DESIGN AND ANALYSIS OF A ROBOTIC SURGICAL MANIPULATOR FOR COCHLEOSTOMY

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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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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADC – Analog to Digital Converter

AMC – Auxiliary Microprocessor

ANSI – American National Standards Institute (of USA)

CAD – Computer Aided Design

CT– Computer Tomography

DAC – Digital to Analog Converter

DC – Direct Current

DOF – Degrees of Freedom

EE – End Effector

ENT – Ear, Nose, Throat

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

MC – Master Controller

MDH – Modified Denavit-Hartenburg

PC – Personal Computer

PCS – PC side Software

PMDC – Permanent Magnet Direct Current (Motor)

RISC – Reduced Instruction Set Computing

SPI – Serial Peripheral Interface

SVD - Singular Value Decomposition

TCP - Tool Center Point

USB – Universal Serial Bus