ABSTRAK

Kecelakaan lalu lintas akibat kelelahan dan fenomena *microsleep* pengemudi masih menjadi masalah keselamatan yang kritis. Berbagai sistem pendeteksi kantuk telah dikembangkan, namun kerap menghadapi dilema antara akurasi tinggi yang membebani komputasi atau komputasi ringan namun rentan terhadap kondisi pencahayaan minim. Penelitian ini mengusulkan pengembangan sistem deteksi kantuk pengemudi secara *real-time* dengan mengintegrasikan pemrosesan dua tahap (*two-stage pipeline*). MediaPipe Face Mesh digunakan untuk melokalisasi dan mengekstraksi area mata secara cepat (<5 ms), dilanjutkan dengan klasifikasi biner status mata menggunakan arsitektur *lightweight Convolutional Neural Network* (CNN) MobileNetV3-Small. Model dilatih menggunakan 84.898 citra dari MRL Eye Dataset melalui pendekatan *transfer learning* dan *on-the-fly data augmentation*. Evaluasi menggunakan kerangka *Design Science Research Methodology* (DSRM) menunjukkan hasil yang optimal. Model klasifikasi mencapai Akurasi sebesar 96,87%, Presisi 97,65%, *Recall* 96,12%, F1-*Score* 96,88%, dan nilai AUC-ROC 0,9959. Melalui optimasi TensorFlow Lite, ukuran model berhasil dipangkas menjadi 1,96 MB dengan waktu inferensi hanya 0,71 milidetik per bingkai. Sistem diatur untuk memicu alarm peringatan kritis apabila mata terdeteksi tertutup selama 10 bingkai pemrosesan berturut-turut (ekuivalen dengan 1000 milidetik). Pengujian membuktikan sistem mampu berjalan stabil di atas 50 FPS pada spesifikasi komputasi standar dengan menerapkan *frame skipping* dan *multithreading*. Sistem ini terbukti efektif, akurat, dan efisien secara komputasi, menjadikannya sangat potensial untuk diimplementasikan sebagai fitur *Advanced Driver Assistance Systems* (ADAS).

Kata Kunci: *Computer Vision*, Deteksi Kantuk, MediaPipe, *Microsleep*, MobileNetV3, *Real-Time*.

ABSTRACT

Traffic accidents caused by driver fatigue and microsleep phenomena remain a critical safety issue. Various drowsiness detection systems have been developed, yet they frequently face a dilemma between high accuracy that burdens computation or lightweight computation that is vulnerable to low-light conditions. This study proposes the development of a real-time driver drowsiness detection system by integrating a two-stage pipeline processing. MediaPipe Face Mesh is utilized to rapidly localize and extract the eye region (<5 ms), followed by binary classification of eye status using the lightweight Convolutional Neural Network (CNN) architecture, MobileNetV3-Small. The model was trained using 84,898 images from the MRL Eye Dataset through a transfer learning approach and on-the-fly data augmentation. Evaluation using the Design Science Research Methodology (DSRM) framework showed optimal results. The classification model achieved an Accuracy of 96.87%, Precision of 97.65%, Recall of 96.12%, F1-Score of 96.88%, and an AUC-ROC value of 0.9959. Through TensorFlow Lite optimization, the model size was successfully reduced to 1.96 MB with an inference time of only 0.71 milliseconds per frame. The system is configured to trigger a critical warning alarm if the eyes are detected closed for 10 consecutive processing frames (equivalent to 1000 milliseconds). Testing proved the system capable of running stably above 50 FPS on standard computing specifications by implementing frame skipping and multithreading. This system proved to be effective, accurate, and computationally efficient, making it highly potential to be implemented as an Advanced Driver Assistance Systems (ADAS) feature.

Keywords: *Computer Vision, Drowsiness Detection, MediaPipe, Microsleep, MobileNetV3, Real-Time.*