

## ABSTRAK

Kanker paru-paru merupakan salah satu penyebab utama kematian akibat kanker di dunia, sehingga proses diagnosis yang cepat dan akurat menjadi penting, khususnya melalui analisis citra histopatologi. Namun, pemeriksaan manual oleh patolog membutuhkan waktu, keahlian khusus, dan berpotensi menimbulkan variasi interpretasi. Penelitian ini bertujuan menerapkan dan mengevaluasi Swin Transformer untuk klasifikasi citra histopatologi kanker paru-paru pada tiga kelas, yaitu *Adenocarcinoma* (ACA), *Squamous Cell Carcinoma* (SCC), dan *Normal Lung Tissue*, serta menguji kemampuan generalisasi model pada dataset eksternal.

Dataset yang digunakan adalah LC25000 sebagai data pelatihan dan validasi internal, serta LungHist700 sebagai data eksternal. Metode penelitian meliputi preprocessing citra berupa resize  $224 \times 224$  piksel, normalisasi, augmentasi data, pelatihan model menggunakan transfer learning, serta evaluasi menggunakan accuracy, precision, recall, F1-score, AUC, dan confusion matrix. Model ResNet50 digunakan sebagai baseline, sedangkan Swin Transformer digunakan sebagai model utama.

Hasil internal menunjukkan bahwa ResNet50 memperoleh accuracy rata-rata 0,9927, F1-macro 0,9927, dan AUC macro 0,9999, sedangkan Swin Transformer memperoleh accuracy rata-rata 0,9999, F1-macro 0,9999, dan AUC macro 1,0000. Pada pengujian eksternal menggunakan LungHist700, Swin Transformer memperoleh accuracy 0,5441, precision macro 0,6877, recall macro 0,4975, F1-macro 0,4732, dan AUC macro 0,7540. Dibandingkan performa internal, accuracy Swin Transformer turun sekitar 45,58%, F1-macro turun sekitar 52,68%, dan AUC macro turun sekitar 24,60%. Penurunan ini menunjukkan adanya domain shift antara LC25000 dan LungHist700 yang dipengaruhi oleh perbedaan pewarnaan H&E, sumber data, variasi pasien, resolusi, dan karakteristik jaringan. Dengan demikian, penelitian ini menegaskan pentingnya external validation dalam pengembangan model deep learning untuk citra histopatologi medis.

Kata kunci: *Swin Transformer*, histopatologi, kanker paru-paru, klasifikasi citra, generalisasi model.

## ABSTRACT

Lung cancer is one of the leading causes of cancer-related deaths worldwide, making rapid and accurate diagnosis essential, particularly through histopathological image analysis. However, manual examination by pathologists is time-consuming, requires specialized expertise, and may lead to inter-observer variability. This study aims to implement and evaluate the Swin Transformer for the classification of lung histopathological images into three classes: Adenocarcinoma (ACA), Squamous Cell Carcinoma (SCC), and Normal Lung Tissue, as well as to assess the model's generalization capability using an external dataset.

The datasets used in this study were LC25000 for training and internal validation and LungHist700 as the external dataset. The research methodology included image preprocessing through resizing to 224×224 pixels, normalization, data augmentation, model training using transfer learning, and evaluation based on accuracy, precision, recall, F1-score, AUC, and confusion matrix. ResNet50 was employed as the baseline model, while Swin Transformer served as the primary model.

The internal evaluation demonstrated that Swin Transformer outperformed ResNet50, achieving an average accuracy of 99.99%, a macro F1-score of 99.99%, and a macro AUC of 1.0000. However, external testing on LungHist700 resulted in an accuracy of 54.41%, a macro F1-score of 47.32%, and a macro AUC of 0.7540. Compared with internal performance, the model showed substantial decreases in accuracy, F1-score, and AUC, indicating the presence of domain shift between the datasets. These differences are likely caused by variations in H&E staining, data sources, patient characteristics, image resolution, and tissue morphology. The findings highlight the importance of external validation in developing reliable deep learning models for medical histopathological image classification.

**Keywords:** Swin Transformer, histopathology, lung cancer, image classification, model generalization.