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Advanced Detection of Small Intestine Ulcers Using Narrow Band Imaging and Hyperspectral Imaging: "A Comparative Study"

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Abstract: ***This study presents a comparative analysis of tight band imaging (NBI) and hyperspectral imaging (HSI) for early and accurate detection of small intestinal ulcers. Small intestinal ulcers, often caused by diseases such as Crohn's disease, NAID use, and bacterial infections, can lead to serious complications if not diagnosed early. Traditional imaging techniques often recognize subtle changes in the mucosa at the early stages. This study evaluates the strength of NBI in improving vascular visualization and the ability to recognize biochemical and structural variation at the tissue level. Through clinical imaging, data processing, and machine learning analyses, this study evaluates both modalities in terms of sensitivity, specificity, and diagnostic accuracy. The results show that HSI offers excellent diagnostic performance, but NBI is advantageous for practical visualization. The improved artificial intelligence through the integration of both methods indicates the important potential for gastrointestinal diagnosis conversion. The integration of both imaging methods through AI enhances early detection,improves targeted biopsies, and ultimately leads to better patient outcomes.***

Keywords: Small Intestine Ulcers, Narrow Band Imaging (NBI), Hyperspectral Imaging (HSI), Gastrointestinal Diagnostics, Machine Learning, Early Detection, Vascular Mapping, Spectral Analysis

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I. INTRODUCTION

Small intestinal ulcers are a serious clinical problem, often indicating the underlying whole body or local stomach. These ulcers can occur due to chronic inflammatory diseases such as Crohn's disease, the use of non-steroidal anti-inflammatory drugs (NSAIDs), and infections caused by Helicobacter pylori. If left untreated, serious complications such as stomach bleeding, strictures, intestinal execution, and even malignant tumors can be carried out[13][11]. Therefore, early identification of these ulcers is essential for the introduction of immediate medical interventions and the prevention of long-term morbidity. They often do not recognize subtle mucosal and vascular changes, especially in the early stages where visual information is minimal. These defects contribute to misdiagnosis or delayed diagnosis, and have a negative impact on patient outcomes. As a result, researchers and clinicians have advanced imaging modalities that provide greater sensitivity and specificity. NBI uses filtered blue and green light. This is strongly absorbed by hemoglobin, improving the visibility of microvascular structures on the mucosal surface. This improvement allows clinicians to more clearly observe abnormal vascular patterns. This is often an early indicator of ulcer changes [5]. NBI has been proven to be particularly useful in detecting superficial lesions and improving the accuracy of target biopsies.

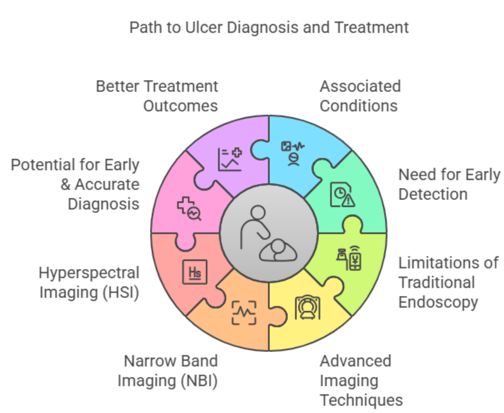

Figure 1. Path to Ulcer Diagnosis and Treatment

This technique allows detection of biochemical and structural variations that are invisible due to traditional imaging. HSIs show great potential in distinguishing between normal, inflammatory, ischemic and necrotic tissue, providing quantitative and objective analysis that can help with a more accurate diagnosis [1] [4]. Techniques such as Support Vector Machines (SVMs) and Folding

Networks (CNNSs) are increasingly being used to classify spectral features and to predict the presence of ulcers with a very accurate accuracy.

