ABSTRAK

Klasifikasi kelompok usia berdasarkan citra wajah merupakan tantangan dalam visi komputer akibat kemiripan karakteristik visual antar kelompok usia, terutama pada fase transisi. Pendekatan Convolutional Neural Network (CNN) terbukti efektif mengekstraksi fitur spasial wajah, namun performa model ini sangat bergantung pada pemilihan hyperparameter yang sering kali tidak optimal jika disetel secara manual. Penelitian ini menerapkan algoritma Particle Swarm Optimization (PSO) untuk mengoptimasi hyperparameter CNN guna meningkatkan performa klasifikasi usia serta mengimplementasikan model ke dalam aplikasi deteksi usia berbasis realtime.

Metode penelitian menggunakan UTKFace Cropped Dataset yang berisi 23.708 citra wajah. Evaluasi kinerja model dilakukan melalui dua skenario pengujian. Skenario pertama mengklasifikasikan data ke dalam empat kelas usia, yaitu Child (0–12 tahun), Teenager (13–18 tahun), Adult (19–40 tahun), dan Old (di atas 40 tahun). Skenario kedua mengklasifikasikan data ke dalam lima kelas usia, yaitu Child, Teenager, Adult, Middle Age, dan Old. Tahapan pra-pemrosesan meliputi pengubahan ukuran citra menjadi 150×150 piksel, normalisasi nilai piksel, serta augmentasi data secara online untuk mencegah overfitting. Algoritma PSO ditugaskan mencari kombinasi optimal pada empat parameter utama, yaitu learning rate, dropout CNN, dropout dense, dan jumlah dense unit. Model hasil pelatihan kemudian diimplementasikan ke dalam aplikasi berbasis Streamlit untuk melakukan pengujian citra statis dan deteksi usia realtime menggunakan webcam.

Hasil penelitian membuktikan bahwa PSO berhasil meningkatkan performa klasifikasi dibandingkan model CNN baseline pada kedua skenario. Pada skenario pertama (empat kelas), tingkat akurasi meningkat dari 83,87% pada model baseline menjadi 83,99% setelah dioptimasi dengan PSO, dengan F1-Score mencapai 74,88%. Pada skenario kedua (lima kelas), tingkat akurasi model meningkat dari 79,20% menjadi 80,34%, dengan metrik precision mencapai 73,42%, recall sebesar 67,88%, dan F1-Score sebesar 69,51%. Meskipun peningkatan akurasi yang diperoleh relatif kecil, model hasil optimasi menunjukkan performa evaluasi yang lebih baik dibandingkan model baseline dan berhasil diimplementasikan secara fungsional ke dalam aplikasi deteksi usia realtime. Secara keseluruhan, integrasi PSO mampu memberikan fine-tuning terhadap hyperparameter CNN sehingga menghasilkan model yang lebih optimal, meskipun penanganan terhadap ketidakseimbangan data pada kelas minoritas, khususnya kelas teenager, masih menjadi aspek penting untuk pengembangan penelitian mendatang.

Kata Kunci: Klasifikasi Kelompok Usia, Convolutional Neural Network, Particle Swarm Optimization, Computer Vision, Citra Wajah, Hyperparameter Optimization, Realtime Detection

ABSTRACT

Age group classification based on facial images is a challenge in computer vision due to the similarity of visual characteristics between age groups, particularly during transitional phases. The Convolutional Neural Network (CNN) approach has been proven effective in extracting spatial features from facial images. However, the performance of this model highly depends on the selection of hyperparameters, which are often not optimal when tuned manually. This study applies the Particle Swarm Optimization (PSO) algorithm to optimize CNN hyperparameters in order to improve age classification performance and implement the model into a real-time age detection application.

This study used the UTKFace Cropped Dataset, which consists of 23,708 facial images. Model performance evaluation was conducted through two testing scenarios. The first scenario classified the data into four age classes: Child (0–12 years), Teenager (13–18 years), Adult (19–40 years), and Old (above 40 years). The second scenario classified the data into five age classes: Child, Teenager, Adult, Middle Age, and Old. The preprocessing stages included resizing images to 150 × 150 pixels, normalizing pixel values, and applying online data augmentation to prevent overfitting. The PSO algorithm was assigned to search for the optimal combination of four main parameters, namely learning rate, CNN dropout, dense dropout, and the number of dense units. The trained model was then implemented into a Streamlit-based application to test static images and perform real-time age detection using a webcam.

The results show that PSO successfully improved classification performance compared to the baseline CNN model in both scenarios. In the first scenario with four classes, the accuracy increased from 83.87% in the baseline model to 83.99% after optimization using PSO, with an F1-score of 74.88%. In the second scenario with five classes, the model accuracy increased from 79.20% to 80.34%, with precision reaching 73.42%, recall reaching 67.88%, and an F1-score of 69.51%. Although the improvement in accuracy was relatively small, the optimized model demonstrated better evaluation performance than the baseline model and was successfully implemented functionally into a real-time age detection application. Overall, the integration of PSO was able to fine-tune CNN hyperparameters, resulting in a more optimal model. However, handling data imbalance in minority classes, particularly the teenager class, remains an important aspect for future research development.

Keywords: Age Group Classification, Convolutional Neural Network, Particle Swarm Optimization, Computer Vision, Facial Image, Hyperparameter Optimization, Real-Time Detection