Abstract

This thesis investigates the integration of form finding techniques, parametric design and artificial intelligence (AI) techniques in the structural optimization of long-span structures, with particular focus on gridshells. These structures, widely recognized for their architectural expression and large-span roofing capabilities, present unique design challenges due to the complex interaction between geometry, stress distribution and fabrication constraints. To address these challenges, this study explores the Multi-body Rope Approach (MRA) and introduces its enhanced variant, the Improved Multi-body Rope Approach (i-MRA). A comparative analysis highlights the impact that integrating fabrication constraints into the form finding process can have on structural performance, material efficiency and post-buckling behaviour, as demonstrated through case studies such as the gridshell roof of the Dakar Islamic Cultural Center. Beyond performance-driven optimization, this research emphasizes the critical role of the designer intent in the generation of structural geometries. To incorporate subjective design preferences into the optimization workflow, a Human-in-the-Loop (HitL) framework is introduced. This methodology combines interactive optimization algorithms and machine learning techniques to integrate user feedback in a dynamic optimization loop in which the expertise and preferences of the designer guide the evolution of structural solutions. The result is a comprehensive and adaptive design protocol that improves structural performance and fosters creativity, allowing the generation of customized architectural shapes that reflect both engineering efficiency and human creativity.