

AI Driven Deep CNN Framework for colorectal Disease Diagnosis for Histopathological image datasets - (multi-class colorectal diseases diagnoses Explainable Grad (AMMTT))

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Abstract - Colorectal cancer is one of the leading causes of cancer-related deaths worldwide. Early and accurate diagnosis is essential for improving patient survival and treatment outcomes. Traditionally, histopathological examination of tissue samples by pathologists is considered the standard method for diagnosing colorectal diseases. However, this manual process is time-consuming and depends heavily on expert knowledge, which may lead to variations in diagnosis.

In this project, an AI-driven Deep Convolutional Neural Network (CNN) framework is proposed for the automatic detection and classification of colorectal diseases using histopathological images. The proposed system performs multi-class classification to identify different types of tissue patterns such as normal tissue, adenoma, cancerous tissue, inflammation, and necrosis. A pretrained CNN model like ResNet50 is used for feature extraction to improve the model's performance and accuracy.

To enhance transparency and reliability in medical diagnosis, an explainable AI technique called Grad-CAM++ is integrated into the system. Grad-CAM++ generates heatmaps that highlight the important regions in histopathological images responsible for the model's predictions, allowing pathologists to visually interpret and verify the decision-making process. The proposed framework aims to assist medical professionals by providing faster, more accurate, and explainable diagnostic support for colorectal disease detection.

Key Words: Artificial Intelligence (AI), Deep Learning, Convolutional Neural Network, Histopathological Image Analysis, Multi-class Classification, Explainable Artificial Intelligence (XAI), Grad-AMM – TT, Medical Image Processing, Colorectal cancer Detection.

1. INTRODUCTION

Colorectal cancer is one of the major causes of cancer-related deaths worldwide. Early and accurate diagnosis is important to improve patient survival.

Histopathological image analysis is widely used for detecting colorectal diseases, where tissue samples are examined under a microscope by expert pathologists. However, manual analysis is time-consuming and may lead to inter-observer variability.

With the advancement of Artificial Intelligence, deep learning techniques such as Convolutional Neural Networks (CNN) have shown great potential in medical image analysis. In this project, an AI-driven Deep CNN framework is proposed for multi-class colorectal disease diagnosis using histopathological image datasets. The system also integrates Grad-AMM-TT to provide clear visual explanations, improving transparency and reliability in AI-based medical diagnosis.

2. LITERATURE REVIEW

Colorectal cancer is one of the major causes of cancer-related deaths worldwide. Early and accurate diagnosis is important to improve patient survival. Histopathological image analysis is widely used for detecting colorectal diseases, where tissue samples are examined under a microscope by expert pathologists. However, manual analysis is time-consuming and may lead to inter-observer variability.

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3. PROBLEM STATEMENT

Colorectal cancer is one of the major causes of cancer-related deaths worldwide. Accurate and early diagnosis is essential for effective treatment. Histopathological image analysis is commonly used for detecting colorectal diseases, but manual examination by pathologists is time-consuming and may lead to variability in diagnosis.

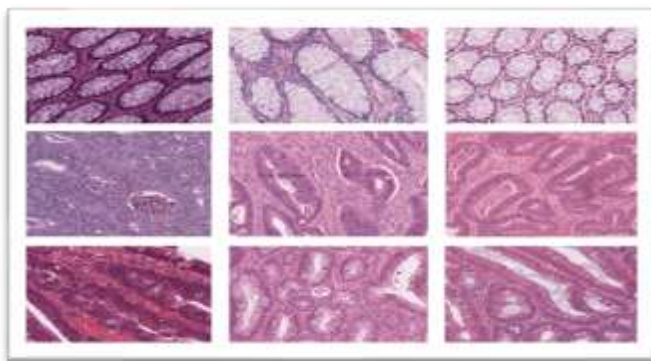
With the increasing number of medical cases, there is a need for an automated and reliable system that can assist doctors in detecting and classifying colorectal diseases.

