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Teknologi Deteksi Cacat pada Hasil Klowong CNC Batik Menggunakan YOLO26
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INTISARI

Inspeksi kualitas kain batik klowong hasil proses mesin *Computer Numerical Control* (CNC) masih dilakukan secara manual sehingga rentan terhadap subjektivitas dan inkonsistensi dalam identifikasi cacat. Perkembangan teknologi *computer vision* dan *object detection* berbasis *You Only Look Once* (YOLO) memberikan peluang untuk mengotomatisasi proses inspeksi kualitas. Meskipun demikian, beberapa jenis cacat masih menjadi tantangan dalam proses deteksi. Penelitian ini bertujuan untuk mengevaluasi performa arsitektur YOLO26 dalam mendeteksi cacat pada kain klowong hasil proses mesin CNC, membandingkan kinerja varian YOLO26n dan YOLO26s, serta menganalisis kemampuan model dalam mendeteksi cacat dengan tingkat kesulitan tinggi.

Penelitian menggunakan dataset sebanyak 5.000 citra kain klowong yang merepresentasikan 45 motif batik dan mencakup sembilan kategori cacat, yaitu *mbleber*, lubang, benang putus, ketembusan, kontinuitas garis, kualitas sudut pola, kontinuitas lebar garis, penyimpangan garis, dan *netes*. Dataset dibagi menjadi data pelatihan, validasi, dan pengujian dengan rasio 70:10:20. Model YOLO26n dan YOLO26s dilatih dan dievaluasi menggunakan metrik *precision*, *recall*, mAP50, dan mAP50-95. Selanjutnya, dilakukan optimasi *hyperparameter* menggunakan *Bayesian Optimization* pada model dengan performa terbaik.

Hasil penelitian menunjukkan bahwa YOLO26s memiliki performa yang lebih baik dibandingkan YOLO26n pada seluruh metrik evaluasi. Setelah dilakukan optimasi *hyperparameter*, YOLO26s memperoleh nilai *precision* sebesar 92,8%, *recall* sebesar 92,9%, mAP50 sebesar 95,4%, dan mAP50-95 sebesar 58,6%. Model juga menunjukkan peningkatan kemampuan dalam mendeteksi beberapa kategori cacat yang sebelumnya memiliki tingkat kesulitan deteksi tinggi serta mampu diimplementasikan pada sistem deteksi *real-time* dengan rata-rata waktu inferensi sebesar 32,29 ms. Secara keseluruhan, hasil penelitian menunjukkan bahwa YOLO26, khususnya YOLO26s yang dioptimasi menggunakan *Bayesian Optimization*, memiliki potensi yang baik untuk diterapkan pada sistem inspeksi kualitas otomatis kain batik klowong berbasis *computer vision*.

Kata kunci: YOLO26, deteksi cacat, kain batik klowong, *computer vision*, *Bayesian Optimization*.

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ABSTRACT

Quality inspection of batik klowong fabric produced through the Computer Numerical Control (CNC) process is still performed manually, making it susceptible to subjectivity and inconsistency in defect identification. Advances in computer vision and object detection technologies based on You Only Look Once (YOLO) provide opportunities to automate the quality inspection process. However, several defect categories remain challenging to detect accurately. This study aims to evaluate the performance of the YOLO26 architecture for detecting defects in CNC-produced batik klowong fabric, compare the performance of YOLO26n and YOLO26s variants, and analyze the model's capability in detecting defects with a high level of detection difficulty.

The study utilized a dataset consisting of 5,000 klowong fabric images representing 45 batik motifs and covering nine defect categories, namely *mbleber*, hole, broke yarn, wax penetration defect, line continuity defect, pattern corner quality defect, line width continuity defect, line deviation defect, and *netes*. The dataset was divided into training, validation, and testing sets with a ratio of 70:10:20. YOLO26n and YOLO26s models were trained and evaluated using precision, recall, mAP50, and mAP50-95 metrics. Furthermore, Bayesian Optimization was applied to optimize the hyperparameters of the best-performing model.

The results indicate that YOLO26s outperformed YOLO26n across all evaluation metrics. After hyperparameter optimization, YOLO26s achieved a precision of 92.8%, recall of 92.9%, mAP50 of 95.4%, and mAP50-95 of 58.6%. The model also demonstrated improved capability in detecting several defect categories that had previously been considered difficult to detect and was successfully implemented in a real-time detection system with an average inference time of 32.29 ms. Overall, the findings show that YOLO26, particularly the YOLO26s variant optimized using Bayesian Optimization, has strong potential for implementation in automated quality inspection systems for batik klowong fabric based on computer vision.

Keywords: YOLO26, defect detection, batik klowong fabric, computer vision, Bayesian Optimization.