBOTIC SURGICAL MANIPULATOR FOR COCHLEOSTOMY

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

Department of Electrical Engineering

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Sri Lanka

June 2015

STUDENT DECLARATION

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ABSTRACT

Robot assisted surgery is proven to be useful in surgeries, proven to be complex in conventional form in terms of accessibility anatomical complexity and small scale, required precision and accuracy. Cochleostomy procedure in cochlear implantation surgery is one such procedure, proven to be a complex practice even for the most experienced surgeon.

In this thesis, the drilling processes involved in conventional cochleostomy are looked at. Due to dexterity and precision robotics offer, it is deemed the efficiency of the in situ drilling procedure of the cochleostomy can be greatly increased with the use of a robotic manipulator tool.

Despite commercial success of general robotic platforms, practical use in task specific microsurgery is still challenging, due to considerable levels of accuracy required at sub-millimeter scales, limited visualization, degrees of freedom, range of motion, large footprint and constrained visual and tool accessibility, under operation microscopes. The proposed task specific surgical manipulator addresses the drawbacks of existing surgical manipulators and other apparatus for the purpose of cochleostomy. The proposed tool: a six degrees of freedom manipulator, is a micromanipulator that is attached to the surgical microscope boom. The surgeon is able to use the manipulator as conventional surgical drill tool for drilling and clearing of bone.

The thesis looks at the development of the introduced surgical manipulator; from concept, theory to a proof of concept prototype. The theoretical analysis, theoretically formulates the concepts, which are the basis of the manipulator design. The theoretical study includes a study of manipulator kinematics, manipulator singularities, analysis of the systems dynamic parameters and the controller design in joint space. Methods of localization and trajectory generation are briefly discussed and validated using simulation.

A simple prototype is developed based on the developed concepts and theoretical formulation. The prototype development includes design of mechanical linkages, drive actuators, a robot controller and software. Simple tests are conducted using the developed prototype to validate required motion control.



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ACKNOWLEDGEMENTS

I would like to thank my supervisor Dr. D. P. Chandima from the department of electrical engineering, University of Moratuwa for his patience, advice and constant encouragement, and my external supervisor Dr. A. D. K. S. Yasawardena, ENT surgeon at the Lady Ridgeway Hospital, for his expert advice, and access to observe surgical procedures.

I thank Mr. Tilak Dissanayake for his advice & support.

I would like to acknowledge and appreciate the support given by J. M. Wickramarachchi & Co., local partner for Cochlear Ltd., with information and correspondence.

I am truly grateful for the support the Electrical department at the university has offered me, which enabled me to complete this research.



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LIST OF ABBREVIATIONS

ADC – Analog to Digital Converter	MC – Master Controller
AMC – Auxiliary Microprocessor	MDH – Modified Denavit-Hartenburg
ANSI – American National Standards Institute (of USA)	PC – Personal Computer
CAD – Computer Aided Design	PCS – PC side Software
CT– Computer Tomography	PMDC – Permanent Magnet Direct Current (Motor)
DAC – Digital to Analog Converter	RISC – Reduced Instruction Set Computing
DC – Direct Current	SPI – Serial Peripheral Interface
DOF – Degrees of Freedom	SVD - Singular Value Decomposition
EE – End Effector	TCP - Tool Center Point
ENT – Ear, Nose, Throat	USB – Universal Serial Bus
FDA – Food and Drugs Administration (of USA)	
GUI – Graphical User Interface	
IC – Integrated Circuit	
ICP – Iterative Center Point (algorithm)	
I2C – Inter-Inter-Connected (bus)	
JC – Joint Controller	
JCM – Joint Controller Microcontroller	
LRH – Lady Ridgeway Hospital	