

Problem Statement and Goals

Optimal EM Placement

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Table 1: Revision History

Date	Developer(s)	Change
Jan. 17	Hussein	Initial commit

1 Problem Statement

1.1 Problem

Microrobots are being explored in minimally invasive surgeries due to their ability to navigate millimeter spaces. The magnetic actuation systems used to control these microrobots suffer from bulkiness and can obstruct a surgeon's view. Electromagnetic actuators can also pose a safety risk due to the heat they emit as a result of the current they receive.

1.2 Proposed Solution

We propose a design that places the actuation system under the operating table while only taking up limited space. We introduce optimization methods to solve the electromagnet (EM) arrangement problem. Central to our approach is an objective function — parameterized by the positions of the EMs — that is designed to maximize the minimum eigenvalue of the system's [manipulability](#), leading to an [E-optimal design](#).

1.3 Inputs and Outputs

1.3.1 Inputs

The program will receive the volume of the under-the-table workspace and properties of the EMs (# of turns, area, current). In addition, the user will input their desired number of EMs in the system and the sample size (a larger size leads to a more optimal solution).

1.3.2 Outputs

The program will output the optimal positions of the EM actuators.

1.4 Stakeholders

1.4.1 General Stakeholders

Surgeons and medical professionals that might operate an actuation system, engineers involved in the physical development of such systems, and researchers working on biomedical engineering systems and/or applications of optimization algorithms.

1.4.2 Specialized Stakeholders

Some specific stakeholders include Dr. Onaizah (HeART Lab), and Dr. Giamou (ARCO Lab).

1.5 Environment

1.5.1 Software

The software is compatible with Windows, MacOS, and Linux.

1.5.2 Hardware

Any personal computer should work.

2 Goals

- The program will provide a physically feasible arrangement of electromagnets that can fit in an under-the-table workspace.
- The provided magnet arrangement will maximize the diversity of magnetic fields that can be generated, leading to increased control over the volume of the workspace.

3 Stretch Goals

- Accept different currents to independent EMs.
- Allow for different kinds of EMs within the same workspace.
- Optimize individual EM angular configuration.

4 Challenge Level and Extras

This project would be considered an **advanced** project as it is a continuation of research work submitted to ICRA 2025, and involves a novel approach to solving the magnet arrangement problem.