# Optimization of Micro-Surgical Scissors Using an Evolutionary Algorithm

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## I. ABSTRACT

Minimally invasive surgery has several benefits as it helps to speed up recovery times by minimizing trauma to the target site and reducing complications. Robotically assisted minimally invasive surgery can further improve outcomes by increasing precision and dexterity and providing access to remote locations in the body. Microrobots and other small scale robots have become a popular area of research as they can be used for complex procedures with small workspaces. Owing to their small size they can navigate through narrow cavities and perform a variety of operations. One of the applications of such robotic tools is surgical cutting of tissues or tumours in the body that are difficult to reach using current robotic tools. Most small-scale robots are remotely actuated as they are too small for on-board power systems and electronics. Magnetic actuation is commonly used for these tools as it only requires a ferromagnetic body on board. Despite their potential, small-scale tools face significant limitations in generating sufficient forces for tissue penetration due to their size. Therefore, it is crucial to optimize the forces produced by these tools.

In this study, we propose an evolutionary algorithm for the optimization of a pair of untethered mobile micro scissors, originally developed by Onaizah et al. The scissors were developed with two magnets optimally placed on the blades to generate a large deflection and force to cut through agar. To further optimize the force output of the system and improve performance, the number of magnets is increased from 2 to 4. However, as the number of magnets increases, determining the optimal position and alignment of magnetic moments becomes challenging. The proposed algorithm aims to overcome this issue and can be adapted to optimize tools with any number of magnets, requiring minimal modifications. This algorithm operates by minimizing the interaction forces among the magnets while maximizing the torque generated in the presence of an external magnetic field.

This algorithm is successfully applied to a 4-magnet configuration for micro-surgical scissors and results in the optimal position and alignment of magnetic moments, leading to an increased magnetic torque. This enhancement is expected to result in higher cutting forces, addressing the inherent challenge of producing sufficient force for tissue cutting and penetration with small-scale tools. The study not only provides a solution for optimizing the design of micro-surgical scissors but also presents a promising tool applicable to other microrobotic systems. This has the potential to improve the capability of small-scale robotic systems in various other applications.