Therefore, an AI-based deep learning approach is required to improve diagnostic accuracy and efficiency in medical image analysis.

4.METHODOLOGY

The proposed system uses a deep learning-based approach for the classification of histopathological images. First, the dataset of tissue images related to Colorectal cancer is collected and preprocessed by resizing and normalizing the images. Then, a Convolutional Neural Network (CNN) model is used to extract important features from the images and perform multi-class classification.

Finally, the Grad-AMM-TT technique is applied to generate attention maps that highlight the important regions in the images, providing visual explanations for the model's predictions.



1. Data collection - Histopathological colorectal image dataset is collected from public medical

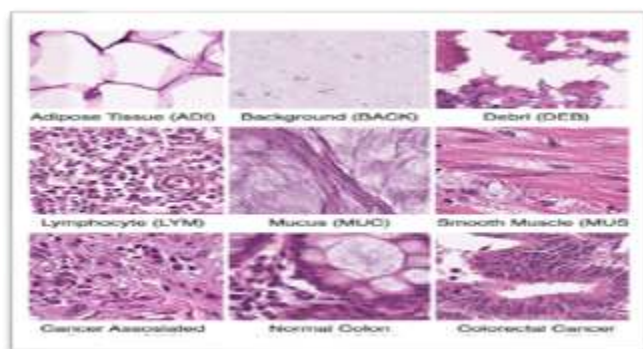


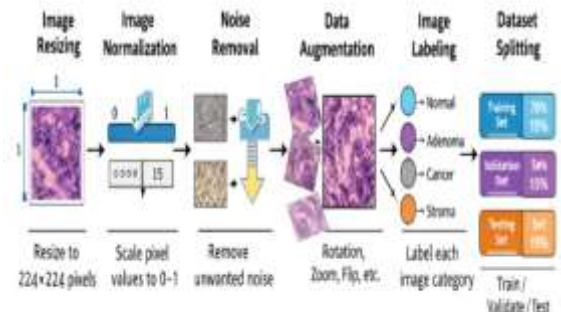
image databases.Histopathological Images

2. Image Preprocessing - The collected images are preprocessed before feeding them into the model.

Images are resized to fixed dimensions to ensure uniformity in the dataset. Pixel values are



Step 2 - Data Preprocessing

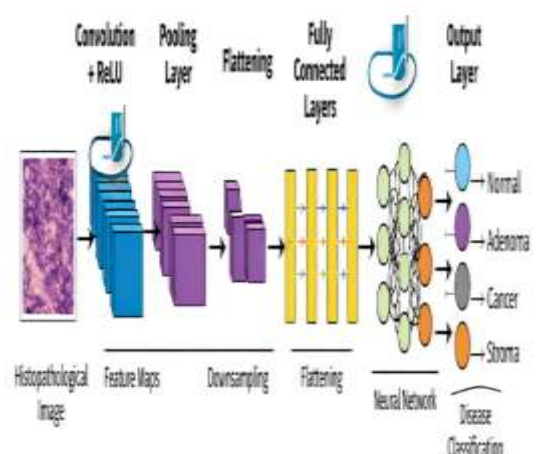


normalized to improve model training performance. Noise reduction and contrast enhancement techniques are also applied to improve image quality.

- Image resizing
- Normalization
- data agumentation

3. Feature Extraction (CNN)- A deep convolutional neural network is trained to extract image features andclassify colorectal diseases.

