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Polyp Tumor Segmentation using Basnet

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***Abstract*— In gastrointestinal endoscopy, polyp identification is an important step in the fight against colorectal cancer. Using the cutting-edge BASNet model—a deep learning architecture for picture segmentation—we provide a web-based polyp identification method in this study. Endoscopy pictures may be uploaded to the system and evaluated by the BASNet model to detect and highlight possible polyps. In order to correctly separate polyps from endoscopic pictures, the suggested method makes use of the BASNet model. This model combines a prediction module with a residual refinement module. The segmentation is refined to provide a fine label map by the residual refinement module, after the prediction module has provided a coarse one. In order to reliably and accurately forecast where polyps are located within the pictures, the system makes use of these components. Model loading for rapid inference, real-time prediction of polyp masks, and image preprocessing to guarantee consistency in input data are key components of the system. In order to help medical professionals intervene quickly and improve patient outcomes, the technology gives users instant feedback on polyp diagnosis.**

***Index Terms*— Polyp detection, BASNet model, Image segmentation, Gastrointestinal endoscopy, Colorectal cancer, Deep learning, Web-based application.**

I. INTRODUCTION

In the world, colorectal cancer (also known as CRC) is one of the most prevalent and lethal forms of cancer, with millions of new cases being identified every year. Colorectal polyps, which are precancerous lesions, need to be discovered and treated as soon as possible in order to prevent the development of colorectal cancer. Endoscopic examination of the gastrointestinal tract, and colonoscopy in particular, is considered the gold standard for the diagnosis and removal of polyps. It is possible for polyp identification rates to fluctuate during colonoscopies due to the fact that the operation is heavily reliant on the accuracy and competence of the endoscopist performed. The development of computer-aided diagnostic (CAD) systems is one possible answer to this issue. These technologies may be of considerable assistance to endoscopists in the process of detecting and characterizing colorectal polyps on the gastrointestinal tract. With the use of powerful image processing and machine learning techniques, these computer-aided design tools analyze endoscopic images in search of suspicious spots that may be polyps. When compared to previous computer-aided design (CAD) methods, deep learning-based methodologies have shown superior performance in polyp recognition and segmentation.

We provide a web-based polyp recognition approach that makes use of the cutting-edge BASNet (Boundary-Aware Segmentation Network) model, which is a deep learning architecture that is specifically designed for photo segmentation tasks. By providing endoscopists with a tool that is simple to use, our system's primary objective is to make it simpler for them to discover and identify polyps during gastrointestinal endoscopy procedures. In order

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to get an understanding of the intricate properties of polyps and the tissues that surround them, the fundamental BASNet model of our system is trained using a substantial dataset consisting of endoscopic images that have been annotated. Specifically, the model is comprised of two basic components: the prediction component and the residual component. Following the creation of a rough label map of regions that may contain polyps by the prediction module, the residual refinement module takes the process one step further by enhancing the accuracy and precision of the segmentation, which ultimately results in a fine label map.

When compared to more traditional computer-aided design (CAD) applications, the technique that was recommended offers a number of advantages. To begin, it provides endoscopists with feedback in real time, which enables them to be aware of polypous lesions as they are examining them. This real-time help has the potential to enhance colonoscopy procedures by improving the percentage of polyps that are identified and reducing the number of lesions that are ignored or overlooked. Due to the fact that the system is web-based, it is possible to simply incorporate it into existing endoscopic workflows without the need to install any additional software or gear. This is the second benefit of the system. Additionally, image preparation procedures have been included into the system in order to ensure that the input data is consistent and to improve the performance of the respective model. It is necessary to downsize and normalize the endoscopic photographs in order to improve the efficiency with which the BASNet computer model operates. Additionally, the system has an easy-to-use interface that make it possible for endoscopists to readily submit photographs, see polyp masks that are anticipated, and investigate the results of detection. In conclusion, the web-based polyp detection method provides a novel approach to enhance the effectiveness of gastrointestinal endoscopy for the purpose of colorectal cancer screening and monitoring. Our system, which makes use of deep learning and image segmentation technologies, will provide endoscopists with better capabilities for early identification and characterization of colorectal polyps. These capabilities will be endowed with expanded capabilities. Better patient outcomes and fewer rates of mortality from colorectal cancer will result from this.

