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Innovative Predictive Modeling and Characterization of Composite Material Properties Using Machine Learning and Genetic Algorithms

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Abstract : This study aims to construct a predictive model proficient in foreseeing the linear elastic and thermal characteristics of composite materials, drawing on a multitude of influencing parameters. These parameters encompass the shape of inclusions (circular, elliptical, square, triangle), their spatial coordinates within the matrix, orientation, volume fraction (ranging from 0.05 to 0.4), and variations in contrast (spanning from 10 to 200). A variety of machine learning techniques are deployed, including decision trees, random forests, support vector machines, k-nearest neighbors, and an artificial neural network (ANN), to facilitate this predictive model. Moreover, this research goes beyond the predictive aspect by delving into an inverse analysis using genetic algorithms. The intent is to unveil the intrinsic characteristics of composite materials by evaluating their thermomechanical responses. The foundation of this research lies in the establishment of a comprehensive database that accounts for the array of input parameters mentioned earlier. This database, enriched with this diversity of input variables, serves as a bedrock for the creation of machine learning and genetic algorithm-based models. These models are meticulously trained to not only predict but also elucidate the mechanical and thermal conduct of composite materials. Remarkably, the coupling of machine learning and genetic algorithms has proven highly effective, yielding predictions with remarkable accuracy, boasting scores ranging between 0.97 and 0.99. This achievement marks a significant breakthrough, demonstrating the potential of this innovative approach in the field of materials engineering.

Keywords : machine learning, composite materials, genetic algorithms, mechanical and thermal proprieties
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