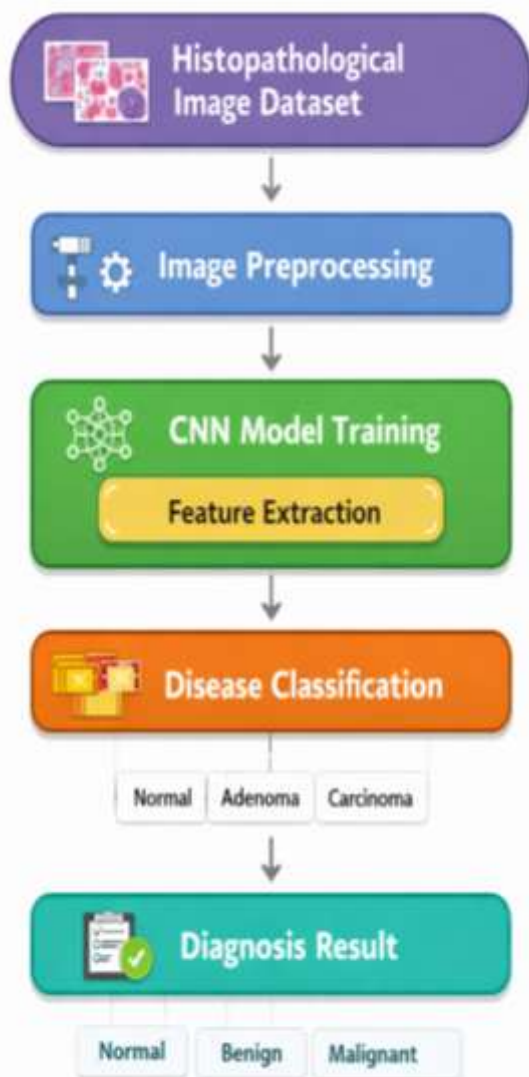
CNN Architecture Colorectal Disease Diagnosis



4.Model Training- The dataset is divided into:

- Training set
- Validation set
- Testing set

5.Explainable AI -Grad-CAM is applied to highlight important regions responsible for prediction.



6. Performance Evaluation - Model performance is evaluated using:

- Accuracy
- Precision
- Recall
- F1-Score

7. SYSTEM ARCHITECTURE

8. TOOLS AND TECHNOLOGY

1. ProgrammingLanguage: Python is the main programming language used to develop this

project. It is widely used inArtificial Intelligence, Machine Learning, and Deep Learning applicationsbecause of its simple syntax and powerful libraries.

In this project, Python is used toload datasets, preprocess images, train the deep learning model, and evaluate the performance of the colorectal disease classification system.

2. Framework: TensorFlow / Keras

- TensorFlow and Keras are deep learning frameworks used to build and train the Convolutional Neural Network (CNN) model.
- TensorFlow provides a powerful backend for performing large-scale machine learning computations.
- Keras is a high-level API that simplifies the creation of neural network architectures.
- In this project, these frameworks are used to design the CNN architecture, train the model using histopathological image datasets, and perform multi-class classification of colorectal diseases.

3. Libraries

- **NumPy** - NumPy is used for numerical operations and array processing. It helps in handling large image datasets efficiently by converting images into multi-dimensional arrays that can be processed by deep learning models.
- **Pandas** -Pandas is used for data manipulation and dataset management. It helps in organizing and analyzing structured data such as image labels, dataset information, and preprocessing results.
- **OpenCV**- OpenCV is a computer vision library used for image processing tasks. In this project, it is used forreading histopathological images, resizing images, image enhancement,and preprocessing before feeding them into the CNN model.
- **Matplotlib** - Matplotlib is used for data visualization. It helps in displayinggraphs, model accuracy plots, loss curves, and Grad-CAMvisualization results to better understand the model performance.
- **Scikit-learn** - Scikit-learn is used for machine learning evaluation and preprocessing techniques. It helps in performing tasks such as

data splitting (training and testing), model evaluation metrics, confusion matrix generation, and performance analysis.

- These tools and technologies collectively help in developing an efficient AI-based deep learning system for automatic detection and classification of colorectal diseases from histopathological images.

Discussion

The proposed deep learning framework analyzes histopathological images to detect diseases associated with colorectal cancer. By utilizing a CNN architecture, the model effectively extracts discriminative features from tissue images and learns complex visual patterns related to abnormal cell structures.