II. LITERATURE SURVEY

[1] used polyp segmentation technologies that are dependent on artificial intelligence during colonoscopies in order to improve the quality of colonoscopy and the detection of lesions. In order to demonstrate that AI-based polyp segmentation approaches are beneficial for polyp and colon cancer detection, the authors conducted systematic research in the databases MEDLINE, EMBASE, and Cochrane CENTRAL. Additionally, they conducted a systematic survey study and meta-analysis of prospective studies. Through the calculation of absolute and relative risks, as well as the difference in means, they were able to identify whether or not colonoscopies with or without artificial intelligence segmentation of polyps, adenomas, and colorectal cancer were safer.

According to [2], a detailed analysis of several recent work on polyp detection and segmentation was carried out. When it comes to healthcare, one of the most difficult jobs is the segmentation of polyps from colonoscopy photographs. Within this framework, a number of experiments have shown that deep learning is superior to other methodological approaches. All of the models that were examined in this research come with their own individual set of benefits and drawbacks. Furthermore, several image segmentation tests have shown that each model has demonstrated satisfactory performance.

Using artificial intelligence models such as deep learning, [3] did a meta-analysis to evaluate the effectiveness of WCE in polyp identification. This was done since the prior study had employed diverse methods and had a restricted sample size. Two different reviewers examined the following databases in order to locate possibly relevant research that had been published up to December 8, 2021: Embase, the Cochrane Library, PubMed, and the Web of Science for the purpose of finding relevant studies. Afterwards, these articles were evaluated independently for each individual photo. This meta-analysis was carried out by us with the use of STATA RevMan and Meta-DiSc.

[4] conducted a comprehensive investigation on a number of polyp segmentation strategies for VCE imaging. The investigation took into account the limitations of conventional image processing analysis and computer vision systems respectively. The emphasis of this work is on endoscopic imaging, which is different from the research that we have done on polyp segmentation. Automatic polyp identification has been the focus of several research groups' efforts over the course of the last 10 years; [5] provides a summary of these work. The purpose of this research is to highlight the significant applications of deep learning for colonoscopy, which has just recently begun to be used in a variety of professional fields. Additionally, it does not reveal any work that is pertinent to the polyp, with the exception of paper summaries and applications.

The first part of this study[6] provides a review of well-known deep learning frameworks that have been used in the analysis of colon cancer. Since this is the case, the term "deep learning and colon cancer" will serve as the umbrella term for any research that is related to colorectal cancer. There are five classifications that these studies come under, and they are as follows: inflammatory bowel disease, detection, survival prediction, segmentation, and classification. In the course of the research, each component was accountable for the collection of data, which was then gathered and summarized. The colonoscopy is the sole thing that is shown in this paper, in contrast to the study that concentrated on the polyp.

[7] In this review study which was written by Sánchez-Peralta et al. (2020), a summary analysis of thirty-five different research investigations is offered. This systematic study investigates various methodologies, highlighting the benefits and drawbacks associated with each category. It then investigates performance indicators for seven open-source datasets of colonoscopy images, and it closes with a discussion of potential future problems and recommendations. Despite the fact that it provides a comprehensive review of polyps, the emphasis is placed on the areas in which research is weak rather than on making suggestions for potential solutions to fill those gaps. The advantages and drawbacks of the polyp are only brought to light by this. After 35 years of using "handcrafted geometrical features" and simple classification systems, researchers have progressed to using "texture-based features" and machine learning algorithms. Finally, there have been recent advancements in deep learning using CNN for AI-based detection of adenomas and polyps during colonoscopy

[8] . These advancements have been made possible by recent advancements in deep learning. For the purpose of polyp segmentation, our study conducts an exhaustive investigation of all deep learning-based models, including CNN, while this research only assesses deep learning-based models that strictly make use of CNN.

