From May to August 2016, I worked as a research student at the Centre for Image Guided Innovation and Therapeutic Intervention (CIGITI) at the Hospital for Sick Children. Here, I assisted an MD-PhD student in performing experiments that aim to optimize the design of robotic instruments for neurosurgery. The tool consists of a long tube which can be inserted into the brain to perform surgery. The tip of the tool consists of a continuum joint, allowing it to bend flexibly due to slots that are cut into it. This joint’s physical characteristics were experimentally measured to determine the relationship between the geometry and resulting range of motion of the tip. To do this, I learned basic design of experiments and used Latin Hypercube sampling on Matlab to evenly and randomly span the optimal ranges for each geometric parameter. I mill machined eight different geometries of joints using a CNC mill.

I setup an experiment to test the physical characteristics of the joints, including techniques and protocols used in this field and presented in papers we use for reference. A force applied at the tip of the joint was measured with a force sensor, while a laser measured tip displacement and a calibrated camera system acquired the resulting image. Image analysis via Matlab calculated the joint’s range of motion parameters. Statistical data analysis techniques were used to calculate the mean and standard error. Before these experiments, the accuracy of the image acquisition system was determined by statistically comparing measured data with known data to quantify the error.

The resulting data to characterize the stiffness properties of the joints were compared to a model developed by the MD-PhD student and presented in “Kinetostatic Design of Asymmetric Notch Joints for Surgical Tools” at the IEEE International Conference on Intelligent Robots and Systems in South Korea, 2016. The relationship between the force applied and range of motion parameters are part of an ongoing study and will be presented in a future paper where I will be co-author. As well, using this data, I developed a figure for a magazine article in IEEE Robotics and Automation Magazine entitled “Miniaturized Continuum Instruments for the da Vinci Research Kit,” which has been accepted by the magazine. These papers validate the kinematics model of continuum joints with experimental results. They extend the knowledge of robotic surgery tool design by presenting realistic behaviours of these joints, thereby facilitating future design of joints to optimize robotic tools. Furthermore, I compiled a summary document explaining the details, process of statistical data analysis and figures of the experimental setup. This will be an aid while writing the methods for future publications. Finally, I delivered a presentation to my lab outlining my work during the summer and a discussion of my results.

Additionally, I worked with a team at CIGITI to design and fabricate miniaturized electrosurgery forceps, which are commonly used in surgery to grasp and burn tissue to control bleeding. This miniaturized tool is designed so it can perform in an endoscopic neurosurgery environment, which is minimally invasive and performed through a keyhole sized hole in the skull, as opposed to an invasive surgery which removes a large section of the skull to access the brain. This project has been submitted to the Hamlyn Surgical Robot Competition, to be held in June, 2017.

Furthermore, my Master’s project is a continuation of a project I started in undergrad, where my team prototyped a functional instrument to facilitate endoscopic ear surgery. I enjoyed working on the project and have fabricated a higher level, functional prototype to be presented at the International Working Group for Endoscopic Ear Surgery annual meeting in April, 2017. For my Master’s work to date, I am designing a survey study that will be used to address the knowledge gap of why most otologists are not currently employing endoscopic ear surgery techniques and what technological advances can be developed to encourage greater use of this new surgical approach. I am applying for Research Ethics Board approval to conduct the study. Part one of the study consists of a survey that will be sent to ear surgeons who are current members of any international Otological Society. This survey will follow a two-round Delphi method and the statistically analyzed results will be disseminated in an otolaryngology journal. The second part is to measure the time to complete various surgical manoeuvres in endoscopic ear surgery. The study will quantify the current limitations and inefficiencies of endoscopic ear surgery instrumentation by measuring the duration of surgical steps. This publication will present data where the time to complete the steps of ear drum reconstruction surgery was measured. The procedure will be completed 10 times each by five ear surgeons independently. These two studies aim to establish the needs and current limitations of endoscopic ear surgery technology to inspire the design of, and provide means of validation, for new endoscopic ear surgery tools. This is the next step of the Master’s project.

Finally, during my undergrad I worked on an eight-month thesis project where I developed a computer model of a nerve stimulating electrode, to optimize the electrode parameters to yield optimal nerve excitability. I developed a model of a simplified human leg with nerve simulating electrodes on Comsol Multiphysics software. The model outputted voltage along the nerve, which was analyzed to calculate nerve excitability using Matlab. The optimal position and size of the nerve stimulating electrodes was determined by analyzing results of varying geometric parameters of the model. This model was intended to be used by future students in the lab to simulate further electrode geometries to find the optimal parameters that would be implantable in the leg and yield appropriate nerve excitability. A thesis presentation was delivered to colleagues and the primary investigator and a final thesis report was submitted to the Division of Engineering Science in April, 2016.