

A Generalizable Framework for Print Defect Detection using Frequency Filtering and Data-Driven Feature Selection

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Abstract

This study introduces an advanced machine learning framework designed to identify micro-scale defects in high-resolution print manufacturing. A primary challenge in automated optical inspection is the inherent variation between the master digital truth (DT) and the captured vision truth (VT) images. To ensure robustness against these variations, our method first employs a frequency-domain correction. This preprocessing step effectively minimizes low-frequency noise (e.g., illumination shifts) while simultaneously amplifying high-frequency signals corresponding to true defects. Following correction, a comprehensive 42-dimensional hybrid feature vector is extracted from each image patch, combining statistical metrics, LBP-based textural descriptors, and SIFT-based structural information. To optimize for both efficiency and performance, a data-driven feature importance analysis is conducted to select a compact, 10-feature subset. This reduced feature set is then used to train a Light GBM classification model. The resulting system demonstrates high accuracy in distinguishing subtle, true defects from natural print texture variations. This pattern-centric approach is shown to be superior to conventional image subtraction methods, offering a significant reduction in false positives on complex backgrounds.

Keywords

Defect Detection, Machine Learning, Pattern Recognition, Quality Control, Light GBM.