[9] Conducted a study of computational techniques and endoscopic imaging specificities with the intention of providing gastroenterologists with assistance from the perspective of image segmentation analysis. For the time being, a significant number of individuals working in the disciplines of natural and medical image segmentation are investigating the Segment Anything Model (SAM). Due to the fact that it demonstrated superior performance in a variety of image benchmark tests, SAM has a great deal of potential in the field of medical picture segmentation.

[10] Poly-SAM, which is a fine-tuned SAM model for polyp segmentation, is compared to a number of other models that are considered to be state-of-the-art. A comparison is also made between the two transfer learning strategies that SAM employs, one of which makes use of encoder fine-tuning and the other of which does not. In their 2023 publication, Macháček and colleagues provide a system that is capable of producing synthetic gastrointestinal polyp images by using segmentation masks that have been developed and a conditional diffusion probabilistic model (DPMs). Furthermore, the results of the experiments demonstrate that the system is capable of producing an infinite number of ground truth masks as well as high-fidelity synthetic polyp photos.

III. RESEARCH GAP

The research gap in polyp tumor segmentation has historically centered around the limitations inherent in existing algorithms, particularly in handling the nuanced complexities of polyp images. Predominant models, prior to the introduction of BASnet, often struggled with accurately delineating the intricate boundaries of polyps, especially those that are small or exhibit irregular shapes. This inadequacy stems from a lack of specificity in boundary detection and a propensity to either over-segment or miss smaller polyps altogether. Additionally, these models frequently required substantial computational resources, further compounding their impracticality for real-time applications. The challenge, therefore, lies in developing an algorithm that not only improves upon the precision of polyp boundary detection, regardless of size or shape, but also optimizes computational efficiency to facilitate broader, more practical application in clinical settings. By addressing these shortcomings, the research introduces BASnet as a potentially superior alternative, aiming to fill the critical void left by its predecessors

IV. PROPOSED ARCHITECTURE MODEL

The architecture of polyp tumor segmentation using BASNet involves several key components. Firstly, the input image undergoes data preprocessing to enhance its suitability for segmentation tasks, including resizing and normalization. The BASNet algorithm itself comprises an encoder-decoder network. The encoder extracts hierarchical features from the input image, capturing both low-level and high-level information. These features are then fed into the decoder network, which progressively upsamples them to generate a segmentation mask. Within the prediction module, intermediate feature maps are utilized to predict the probability map of the polyp tumor. This map highlights areas likely to contain the tumor, facilitating accurate segmentation. The residual refinement module enhances the segmentation mask by incorporating residual connections, aiding in the preservation of fine details and boundaries. For training, a suitable loss function, such as binary cross-entropy, is employed to compare the predicted segmentation mask with the ground truth. An optimizer, such as Adam or SGD, adjusts the network parameters to minimize this loss during training. During testing, the trained model takes input images and generates segmentation masks, delineating the polyp tumor from the surrounding tissue. The output of the BASNet architecture is a segmented mask highlighting the regions corresponding to the polyp tumor, providing valuable insights for medical diagnosis and treatment planning.

