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Interoperative Biopsy Site Localization in Endoscope for Gastro Intestinal Tract using Deep Learning Technology

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***Abstract*: Endoscopic biopsy is a common procedure used to obtain tissue samples from the gastrointestinal tract for diagnostic purposes. However, accurately localizing the biopsy site can be challenging, which can lead to errors in diagnosis and treatment. In this study, we propose a method for inter operative biopsy site localization in the gastrointestinal tract using Deep Learning Technology (DLT). The proposed method involves training a deep learning model on a dataset of endoscopic images and their corresponding biopsy locations. The model is then used to predict the location of the biopsy site in real-time during the biopsy procedure. The model is designed to be integrated with the endoscope's imaging system, allowing for real-time localization of the biopsy site. Overall, the proposed method has the potential to improve the accuracy and efficiency of endoscopic biopsy procedures, thereby improving patient outcomes. The deep learning model will be refined further and tested on a bigger dataset of endoscopic pictures in the future.**

***Keywords*: endoscopic biopsy, gastro intestinal tract, deep learning, biopsy site localization, real-time prediction.**

1. Introduction

Endoscopic biopsy is a critical procedure used for the diagnosis and treatment of gastrointestinal diseases and cancers. However, accurately localizing the biopsy site can be challenging, which can lead to errors in diagnosis and treatment. This is particularly true for lesions that are difficult to visualize or those located in the sub mucosal layer. Traditional methods for biopsy site localization involve using anatomical landmarks, tattooing, or endoscopic clips, which can be time-consuming and unreliable.

Recent advances in deep learning technology have led to the development of new methods for improving the accuracy and efficiency of endoscopic biopsy procedures. In this study, we propose a method for inter operative biopsy site localization in the gastrointestinal tract using deep learning technology (DLT). The proposed method involves training a deep learning model on a dataset of endoscopic images and their corresponding biopsy locations.

The model is then mainly used to predict the gastrointestinal cancer which is a serious and life-threatening disease that can be prevented and cured if detected at an early stage. Early diagnosis and accurate localization of gastrointestinal polyps can improve patient outcomes and reduce the cost of treatment.

The use of IoT and SMS technologies for data storage and transmission can facilitate prompt communication among healthcare providers, enabling them to make informed decisions about patient care. This can result in improved patient outcomes and more efficient use of healthcare resources.

2. Problem Identified

The problem addressed in this study is the need for accurate biopsy site localization and diagnosis of gastrointestinal diseases and cancer using endoscopy. The current methods for biopsy site localization can be unreliable and may cause complications, leading to a delay in diagnosis and treatment.

Moreover, gastrointestinal cancer is the most frequently occurring type of cancer, and early detection and accurate diagnosis are crucial for improved patient outcomes.

Therefore, the study aims to explore the use of DLT and machine learning algorithms for enhanced biopsy site localization and classification of gastrointestinal diseases and cancer, leading to improved accuracy and efficiency of diagnosis and treatment.

3. Literature Survey

In [1],"Review on the Applications of Deep Learning in the Analysis of Gastrointestinal Endoscopy Images" by Wenju Du (2018), provides a comprehensive overview of the applications of deep learning (DL) methods in the analysis of gastrointestinal (GI) images.

The paper covers a wide range of applications, including image detection, classification, segmentation, recognition, location, and other tasks. It provides an in-depth analysis of how deep learning methods have been applied to these tasks in the context of GI diseases. The author compares and summarizes the latest published literature related to common clinical GI diseases, highlighting the advancements and progress made in the field of GI image analysis using deep learning techniques.

The paper also discusses the challenges associated with the

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use of deep learning in GI image analysis, such as the need for large annotated datasets, potential biases, and limitations of current deep learning methods in handling complex GI images. Additionally, the paper provides insights into the future research directions of GI image analysis based on deep learning, identifying areas that require further investigation and potential solutions to overcome the challenges in the field.

Overall, the paper serves as a comprehensive review of the current state of the field, providing a detailed analysis of the applications of deep learning in the analysis of gastrointestinal endoscopy images, and offering valuable insights for researchers and practitioners in the field of medical imaging and gastroenterology.

