

MULTI-OBJECTIVE OPTIMIZATION FRAMEWORK FOR SIMULTANEOUS DESIGN OPTIMIZATION & REQUIREMENTS ENGINEERING OF ELECTRIC POWERTRAINS

Martin Hofstetter, Dominik Lechleitner

Graz University of Technology

Keywords: multi-objective optimization; requirements engineering; design optimization; electric powertrains

Abstract

The development of technical products is driven by diverse and often conflicting requirements. In early development phases, these requirements are often vague, incomplete, and continuously refined and subject to change as development progresses. Moreover, technical product design typically represents a multi-objective optimization problem, where the product must be competitive regarding multiple key performance indicators (KPIs) such as performance, cost, energy efficiency, and package integration. This challenges engineers to concurrently develop the product design alongside the requirements on which the design is based on. Managing this combination of uncertain requirements and multi-KPI design optimization represents a complex challenge in product development. The present work introduces a combined requirements engineering and design optimization approach on the product example of electric vehicle powertrains. It is implemented building on the existing OPED (Optimization of Electric Drives) method, which digitalizes the transition from requirements to technical solutions by integrating parametric system models with an AI-based evolutionary optimization algorithm. This enables systematic exploration of trade-offs, robust handling of uncertainties, and the effective specification of requirements. The outcome is a Pareto front of optimal and feasible powertrain solutions, providing engineers and decision makers with a quantitative basis for requirement definition and product design in the development process.

A case study demonstrates the approach by determining the optimal maximum vehicle speed for the powertrain of an electric passenger car. OPED evaluates the influence of the maximum vehicle speed requirement on cost, energy efficiency, and package integration. A Pareto front is generated that contains optimal powertrain solutions alongside the respective maximum vehicle speed. Results show that OPED effectively combines requirements engineering and system design optimization, thereby supporting agile and robust product development.