Cut-Pattern Simulation for Laser-Trimming of Resistors

Reinforcement Learning–Based Optimization for Laser Trimming Machines

Graduate

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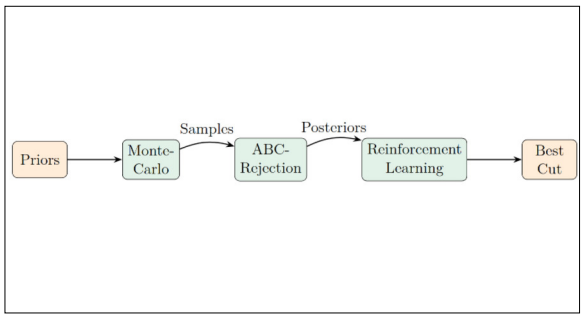
Problem: Lasertrimming is a precision manufacturing process used to adjust electrical resistors to a desired target value by selectively removing conductive material. In industrial practice, suitable trim patterns are typically found through manual experiments and accumulated experience, supported by iterative measurements. This trial-and-error procedure is time-consuming, highly dependent on previous knowledge and does not guarantee to find an optimal solution with respect to accuracy, stability or production speed, as multiple process parameters must be adjusted simultaneously.

Approach: This thesis proposes a simulation-based pipeline to automatically generate and evaluate laser-trimmmed patterns and finally find an optimal patterns. A mathematical resistor model is used to simulate resistance changes caused by arbitrary cut geometries. Monte-Carlo sampling captures parameter uncertainties, while an approximate Bayesian rejection step filters physically plausible samples. Trim patterns get generated and assessed using criteria regarding resistance deviation, local stability and current density distribution. Based on these metrics (and some more) a reinforcement learning agent iteratively improves cut design, aiming to find patterns that optimally fulfill these requirements. Ultimately a single pattern shall be found, that fits the best for given samples of a resistor.

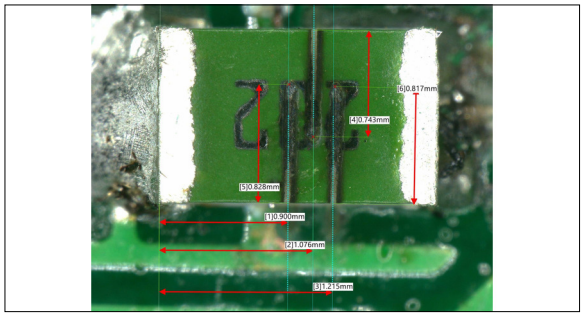
Result: The proposed pipeline was fully implemented and integrated into a single workflow, which is able to mathematically describe the resistor, use it to statistically represent the production conditions. Then further is able to generate cut patterns and improve the cuts with a basic reinforcement learning algorithm. The model was validated with a measurement setup.

The validation with a paired t-test revealed a rising error correlated with the length of the cut.

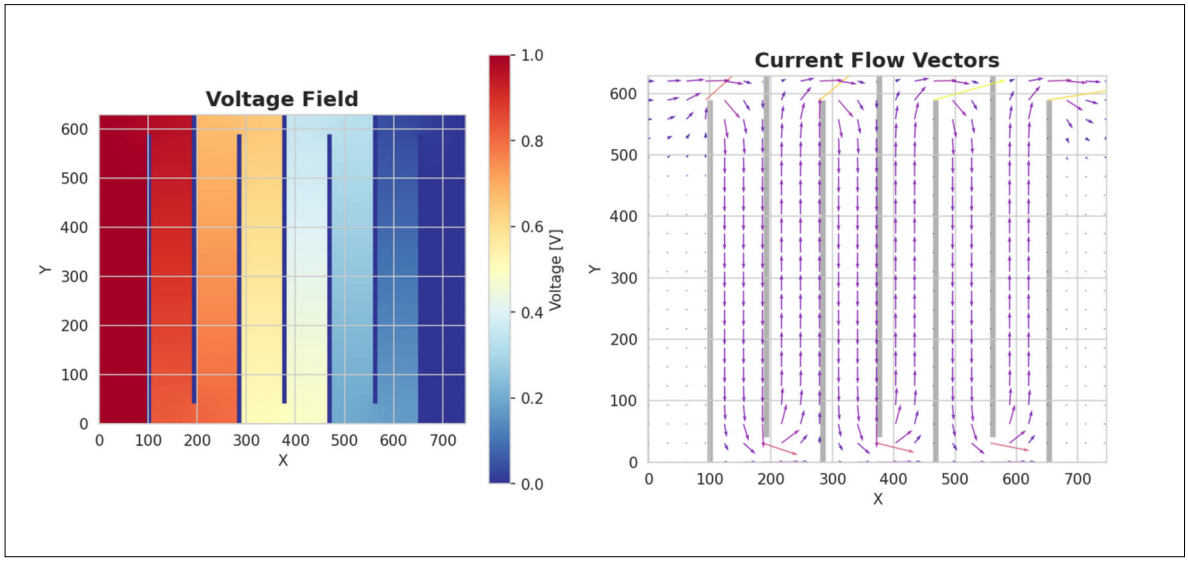
Project Pipeline
Own presentment



Cut pattern to validate the resistor model
Own presentment



Current density of a resistor with a sample serpentine cut
Own presentment



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