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Review on Abnormalities Detection from Medical Video Endoscopy using Deep learning Approaches

[1]Vijaya Patil, [2]Diksha Pawar, [3]Sheela Hundekari, [4]Pravin Yannawar
[1 2 3 4]Department of Computer Science, Dr. Babasaheb Marathwada University, Chh. Sambhaji Nagar. MH-431001.
Email: [1]vijaya.cse.msc@gmail.com, [2]dikshasalunkhe97@gmail.com, [3]Sheelahundekari90gmail.com, [4]plyannawar.csit@bamu.ac.in

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Abstract

Endoscopy serves as a vital tool for identification and evaluation of GI diseases, with its capabilities further strengthened by inclusion of deep learning techniques. Early detection of such a GI disease such as polyp, lesion, and ulcer is very important for prevention serious complication like cancer crucial for effective treatment. . The application of artificial intelligence (AI), most notably deep learning, into medical video analytics has evolved into an innovative approach to this challenge. Systematic literature review (SLR) examines 42 studies to provide a systematically overview of detection abnormalities from endoscopic video using deep learning. It include CNN successfully use for detect, classification, segmentation on endoscopic images. Review systematically examines the powerful impact of deep learning on endoscopic videos, highlighting its current strengths and limitations. Future research directions are investigated, which special strategies outlined to tackle current challenges and enable the inclusion of deep learning into clinical workflow. This eventually aims to advance medical imaging technologies, resulting in one precise, individualized and optimized healthcare for patients.

Introduction

Endoscope is long, thin, flexible tube with a tiny camera with light. It is use in endoscopy to visualize inside body for diagnose and treat a number of internal organs, including the digestive system. Human health is seriously threatened by diseases of the digestive tract, including malignant growths of the colon, stomach, small intestine, esophagus, and other digestive organs. Gastrointestinal system is examined using a variety of endoscopic techniques such Colonoscopy, bronchoscopy, gastroscopy, pressure enteroscopy [1]. Upper GI endoscopy Examines the esophagus, stomach, and the first part of the small intestine a colonoscopy looks at the rectum and the entire large intestine. Capsule endoscopy (WCE) involves the patient swallowing a tiny, disposable capsule that contains a wireless camera that records images as it naturally travels through the digestive system, mainly the small intestine, which is challenging for traditional endoscopes to reach. To minimize medical expert's attention and time, it is essential to detect regions of interest within immense amount of collected video data [2]. For detection abnormalities such as Polyp, inflammation, lesion, cancer, ulcer etc in the examined human organ is the primary goal of an endoscopic procedure [3]. Early detection of such a chronic disease is very important for prevention serious complication like cancer. As result, the screening procedure can significantly lower both the death rate and treatment expenses. In particular, the deaths are caused by various gastrointestinal cancers, which can be

cured if they are discovered before they become malignant growths. However, video endoscopy is an uneasy process that requires time and expertise [4]. GT imaging is essential after the age of fifty for the early identification of a number of abnormalities, including polyps, erosions, ulcers, and bleeding. In healthcare, for detection and analysis of abnormalities use deep learning models. Its capacity to examine large-scale data and extract key insights allows for significantly improves predictive accuracy and efficiency. Additionally, deep learning is particularly effective at working with unstructured data [5].

1. Abnormalities in Gastrointestinal Tract

a) Lesion: lesions are initial symptoms that might point to serious medical condition like cancer.It can be characterized as any abnormal modification in the body's tissue or organs, which can result from a number of factors, such as inflammatory processes, infections or abnormal cell growth. Numerous organs, including the gastrointestinal tract, respiratory system, urinary tract, and reproductive system, might have lesions [5].

b) Polyp: To effectively prevent colorectal cancer(CRC),polyps must be detected early. Visual esxamination using endoscopic videos is the most used technique for this procedure. However, because there are several sources of mistakes and incorrect diagnoses, the clinical examination is insufficient [6]. To reduce this miss rate, researchers are developing computer-aided polyp detection (CAPD**)** systems using deep learning. While existing disease detection methods offer potential, they often struggle with accuracy and speed, especially in real-time clinical settings [7].