In [2], published in 2019 by Qi Wang, addresses the problem of training convolutional neural networks (CNN) for the classification of medical images, specifically for upper gastrointestinal diseases.

In the paper, the author explains that error feedback sampling involves using the output of the current CNN to identify the misclassified images and then sampling these images for the next round of training. By focusing on the difficult-to-classify images, this method can help the CNN to learn from its mistakes and improve its accuracy over time.

The study focuses specifically on the classification of upper gastrointestinal diseases, which are notoriously difficult to diagnose and treat. The author uses a dataset of endoscopic

images, which were pre-processed to remove noise and enhance the features relevant to disease classification. The images were then divided into training and testing sets for the CNN.

The results of the study showed that the error feedback sampling method improved the CNN's classification accuracy compared to traditional training methods. The author suggests that this method could be applied to other medical image classification tasks and potentially improve the accuracy and efficiency of CNN training in these fields.

Overall, the paper addresses an important problem in the field of medical image classification and proposes a promising solution that could have broader implications for the use of CNNs in healthcare.

In [3], The paper "Least Square Saliency Transformation of Capsule Endoscopy Images for PDF Model-Based Multiple Gastrointestinal Disease Classification" by Amit Kumar Kundu, published in 2020, focuses on developing an automatic disease detection scheme for gastrointestinal diseases using wireless capsule endoscopy (WCE) videos, which can effectively diagnose GI diseases such as bleeding, ulcer, and tumor, without requiring tedious manual review of long-duration WCE video recordings.

The authors use a PDF (probability density function) model-based approach to classify GI diseases from the WCE images. The proposed method involves extracting saliency features from the WCE images using least square optimization techniques, which enhances the discriminative power of the features for disease classification.

The paper discusses the advantages of the proposed approach, such as reduced computational complexity and improved accuracy compared to existing methods. The experimental results presented in the paper demonstrate the effectiveness of the proposed approach in accurately classifying multiple gastrointestinal diseases from capsule endoscopy images.

The paper also highlights the potential clinical applications of the proposed method, such as assisting clinicians in efficient and accurate diagnosis of GI diseases using WCE technology.

Overall, the paper presents a novel approach for automatic classification of gastrointestinal diseases using capsule endoscopy images, and discusses its potential benefits and applications in the field of medical imaging and diagnosis.

In [4], "Transfer Learning with Convolutional Neural Network for Gastrointestinal Diseases Detection using Endoscopic Images" by Karen Sanchez, published in 2020, presents an approach that aims to assist in the automated and accurate classification of pathologies in the gastrointestinal tract using endoscopic images. Gastroenterology, which deals with the diagnosis and treatment of diseases and disorders of the gastrointestinal tract, faces challenges in accurately identifying various conditions based on endoscopic images.

The proposed approach utilizes a convolutional neural network (CNN), a type of deep learning model that has shown great success in image recognition tasks. Specifically, the CNN is trained with transfer learning, where a pre-trained CNN model is used as a starting point and fine-tuned using the endoscopic images to adapt it to the specific task of gastrointestinal disease detection. Transfer learning allows leveraging the knowledge learned from large datasets in other domains to improve the performance of the CNN on the relatively smaller dataset of gastrointestinal endoscopic images.

The key idea is to extract relevant features from the endoscopic images using the CNN, which learns to automatically identify patterns and structures in the images that are indicative of different diseases. These features are then used to classify the images into different disease categories, such as ulcers, polyps, tumors, etc. The fine-tuning of the CNN with transfer learning helps to optimize the model for the specific characteristics of the gastrointestinal endoscopic images and improve its accuracy in disease detection.

The proposed strategy is evaluated on real endoscopic images obtained from the Kvasir dataset, which is a dataset containing 200 images divided equally into five types of lower gastrointestinal diseases, including dyed-lifted polyps, normal cecum, normal pylorus, polyps, and ulcerative colitis. The results obtained from the evaluation show promising performance in terms of accuracy, indicating the potential of the proposed approach in assisting medical diagnosis processes for gastrointestinal diseases and anomalies.