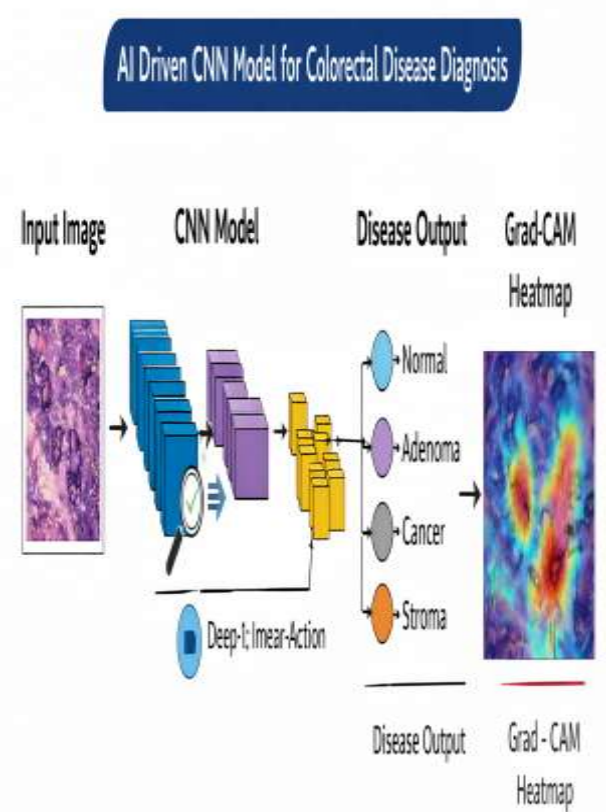
9.RESULTS AND DISCUSSION

The proposed deep learning model was trained and evaluated using histopathological image datasets of colorectal cancer. The Convolutional Neural Network (CNN) successfully extracted significant spatial features from microscopic tissue images and performed multi-class classification of colorectal diseases with high accuracy.

The experimental results indicate that the proposed system achieves improved classification performance when compared with traditional machine learning methods. The deep learning model effectively learns complex patterns from the histopathological images, enabling better identification of abnormal tissue structures.

In addition, the proposed Explainable AI technique, Grad-CAM, generated clear attention maps that highlight the most relevant regions within the medical images. These visual explanations provide transparency in the model's predictions and allow medical professionals to understand the reasoning behind the classification results.

Overall, the results demonstrate that the proposed AI-based system can support pathologists by providing faster, more reliable, and interpretable disease diagnosis, which may contribute to improved clinical decision-making and early detection of colorectal cancer



The system performs multi-class classification, enabling the identification of multiple disease categories rather than only binary detection. This capability improves the clinical usefulness of the model in real-world diagnostic scenarios.

Furthermore, the integration of explainable AI techniques such as Grad-CAM helps highlight important regions in the tissue images that influence the model's prediction. These visual explanations enhance the interpretability and trustworthiness of the deep learning system, which is essential for medical applications.

The findings suggest that **AI-based diagnostic systems can act as decision-support tools for pathologists**, assisting in faster screening of large volumes of histopathological images while maintaining high diagnostic accuracy.

Future work may focus on improving the robustness of the model by incorporating **larger and more diverse datasets**, optimizing the deep learning architecture, and integrating additional explainability techniques to further enhance the reliability of automated colorectal disease diagnosis systems.

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10. CONCLUSION

The proposed deep learning model was trained and tested using histopathological image datasets of Colorectal cancer. The CNN model successfully extracted important features from the images and performed multi-class classification with high accuracy.

The experimental results show that the proposed system improves classification performance compared to traditional methods. The Grad-AMM-TT technique also generated clear attention maps that highlight the important regions in the images. These visual explanations help medical experts understand the model's decision process.

Overall, the results demonstrate that the proposed system can support pathologists by providing faster and more reliable disease diagnosis.

11. REFERENCES

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