By analyzing data from both modalities and analyzing comparative performance related to AKZ. Furthermore, we examine the synergistic benefits of the combination of NBI and HSI for a more comprehensive diagnostic approach. Integration of vascular sample analysis from NBI to HSI spectra and biochemical findings could lead to the development of hybrid imaging strategies and significantly improve the detection and classification of small intestinal ulcers [7]. This paper aims to provide a systematic assessment of these technologies, to provide additional insights through advanced imaging-algorithms that can revolutionize stomach diagnosis and improve patient care in clinical settings.

Clinical Relevance

Early detection of small intestinal ulcers is of clinical importance, especially in patients with nonspecific symptoms such as mysterious anemia and abdominal litigation. Traditional imaging often does not capture ulcers in early stages, particularly in remote or rural health care systems where endoscopic expertise may be limited. The integration of NBI and HSI Technologies provides a non-invasive and improved visualization method that can be adapted to a wide range of clinical delivery. Portable, diagnostic AI-enabled AI tools with these modalities, diagnostic errors can significantly reduce and improve the accuracy of targeted organisms and reduce the total cost of healthcare systems. Early detection of small intestinal ulcers is of clinical importance, especially in patients with nonspecific symptoms such as mysterious anemia and abdominal litigation. Traditional imaging often does not capture ulcers in early stages, particularly in remote or rural health care systems where endoscopic expertise may be limited. The integration of NBI and HSI Technologies provides a non-invasive and improved visualization method that can be adapted to a wide range of clinical delivery. Portable, diagnostic AI-enabled AI tools with these modalities, diagnostic errors can significantly reduce and improve the accuracy of targeted organisms and reduce the total cost of healthcare systems.

II.LITERATURE REVIEW

In recent years, extensive research has been conducted on advanced imaging techniques for gastrointestinal diagnosis, particularly focusing on closed-band imaging (NBI) and hyperspectral imaging (HSI). These techniques have been developed as powerful tools to overcome the limitations of traditional white light endoscopy and to provide improved visualization and detailed tissue analysis. According to Yoshida et al. (2019), NBI significantly improves the accuracy of identifying small intestinal ulcers compared to traditional endoscopy by improving contrast between blood vessels and surrounding tissues [10]. This technique has proven effective in detecting active ulcers, distinguishing between inflammatory and neoplastic changes and leading to target biopsies. Research by Smith et al. (2021) showed that HSIs can distinguish healthy, ulcerated tissues based on their own spectral profiles [2]. In contrast to NBI, which focuses primarily on vascular visualization, HSI offers a more comprehensive approach with quantified biochemical and structural tissue changes, allowing for early detection of ulcers [1][2].

Comparative studies also highlight the advantages and disadvantages of both technologies. Tanaka et al. (2020) conducted a study comparing NBI with HSI to demonstrate the mapping of vascular patterns [12]. HSIs have shown to provide excellent accuracy in identifying subtle mucosal changes and ulcers at the early stages [8]. This complementary nature suggests that a combination of these techniques can improve diagnostic accuracy. The spectral analysis promised itself in reducing false negatives and improving sensitivity, and promised spectral analysis if the spectral analysis showed promising in reducing false negatives and improving sensitivity [12][13]. These studies highlight the importance of multimodal imaging strategies for better clinical outcomes. Their total application may be important for detection of ulcers in the small intestine, providing clinicians with more accurate and reliable equipment for early diagnosis and effective treatment.