c) Ulcer: Ulcer is one of the most prevalent abnormalities in the gastrointestinal (GI). Roughly 10% of people worldwide suffer from ulcers. They can happen along the GI tract and are erosions in the mucosal lining. Serious conditions like ulcerative colitis and Chron's can occasionally are caused by ulcers. Endoscopy procedures are used in medicine to identify GI tract ulcers [8]. Deep learning of AI is powerful for detection of ulcer [9]

d) Helicobacter pylori: An endoscopic examination help in the diagnosis of H.pylori infection. H. pylori-positive gastritis is characterized by atrophy, diffuse redness, mucosal swelling, enlarged folds, and modularity [10]. H.pylori is one of reason of Gastric cancer .In a study conducted in Japan, gastric cancer developed (over a mean follow-up of 7.8 years) in 2.9% of patients with peptic ulcer, dyspepsia, or gastric hyperplasia who had H. pylori infection, whereas no cases were detected in uninfected patients with these conditions [11].

e) Inflammation: Inflammation is a common manifestation of gastric abnormalities, encompassing conditions such as dyspepsia, chronic gastritis, and acid reflux, which are typically linked to inflammation of the gastric mucosa.It causes the risk of exacerbation and dysplasia. However, detection of persistent histologic inflammation is not easy using conventional endoscopy [12].

f) Cancer: Colorectal cancer (CRC) accounts for the second largest number of cancer-related deaths worldwide. Precancerous polyps with mean domicile duration of more than ten years are the cause of colorectal cancer (CRC). According to the National Polyp Study, routine colonoscopies and removal of polyp can prevent between 70% and 90% of colorectal Malignant growths [13] Pinto et al extract all the frames from the original CE video. Using CNN, input images then classified as “Normal” or “Abnormal”. Then he combines the “abnormal” frames to generate the summarized video. Finally video contain abnormalities [14]. Fig 1.Shows endoscopic images with abnormalities.

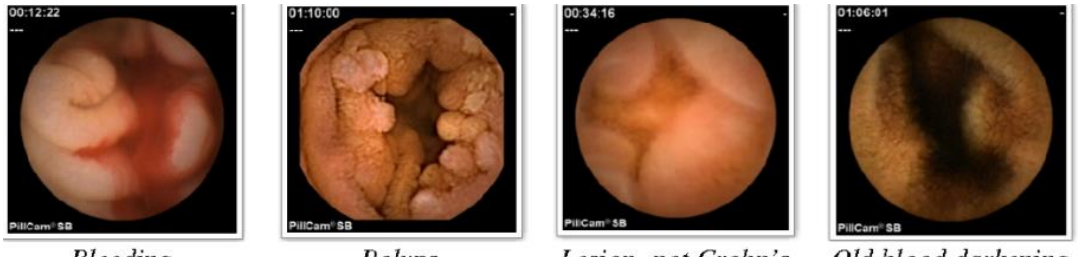

Figure 1: Sample endoscopic images of the GI tract with the presence of abnormalities

Literature Selection Methodology and Technical Foundations

The identification and detection of gastrointestinal tract abnormalities is a challenging task.To exceed the earlier results, an efficient and effective deep learning-based algorithm, HGANet, is proposed by minimal pre-processing and optimized augmentation

operations of endoscopic images of Kvasir dataset and skewed Kvasir-Capsule dataset for detection of human gastrointestinal tract abnormalities[15]. Ruwan *et.al* propose a new multi-texture analysis method that effectively distinguish images showing mucosal abnormalities from the ones without any abnormality since most abnormalities in endoscopy images have textures that are clearly detectable from normal textures using an advanced image texture analysis method. The method uses a "texton histogram" of an image block as features. The histogram captures the distribution of different "textons" representing various textures in an endoscopy image Corresponding recall and specificity for colonoscopy videos are 91% and 90.8%, respectively [16]. Ayoub *et. al* choose KELM classifier because it showed very good performance dadasasc compare to SVM and RF classifier[1]. Konstantin *et. al.* introduced two novel multi-class classification techniques, one involving the deep learning neural network strategy and another novel multi-class classification algorithm involving global image features for the detection, he tested available localization methods on the basis of deep learning neural networks and tested them against our first localization method. [17]. Samir *et. al*a deep CNN model for the identification and localization of GI anomalies in WCE images. The model operates in two phases, In the first phase an input image is passed through an attention based CNN classifier with 11-layers which classifies the image into one of the four categories namely, inflammatory, polyp, vascular, or normal. [18]. Huang *et. al* uses two milestone CNN architecture namlely AlexNet and GoogLeNet for classification ulcer and non ulcer .He examine and analyze the image identifies as containing ulcer object using CNN[19]. Ayyaz *et. al* selected two different CNN models (VGG19 and Alexnet) for detection of endoscopic lesion. He proposed methodology consists of seven steps, such as data acquisition, preprocessing, feature extraction using VGG19 and Alexnet, transfer learning, feature selection using a genetic algorithm, feature fusion, and classification [20].

