Title:

Intelligent Real Time Fabric Weave Identification and Characterization using Visual Sensor Network for Textile Applications

By

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ABSTRACT:

The increasing demand for high-quality textile products requires efficient and intelligent fabric inspection systems. Traditional manual inspection methods are not only time-consuming but also susceptible to to human error. This research proposes a Federated Learning-based intelligent visual inspection system for real-time fabric classification. The proposed model comprised of two visual sensor network nodes equipped with digital microscopes. Each node runs a RESNET50 deep learning model optimized with Particle Swarm Optimization. The system enables combined model training using Federated Learning (FL) with a central server, ensuring privacy-preserving model updates without sharing raw data.

The first contribution is the development of a custom fabric datasets for the weave patterns and fabric defects by considering the three types of fabric samples, plain, satin, and twill. This dataset is a benchmark dataset to be used in the classification of the weaves and defects and filling the existing gap of available publicly accessible fabric datasets in textile classification.

The second contribution is the integration of Particle Swarm Optimization (PSO) in the hyperparameter optimization process, i.e. the optimization of the learning rate and the momentum of the RESNET50 model. The optimization increased the classification performance greatly, and the PSO-optimized RESNET50 model obtained the accuracy of weave classification as 98.32% and 98.67% for defect detection; the highly efficient deep learning model appropriate for the textile applications.

The third contribution is the implementation of a Federated Learning (FL) based model using distributed nodes of a visual sensor network. By averaging the model weights trained by multiple local models, the system not only improves the generalization capability, but also maintains data privacy. There was also an improvement in classification accuracy of the suggested FL-PSRT50 VSN MODEL by 98.99% and 99% for weave classification (Fabric Characterization Node (FCN)) and defect identification (Defect Detection Node (DDN)) in real time.

This novel framework aligns with Industry 5.0 principles and contributes to the Sustainable Development Goals (SDGs) by offering a scalable, privacy-preserving, and intelligent textile quality control solution suitable for deployment in smart manufacturing environments.