# DETEKSI ANOMALI PROOF OF DELIVERY BERBASIS MULTI-MODAL MENGGUNAKAN ANALISIS KUALITAS VISUAL DAN ANOMALI LOKASI

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## ABSTRAK

Proof of Delivery (POD) adalah dokumen bukti fisik atau digital yang sah, yang mengonfirmasikan bahwa barang telah berhasil dikirim dan diterima. Namun, dalam praktik operasional, kualitas foto POD sering kali bermasalah, seperti foto yang buram, paket tidak terlihat pada foto, atau lokasi pengambilan foto yang tidak jelas. Oleh karena itu, diperlukan pendekatan otomatis yang mampu membantu proses verifikasi POD secara konsisten dan relevan terhadap kondisi operasional nyata.

Penelitian ini mengusulkan sistem deteksi anomali Proof of Delivery berbasis pendekatan multi-modal yang mengintegrasikan informasi visual dan spasial. Informasi visual dianalisis melalui penilaian kualitas citra untuk mendeteksi foto buram serta deteksi keberadaan paket menggunakan metode object detection YOLO. dianalisis dengan menghitung jarak antara lokasi pengambilan foto dan lokasi tujuan, yang selanjutnya dievaluasi menggunakan metode unsupervised anomaly detection Isolation Forest. Skor anomali dari masing-masing modul kemudian digabungkan menggunakan pendekatan decision-level multi-modal fusion untuk menghasilkan skor anomali akhir. Hasil ablation study menunjukkan bahwa pendekatan multi-modal memberikan performa yang lebih stabil dibandingkan pendekatan single-modal, yang ditunjukkan oleh F1-score 0,696, AUC 0,786, serta recall 0,983.

Temuan ini menunjukkan bahwa integrasi citra dan lokasi mampu mengurangi keterbatasan masing-masing modalitas ketika digunakan secara terpisah. Sistem yang diusulkan berpotensi digunakan sebagai alat bantu verifikasi Proof of Delivery secara lebih efisien dan konsisten.

**Kata Kunci:** Proof of Delivery, Deteksi Anomali, Multi-Modal, Object Detection, Isolation Forest.

# A MULTI-MODAL APPROACH FOR PROOF OF DELIVERY ANOMALY DETECTION BASED ON VISUAL QUALITY AND SPATIAL ANOMALY ANALYSIS

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## ABSTRACT

Proof of Delivery (POD) is a legally recognized physical or digital document that confirms goods have been successfully delivered and received. However, in operational practice, POD photo quality frequently presents issues, such as blurred images, packages not visible in the photo, or unclear photo capture locations. These limitations create challenges for consistent and reliable verification. Therefore, an automated approach is required to support POD verification in a manner that aligns with real-world operational conditions.

This study proposes a multi-modal anomaly detection system for Proof of Delivery that integrates visual and spatial information. Visual information is analyzed through image quality assessment to detect blurred images and through object detection using the YOLO method to verify package presence. Spatial information is analyzed by calculating the distance between the photo capture location and the intended delivery destination, which is subsequently evaluated using the unsupervised anomaly detection method Isolation Forest. The anomaly scores generated by each module are combined using a decision-level multi-modal fusion approach to produce a final anomaly score.

The ablation study results demonstrate that the proposed multi-modal approach provides more stable performance compared to single-modal approaches, achieving an F1-score of 0.696, an AUC of 0.786, and a recall of 0.983. These findings indicate that integrating image and location data mitigates the limitations of each modality when used independently. The proposed system has the potential to serve as a more efficient and consistent support tool for Proof of Delivery verification.

**Keywords:** Proof of Delivery, Anomaly Detection, Multi-Modal, Object Detection, Isolation Forest.