Data-Driven Models for Fast Prediction of Steel Property Distributions

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Stochastic models developed for the cooling process after hot deformation in the rolling process have enabled accurate and reliable prediction of the final properties of steel [1][2]. However, their use in industrial settings is difficult due to the computational complexity of the models and the techniques used, such as the Monte Carlo method. The stochastic models used take into account the uncertainties of process parameters, heterogeneities, and the probabilistic nature of the process, which further increases the complexity.

Data-driven models come to the rescue here, using high-performance computing to provide sufficient training data. Proper development of these models translates into a significant reduction in the time required to predict property distributions at the end of the hot rolling and cooling processes. Initially, stochastic models are identified for a specific selected steel (S355J2) using inverse analysis techniques, which allows for the determination of model coefficients. Next, a methodology utilizing the MLP architecture was proposed to create models that can quickly predict final property distributions for experimental roll configurations. These ML models use input parameters such as strain, strain rate on subsequent rolls, as well as heating temperature, heating time, and cooling rate. The output of these models allows for the preservation of the distributions of microstructural parameters such as phase fractions and material properties. The obtained results (see Fig. 1) demonstrate that the approach provides accurate predictions at significantly reduced computational cost compared to traditional approaches, providing a starting point for real-time process optimization.

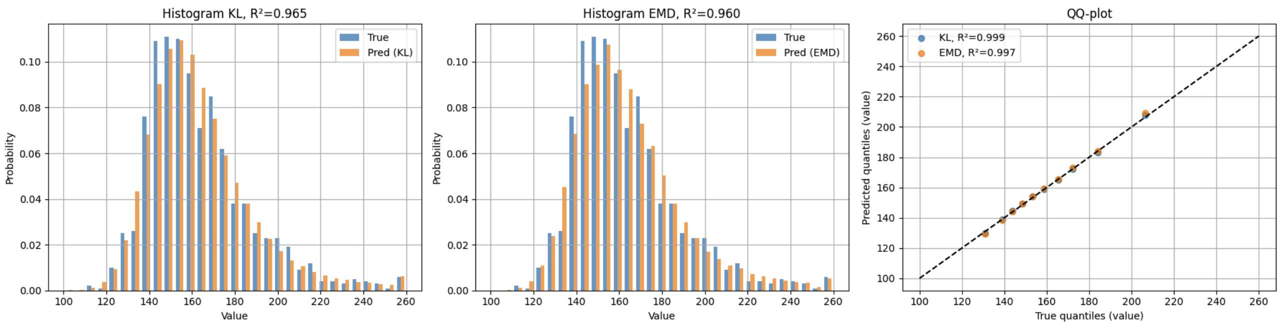

Figure 1. Comparison of impact toughness energy (E_{imp}) distributions from the ML model and the stochastic model for two different loss functions: Kullback–Leibler Divergence and Earth Mover's Distance.

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