

AUTOMATIC DIGESTIVE TRACT INFECTION DETECTION THROUGH WIRELESS CAPSULE ENDOSCOPY

Abstract

Patient monitoring via remote is becoming increasingly important as medical imaging technology advances. The internet of things (IoT) is incorporated in medical technology to collect data from the human body via sensors, wireless communication, and other means. The intersection of medicine and information technology, such as medical informatics, will improve healthcare by lowering costs, increasing efficiency, and saving lives. Wireless capsule endoscopy (WCE) is quickly becoming a valuable tool for diagnosing illnesses in the human digestive tract. Using WCE, physicians diagnose several disorders in the digestive tract such as ulcers, bleeding, polyps, chronic diarrhoea, small intestine cancer/tumor, and Crohn's disease in an intrusive manner. The main disadvantage associated with WCE is that the huge number of recorded images must be examined by clinicians. It is a tedious and time-consuming task. Researchers are working to build and improve the efficacy of WCE by employing software to detect these diseases at a rapid rate of advancement. This paper presents an automated ulcer detection method through wireless capsule endoscopy. Based on this various researcher's ideas suggested approach can lessen the work required of doctors to review WCE videos and accurately identify ulcerous frames.

Keywords: Internet of things, Gastro intestinal Disease, wireless capsule endoscopy.

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I. INTRODUCTION

Among the syndrome of many dangerous diseases present in human digestive system, Ulcer is one of the most malformations observed in GI tract. Ulcer are the partial erosion in the mucosal lining along the GI tract, most commonly occurring at the soft linings such as duodenum, stomach, esophagus, and jejunum. Though ulcer is very common disease which occurs in the human population has an approximate effect of 10% of world population. Ulcer also has its chronic effect in serious diseases such as chro's and ulcerative colitis. Detection of ulcer on the GI tract are medically detected through endoscopy techniques. Endoscopy techniques are the basic technique of detection which is practiced over the last 5 decades. However, endoscopy techniques are quite painful and this endoscopy method couldn't visualize the minute areas of the small intestine in GI tract [Vani V., et al 2020]. For visualizing the ulcer precisely in the small intestinal area, wireless capsules endoscopy (WCE) techniques are excessively used. WCE provides a painless solution for visualizing the image of entie GI tract [Abdullah Al manu., et al 2019]

Description of WCE: These are pill sized capsule which can be easily swallowed, where the personhas to be on a diet for the last 12 hours. The Capsule (WCE) consist of many parts for visualizing and capturing the images. It collectively contains optic dons, LEDs, CMOS cameras, ASIC circuit, antenna, and a battery [Meryem souladi., et al 2017]. WCE starts to take images moving from the digestive tract simultaneously the colored images are captured in the entire GI tract which approximately takes 6 hours [K.Priya, K.S Archana et. al., 2015]. The frame rate is approx. 50000 images obtained within a time period of 8 hours. The various methods used to detect the ulcer through wireless capsule endoscopy, as shown in Figure 1. The rest of the paper id organized in the relevance of related work, case study of endoscopy detection using WCE, ulcer detection images, challenges, and conclusion.

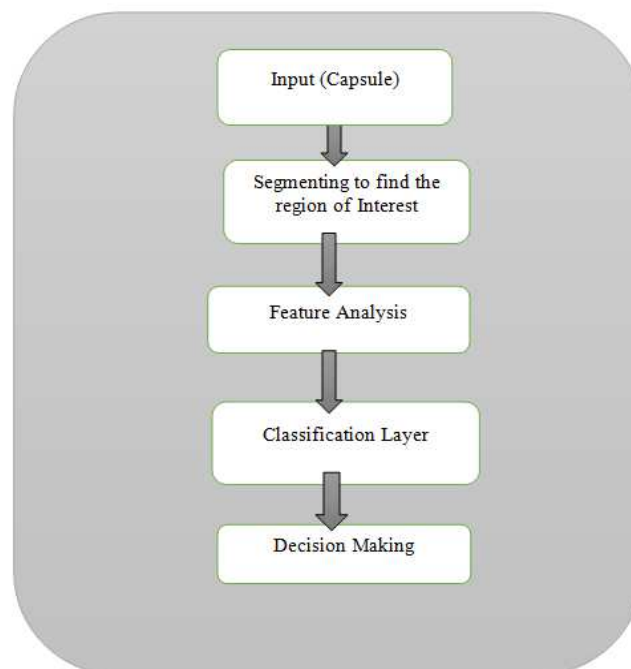


Figure 1: Architecture of ulcer detection through wireless capsule endoscopy

1. **Related Work:** There have been many efforts made by researchers to automate ulcer detection systems. In the clinical perspective, bleeding detection is essential because it is used to identify many GI tract diseases. According to the statistics report released by the American Cancer Association in 2016, about 305000 Americans are affected by digestive tract cancer, including 132000 women and 173000 men; 153000 of these people have died due to digestive tract diseases [1], including 64000 women and 89000 men. To reduce the burden of physicians for detecting bleeding, various types of computer-aided systems have already been introduced into WCE images. As a result, these techniques produced unsatisfactory results in terms of sensitivity and specificity.