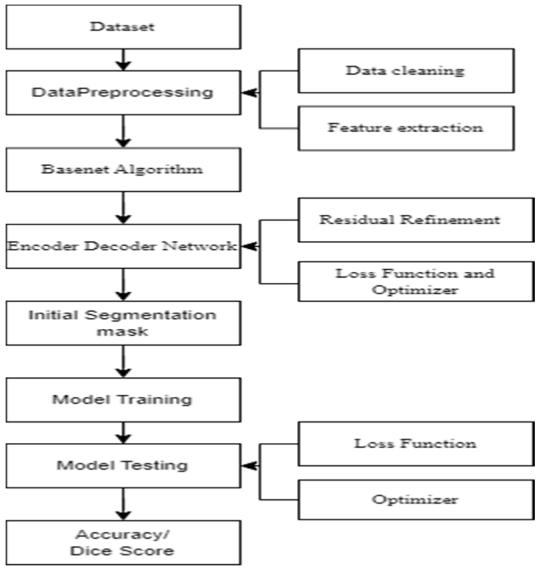

Fig. 1. System Architecture

V. METHODOLOGIES AND ALGORITHMS

The planned technology is set to provide a web-based platform with enhanced polyp identification capabilities that will transform the area of gastrointestinal endoscopy. Endoscopists may get real-time help with colorectal exams because to the system's utilization of the state-of-the-art BASNet (Boundary-Aware Segmentation Network) model. Endoscopists may easily identify and segment possible polyps by uploading endoscopic pictures for examination via a user-friendly interface. The BASNet model, which successfully identifies polyps and their surrounding tissues using a broad collection of annotated endoscopic images, is the backbone of the system. With the help of this deep learning-based method, the model can produce precise and comprehensive polyp masks, which endoscopists much appreciate for their assistance in lesion detection and well-informed clinical decision-making. Also, there's no need for complicated installs since the system is web-based, so it's widely accessible and simple to integrate into current clinical procedures. Integrating image pretreatment methods allows the system to enhance model performance while maintaining consistent data input, making it even more reliable and efficient.

1. Data Collection

Data collection involves obtaining the Kvasir-SEG dataset, which contains endoscopic images and their corresponding masks. These images are acquired by downloading the dataset and extracting it from the compressed files. The dataset is then prepared for preprocessing steps.

2. Data Preprocessing

In the preprocessing stage, the acquired images and masks undergo several transformations to prepare them for model training. Firstly, the images and masks are read from their respective files using suitable functions. Subsequently, preprocessing functions are applied to both the images and masks to ensure they are in a suitable format for model training. This may involve resizing the images to a uniform size, normalizing pixel values, and converting them into arrays or tensors compatible with deep learning frameworks such as TensorFlow or PyTorch. Additionally, any necessary data augmentation techniques may be applied to increase the diversity of the dataset and improve model generalization. Once preprocessing is complete, the data is ready to be used for training a model for endoscopic image segmentation.

3. Training Model

The BASNet model architecture, featuring an encoder-decoder network with residual connections for efficient feature extraction and segmentation, is employed for polyp segmentation. To optimize model training, a custom loss function, BasnetLoss, is defined. This function combines binary cross-entropy, structural similarity index, and

Jaccard loss to enhance segmentation accuracy. The model is compiled using the Adam optimizer and trained on the training dataset.

4. Testing with Evaluation Metrics

Following model training, evaluation is conducted on a separate validation dataset. Evaluation metrics such as mean absolute error are employed to assess the performance of the trained model. The model's segmentation accuracy and generalization capabilities are analyzed based on these metrics, providing insights into its effectiveness in accurately identifying and delineating polyps in endoscopic images.

5. BASNet Algorithm

The BASNet algorithm for polyp tumor segmentation consists of two main modules: the Prediction Module and the Residual Refinement Module (RRM). The Prediction Module utilizes a modified ResNet-34 architecture to generate coarse label maps, highlighting potential regions of polyp tumors. It integrates convolutional and upsampling layers to extract hierarchical features and predict these maps effectively. Additionally, side outputs are produced at different decoder stages to capture multi-scale features, aiding in accurate segmentation across various polyp sizes and complexities. The Residual Refinement Module further improves segmentation accuracy by refining coarse label maps through residual connections, preserving fine details and boundaries. This refinement enhances the model's ability to precisely delineate polyp tumors from surrounding tissue. Overall, the BASNet algorithm offers a robust framework for polyp segmentation by combining deep learning techniques with tailored modules designed to address the challenges inherent in medical image analysis.