Table 1: shows A deep learning model achieve high accuracy of various abnormalities.

Sr. NO	Application Area	Best Reported Accuracy	Notable Deep Learning Models	Citation
1	General GI Abnormalities	99%	Custom CNN, DenseNet, ResNet	Aoki *et. al.* [21]
2	Gastric lesion	92.31%	ResNet50, EfficientNet B0	Lee *et. al*. [22]
3	Colon leasion	91.50	DLGNet	Wang *et. al.* [23]
4	Ulcer Detection (Crohn's, etc.)	95%	CNN, VGG-Net, GoogleNet	Alasker *et .al*. [24]
5	Polyp Detection	94%	SSD, Faster R-CNN, fine-tuned DNNs	Ayoub *et. al*. [1]
4	Esophageal Abnormalities	93.7%,	3D Sequential DenseConvLstm	Ghatwary *et.al*. [25]
5	Video Summarization	93%	Pre-trained CNN	Pinto *et. al.* [14]

Methods and Technique

1. Datasets

HyperKvasir dataset: There is prominent variation in the HyperKvasir dataset anatomical coverage and pathological findings. It contains 374 endoscopy videos (approximately 9.78 hours in total) and 8, 89,372 frames, spanning the upper and lower gastrointestinal (GI) tract. These are organized into 30 classes, such as ulcers, polyps, and cancer, and include variations in size, resolution, and imaging modality. The videos are stored in .avi format and reflect real-world endoscopic practice, with differences in scope models, operators, and acquisition settings [26].

The CVC-ClinicDB dataset: The CVC-ClinicDB dataset includes 612 frames taken from colonoscopy videos,which feature numerous instances of polyp. The region of images that polyp involves is represented by a mask which serves as a ground truth. CVC-ClinicDB has been generated from 25 different video studies. For each study at least a sequence containing a polyp was extracted. Considering this, CVC-ClinicDB database is composed by frames from 29 different sequences containing a polyp. Finally, a set of frames was selected from each sequence, paying particular attention in showing several points of view of the polyp [27].

2. Deep learning task

Deep-learning-based techniques are playing a crucial role in the production of authentic and more detailed results of digestive track diseases. DL techniques have shown improved performance in many cases, challenging due to the diversity of patterns and the complexity of textures of the abnormalities [18]. The results by using deep-learning-based approaches are more accurate than manually. As diseases like polyp, cancer, ulcer are increasing day by day, it is very important to develop a reliable and powerful system that automatically detects such diseases at an early stage [20].Two fundamental machine learning issues are segmentation and classification. A system that categorizes or divides the lesion areas in the context of disease detection is known as a CADx system [28DL architectures refer to neural networks with large amounts of hidden layers. Recently, DL methods have been regarded as the most advanced AI techniques by virtue of their state-of-the-art performances, especially deep convolutional neural networks (DCNNs) have brought breakthroughs in image processing. .Figure 1 shows architecture of DL. The training of DL methods is usually divided into two categories: supervised learning and unsupervised learning [29].