2. **Clinical sector in Image Processing:** Image processing in medicine is concerned with developing problem-specific processes for enhancing raw medical image data to enhance selective visualization and analysis. Medical image processing covers a wide range of topics: some focus on general applied theory, while others are focused on specific applications [T. Ghosh, A. Das, and R. Sayed]. In the field of medical image processing, there are a number of challenges:
 - Image Analyzing to predict the disease.
 - Accurately segment the interested features to find the disease through automation.
 - The registration and fusion of multimodal images can be automated and accurate
 - Identifying and classifying image features, i.e. characterization and typing of structures.
 - It is essential to develop integrated clinical systems that combine medical expertise, engineering skills, physics skills, and computer skills. Designing, implementing, and validating complex medical systems requires both medical expertise and the collaboration of biologists, engineers, physicists, and computer scientists.

As a result, conventional or traditional detection and analysis algorithms have limited success. In many medical applications, poor image quality leads to unreliable feature extraction, analysis, and recognition. Through various development of automation this problem can be solved. Hence, the researchers from various countries had handled various methods for prediction [T. Aoki, A. Yamada, K. Aoyama et al 2019].

Experiment	No. of Patients	Dataset	Algorithm	Accuracy
Yuan et.al.,2017	62 Patients	300 images	CNN, DenseNe	98%
Li and Meng.,2009	10 Patients	200 images	CAD,SVM	90%
Karargyris and Bourbakis et. al. 2011	10 Patients	600 images	SUSAN edge detector, discrete curvelet transform (DCT)	97%
Fu et al.2014	20 Patients	607 images	pixel based methods	95%
Saraiva et, al.,2021	24 Patients	728 images	CNN	96.9%
Nadimi et. al., 2019.	255 Patients	1695	CNN	98%

The literature on automatic ulcer detection has seen a lot of work. Based on the kind of features they employ for ulcer detection, such as color, texture and texture features, these approaches can be divided into three groups. In [Yeh J.-Y., Wu T.-H et. al. 2014], it was once more suggested to use color and textural cues to assess the condition of the small intestine and spot bleeding and ulcers in WCE pictures. In this method, authors first extracted color features using the RGB, HSV, and color coherence vector, and then extracted texture features using the grey-level co-occurrence matrix (GLCM). Additionally, techniques for feature selection included One Rule (oneR), SVM-recursive feature elimination, and Relief. In [19Szczyński P., Klepaczko et. al. 2014], a three-stage paradigm for pathology segmentation and identification was presented. In the work indicated above, pixels were categorized according to the neighborhood's texture properties. A novel vector supported convex hull approach was then used to perform the classification. Complete LBP and global-local oriented edge magnitude pattern descriptors were merged in a similar study [Charfi S., and El Ansari et. al. 2017].

- 3. Ulcer Detection through Wireless Capsule:** The wireless capsule endoscope (WCE) is becoming an increasingly useful tool for detecting problems in the digestive system. Using WCE, physicians can diagnose various abnormalities in the digestive tract, including ulcers, bleeding, polyps, chronic diarrhea, small intestinal cancer/tumors, and Crohn's disease. By utilizing software that detects these diseases at a rapid rate of advancement automatically, researchers are working to develop and improve the performance of WCE. WCE is composed of three basic components: a capsule endoscope, a sensor system, and a computer with an operating system that allows for the inspection and explanation of images. There are different sensors attached to the abdomen and waist in the WCE system. As well as sensors, we will include a data recorder. By using these sensors, the capsule can wirelessly transmit images. A glass of water is then consumed by the patient after swallowing the capsule. Images are taken by the capsule as it passes through the digestive tract. After transmitting wirelessly, the data is received by the receiver and stored in a data recorder. As shown in figure 2, the wireless capsule endoscopy offers an inside look at the internal workings and experiments. In some cases, the clinician will need to examine frame-by-frame a video of approximately 55,000 images. Hence, automatic detection is an immediate necessity since WCE is time-consuming (2-3 hours required).



