ABSTRAK

Penerapan *Deep Learning*, khususnya *Convolutional Neural Network* (CNN), telah menjadi standar emas dalam pengembangan sistem *Computer-Aided* Diagnosis (CAD) dermatoskopi. Namun, tantangan fundamental yang menghambat kinerja diagnostik adalah ketidakseimbangan kelas (*class imbalance*) ekstrem pada *dataset* publik seperti HAM10000. Dominasi kelas mayoritas, khususnya *Melanocytic Nevi* (NV), menyebabkan model bias dan gagal mengenali kelas minoritas krusial seperti *Dermatofibroma* dan *Vascular Lesions*. Upaya konvensional menggunakan augmentasi geometris kurang efektif karena hanya memanipulasi posisi piksel tanpa menghasilkan variasi fitur semantik baru. Di sisi lain, pendekatan generatif *Auxiliary Classifier* GAN (ACGAN) rentan terhadap *mode collapse*, sedangkan *Wasserstein* GAN *with Gradient Penalty* (WGAN-GP) memiliki stabilitas tinggi namun bersifat *unconditional* sehingga tidak dapat menyeimbangkan kelas spesifik secara terarah. Oleh karena itu, penelitian ini berfokus pada peningkatan sensitivitas model terhadap penyakit kulit langka melalui sintesis data yang stabil dan terkontrol.

Penelitian ini mengusulkan arsitektur hibrida *Auxiliary Classifier Wasserstein* GAN *with Gradient Penalty* (ACWGAN-GP). Metode ini mengintegrasikan mekanisme kontrol label ACGAN dengan stabilitas WGAN-GP untuk mensintesis citra lesi kulit realistis pada kelas minoritas. Proses diawali dengan akuisisi *dataset* HAM10000, pra-pemrosesan (*resizing*, normalisasi), dan pembagian data terstratifikasi. Selanjutnya, dilakukan optimasi *hyperparameter* menggunakan Optuna untuk mendapatkan konfigurasi terbaik model generatif. Kualitas citra sintetis dievaluasi menggunakan metrik *Fréchet Inception Distance* (FID), *Inception Score* (IS), dan *Kernel Inception Distance* (KID). Data sintetis berkualitas tinggi kemudian digunakan untuk *oversampling* dalam pelatihan ResNet50 yang dimodifikasi dengan mekanisme *Soft Attention*. Pengujian dilakukan secara komparatif antara augmentasi geometris konvensional, ACGAN, dan ACWGAN-GP.

Hasil menunjukkan bahwa model ACGAN mengalami kegagalan pelatihan berupa *mode collapse*, sedangkan metode ACWGAN-GP terbukti optimal dengan stabilitas baik serta kualitas citra unggul (FID 178.12 dan IS 2.37). Dampak augmentasi ACWGAN-GP terbukti signifikan terhadap kinerja klasifikasi ResNet50 pada kelas minoritas. Hal ini ditandai dengan lonjakan *Recall* pada kelas *Actinic Keratoses* (akiec) dari 0.25 pada *baseline* menjadi 0.69, serta pencapaian *Recall* sempurna 1.0 pada kelas *Vascular Lesions* (vasc). Secara keseluruhan, metode usulan berhasil meningkatkan rata-rata *Recall* makro sebesar 12% dibandingkan metode konvensional. Peningkatan metrik ini krusial dalam domain medis untuk menurunkan tingkat *False Negative*. Disimpulkan bahwa penambahan fitur semantik melalui sintesis generatif terkontrol mampu memperbaiki batasan keputusan model pada data tidak seimbang, sehingga meminimalkan risiko kesalahan diagnosis.

Kata Kunci: *Deep Learning*, *Imbalanced Data*, ACWGAN-GP, ResNet50, Klasifikasi Penyakit Kulit

ABSTRACT

Deep Learning, specifically Convolutional Neural Networks (CNN), has become the gold standard for developing Computer-Aided Diagnosis *(CAD) systems in dermoscopy. However, a fundamental challenge hindering diagnostic performance is the extreme class imbalance found in public datasets like HAM10000. The dominance of majority classes, such as Melanocytic Nevi (NV), causes classification models to become biased. As a result, these models often fail to recognize clinically crucial minority classes like Dermatofibroma and Vascular Lesions. Traditional methods using geometric data augmentation are ineffective because they only manipulate pixel positions without creating new meaningful features. Meanwhile, existing generative approaches have limitations: Auxiliary Classifier GAN (ACGAN) is prone to training instability, while Wasserstein GAN with Gradient Penalty (WGAN-GP) is stable but lacks the ability to target specific disease classes. Therefore, this study addresses the urgent need to improve model sensitivity for rare skin diseases through stable and controlled data synthesis.*

The method proposed in this study is a hybrid architecture called Auxiliary Classifier Wasserstein GAN with Gradient Penalty (ACWGAN-GP). This method combines the class-control mechanism of ACGAN with the training stability of WGAN-GP to synthesize realistic images for minority classes. The research process began with acquiring the HAM10000 dataset, preprocessing the images, and splitting the data. Furthermore, hyperparameter optimization was performed using the Optuna framework to find the best configuration for the generative model. The quality of the synthetic images was evaluated using Fréchet Inception Distance (FID), Inception Score (IS), and Kernel Inception Distance (KID). These high-quality synthetic images were then used to oversample the data and train a ResNet50 classification model modified with a Soft Attention mechanism. The testing phase compared three scenarios: conventional geometric augmentation, ACGAN augmentation, and the proposed ACWGAN-GP augmentation.

*The results showed that the ACGAN model failed during training due to mode collapse. In contrast, the proposed ACWGAN-GP method proved to be the most optimal, demonstrating good training stability and superior image quality with an FID of 178.12 and an IS of 2.37. The impact of data augmentation using ACWGAN-GP was significant on the performance of the ResNet50 classifier for minority classes. This was marked by a jump in the Recall value for Actinic Keratoses (akiec) from 0.25 in the baseline scenario to 0.69, and a perfect Recall of 1.0 for Vascular Lesions (vasc). Overall, the proposed method successfully increased the average Macro Recall by 12% compared to conventional methods. This improvement is critical in the medical domain as it represents a reduction in false negatives. This study concludes that adding semantic features through controlled generative synthesis can improve the model's decision boundaries, thereby minimizing the risk of mis*diagnosis *in rare skin diseases.*

Keywords: *Deep Learning*, *Imbalanced Data*, ACWGAN-GP, ResNet50, *Skin Disease Classification*