Master Thesis Proposal

Machine learning enhanced design of short fiber reinforced composites

Background

Short fiber reinforced composites (SFRCs) are being increasingly used due to their interesting mechanical properties and ease of processing. There are a wide variety of microstructural parameters which affect the macro-mechanical response of short fiber reinforced composites. Figure 1 shows a numerical Representative Volume Element (RVE) of an SFRC and its spatial discretization.

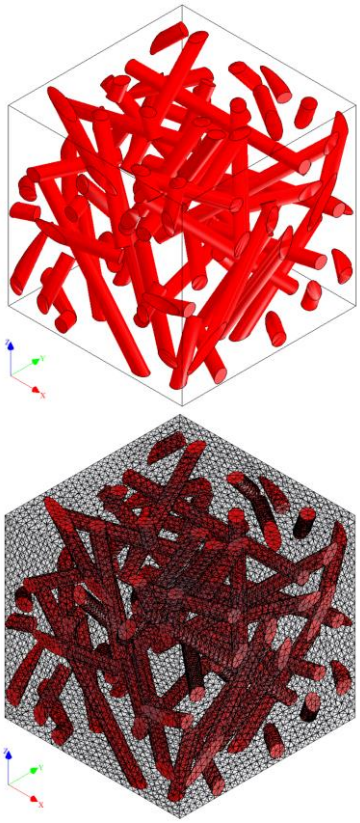

Figure 1: An RVE of a short fiber reinforced composite and its spatial discretization.

Purpose

In order to design an SFRC with specific requirements at the macro-level, efficient design schemes are needed which can consider micro-structural properties of these materials. Machine learning methods are useful techniques to develop such design methodologies. Finite Element Analysis is a powerful approach for accurate prediction of mechanical performance of materials and structures. **Thus, the main purpose of this project is to use Artificial Neural Networks (ANN) and RVE Finite Element simulations to develop a tool for designing SFRCs with desirable macro-mechanical performance.**

Project description

In previous projects, we have developed an ANN model for elastic properties of SFRCs [1]. Required data for training the model was generated using a two-step homogenization approach, combining Finite Element Analysis (using a commercial package: Digimat-FE) and Orientation Averaging [2]. This study was then extended in another project [3] to non-linear path dependent elasto-plastic behavior of SFRCs. To create the required data for training an ANN model, mean-field simulations were conducted using a commercial software (Digimat-MF). As opposed to the first project, where a Feed forward ANN was sufficient to develop the model, in this project we needed to use a Recurrent Neural Network (RNN) due to the time-series nature of the data for the model.

In addition to predicting the mechanical performance of materials, designing new materials is also of great importance. Thanks to advanced simulation tools and powerful computers, it is nowadays possible to avoid time-consuming and expensive experiments to achieve that goal. In this proposed project, instead of solely focusing on predicting the mechanical performance, we intend to use FEA and ANN to develop a methodology for *designing* SFRCS with *desired macro-mechanical performance*.

Student background

This project is suitable for one or two master students who are interested in numerical simulations and artificial neural networks. Programming skills are highly valued, and previous experiences with solid mechanics and material modelling is a plus.

References:

[1] Mentges et al. (2021). Composites Part B, (accepted for publications).
[2] Mirkhalaf et al. (2020). Composites Part B, Volume 202, 108388.
[3] Friemann (2021). Master thesis, Chalmers University of Technology.

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