



## ABSTRAK

### **Klasifikasi Tulisan Tangan Aksara Sunda Menggunakan *Capsule Network* (CapsNet)**

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Penelitian ini dilatarbelakangi oleh keterbatasan arsitektur *Convolutional Neural Network* (CNN) dalam mempertahankan informasi spasial pada klasifikasi aksara Sunda, khususnya elemen kecil seperti *rarangkén*, serta sensitivitas tinggi terhadap *affine transformation* seperti rotasi, translasi, dan skala. Kelemahan ini dapat menyebabkan misklasifikasi pada aksara serupa sehingga menurunkan akurasi sistem pengenalan, yang pada akhirnya menghambat upaya pelestarian aksara tradisional melalui digitalisasi. Oleh karena itu, diperlukan pendekatan alternatif yang lebih presisi dalam menangkap relasi spasial antar elemen.

Sebagai solusi, penelitian ini mengembangkan sistem klasifikasi tulisan tangan aksara Sunda menggunakan *Capsule Network* (CapsNet) yang memanfaatkan mekanisme *routing-by-agreement* dan representasi berbasis vektor. Tahapan penelitian mencakup pengumpulan dataset dari 36 partisipan, prapemrosesan citra (*grayscale*, deteksi tepi, morfologi, augmentasi, *resize*, normalisasi), pembangunan model CapsNet dan CNN, pelatihan dengan *fine-tuning*, serta evaluasi menggunakan metrik *top-1*, *top-3*, *top-5 accuracy*, *precision*, *recall*, dan *F1-Score*, termasuk *robustness test* dengan 16 jenis augmentasi ekstrem.

Hasil penelitian menunjukkan CNN v1 memberikan performa terbaik dengan *top-1 accuracy* 94.29% dan *F1-Score* 0.943, sedangkan CapsNet terbaik mencatat *top-1 accuracy* 90.67% dan *F1-Score* 0.906. Pada *robustness test*, CNN bahkan mengalami peningkatan *F1-Score* menjadi 0.961, sementara CapsNet mengalami penurunan sangat kecil (0.901). Temuan ini menunjukkan bahwa meskipun CapsNet unggul secara teoritis dalam mempertahankan informasi spasial, CNN yang telah dioptimasi justru lebih unggul dalam praktik, baik dari segi akurasi maupun adaptasi terhadap augmentasi ekstrem.

**Kata Kunci:** Aksara Sunda, *Capsule Network*, *Convolutional Neural Network*, Pengenalan Aksara, Digitalisasi Budaya, *Affine Transformation*

## ABSTRACT

### *Handwritten Sundanese Script Classification Using Capsule Network (CapsNet)*

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*This research is motivated by the limitations of the Convolutional Neural Network (CNN) architecture in preserving spatial information for Sundanese script classification, particularly for small elements such as rarangkén, as well as its high sensitivity to affine transformations such as rotation, translation, and scaling. These weaknesses can lead to misclassification of similar characters, thereby reducing the accuracy of recognition systems and ultimately hindering efforts to preserve traditional scripts through digitization. Therefore, an alternative approach is needed that can more precisely capture the spatial relationships between elements.*

*As a solution, this study develops a handwritten Sundanese script classification system using a Capsule Network (CapsNet), which leverages the routing-by-agreement mechanism and vector-based representations. The research stages include collecting a dataset from 36 participants, image preprocessing (grayscale conversion, edge detection, morphological operations, augmentation, resizing, and normalization), building CapsNet and CNN models, training with fine-tuning, and evaluation using metrics such as top-1, top-3, and top-5 accuracy, precision, recall, and F1-Score, including a robustness test with 16 types of extreme augmentations.*

*The results show that the best-performing CNN v1 achieved a top-1 accuracy of 94.29% and an F1-Score of 0.943, while the best CapsNet achieved a top-1 accuracy of 90.67% and an F1-Score of 0.906. In the robustness test, CNN even improved its F1-Score to 0.961, while CapsNet experienced only a very slight decrease (0.901). These findings indicate that although CapsNet is theoretically superior in preserving spatial information, the optimized CNN outperforms it in practice, both in terms of accuracy and adaptation to extreme augmentations.*

**Keywords:** *Sundanese script, Capsule Network, Convolutional Neural Network, script recognition, cultural digitization, Affine Transformation*