

*Glaucoma* merupakan penyakit degeneratif progresif yang menyerang saraf optik akibat gangguan pada sistem drainase cairan mata (*aqueous humor*) dan dapat menyebabkan kebutaan permanen. Salah satu pendekatan untuk mendeteksi *glaucoma* adalah melalui klasifikasi citra fundus retina menggunakan teknik *computer vision*. Penelitian sebelumnya pada dataset PAPILA telah menunjukkan hasil yang baik, namun masih terbatas pada penggunaan teknik *cropping* sebagai metode *preprocessing*. Pendekatan tersebut belum mampu mengatasi variasi kualitas citra fundus, seperti pencahayaan yang tidak merata, kontras rendah, dan *noise*. Oleh karena itu, penelitian ini berfokus pada eksplorasi beberapa teknik *preprocessing*, khususnya *image enhancement*, untuk meningkatkan performa klasifikasi *glaucoma*. Metode yang digunakan meliputi CLAHE, *contrast stretching*, *brightness*, dan *brightness channel prior* (BCP), yang dikombinasikan dengan berbagai representasi citra seperti RGB, BG, dan *grayscale*. Dataset utama yang digunakan adalah PAPILA, sedangkan dataset ACRIMA digunakan untuk evaluasi lanjutan guna menguji konsistensi pengaruh *preprocessing* pada dataset lain. Hasil evaluasi menunjukkan bahwa EfficientNetB0 merupakan arsitektur dengan performa terbaik dan selanjutnya divalidasi menggunakan *Stratified 5-Fold Cross Validation*. Berdasarkan hasil validasi, performa *accuracy* model EfficientNetB0 tanpa *preprocessing* (RGB) menghasilkan *accuracy* sebesar 70.95% sebagai *baseline*. Dengan penerapan teknik *preprocessing Brightness*, *accuracy* meningkat menjadi 78.70%, menunjukkan peningkatan sebesar 7.75% dibandingkan *baseline*. Pengujian statistik menggunakan uji Friedman menghasilkan nilai  $p\text{-value} = 0.000029 (< 0.05)$ , yang mengindikasikan adanya perbedaan performa yang signifikan secara statistik antar teknik *preprocessing*. Uji lanjut (*post-hoc*) berupa *Wilcoxon signed rank test* dengan koreksi Bonferroni menunjukkan bahwa *Brightness Channel Prior* (BCP), *Contrast Stretching* (CS), BG+CS, dan *Brightness* terbukti memberikan peningkatan performa yang signifikan dibandingkan RGB dalam mengklasifikasi dataset PAPILA untuk deteksi dini *glaucoma*.

**Kata kunci**—*Glaucoma, CNN, Image enhancement, Preprocessing, PAPILA*

## ABSTRACT

*Glaucoma is a progressive degenerative disease that affects the optic nerve due to disorders in the drainage system of the aqueous humor and can lead to permanent blindness. One approach to detecting glaucoma is through the classification of retinal fundus images using computer vision techniques. Previous research on the PAPILA dataset has shown promising results, but it remains limited to the use of cropping techniques as a preprocessing method. This approach has not yet been able to address variations in fundus image quality, such as uneven lighting, low contrast, and noise. Therefore, this study focuses on exploring several preprocessing techniques, particularly image enhancement, to improve the performance of glaucoma classification. The methods used include CLAHE, contrast stretching, brightness, and brightness channel prior (BCP), combined with various image representations such as RGB, BG, and grayscale. The primary dataset used was PAPILA, while the ACRIMA dataset was used for further evaluation to test the consistency of the preprocessing effects on other datasets. The evaluation results show that EfficientNetB0 is the architecture with the best performance and was subsequently validated using Stratified 5-Fold Cross-Validation. Based on the validation results, the accuracy of the EfficientNetB0 model without preprocessing (RGB) was 70.95%, serving as the baseline. With the application of the Brightness preprocessing technique, accuracy increased to 78.70%, representing a 7.75% improvement over the baseline. Statistical testing using the Friedman test yielded a p-value of 0.000029 ( $< 0.05$ ), indicating a statistically significant difference in performance among the preprocessing techniques. Further (post-hoc) testing using the Wilcoxon signed-rank test with Bonferroni correction showed that Brightness Channel Prior (BCP), Contrast Stretching (CS), BG+CS, and Brightness were proven to provide a significant performance improvement compared to RGB in classifying the PAPILA dataset for the early detection of glaucoma.*

**Keywords**—Glaucoma, CNN, Image enhancement, Preprocessing, PAPILA