TUHH
Technische Universität Hamburg-Harburg

MTEC
Medical Technology | Intelligent Systems

Project work / MSc thesis

Title: Optimization of a TSP for dose delivery and robot coordination in robotic radiation therapy using a QUBO solver

Background: In robotic radiation therapy, ionizing radiation is delivered by a linear accelerator that is mounted on a robotic arm. This allows to deliver dose from practically arbitrary many directions that overlap in the target. Treatment planning determines from which directions dose should be delivered. However, target movement and deformation during treatment, e.g. due to breathing, can be detrimental but can be tracked for example by using an ultrasound probe mounted on another robot. During treatment, movement of the dose delivering robot and the US robot have to be coordinated and can be optimized to require as little time as possible by solving a traveling salesman problem (TSP). This can be solved efficiently using particular hardware implementations of quadratic unbounded binary optimization (QUBO) problems.

Tasks: The current implementation of the TSP for robot coordination should be evaluated. Furthermore, the TSP should be implemented as a QUBO problem allowing for efficient solving. The implementation should be integrated in the existing treatment planning framework. Differences in quality and computation time should be evaluated.

Specific steps include:

1. Familiarize with the treatment planning framework.
2. Study the current implementation of the TSP.
3. Implement QUBO optimization of the TSP.
4. Integrate the QUBO optimization into the treatment planning framework.
5. Compare the implemented approach to the existing TSP optimization.

Requirements: Good programming skills in Java, ability to work independently, ideally experience with TSP optimization or other types of mathematical optimization

Not required is experience with medical technology or radiation therapy.

Difficulty: 

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References: Matthias Schlüter, Christoph Fürweger, and Alexander Schlaefer. "Optimizing robot motion for robotic ultrasound-guided radiation therapy." *Physics in Medicine & Biology* 64.19 (2019): 195012.