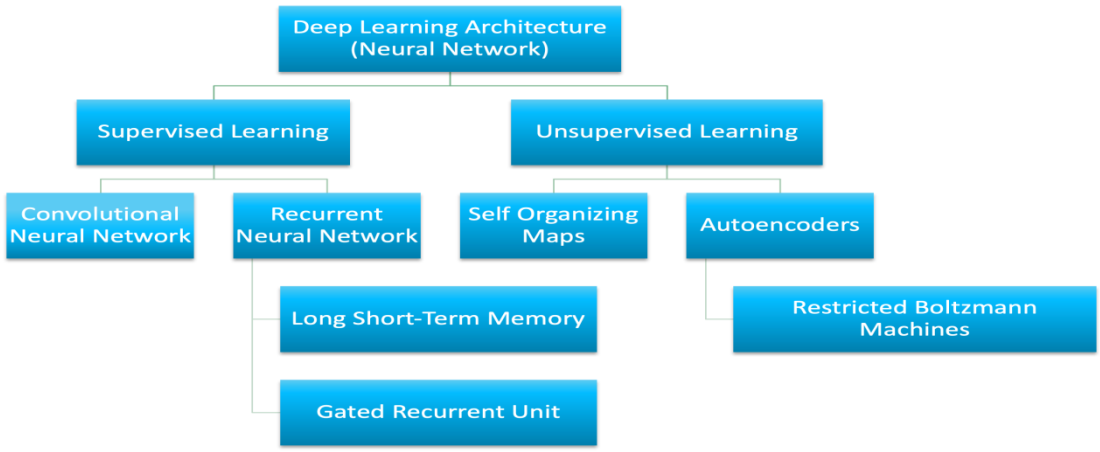

Figure 1. Architecture of Deep Learning

a. Supervised deep learning

Deep Learning which contain supervise neural network having multiple layer. It is useful for detection of abnormality from endoscopic images and videos .for detection of lesion from endoscopic video frame using CNN, R-CNN with VGG16 which is one of the frequently used deep neural network models for object recognition (Yamada) DL architectures based on the supervised manner in GI image analysis. The most popular deep models used in GI image classification are LeNet, AlexNet, VGGNet, GoogleNet, ResNet and so on [29].

- **Convolutional Neural Network**

Often these layers are stacked together in a simple CNN, and more complex CNN models can contain many layers. hundreds of layers CNNs have automatic feature learning that significantly enhances the endoscopic image analysis. Accuracy and efficiency of image processing. Studies have shown that CNNs can effectively perform tasks such as polyp detection, lesion classification, and region recognition [30].GoogLeNet and AlexNet are usually applied for feature extraction and classification and yield very good results. For example, they have been used in medical data analysis, including anatomical applications. CNN has been proved to be a powerful model to extract robust features from images, it is often treated as a feature extractor to generate features fed to classifiers [31] .CNN models were used to detect polyps in colonoscopy videos. Each CNN model used individual features, including texture-, shape-, and color-based ones, which were combined with temporal

information to detect the occurrence of polyps**[**32]. We analyze various approaches including the traditional methods and the most recent ones that use for machine learning based approaches. CNN was recently reported to be highly beneficial in the field of endoscopy, including esophagogastroduodenoscopy (EGD), colonoscopy, and capsule endoscopy (CE)DL-based medical technology, such as the automatic detection of cancer or pathological endoscopic findings and more accurate decision-making, are currently or soon to be in use in our daily lives[33].An example of GI image by CNN is shown in Fig 3.in first step input the image and then it extracted by first layer of convolutional then activate function after that it use pooling layer. most of this techniques use for detetection abnormality such as leasion.in study researchers get high accuracy[34].CNN architecture on GI images shows in Figure2.

