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Sustainability-driven structural design using artificial intelligence

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1 Abstract

The construction industry is responsible for a large share of the global environmental impact. The need for addressing sustainability and increased competition calls for the development of innovative design methods that include sustainability in a transparent way. The aim of this work is to propose a framework to use machine learning and artificial intelligence (AI) for structural design optimization based on sustainability and buildability criteria. AI opens up new possibilities to optimize and assess structures early in the planning and design stages. In that way, it is possible to decrease the negative and enhance the positive environmental, economic and social impacts and create a more time- and cost-effective design process. The work is meant to serve as a first step toward the development of AI-based methods in the construction industry, which can bring digitalization in the construction industry to a new level and create new services and business models.

Keywords: Sustainability, structural design optimization, artificial intelligence, set-based design, life cycle sustainability assessment, multi-criteria decision analysis, construction.

2 Introduction

The construction industry is often depicted as a conservative industry relying on traditional methods. The European market for the construction industry is growing, and competition as well as the focus on sustainability is increasing. Authorities and municipalities responsible for the transport system and associated infrastructures are today in great need of addressing sustainability when upgrading and renewing the transport system. The same applies to both private and public residential builders. This together with the increased competition calls for an innovative design method that includes sustainability in a transparent way.

Simultaneously, the rapid development of artificial intelligence (AI) can lead to major changes in the structural engineering process and opens up new possibilities to consider sustainability in the design stage. This can help reduce negative and enhance positive environmental, economic and social impacts, lead to a more efficient construction process, cost-effective solutions and new business models. With AI, the construction industry has the possibility to design, evaluate and optimize design concepts faster than ever. With the traditional calculation worksheets and design software used by structural engineers today, such optimization process would be costly and time-consuming.

The purpose of this study is to propose a framework to integrate AI with structural design and sustainability assessment methods and analyze the potential of this design framework in civil engineering applications. The proposed framework makes it possible to optimize the technical solution

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