ABSTRAK

Penelitian ini mengembangkan sistem deteksi multi-objek berbasis *deep learning* untuk mengenali dan mentransliterasi aksara Batak pada pustaha laklak, naskah kuno budaya Batak Toba, yang dioptimalkan untuk perangkat Android. Dengan memanfaatkan arsitektur YOLOv8n (*nano*) yang ringan, dibangun pipeline yang mencakup proses anotasi, augmentasi, dan pelatihan model pada resolusi 480 × 480 piksel selama 70 epoch, menggunakan dataset yang terdiri dari 116 kelas aksara Batak yang diperoleh dari citra latar putih serta foto asli naskah di museum dan koleksi pribadi.

Pada data uji, model berhasil meraih *mean average precision* pada IoU 0,5 (mAP@0,5) sebesar 40,6 %, dengan performa tertinggi pada huruf “I” (94,9 %) dan performa terendah pada kelas “YO” (0 %) akibat representasi data yang terbatas. Untuk implementasi seluler, bobot model dikonversi ke format NCNN dan dioptimalkan melalui *quantization* FP16, sehingga mampu beroperasi secara *real-time* dengan infrastruktur minimal.

Pengujian pada tiga smartphone Android—Samsung Galaxy M30s, A32, dan A54—menunjukkan kecepatan inferensi rata-rata antara 18,5–20 ms per frame (27–60 FPS) serta penggunaan memori puncak antara 62–117 MB tanpa indikasi kebocoran memori, menjamin proses yang stabil dan responsif. Melalui antarmuka aplikasi yang menampilkan pratinjau kamera langsung dengan kotak pembatas dan label kelas aksara Batak tepat pada posisi objek, sistem ini menawarkan solusi interaktif dan portabel untuk pelestarian digital aksara Batak.

Kata Kunci: YOLOv8, aksara Batak, pustaha laklak, deteksi objek, aplikasi Android, pelestarian budaya

ABSTRACT

This study presents a deep learning–based multi-object detection system for recognizing and transliterating Batak script from pustaha laklak, an ancient manuscript of the Batak Toba culture, optimized for real-time operation on Android devices. Leveraging the lightweight YOLOv8n (nano) architecture, we constructed a processing pipeline that includes image annotation, data augmentation, and model training at a resolution of 480 × 480 pixels over 70 epochs. Our dataset comprises 116 distinct Batak character classes drawn from both white-background scans and original manuscript photographs sourced from museums and private collections.

On the held-out test set, the model achieved a mean average precision at IoU 0.5 (mAP@0.5) of 40.6%, demonstrating particularly strong recognition of the character "I" (94.9%) while under-represented classes such as "YO" yielded 0% due to limited samples. For mobile deployment, the trained weights were converted to the NCNN inference framework and quantized to FP16, enabling efficient execution with minimal hardware requirements.

Benchmarking across three Android smartphones—Samsung Galaxy M30s, A32, and A54—revealed average inference times of 20 ms (range 12–28 ms), 19 ms (11–27 ms), and 18.5 ms (10–27 ms) per frame, respectively, corresponding to 30–45, 30–48, and 35–60 FPS. Peak native-heap memory usage remained below 200 MB on all devices (117 MB, 70 MB, and 62 MB, respectively), with no memory leaks detected. In a user-friendly Android interface, live camera preview frames are overlaid with bounding boxes and class labels for each detected character, delivering a stable, responsive, and portable solution for the digital preservation and interactive study of Batak script.

Keyword: *YOLOv8,* Batak *script,* pustaha laklak*, object detection, Android application, cultural preservation.*