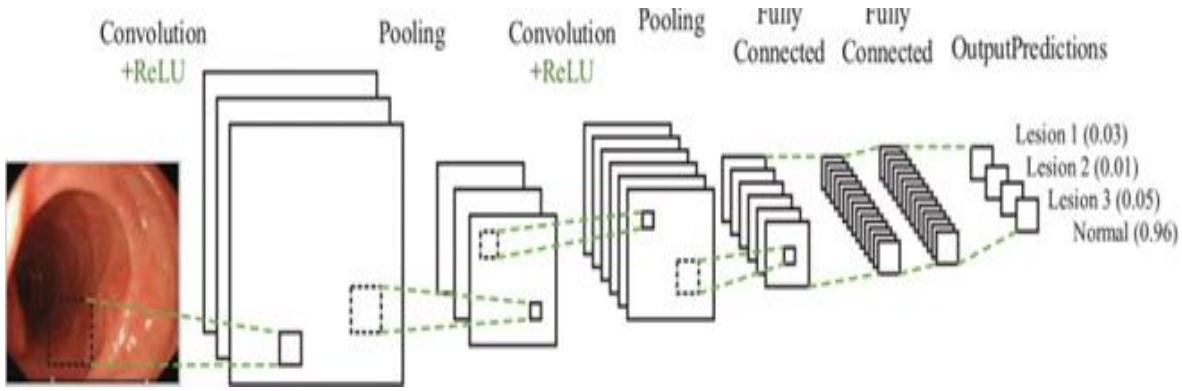

Figure 2.CNN architecture on GI images

- **Recurrent Neural Network:**

RNNs (Recurrent Neural Network) are used in deep learning to analyze sequential data such as video frames and Recurrent neural layers (RNNs) are used to process a sequence of input data to extract feature or produce another sequence [34].RNNs could map input sequences to output sequence and are more capable in serialized data processing. For example, the work in combines RNNs and CNNs together, which allows the processing of all contextual information regardless of image size[29].Faster-RCNN is the first detector so far that replaces hand-crafted ROI selection step with a network i.e., the regional proposal network (RPN) towards fully end-to-end fashion, Object detection is driven by the success of region proposal methods and region-based convolutional neural networks (RCNNs) [35].

2. Classification

The use of deep learning in classification of endoscopic images has achieved impressive development, Not only do these methods enhance the effectiveness of diagnosis but they also increase the range of use of the endoscopic technology, CNNs have high potential in the domain of endoscopic image classification using deep learning [36]**.** Abnormalities in endoscopic video frames provide semantic information, guiding the selection of relevant frames. This section examines previous research on detecting abnormalities in endoscopy videos and extracting contextual information for frame classification [2]. Classification is supervised learning task where the model arranges input data into one of the several predefine classes. Deep learning has significantly advanced the classification and detection of abnormalities from medical videos, such as endoscopy, echocardiography, and seizure monitoring. Detection based on two different approaches first one is single video frames (CNN approach) and another is frame sequences, i.e., taking CNN+long short-term memory (LSTM) approach is hybrid DL model which is effectively capture both spatial features and temporal dynamic in sequential data, In step 1 is preprocessing in that Video frames were first resized to 224 x 224 pixel resolutions [37]. The images that contained extraneous background and text so that in step of preprocessing remove test and unwanted background. Eighty percentage data were used for twenty percentage for testing. after preprocessing data is ready for experiment in next step. After that disease detection and classification were implemented with appropriate mechanism. In this study detect lesion with appropriate classification method. In final step evaluated quantitatively and qualitatively using appropriate evaluation metrics and visualization techniques as shown in fig 2.[38].

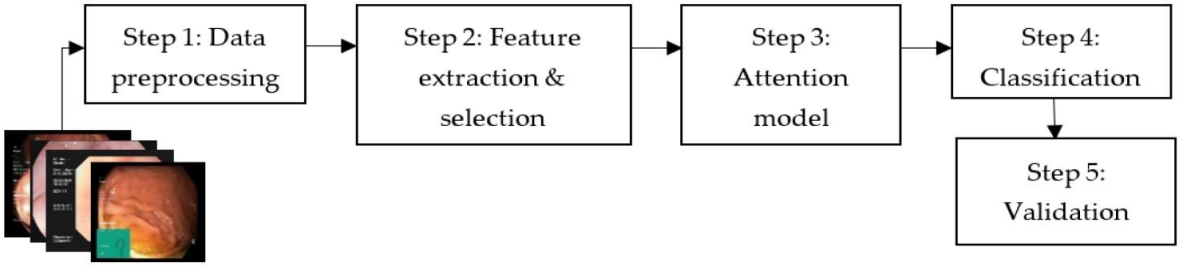

Figure 3.CNN model for lesion classification.

3. Segmentation:

Image segmentation involves partitioning an image into parts or areas in order to detect objects or things of interest. Image segmentation aims at simplifying the process of depicting an image as logical and aesthetically significant parts, These segments find applications in various fields, including object recognition, image manipulation, and medical image analysis [39]. The DeepPoly model uses a DoubleU-Net architecture which stacked one U-net network on another U-net network to perform polyp segmentation and classification also Another example is a deep learning method based on UNet++ and VGG-16, used for accurately delineating the resection margins of early gastric cancer [36]. One endoscopic picture can have several types of tissue and all such areas should be chosen and classified into the classes, which are discussed by the specialists, segmentation problem is solved in many ways. The result based segmentation is relied on when each pixel of the image is classified to belong to one of the classes [40] .The initial phase of this study, the focus was on detecting and segmenting abnormalities in the human gastrointestinal (GI) system. The researcher proposed approach used a specialized convolutional neural network model, GISegNet, which was trained and tested using the Kvasir dataset, with an emphasis on semantic segmentation tasks which is shows in figure 4 performance of GISegNet was compared to existing segmentation models, such as UNet and PSPNet.[41].

