Colon Cancer Classification from Histopathological Images Using Convolutional Neural Networks

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Abstract

Colon cancer is one of the major causes of cancer-related deaths, and early diagnosis is essential for effective treatment. Traditional histopathological image analysis relies on expert pathologists and is often time-consuming and subjective. This paper proposes an automated colon cancer classification system using Convolutional Neural Networks (CNNs) to improve diagnostic efficiency and accuracy. Histopathological images from the LS25000 colon dataset are pre-processed using resizing, normalization, and data augmentation techniques such as rotation and flipping. The CNN model automatically extracts relevant features and classifies images into normal, benign, and malignant categories. Model performance is evaluated using standard metrics including accuracy, precision, recall, F1-score, and confusion matrix. In addition, Grad-CAM visualization is employed to highlight important image regions influencing the model's predictions, enhancing interpretability. Experimental results demonstrate that the proposed approach provides accurate and consistent classification, making it a reliable decision-support tool for assisting pathologists in early colon cancer detection.
Keywords: Colon Cancer; Convolutional Neural Network; Deep Learning; Histopathological Images; Medical Image Analysis.

1. Introduction

Colon cancer is a major global health concern, affecting millions of people each year. Early diagnosis significantly improves patient survival rates; however, the current diagnostic process largely depends on the manual analysis of histopathological tissue samples by experienced pathologists. This method is not only time-consuming but also susceptible to variability in diagnosis due to human judgment and fatigue. With the rapid development of machine learning and deep learning technologies, automated medical image analysis has gained significant attention in recent years. Among these techniques, Convolutional Neural Networks (CNNs) have shown remarkable success in image classification tasks by automatically learning meaningful features directly from raw image data, eliminating the need for manual feature extraction.

In this study, a CNN-based framework is proposed for the classification of colon cancer using histopathological images. The primary goal of this approach is to support pathologists by delivering faster, more consistent, and accurate diagnostic results. By enhancing early detection capabilities, the proposed system has the potential to contribute to improved clinical decision-making and better treatment outcomes for patients.efficiency and achieved promising results. Despite this, the study suggested the need for better visualization techniques to improve clinical trust in AI-based systems.

2. Method

The proposed system utilizes a Convolutional Neural Network (CNN) to classify colon cancer from histopathological images into three categories: normal, benign, and malignant. The methodology consists of several key stages designed to improve diagnostic accuracy and interpretability. Initially,

histopathological images are collected from the LS25000 colon dataset. Figure 1 shows Flow Chart
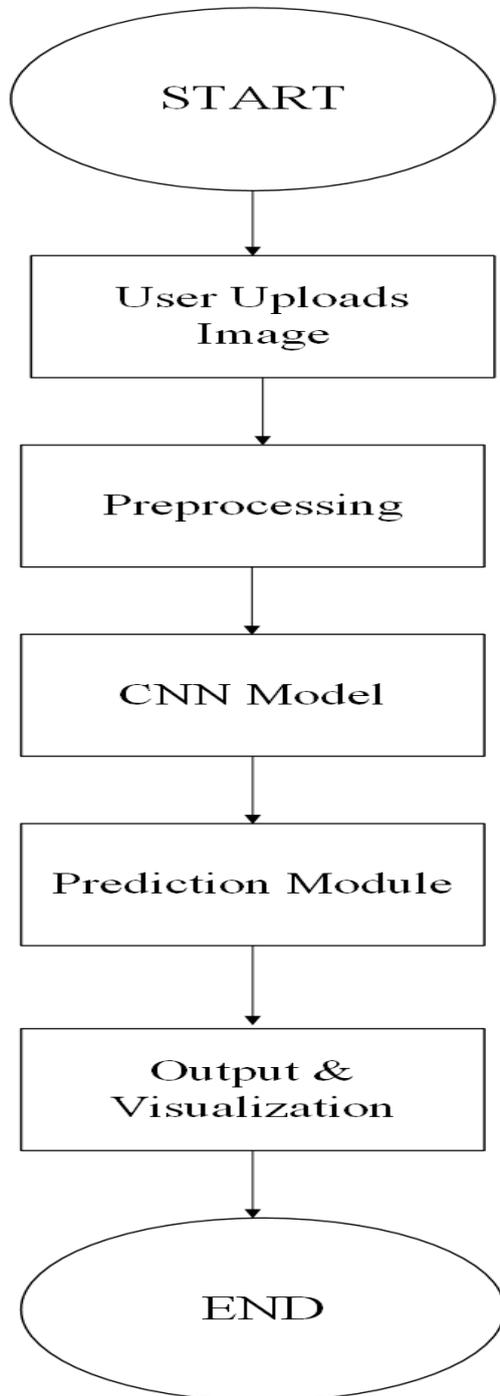

Figure 1 Flow Chart

To enhance data quality and model performance, preprocessing techniques such as image resizing, normalization, rotation, and flipping are applied.

