FLUX ROBOTICS

Project 1: Develop an in-house GUI platform to allow operators to control the magnetic surgical robot arm with ease

Type: *Software / Electronic / Mechanical Engineering*

Summary:

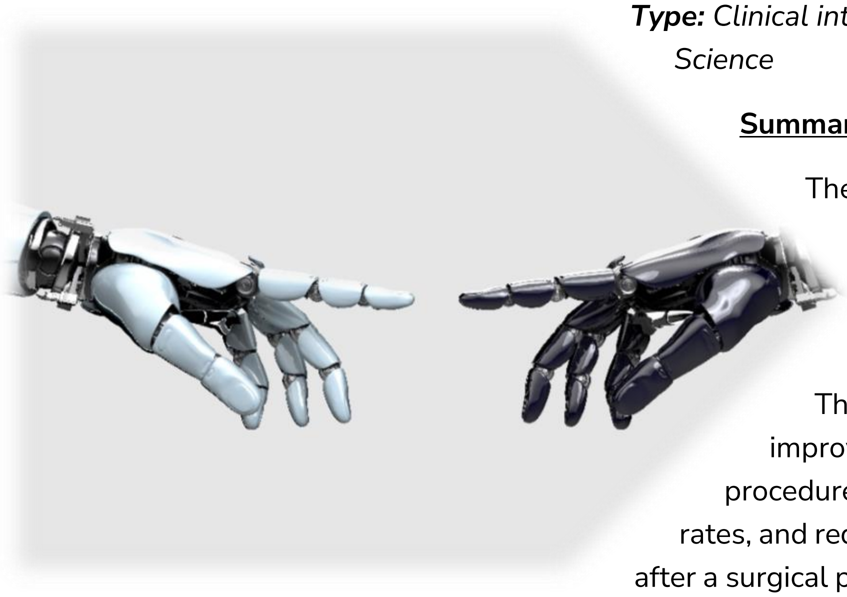
Are you excited about designing, improving, and building applications and software? Do you want to be part of an enthusiastic team? Then we would like to get in touch with you! The software engineering team at Flux Robotics develops software in a broad spectrum ranging from compact embedded controls to advanced, user-friendly user interfaces. We contribute to the system architecture and work according to test-driven development and model-based design. As a team, we are constantly working to keep abreast of the latest developments and develop new solutions. Software engineer at Flux Robotics is a challenging and independent position where you are part of a multidisciplinary team. You are responsible for developing complex software for high-tech and medical systems. You ensure that a system is workable, and quality is guaranteed.

In this project, you will work on the front-end development of magnetic surgical robots in healthcare. The main focus will be on a prototype called the ARMM system (Advanced Robotics for Magnetic Manipulation) that aims to provide surgeons with enhanced surgical dexterity by introducing magnetic actuation techniques, magnetic interventions, and advanced diagnostics for patients with signs of chronic total occlusion (CTO) and other vascular diseases. Accurate and timely interventions on such patients can result in timely preventive measures and can reduce the burden and costs of the currently inefficient interventional pathway for these patients.

This project can be divided into two key deliverables (and can be a collaborative/group project):

1. The first deliverable is to develop an in-house GUI platform written in C++with the Qt toolkit to allow operators to control the magnetic system in line with IEC 62304 requirements for class III medical systems.
2. The second deliverable is to expand on the current framework by generating C++ code from an existing Simulink model to deploy as a standalone ROS 2 node.

Project 2: Very early economic evaluation of a magnetic surgical system that can be utilized as a tool during interventional radiology



Type: *Clinical internship / Master Health Science*

Summary:

The ARMM (Advanced Robotics for Magnetic Manipulation) system is currently under development at the UT. The ARMM system aims to improve minimally-invasive procedures, decrease complication rates, and reduce hospital length of stay after a surgical procedure. The system aims to provide surgeons with enhanced surgical dexterity by introducing magnetic actuation techniques, magnetic interventions, and advanced diagnostics for patients with chronic total occlusion (CTO) signs. Accurate and timely interventions on such patients can result in timely preventive measures and can reduce the burden and costs of the currently inefficient interventional pathway for these patients2. It is, however, still unclear a) what the potential health benefits and costs (reduction) of using the ARMM system are compared with the standard procedure (potential cost-effectiveness), and b) what are the main drivers of the cost-effectiveness of the ARMM system. This information is crucial to support the further development of this technology and turn it into a successful product.