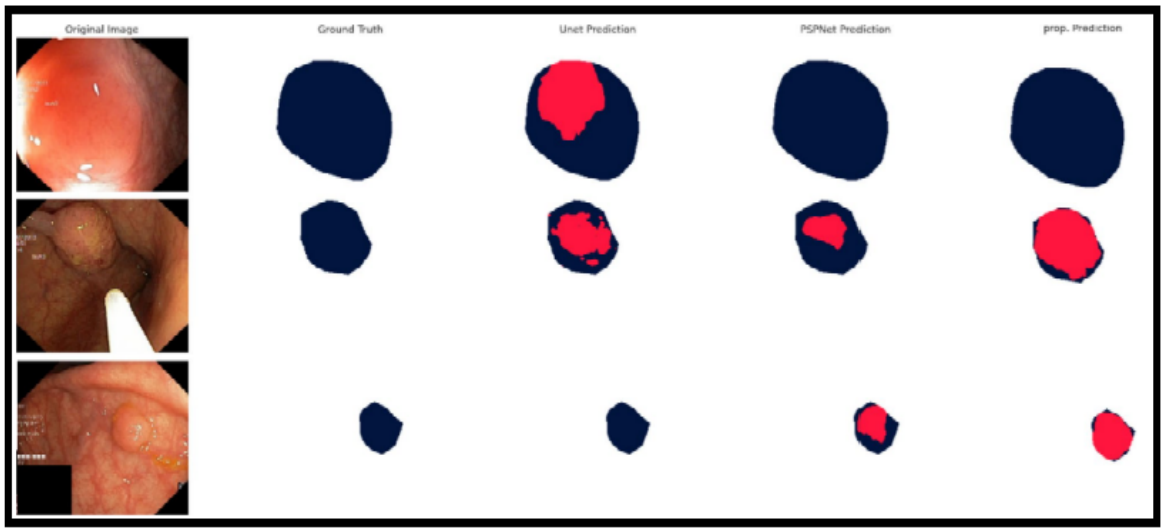

Figure 4.comaprision in segmentation GISegNet and other segmentation model with HyperKvasir dataset

The researcher can use deep neural network to partition anatomy of endoscopy images a few approaches have been proposed by the researcher to partition areas of the images in the medical world. Fine-tuning of SegNet to segmentation of cancer in endoscopic frames of GI tract is possible. Deep convolutional network can also be used to divide various types of mucosal structures. Random fields used in modeling human discrimination and can also be helpful when mixed with CNN as idea presented in[4].UNet and ResNet34 is backbone network for segmentation. Seven models, including U-Net, UNet++, ResUNet, ResUNet++, DeepLabV3,

Feature Pyramid Network (FPN), and Swin-Unet V2, were implemented and benchmarked in one study using the Kvasir-SEG dataset under a standardized experimental framework with consistent preprocessing, augmentation, and evaluation metrics. With a Dice Coefficient of 0.9140 and an IoU of 0.8433, U-Net++ proved to be the best model among those tested, indicating its exceptional capacity to identify intricate polyp borders. Although it had a higher processing cost, transformer-based Swin-Unet V2 also demonstrated encouraging results in capturing long-range relationships [42].

Research Outlook

Deep learning systems' excessive dependence on sizable, high quality, annotated datasets is one of their main disadvantages. Due to privacy restrictions, case availability limitations, and the high expense of expert annotations, many medical institutions find it difficult to obtain sufficiently large and diverse datasets. Therefore, trained models might become prepossession or fall short in capturing abnormalities. Excellent real-time performance however, researchers often build deep networks with additional parameters and constraints to improve accuracy, which lengthens computation times and complicates real-time viability. Understanding lightening systems for effective real-time computation is therefore crucial for future research directions.

Conclusion

Deep learning techniques, particularly advanced segmentation architectures, have shown promising result in detecting gastrointestinal abnormalities from endoscopic video. Model such as U-Net, UNet++, ResUNet, ResUNet++, DeepLabV3, Feature Pyramid Network (FPN), and Swin-Unet V2 were explored for this purpose. The research indicated that by leveraging like UNet++, system can effectively identify and delineate abnormal tissue, offering significant clinical value by supporting gastroenterologists detection of GI abnormalities, improving diagnostic consistency, and reducing the time required for manual evaluation.

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