III.METHODOLOGY

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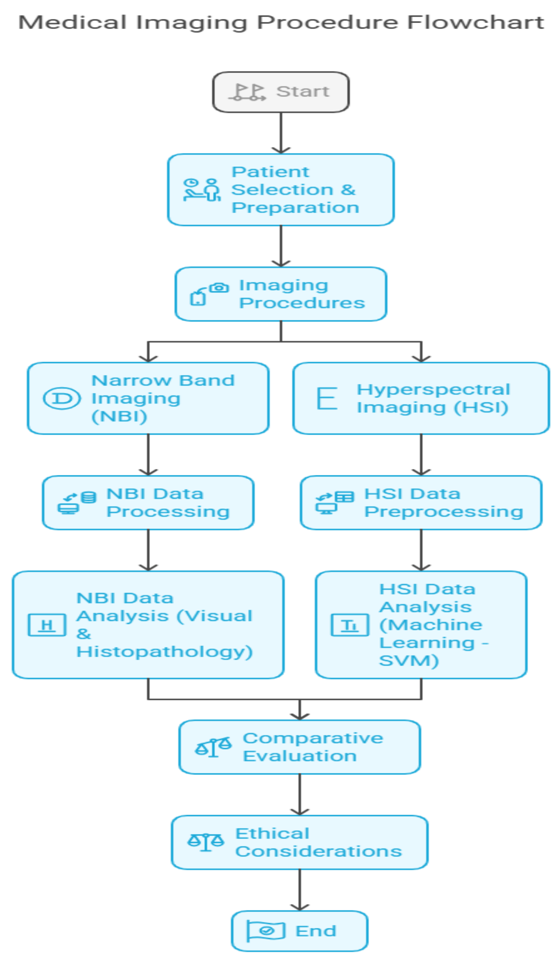


This study employs a systematic and structured approach to compare the efficacy of Narrow Band Imaging (NBI) and Hyperspectral Imaging (HSI) in detecting small intestine ulcers. The methodology is divided into the following key steps:

Patient Selection and Preparation

This study selected patients with symptoms such as small intestinal ulcers such as abdominal pain, bleeding, and anemia of unknown cause. Prior to imaging, a standard ran merging protocol is observed to ensure clear visualization of the intestinal mucosa.

Imaging procedures

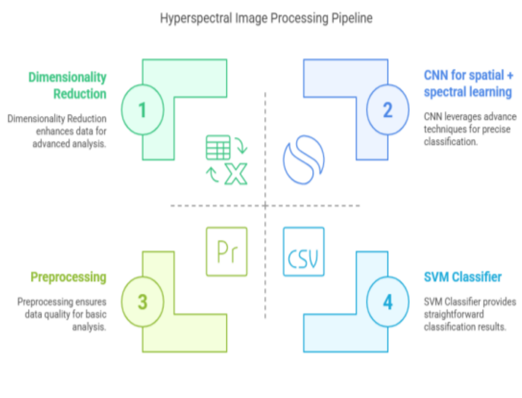
1. **Narrowband Imaging (NBI)**: NBI uses specific blue (415 nm) and green (540 nm) wavelengths to improve

mucosal surface architecture and microvascular patterns. Hemoglobin absorbs light at these wavelengths and makes the vessels appear more clearly, so this technique improves the detection of lesions by highlighting the vascular structure.

2. **Hyper-Spectral Imaging (HSI**): HSI captures a wide range of light across numerous coherent ligaments and provides detailed spectral information for each pixel in the tissue. This allows for the identification of subtle tissue abnormalities based on their own spectral signatures. In the small intestinal context, HSIs can distinguish between normal and ischemia or necrotic tissue by analyzing these spectral properties.

Image Acquisition and Data Processing

1. **NBI**: NBI is activated during endoscopy to assess mucosal surfaces. Lesions are identified based on changes in mucosal patterns and vascular structure. To correlate endoscopic findings with histopathology, the biopics goal is being implemented in suspicious areas.



2. **HSI**: HSI data is recorded using a hyperspectral camera system during endoscopy. The collected data is subjected to a prepared procedure, including calibration, to convert raw intensity values into reflective values, and to background removal to eliminate non-relevance information, and to noise reduction through techniques such as Savitzky-Golay Smoothing and standard regular variance conversion (SNV). These steps improve the quality of the spectral data for accurate analysis.

Data Analysis and Interpretation

1. NBI: Lesions are characterized based on an established NBI classification system that evaluates features such as mucosal patterns and vascular structures. Results are compared with histopathological results to determine the accuracy of the diagnosis.

2. **HSI**: Translated classification algorithms such as Support Vector Machines (SVMs) are used to distinguish between normal and ulcerated tissues based on their spectral signature. The performance of these classifiers is evaluated using metrics such as sensitivity, specificity, and accuracy.

