

INTISARI

Perkembangan teknologi *deep learning* pada bidang kesehatan memberikan peluang besar dalam membantu proses diagnosis penyakit berbasis citra medis, termasuk klasifikasi citra histopatologi kanker payudara. Keterbatasan dataset medis dan rendahnya interpretabilitas model *deep learning* masih menjadi tantangan dalam pengembangan sistem diagnosis berbasis kecerdasan buatan. Penelitian ini bertujuan untuk mengevaluasi performa beberapa model *transfer learning* dalam klasifikasi citra histopatologi kanker payudara menggunakan *data augmentation* serta menganalisis interpretabilitas model menggunakan metode *Gradient-weighted Class Activation Mapping (Grad-CAM)*. Penelitian ini menggunakan pendekatan eksperimen kuantitatif dengan dataset citra histopatologi kanker payudara BreakHis pada pembesaran 200× yang diperoleh melalui platform Kaggle. Dataset terdiri atas 2.013 citra yang dibagi menjadi data *training* sebesar 80% dan data *testing* sebesar 20%. Tahapan penelitian meliputi *preprocessing* data, penerapan *data augmentation*, implementasi model *transfer learning* menggunakan ResNet50, DenseNet121, dan EfficientNetB0, proses pelatihan model, evaluasi performa klasifikasi, serta interpretasi model menggunakan Grad-CAM. Evaluasi model dilakukan menggunakan *accuracy*, *precision*, *recall*, *F1-Score*, dan *confusion matrix*. Hasil pengujian menunjukkan bahwa DenseNet121 merupakan model dengan performa terbaik dengan nilai *accuracy* sebesar 90,57%, *precision* sebesar 94,44%, *recall* sebesar 91,73%, dan *F1-Score* sebesar 93,07%. Hasil *confusion matrix* menunjukkan bahwa DenseNet121 mampu mengklasifikasikan 110 citra *benign* dan 255 citra *malignant* dengan benar, dengan 15 *false positive* dan 23 *false negative*. Visualisasi Grad-CAM menunjukkan bahwa DenseNet121 mampu memusatkan perhatian pada area jaringan yang relevan dalam proses klasifikasi dengan tingkat keyakinan sebesar 88,96%. Berdasarkan hasil tersebut, DenseNet121 menunjukkan performa klasifikasi terbaik dibandingkan ResNet50 dan EfficientNetB0 serta memberikan visualisasi yang mendukung interpretabilitas proses pengambilan keputusan model pada citra histopatologi kanker payudara.

Kata kunci: *transfer learning*, histopatologi kanker payudara, *data augmentation*, *deep learning*, Grad-CAM

ABSTRACT

The development of deep learning technology in the healthcare sector provides significant opportunities to support disease diagnosis based on medical images, including the classification of breast cancer histopathological images. The limitations of medical datasets and the low interpretability of deep learning models remain challenges in the development of artificial intelligence-based diagnostic systems. This study aims to evaluate the performance of several transfer learning models for breast cancer histopathological image classification using data augmentation and to analyze model interpretability using the Gradient-weighted Class Activation Mapping (Grad-CAM) method. This study employs a quantitative experimental approach using the BreakHis breast cancer histopathological image dataset at 200× magnification, obtained through the Kaggle platform. The dataset consists of 2,013 images, which are divided into 80% training data and 20% testing data. The research stages include data preprocessing, the application of data augmentation, the implementation of transfer learning models using ResNet50, DenseNet121, and EfficientNetB0, model training, classification performance evaluation, and model interpretation using Grad-CAM. Model evaluation was performed using accuracy, precision, recall, F1-score, and confusion matrix. The experimental results show that DenseNet121 achieved the best performance, with an accuracy of 90.57%, precision of 94.44%, recall of 91.73%, and F1-score of 93.07%. The confusion matrix results show that DenseNet121 correctly classified 110 benign images and 255 malignant images, with 15 false positives and 23 false negatives. The Grad-CAM visualization shows that DenseNet121 was able to focus its attention on relevant tissue regions during the classification process, with a confidence score of 88.96%. Based on these results, DenseNet121 demonstrated the best classification performance compared with ResNet50 and EfficientNetB0 and provided visualizations that support the interpretability of the model's decision-making process in breast cancer histopathological image classification.

Keywords: transfer learning, breast cancer histopathology, data augmentation, deep learning, Grad-CAM