**Introduction**

In the demanding environment of modern manufacturing, product inspection is a critical process for guaranteeing final quality, maintaining brand reputation, and ensuring consumer safety. For a long time, enterprises have primarily relied on manual visual inspection to identify and reject defective components. However, this traditional method has inherent limitations; it is not only inefficient and costly but also prone to inconsistencies. The accuracy of manual inspection can be easily compromised by operator fatigue, subjective judgment, and working conditions, making it insufficient to meet the growing demands of industrial automation. In stark contrast, machine vision technology offers a revolutionary solution, providing an objective, efficient, and stable method for automated surface defect detection, and its application in manufacturing is rapidly expanding.A critical component of a machine vision system is the image preprocessing phase, which aims to improve image quality to meet the demands of a specific application. Common preprocessing methods include Gaussian filtering, which is effective at suppressing high-frequency noise, and Median filtering, a nonlinear technique adept at removing noise while preserving edge information.Other advanced methods include Contrast-Limited Adaptive Histogram Equalization (CLAHE), which enhances image contrast by transforming the image's histogram distribution while limiting noise amplification, and Non-Local Means (NLM) denoising, which leverages the self-similarity within images to suppress noise while preserving fine details. Denoising with Weighted Averaging.Existing research recognizes the individual utility of these techniques in various applications.While many image preprocessing techniques exist, their effectiveness varies significantly across different industrial scenarios, and improper application can compromise image quality and reduce recognition accuracy. Current research, however, primarily concentrates on the analysis of individual preprocessing methods. This has resulted in a lack of comprehensive comparisons and analyses of how different preprocessing algorithms perform against one another in the specific context of industrial surface defect detection.

The purpose of this paper is to fill this research gap by conducting a systematic comparison of four common preprocessing methods to improve the accuracy of surface defect detection for industrial components. This study utilizes the NEU Surface Defect Database to evaluate each algorithm. The performance of these methods is evaluated not only on overall and class-specific accuracy but also through a Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) analysis and an examination of their training convergence dynamics. This study's core contribution is its systematic comparative analysis of four common preprocessing techniques for industrial defect detection, directly addressing a critical gap in the literature that has largely overlooked such comprehensive comparisons. The research employs a multi-dimensional evaluation framework that goes beyond simple accuracy to include TOPSIS analysis and an examination of training convergence, offering a more holistic measure of each algorithm's performance. Furthermore, the findings provide valuable, evidence-based guidance for practitioners on selecting between local and global image enhancement techniques in real-world applications. By conducting this evaluation on the public NEU dataset, the work establishes a reliable and reproducible benchmark for future research in the field.

This paper is divided into the following sections: the Methodology section outlines the dataset and analytical approach, the Results section presents the comparative performance data, and the Discussion section analyzes the findings and their implications for industrial applications.