3. **Comparative Analysis**

The diagnostic performance of NBI and HSI is analyzed by analyzing its sensitivity, specificity, and general accuracy in the detection of small intestinal ulcers. Additionally, factors such as the ability to recognize subtle mucosal changes and the practicality of the technology in a clinical setting are considered.**Ethical Considerations**

This study includes ethical guidelines to ensure a declaration of consent for all participants and to maintain patient confidentiality throughout the research process. With the systematic implementation of these steps, the purpose of this study is to provide a comprehensive assessment of NBI and HSI in the detection of clinical practice potential practices and small intestinal ulcers in the clinic.

AI-based classification approach

Hyperspectral imaging data was analyzed using machine learning models, particularly using vector machines (SVM). This process included characteristic extraction of spectral signatures, reduction of dimensions using principal component analysis (PCA), and classification of non-ulcer tissue. Collapsing networks (CNNs) were used for more complex data records, recording spatial and spectral dependencies simultaneously. Model outputs were evaluated using accuracy, sensitivity, specificity, and ROC curves.

Figure 2. Hyperspectral Image Processing Pipeline

Imaging Technique	Sensitivi-ty (%)	Specif-icity (%)	Accurac y (%)	Real-Time Capabilit y
Narrow Band Imaging (NBI)	85	78	82	High
Hyperspec tral Imaging (HSI)	92	88	90	Moderat e

Table 1. Comparative Performance of NBI and HSI Techniques

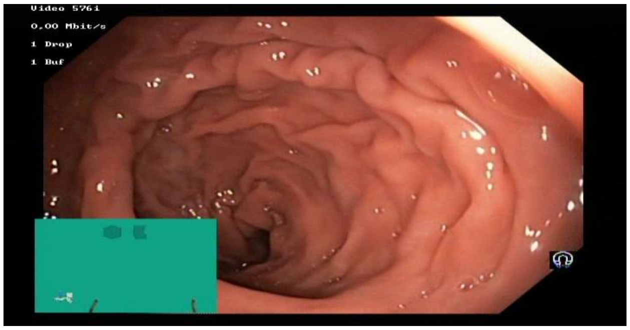
IV.RESULTS AND DISCUSSION

This photo appears to come from the early stages of the colonoscopy process, showing the interior of the colon. The colon wall is clearly visible in several circular folds (haustra), which are normal anatomy. The mucous membrane appears moist and shiny. This indicates healthy hydration and typical mucosal secretion. There are no direct signs of lesions, polyps, or inflammation. However, this photo appears to have been captured a narrower segment where the house tiger is more prominent and compact, perhaps the elevated large intestine. The illumination and clarity indicate a good view of the endoscope. The presence of "drop" and "BUF" counters on the screen indicates monitoring of the network package for real-time video transmission. The green overlay at the bottom left can refer to the navigation or mapping software used during the procedure.

Figure.4

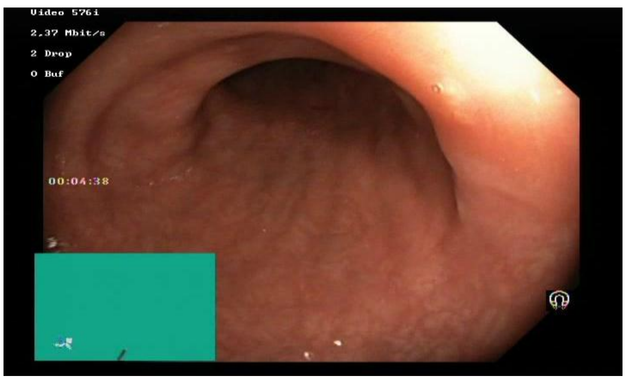
This photo shows an improvement in deeper sections of the large intestine, perhaps lateral or descent. There, the lumen is more expanded and appears to be a wider area of the house tiger. The mucosal surface is relatively smooth and healthy pink, indicating normal angiogenesis and lack of active pathology. The timeline and data overlay indicate that this is a video recording used for clinical records and subsequent reviews. In this view,

Figure.3



There is no visible presence of polyps, ulcers, or inflammation. This usually indicates a healthy colon. The visualized lumens appear symmetrical and unobstructed. This allows the endoscope to proceed easily. The tool position at the bottom left of the photo is the real-time alignment of the endoscope. Overall, this snapshot shows a normal section of the colon that is not aware of acute abnormalities or lesions.