In this assignment, you will perform an early cost-effectiveness analysis to answer whether the addition of the ARMM system is expected to be cost-effective in its use for the revascularization of chronic total occlusions compared to conventional care.

You will develop an early cost-effectiveness model. To construct the model, interviews will be held with clinicians who have a clear idea of the current care pathway and the impact of the ARMM on this workflow. To obtain model inputs, you will perform a) a review of the literature, b) observational data analysis from pilot studies, and experts' opinions elicited as some of the data will not be available from the literature. You will also perform a cost analysis of the current care pathway and the care pathway when using the ARMM system.

Project 3: A motion planning Gazebo implementation and simulation for the KUKA LBR iiwa robotic arm

Type: *Software / Electronic / Mechanical Engineering*

<u>Summary:</u>

The ARMM (Advanced Robotics for Magnetic Manipulation) system is currently under development at the UT. The ARMM system aims to improve minimally-invasive procedures, decrease complication rates, and reduce hospital length of stay after a surgical procedure. The system aims to provide surgeons with enhanced surgical dexterity by introducing magnetic actuation techniques, magnetic interventions, and advanced diagnostics for patients with chronic total occlusion (CTO) signs. Accurate and timely interventions on such patients can result in timely preventive measures and can reduce the burden and costs of the currently inefficient interventional pathway for these patients. An essential part of the project is developing a control strategy for a commercial robotic arm, the KUKA iiwa (or the LBR Med), that clinicians can use to conduct a magnetic intervention efficiently.

In this assignment, you will develop a motion planning framework for the KUKA LBR iiwa robotic arm, written in C++ with the Qt toolkit, to allow operators to control the magnetic system easily.

You will perform a comprehensive review of control strategies for commercial robotic arms in operating theatres and present a simulation of a magnetic surgical procedure being performed with the help of an autonomous robotic manipulator. This simulation shall be developed with the following minimum requirements in mind:

- Knowledge of the safety requirements for the KUKA LBR iiwa manipulator
- A full kinematic model for the manipulator, allowing for reading the state of and writing the pose commands to the robot
- Simulation should be performed in ROS2 and simulated with Gazebo

Project 4: Integration of a haptic framework for collision-detection during tele-manipulated robotic vascular surgeries

Type: *Software / Electronic / Mechanical Engineering*

Summary:

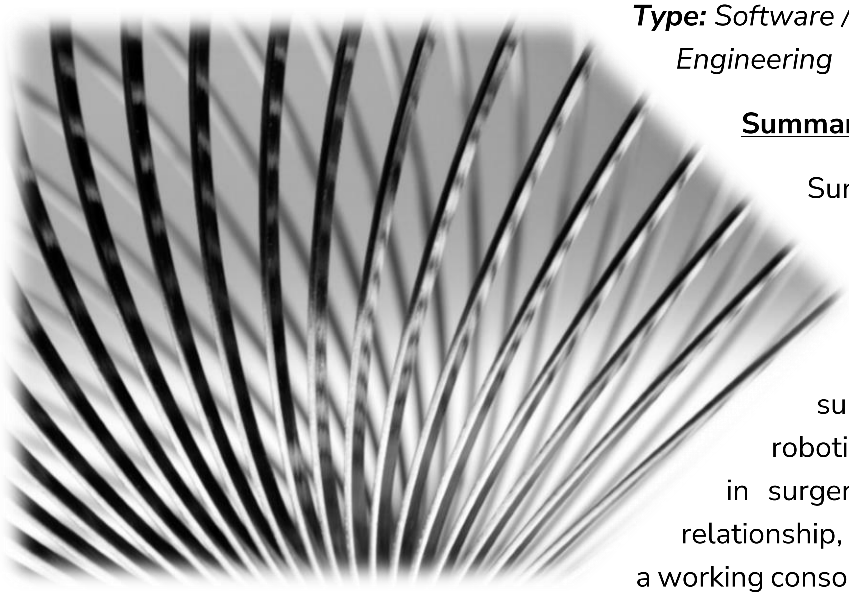
Surgery using a robotic system has proven to have significant potential but is still a highly challenging task for the surgeon. Vascular procedures such as ablations require considerable effort and time from the surgeon as they are delicate. This project focuses on developing and integrating a framework that will allow the clinician to perform a vascular procedure (FEVAR intervention) following a shared-control approach with the robotic ARMM system. This framework is expected to result in a quicker and more efficient process. This framework will also allow the clinician to be in control of part of the procedure (insertion of the guidewire) and maneuvering of the end effector of the robot (adjust the direction of the electromagnetic coil, thus the direction of the magnetic actuation on the actuation points) while having some autonomously from the robot.