These augmentation methods increase dataset diversity and help prevent overfitting. The CNN architecture automatically extracts spatial and texture-based features from the processed images through convolution and pooling layers. Fully connected layers are then used to perform multi-class classification. The model is trained using appropriate loss functions and optimization algorithms to ensure stable learning. For evaluation, standard performance metrics including accuracy, precision, recall, F1-score, and confusion matrix are employed to measure classification effectiveness. Additionally, Gradient-weighted Class Activation Mapping (Grad-CAM) is integrated to visualize the regions of the image that influence the model's predictions. This improves transparency and allows medical professionals to better understand the decision-making process of the system.

3. Results and Discussion

The experimental analysis indicates that the CNN-based model effectively learns complex tissue patterns and performs reliable feature extraction from histopathological images. Training and validation accuracy and loss curves demonstrate stable model convergence while helping identify potential overfitting or underfitting issues.
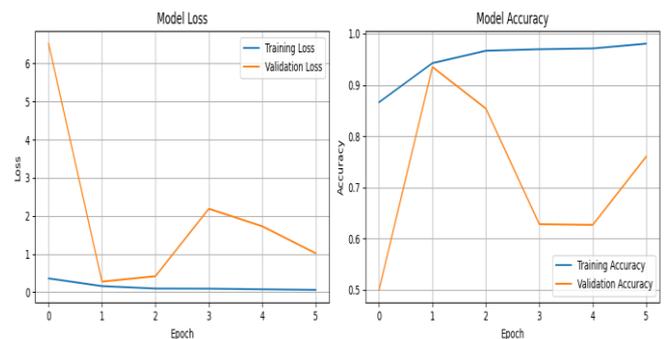

Figure 2 Model Loss and Accuracy

Although detailed numerical values are not provided, initial observations suggest that the proposed approach achieves consistent and accurate classification performance across the three tissue categories. The use of Grad-CAM further strengthens the system by offering visual explanations, enabling pathologists to verify whether the model focuses on clinically relevant regions.
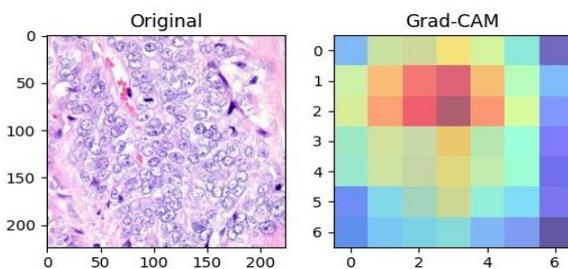
Figure 3 Percentage Calculation

Figure 4 Original and Grad

Overall, the framework shows strong capability as a decision-support tool by improving classification consistency and reducing reliance on manual diagnosis.

Conclusion

This study presents an automated colon cancer classification system based on Convolutional Neural Networks. By combining image preprocessing, deep feature extraction, multi-class classification, and explainable AI techniques, the proposed framework supports faster and more reliable diagnosis. The automated approach reduces the workload on pathologists while maintaining diagnostic interpretability, increasing clinical trust in AI-driven systems. Future work should focus on training the model with larger and more diverse datasets to improve generalization. Exploring advanced CNN architectures, transfer learning methods, and real-time deployment through cloud or web platforms could further enhance the system's clinical applicability.
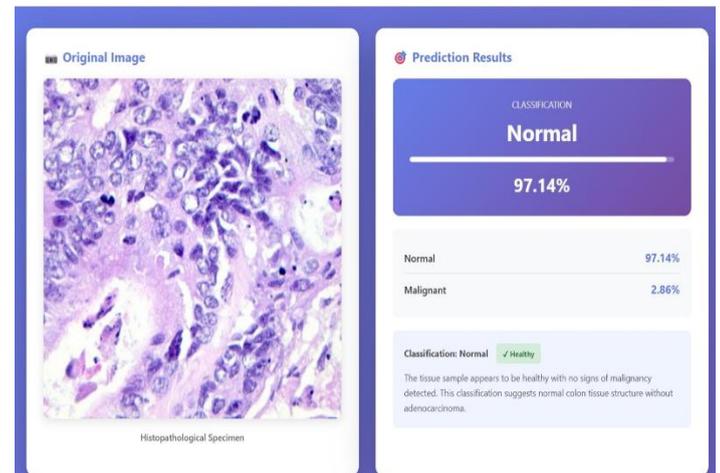
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Figure 5 Original and Prediction Results

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