Figure.5



The third image shows segments of the large intestine, perhaps a sigmoid rectum or rectal range, where the walls appear less folded. The mucosal cladding remains consistent with texture and coloration, and is smooth and even visible without providing structural irregularities. Lack of projection, abnormal pigmentation or bleeding indicates healthy sections. Due to insights during the procedure to improve vision (air introduction), perhaps a little more of the large intestinal wall can be seen here. The bitrate improvements in the data overlay (2.37 Mbit/s) indicate an improved video quality for this recording. This is supported by a clearer diagnostic evaluation. The lower left quadrant still contains endoscopic navigation graphics, which helps correlate anatomical position during colonoscopy. This image contributes to confirming normal stomach intestinal status that does not show pathological findings of this segment. This supports optimal visualization and continuity of complications, with no complications, at this stage.

V.ACKNOWLEDGMENTS

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VI.FUTURE SCOPE

This study opens several avenues for future research and development:

1. Real-Time HSI: Improving processing speed to enable real-time hyperspectral imaging during endoscopy.
2. AI Integration: Using deep learning models for more accurate and automated ulcer detection.
3. Multimodal Systems: Combining NBI and HSI into a single device for comprehensive diagnostics.
4. Portability: Developing compact and cost-effective HSI system for widespread clinical use.
5. Expanded Trials: Conducting larger clinical studies to validate results across diverse patient groups.
6. Wider Applications: Applying these techniques to detect other gastrointestinal issues like tumors and inflammation.
7. Cloud Support: Implementing Cloud-based platforms for remote data analysis.
8. Robotic Integration: Merging imaging technologies with robotic endoscopy for precise diagnostics.

IMPACT AND BENEFITS

The comparative analysis of Narrow Band Imaging (NBI) and Hyperspectral Imaging (HSI) offers significant advantages in clinical practice:

1. Early Diagnosis: Both imaging methods, especially HSI, enhance early detection of small intestine ulcers, enabling timely treatment and better patient outcomes.
2. Non-Invasive Precision: These techniques reduce the need for invasive diagnostics by accurately visualizing and analyzing mucosal changes.
3. Improved Clinical Decisions: AI-driven HIS classification provides objective, data-backed insights that support accurate diagnosis and targeted biopsies.
4. Cost-Effectiveness: Early detection reduces long-term treatment costs by preventing ulcer-related complications such as bleeding and perforation.
5. Advancement in Gastroenterology: This research contributes to the evolution of diagnostic tools, encouraging the adoption of AI and spectral imaging in routine endoscopy.
6. Potential for Broader Use: The methodologies can be adapted for detecting other gastrointestinal conditions, including early cancerous lesions.

VII.CONCLUSION

This comparative study highlights the intensity and limitations of tight band imaging (NBI) and hyperspectral imaging (HSI) in the detection of ulcers from the small intestine. While NBI offers real-time visualization with improved vascular contrast, HSI provides excellent diagnostic accuracy through detailed spectral analysis and classification of machine learning. However, NBI continues to be valuable for simple integration and immediate visual feedback during endoscopy.

This study shows that a multimodal imaging approach combining the intensities of both methods can significantly improve gastrointestinal diagnosis. Furthermore, the integration of artificial intelligence into imaging technologies paves the way for more accurate, faster, and less invasive clinical procedures.

This work highlights the diagnostic potential that AI supports in forming the basis for future advancements in medical imaging and improving patient care and outcomes.

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