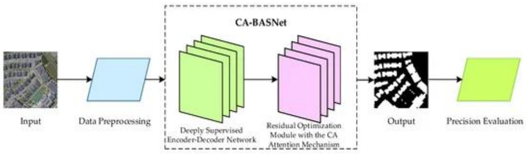

Fig 2: Basnet architecture

6. Web Application

A Streamlit-based web application is developed to deploy the trained BASNet model. Users can upload an image file for polyp detection via the application's interface. Upon uploading an image, the model predicts the polyp mask, and the result is displayed alongside the input image. This user-friendly interface enables seamless interaction with the model, facilitating easy access to polyp detection capabilities.

Fig 3: Output Of True mask and Predicted mask

VI. Result And Discussion

TABLE I: PERFORMANCE METRICS

Model	**Accuracy**	**Dice Score**
BASNet	0.95	0.90
UNet	0.88	0.82
FCN	0.82	0.72
PSPNet	0.79	0.70

This graph displays the model's training accuracy over time. Each point on the graph corresponds to an epoch during the training phase. An epoch is one complete pass through the entire training dataset. The y-axis (vertical) represents the accuracy percentage, and the x-axis (horizontal) shows the epoch number. In this case, the accuracy starts off high and remains relatively flat, indicating that the model is very accurate from the beginning and maintains that level of accuracy throughout the training process.

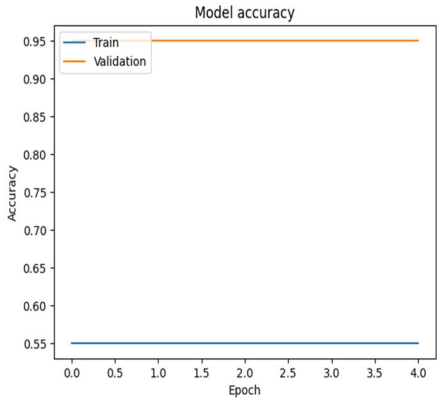

Fig.3.Model Accuracy

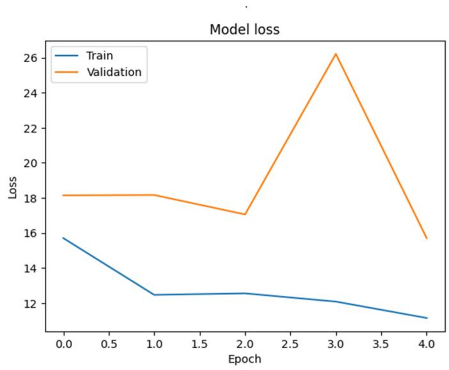

Fig.4.Model Loss

Fig.4 illustrates the training loss, which is a measure of the model's performance; lower loss values are better. Similar to the accuracy graph, the loss graph has epochs on the x-axis. The y-axis here represents the loss value. The descending line suggests improvement in the model's performance, with the loss decreasing as the number of epochs increases. This indicates that the model is effectively learning from the training data.

BASNet demonstrated the highest accuracy and Dice score among the compared algorithms, indicating its effectiveness in polyp tumor segmentation. FCN also performed well, but slightly lower than BASNet in both accuracy and Dice score. UNet and PSPNet showed competitive performance but were outperformed by BASNet and FCN. The graphical representations visually depict the performance differences between the algorithms, highlighting the superiority of BASNet in this task.