Figure 2: Wireless capsule endoscopies with camera

As per [S. Liangpunsakul et. al., 2003] Probabilistic neural networks are applied to detect bleeding portions and are also improved to detect bleeding portions with greater precision. To detect the bleeding region accurately, [Sivakumar et al. 2019] used a super pixel technique with a Naive Bayes classifier. The model, however, has only been trained with two statistical features and has not been validated using the other available techniques. By multiple random training datasets and the application of the support vector machine, it is possible to reduce the information loss up to a statistically significant level [Rebecca L. Siegel et. al. 2016].

Several breakthroughs have been made in classification tasks using deep learning methods based on the convolutional neural network (CNN). The application of deep learning to ulcer recognition by using a large WCE dataset of large volume to provide adequate diversity. This is due to the difficulty of mathematically describing the great variation in shapes and features of abnormal regions in WCE images and the powerful ability of deep learning to extract information from data. A neural network model based on autoencoders, proposed by [Yuan and Meng et., 2017], introduces an image manifold constraint to a sparse autoencoder in order to recognize polyps in WCE images. The manifold constraint can preserve large intervariances between images and small intravariations between images within a category by forcing images belonging to the same category to share similar features. In this study, 3,000 normal WCE images and 1,000 WCE images with polyps extracted from 35 videos of patients were used to test the proposed method. Using 3D convolution to detect polygons in WCE videos has also been explored [L. Yu, H. Chen et. al. 2017]. It is also possible to diagnose ulcers using deep learning methods. In these studies, CNN models are trained and evaluated using off-the-shelf models. Deep learning methods are clearly superior to conventional machine learning methods based on experimental results and comparisons in these studies.

- 4. Ulcer recognition in deep Convolutional Neural Network:** Diagnoses of ulcers can also be made using deep learning methods. There is no doubt that deep learning methods are superior to conventional machine learning methods, as demonstrated by experimental results and comparisons in these studies [S. Fan, L. Xu, Y. Fan, K. Wei et. al., 2018]. Based on our analysis of ulcer sizes, we find that most ulcers only occupy a tiny area. Deep CNNs can generate feature hierarchies by layering features inherently. A shallow layer produces high-resolution hyper features with poor representation capacity; a deep layer produces high-resolution deep features with poor representation capacity [T.-Y. Lin, P. Dollar et. al., 2017].

Deep learning techniques based on CNN are known to perform effectively. With the development of numerous deep CNN designs, including AlexNet, VGGNet, GoogLeNet, and ResNet [K. Simonyan and A. Zisserman et. al. 2014], the error rate in computer vision challenges has drastically dropped. Examples include ImageNet and COCO. Based on various research the dataset's ulcer size analysis reveals that most of the ulcers only take up a little portion of the entire image. Deep CNNs can layer-by-layer compute feature hierarchies. In contrast to deep features from deep layers, which are semantically robust but have poor resolution, hyper features from shallow layers have great resolution but lack representation capacity [W. Liu, D. Anguelov, D. Erhan et al 2016]. These characteristics lead us to suggest a framework that combines deep and hyper properties in order to recognize ulcers at very diverse scales.

II. CHALLENGES OF MEDICAL DIAGNOSIS

This paper presents an automated ulcer detection method through wireless capsule endoscopy. Based on this various researcher's ideas suggested approach can lessen the work required of doctors to review WCE videos and accurately identify ulcerous frames. The WCE image is first pre-processed for improvement. Second, the ulcerous zones are identified using color and texture-based segmentation utilizing the saliency map. Clinicians distinguish an ulcer from a WCE image primarily on a few key pieces of information. To mimic a doctor's diagnosis, texture and colour saliency maps are used in this instance. Thirdly, the segmentation procedure may produce false positive results when attempting to pinpoint the exact position of the ulcer or segment only a tiny portion of it. In order to recognize the segmented regions, the automatic classification phase is crucial and will be useful.

All of the published algorithms have three main flaws:

- Given that the suggested approaches were tailored to over fitting with produce the highest detection accuracy outcomes for the relevant datasets;
- With small set of dataset the researchers found good accuracy
- With large dataset that the network had not yet seen were assigned to the test set, which resulted in a huge testing dataset and moreover, during the training process, the network self-determined the best set of features from the data. Therefore, with the advanced various algorithms the infections are identified easily and their accuracy was improved.

III. CONCLUSION

The utilization of internet of things has reduced the burden on the clinician for the detection of disease through data storage and the timely treatment in the future. This has reduced the cost, increased the efficiency of the treatment and saved lives. Deep learning techniques based on CNN are known to perform effectively, with the development of numerous deep CNN designs, including AlexNet, VGGNet, GoogLeNet, and ResNet, the error rate in computer vision challenges has drastically dropped. Although, there are few flaws that needed to be worked out in order to improve the accuracy of the outcomes. The development of modern pharmaceutical either drugs or devices are in the need of the hour for the betterment of social well-being.

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