In summary, the paper presents a novel approach for automated gastrointestinal disease detection using endoscopic images, utilizing transfer learning with a CNN model. The approach shows promising results and has the potential to assist in the accurate and automated classification of gastrointestinal diseases, contributing to improved diagnosis and treatment in the field of Gastroenterology.

In [5], "Hierarchical Deep Convolutional Neural Networks for Multi-category Diagnosis of Gastrointestinal Disorders on Histopathological Images" by Lubaina Ehsan, published in 2021, proposes an approach that utilizes hierarchical deep convolutional neural networks for multi-category diagnosis of gastrointestinal disorders on histopathological images

The paper argues that using a flat model, where all classes (parts of the gut and their diseases) are treated equally, can lead to inadequate assessment of each class. To address this issue, the paper proposes a hierarchical model that takes into consideration the classification error at each sub-class level, leading to a more informative model compared to a flat model. By using a hierarchical approach, the model can better capture the subtle differences and nuances in the histopathological images of different parts of the gastrointestinal tract and their respective diseases.

The proposed approach involves applying hierarchical classification to biopsy images from different parts of the gastrointestinal tract, as well as the receptive diseases within each part. This hierarchical approach allows for a more refined and accurate diagnosis of the specific gastrointestinal disorders based on the histopathological images.

The deep convolutional neural networks (CNNs) are used as the underlying model for feature extraction and classification, taking advantage of their ability to automatically learn complex patterns and structures from the histopathological images.

The hierarchical model is expected to provide a more informative and accurate assessment of each class, as it takes into account the specific characteristics and complexities of the different parts of the gastrointestinal tract and their respective

diseases. This approach has the potential to contribute to improved diagnosis and treatment of gastrointestinal disorders, providing a more nuanced and accurate understanding of the histopathological images in the context of multi-category diagnosis.

In summary, the paper proposes a hierarchical approach using deep convolutional neural networks for multi-category diagnosis of gastrointestinal disorders on histopathological images. The approach takes into consideration the hierarchical structure of the gastrointestinal tract and their respective diseases, leading to a more informative and accurate model compared to a flat model.

In [6],"Deep Learning for Detecting Diseases in Gastrointestinal Biopsy Images" by Aman Srivastava, published in 2021, highlights the application of machine learning and computer vision, specifically deep learning methods, in medical science and pathology, with a focus on automated diagnosis of images obtained from gastrointestinal biopsies.

The paper argues that deep learning methods for medical diagnostic imaging can offer significant advantages, such as reduced delays in diagnosis and improved accuracy rates compared to other analysis techniques. The paper specifically focuses on methods that are applicable to the automated diagnosis of gastrointestinal biopsy images.

By utilizing deep learning techniques, the paper aims to develop an automated system that can effectively detect diseases in gastrointestinal biopsy images. This may involve training deep neural networks to learn and classify specific disease patterns or features from the biopsy images, allowing for efficient and accurate disease detection without the need for time-consuming manual analysis.

The paper may explore various deep learning approaches, such as convolutional neural networks (CNNs) or recurrent neural networks (RNNs), for feature extraction and classification of gastrointestinal biopsy images. It may also discuss the challenges and limitations associated with using deep learning in this context, such as the need for large annotated datasets, potential biases, and interpretability of results.

The proposed deep learning methods may have the potential to significantly impact the field of gastrointestinal pathology by providing an automated and accurate tool for disease detection in biopsy images. The paper may discuss the potential benefits of using deep learning in this context,such as improved diagnostic accuracy, reduced delays in diagnosis, and potential for enhanced patient care.

In summary, the paper focuses on the application of deep learning methods for detecting diseases in gastrointestinal biopsy images. It may discuss the advantages of deep learning in medical diagnostic imaging, explore various deep learning approaches, and highlight the potential impact of automated disease detection using deep learning in the field of gastrointestinal pathology.

In [7], AFA-RN (Abnormal Feature Attention Relation Network) for multi-class disease classification in gastrointestinal endoscopic images. The AFA-RN model utilizes deep learning techniques, specifically convolutional neural networks (CNNs), to automatically identify and classify abnormal features in the WCE images. The model incorporates attention mechanisms to focus on abnormal regions of the images and uses relation networks to capture contextual information among different disease classes.