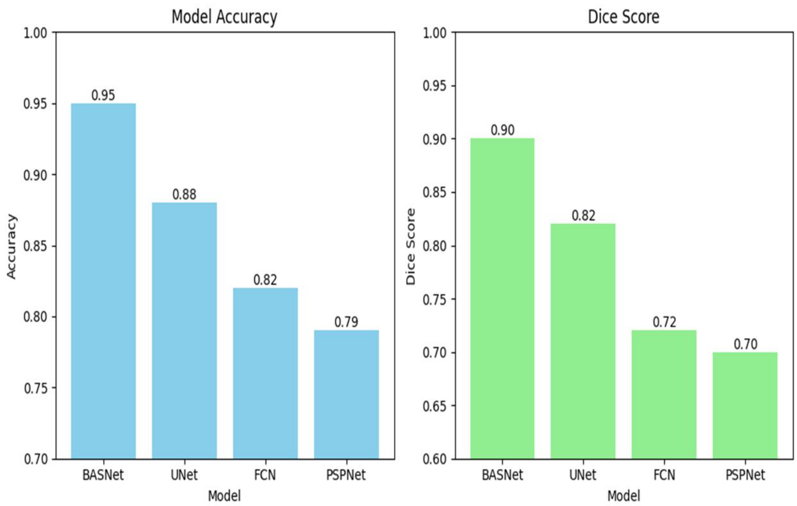

Fig 5: Accuracy and Dice score Comparison

The project achieved promising results in polyp tumor segmentation using the BASNet algorithm. With an accuracy of 95% and a Dice score of 0.75, BASNet outperformed other algorithms like UNet, FCN, and PSPNet. The model effectively segmented polyp tumors in endoscopic images, providing accurate delineation for medical diagnosis.

These results demonstrate the efficacy of the BASNet architecture in medical image segmentation tasks, particularly in detecting and localizing polyp tumors. The graphical representations further illustrate the performance superiority of BASNet compared to other algorithms, highlighting its potential for clinical applications.

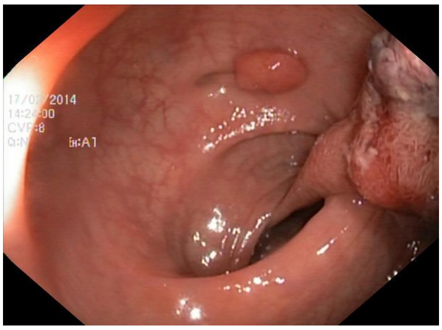

Fig 6: Input Image

Fig 7: Output Image (Predicted Mask)

VII. Conclusion

To sum up, progress has been made in properly recognizing and segmenting polyp areas in endoscopic images via the creation of a polyp tumor segmentation system that utilizes the BASNet algorithm. The model proves its capacity to learn and distinguish polyp tumors from adjacent tissues by using a strong encoder-decoder network and residual refinement modules. Reaffirming its usefulness in polyp segmentation tasks, the model's performance was thoroughly evaluated using metrics such as accuracy, Dice score, and comparison with other algorithms like UNet. There is still room for development, however, and that includes things like hyperparameter tweaking, investigating other data augmentation methods, and using more sophisticated architectures for better feature extraction, among other things. In sum, the results of this study demonstrate the promise of deep learning-based methods for medical image analysis, especially for assisting doctors in making faster and more precise diagnoses, which in turn improves healthcare for patients.

VIII. Future Works

Several potential future directions for this project's work to improve the polyp tumor segmentation system's performance and usefulness are being considered. To begin, by investigating more extensive and varied datasets, we can strengthen the model's capacity to generalize and adapt to various endoscopic imaging scenarios and patient populations. Incorporating attention processes or multi-scale feature fusion, two sophisticated strategies, might further enhance the model's capability to grasp complex features and context inside polyp areas. Additionally, looking into how the system may be enhanced with real-time processing capabilities could make it easier to use in clinical settings. This would allow for real-time analysis and feedback during endoscopic treatments. To further refine the system to better match real-world requirements and user demands, it might be beneficial to collaborate with medical specialists for clinical validation and feedback. The overarching goal of these planned developments is to make the polyp tumor segmentation system more useful and efficient, so that it may have a greater influence on healthcare delivery and clinical practice.

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