In this assignment, you will explore using a haptic interface for developing a robot-patient collision-free security feature, which can potentially be used in further research.

Amongst others, you will focus on:

- Integrating a haptic control interface for controlling an industrial robot, Kuka iiwa14 R820 for vascular surgeries.
- Expand on an existing framework for the pre-operative planning of the robot arm concerning the patient's body
- Torque limits of each joint change dynamically, together with the motion of the robot end-effector. These torque limits are essential to predict before the robot collides with an external object.

Project 5: Design optimization of an electromagnetic coil and liquid cooling assembly aimed at magnetic fEVAR interventions.



Type: *Software / Electronic / Mechanical Engineering*

Summary:

Surgery using a robotic system has proven to have significant potential but is still a highly challenging task for the surgeon. Most surgical robotic platforms currently used in surgery employ a master/slave relationship, with the surgeon seated at a working console, manipulating the master system, and visualizing the operation on a video screen. This takes a lot of the touch and sensibility away from the surgeon. Although enormous strides have been made to advance current technology to clinical use, limitations exist, such as expense, transmission delay, and medical and legal issues. In this project, we propose a mobile surgical robot that will share the limited space available in the operating room (OR) with the medical staff and other equipment, using the multiple functions of future operating rooms, which will also be essential in optimizing resource management. Having in mind the exponential use of robots and equipment in the OR, the aim is to design the robot end-effector in such a way that it does not occupy any more space than it needs to while maintaining full capabilities with a focus on balance and stability of the system during its wide range of motion.

For a given mass and heat dissipation constraints, the goal is to develop a routine that provides the coil geometry that maximizes the average magnetic field generated in a target region.

Project 6: Design and control of a magnetic flexible tool (e.g. a guidewire) for the treatment of cardiovascular / gastro-intestinal diseases

Type: *Software / Electronic / Mechanical Engineering*

Summary:

The clinical problem we would like to address is one of the most prevalent cardiovascular diseases referred to as progressive atherosclerosis, leading to blocked arteries that almost half a million people suffer from. Solving this requires dedicated and expert operative skills. During the intervention, catheters[1] must be passed through the blockage. This is the most challenging part since the surgeon can only manipulate and steer the catheter at the insertion point. Ultimately, this challenge results in limited dexterity and accuracy concerning the control of the catheter tip. Such interventions can be prolonged significantly with limited instrument control, resulting in extended radiation exposure from fluoroscopy. Our solution is referred to as magnetic surgery. A surgeon makes one small incision, inserts the catheter into the body, and controls the tip of the catheter with a magnet – inducing additional push/pull magnetic forces at the target location. This project sets out to gather scientific evidence that supports the use of this system in clinical practice – thus testing the system in an operating room.

This project presents a workflow that performs magnetic control of a steerable guidewire under fluoroscopy guidance. The designed magnetically steerable guidewire should be fabricated by a replica molding method. A computational-efficient kinematic model should be proposed to describe the relationship between the applied magnetic field and tip push/pull forces. Furthermore, the overall procedure should be experimentally validated on phantom mimicking vascular structures. This could potentially result in faster and safer interventions. Since this surgical technique combines the best open and MI surgeries, it can result in less pain, faster recovery, and fewer incisions for patients.

[1] This project can also be applicable for endoscopes, hence diagnostic tools, for treating cancers.