Development of an AI-Based Fabric Property Prediction Platform

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Abstract

The development of new fabric designs in the textile industry traditionally relies on trial-and-error approaches, personal experience, and repeated sampling, resulting in high prototyping costs and long product development cycles. This study aims to develop and validate an AI-based platform that predicts the physical and mechanical properties of fabrics using production parameters.

In this work, more than 25,000 data entries collected over three years were obtained from the Enterprise Resource Planning (MRP) system of a textile company. The dataset includes key parameters such as reed width, reed density, number of dents, pattern family, yarn properties in warp and weft directions, and their respective densities. In addition, textile-specific feature engineering techniques were applied to preprocess the data. Model performance was evaluated using repeated (n = 20) group-aware random splits, with an 80/20 train–test ratio, ensuring that fabric designs were not shared between training and test sets. Machine learning algorithms, including Random Forest and XGBoost, were used to predict eight fabric properties, including fabric width, weight, finished warp and weft densities, shrinkage after washing, and tensile strength. To enhance model transparency and support internal adoption, Explainable AI (XAI) methods, such as SHAP summary and waterfall plots, were used in collaboration with R&D teams.

The models achieved strong predictive performance on the test data, with R^2 values ranging from 0.67 to 0.98. Pilot results demonstrated that the platform can accurately predict fabric properties such as finished warp and weft densities (MAPE 0.96), fabric weight (MAPE $<$ 4 %, $R^2 >$ 0.92) and fabric width (MAPE $<$ 2 %, $R^2 >$ 0.75) in a short time. In general, performance variability across splits was low, indicating stable model behavior. Finally, a user-friendly cloud-based platform was developed and is being integrated into the company's workflow. By enabling digital pre-screening of new fabric designs, the platform supports right-first-time production. This approach reduces material waste, improves operational efficiency, enables significant time and cost savings, and contributes to the digital transformation of the textile industry.

Keywords: Digitalization, Decision Support Systems, Fabric property prediction, AI in textile

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