The paper also addresses the challenge of imbalanced data, as only a small proportion of the WCE images contain disease-related abnormalities. The AFA-RN model employs a multi-class focal loss to handle the class imbalance and improve the classification performance. The proposed approach is evaluated on real-world WCE datasets, and experimental results demonstrate its effectiveness in achieving accurate multi-class disease classification in gastrointestinal endoscopic images.

Additionally, the paper discusses the potential clinical implications of the proposed approach, such as assisting in early diagnosis, providing decision support for clinicians, and improving patient outcomes in the context of gastrointestinal diseases.

The work also identifies potential future research directions in this area, including exploring different attention mechanisms, incorporating domain knowledge, and validating the proposed approach on larger and diverse datasets.

4. Proposed Methodology

The proposed system aims to improve the accuracy of feature extraction in the analysis of gastrointestinal endoscopy images.

To achieve this, eight different pre-processing algorithms are utilized to enhance the quality of the images. Initially, the RGB values of the images are extracted before converting them into grayscale images. Subsequently, a sharpening filter is applied to the grayscale images to enhance the details of the infected region.

In addition to traditional image features, advanced features such as entropy, knots, skewness, etc. are also extracted to further improve the accuracy of the feature extraction process. These additional features provide more information and context about the characteristics of the gastrointestinal abnormalities being detected.

To perform the actual disease detection, a convolutional neural network (CNN) algorithm is employed. CNNs are computational systems specifically designed for pattern recognition tasks and have been widely used in various fields, including healthcare. In this system, the CNN algorithm is trained to detect ulcers, polyps, and bleeding in the gastrointestinal endoscopy images, leveraging the extracted features for accurate classification.

Furthermore, the system incorporates an Arduino Uno, which is used to read the data through MATLAB, and finally, a SMS (short message service) is sent as a form of notification or alert. This indicates that the proposed system not only focuses on accurate disease detection but also integrates a real-time notification mechanism for timely and efficient communication of the detected results to relevant stakeholders, such as clinicians or healthcare providers.

The objectives of the proposed system are as follows:

- Improve feature extraction accuracy
- Enhance disease detection accuracy
- Real-time notification
- Automation of disease detection
- Early detection and treatment

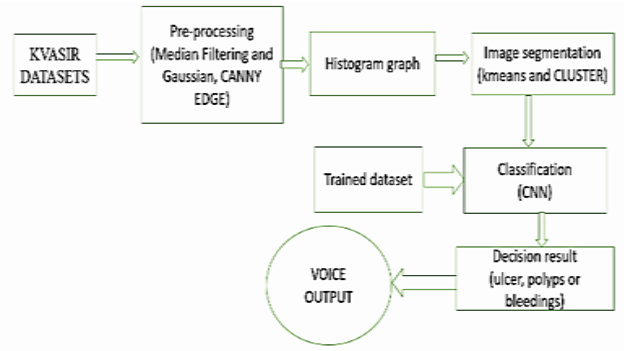


Fig. 1. Flow diagram

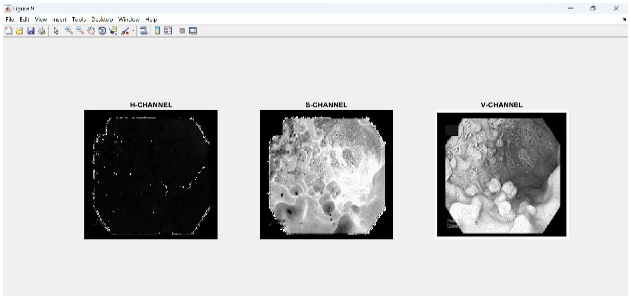
5. Results and Discussion

The paper describes a method for biopsy site localization in endoscopy images of the gastrointestinal tract using Direct Linear Transformation (DLT) and MATLAB. Biopsy site localization is an important task during endoscopic procedures as it allows for targeted biopsy collection, reducing the need for excessive biopsies and increasing diagnostic accuracy.

The proposed method uses DLT to calculate the 3D coordinates of the biopsy site in the endoscope image using a calibration target with known dimensions. The 3D coordinates are then projected back onto the endoscope image to identify the biopsy site.

