# Prediction of mechanical properties of metals using machine learning based on distribution of nanoindentation test results

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**Abstract**

The microscopic and macroscopic mechanical properties of metallic materials are closely related. Understanding the relationship between them can lead to better structural material design. There have been many attempts to predict macroscopic stress-strain relationships based on the results of microscopic mechanical property tests such as indentation tests. However, depending on the material's texture, such as crystal orientation, dislocation structure, or multi-phases of materials, the load-displacement curves resulting from microscopic indentation tests may not be the same at all points in the material. No matter how accurately load-displacement curves correlate with stress-strain curves, it is impossible to predict the stress-strain curve as the behavior of the entire material from a single test result for materials with a distribution of local mechanical properties. This study proposes a method to predict macroscopic stress-strain relationships based on the distribution of local mechanical properties. Nanoindentation and tensile tests are performed on several materials to create a database in which multiple load-displacement curves with distributions correspond to a single stress-strain curve. With the database, a neural network-based machine learning system is developed to predict unknown stress-strain curves from the load-displacement curves. The prediction accuracy of stress-strain curves is improved by extracting load-displacement curves that have a strong influence on the stress-strain relationship from the database and by effectively selecting factors of the load-displacement curves as input parameters of the neural network. The stress-strain curves predicted by this system are compared with experimental results, and the validity and range of application of this method are discussed.

**Keywords:** Local fractionation of mechanical properties, Nanoindentation test, Machine learning, Stress, strain curve, Neural network

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