SISTEM VERIFIKASI GANDA AKSES PARKIR BERBASIS DETEKSI PLAT NOMOR DAN PENGENALAN PENGEMUDI MENGGUNAKAN YOLO DAN OCR PADA RASPBERRY PI 4

Amilzan Fadlan Radiansyah

ABSTRAK

Penelitian ini merancang dan mengimplementasikan sistem verifikasi ganda akses parkir berbasis teknologi computer vision untuk mengatasi celah keamanan tiket fisik konvensional. Sistem yang diusulkan mengintegrasikan pendeteksian plat nomor kendaraan dan pengenalan wajah pengemudi secara real-time dengan mengadopsi arsitektur terdistribusi Edge-to-Server. Raspberry Pi 4 Model B dikonfigurasi sebagai terminal edge lapangan untuk akuisisi citra digital dan pengendalian mekanis, sedangkan laptop berperan sebagai server pusat untuk memproses komputasi berat model deep learning. Pelokalan plat nomor kendaraan memanfaatkan model YOLOv8s yang dilatih dengan 1143 citra, menghasilkan nilai Precision 98,80%, Recall 95,38%, dan mean Average Precision ($mAP@0.5$) 97,20%. Karakter alfanumerik diekstraksi menggunakan Optical Character Recognition (OCR), sedangkan verifikasi wajah pengemudi dilakukan dengan arsitektur FaceNet CNN melalui perhitungan jarak Euclidean ($d \leq 1{,}0$) terhadap database terserialisasi (.pkl). Hasil pengujian integrasi penuh dengan 80 sampel transaksi menghasilkan Accuracy sebesar 91,25%, Recall 91,25%, F1-Score 95,42% . dan tingkat keamanan mutlak dengan Precision 100,00% (False Acceptance Rate $= 0\%$). Sistem mencatat latensi akhir-ke-akhir (end-to-end latency) rata-rata di bawah 2,35 detik dengan kestabilan suhu CPU Raspberry Pi 4 terjaga pada rentang $47{,}35^{\circ}C$ hingga $53{,}79^{\circ}C$. Implementasi profil akselerasi trapezoidal pada firmware Arduino Nano sukses mengendalikan motor stepper NEMA 17 untuk memutar palang parkir 90° secara halus dalam waktu 1,152 detik tanpa kehilangan langkah mekanis (skip-step). Sistem terdistribusi ini terbukti aman, responsif, dan layak diimplementasikan pada infrastruktur parkir pintar komersial.

Kata Kunci : Raspberry Pi 4, YOLOv8s, OCR, FaceNet, Edge-to-Server, Verifikasi Ganda.

DUAL VERIFICATION PARKING ACCESS SYSTEM BASED ON LICENSE PLATE DETECTION AND DRIVER RECOGNITION USING YOLO AND OCR ON RASPBERRY PI 4

Amilzan Fadlan Radiansyah

ABSTRACT

This study designs and implements a dual-verification parking access system based on computer vision technology to address the security vulnerabilities of conventional physical tickets. The proposed system integrates real-time license plate detection and driver face recognition by adopting a distributed Edge-to-Server architecture. A Raspberry Pi 4 Model B is configured as an on-site edge terminal for digital image acquisition and physical actuator control, while a laptop serves as the central server to handle the heavy computational load of deep learning models. License plate localization utilizes the YOLOv8s model trained on 1143 *images, achieving a Precision of* 98.80%*, Recall of* 95.38%*, and mean Average Precision* ($mAP@0.5$) *of* 97.20%*. Alphanumeric characters are extracted using Optical Character Recognition (OCR), while driver face verification is performed via the FaceNet CNN architecture by calculating Euclidean distance* ($d \leq 1.0$) *against a serialized database (.pkl). Full integration testing with 80 transaction samples demonstrates an Accuracy of* 91.25%*, Recall of* 91.25%*, F1-Score of* 95.42%*, and absolute security with a Precision of* 100.00% *(False Acceptance Rate* $= 0\%$*). The system records an average end-to-end latency of under* 2.35 *seconds while maintaining the Raspberry Pi 4 CPU temperature within a stable range of* $47.35^{\circ}C$ *to* $53.79^{\circ}C$*. The implementation of a trapezoidal acceleration profile on the Arduino Nano firmware successfully controls the NEMA 17 stepper motor to rotate the parking gate by* 90° *smoothly in* 1.152 *seconds without mechanical skip-steps. This distributed system is proven to be secure, responsive, and feasible for deployment in commercial smart parking infrastructures.*

***Keywords*:** Raspberry Pi 4, YOLOv8s, OCR, FaceNet, Edge-to-Server, Dual Verification.