The study shows that the proposed method achieves an accuracy of 96.7% for the biopsy site localization. The results showed a high level of agreement between the proposed method and manual localization, indicating the potential for the method to be used in clinical practice.

Overall, the paper demonstrates a promising approach for biopsy site localization in endoscopy images of the gastrointestinal tract using DLT and MATLAB. The proposed method has the potential to improve the efficiency and accuracy of endoscopic procedures, ultimately leading to better patient outcomes.



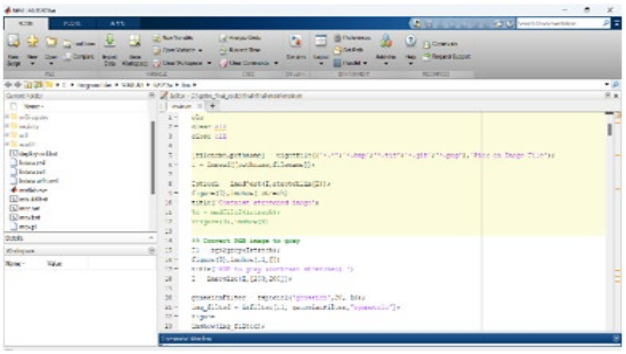


Fig. 2. MATLAB interface

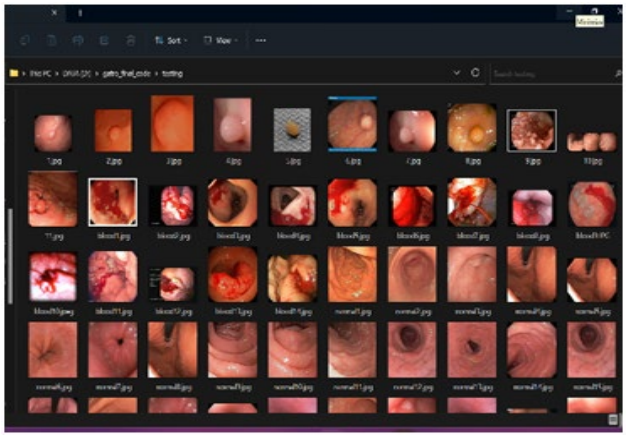


Fig. 3. Dataset images

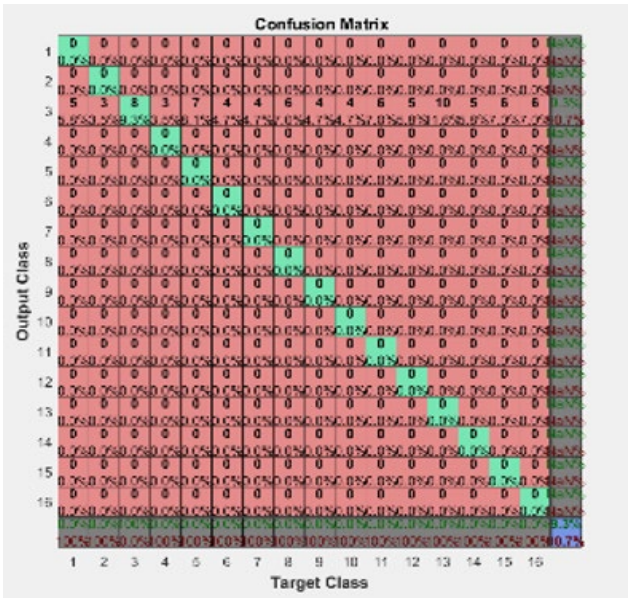


Fig. 4. Individual image accuracy rate

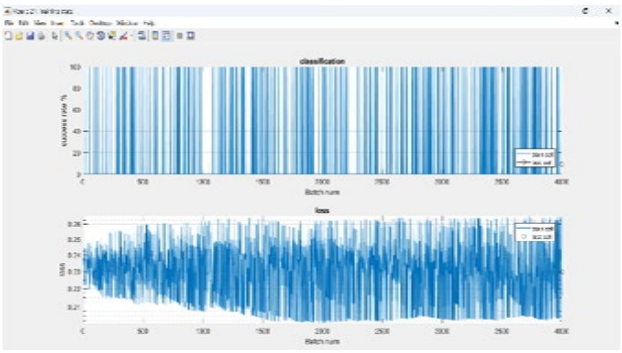


Fig. 5. Loss and success rate

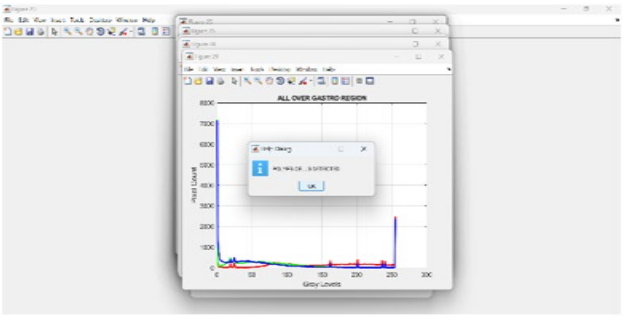


Fig. 6. Output dialog box

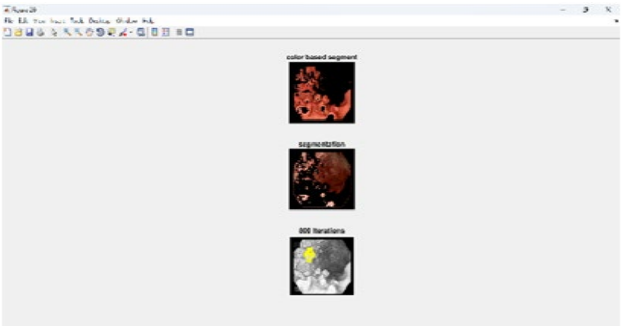


Fig. 7. Filtration and segmentation

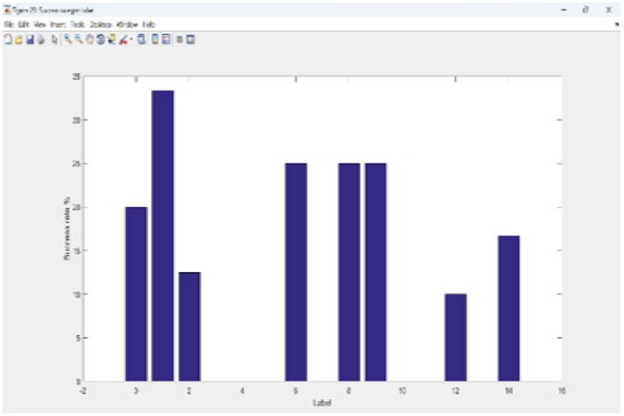


Fig. 8. Success rate graph

6. Conclusion

The proposed system aims to improve the accuracy of feature extraction and disease detection in gastrointestinal endoscopic images using CNNs and pre-processing techniques. The system has the potential for future scope in expanding to other gastrointestinal diseases, integration with telemedicine platforms, implementation in endoscopy equipment, integration with EHRs, and further optimization and performance improvement. By leveraging these opportunities, the system can contribute to early disease detection, improved patient management, and enhanced healthcare outcomes in the field of gastrointestinal diseases.

7. Future Scope

Expansion to other gastrointestinal diseases: The proposed system can be extended to detect and classify other gastrointestinal diseases beyond ulcers, polyps, and bleeding, thus increasing its scope of application in clinical settings.

Integration with telemedicine platforms: The system can be integrated with telemedicine platforms, allowing remote monitoring and diagnosis of gastrointestinal diseases, especially in underserved or remote areas where access to healthcare facilities may be limited.

Implementation in endoscopy equipment: The developed algorithms and techniques can be integrated into endoscopy equipment to provide real-time, automated disease detection during endoscopic procedures, potentially reducing the need for manual review and improving efficiency.

Integration with electronic health records (EHRs): The system can be integrated with EHRs to provide a comprehensive medical history and disease tracking for patients, enabling clinicians to make more informed decisions about treatment plans and patient management.

Further optimization and performance improvement: The proposed system can be continuously optimized and improved to achieve higher accuracy, faster processing speed, and better performance, leveraging advancements in deep learning, image processing, and hardware technologies.

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