Exploring Deep Learning Concepts for Detection and Classification of Colonic Polyps

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ABSTRACT

Computer-aided diagnosis (CAD) has become a prominent tool of the decade for the diagnosis of various diseases affecting the mankind. The second most common cancer among women and the third most among man with high fatality rate is Colon Rectal Cancer (CRC).The intestinal/colonic polyp is the precursor for most of the CRC. Early diagnosis and removal of the polyp is the most effective way to prevent CRC. Colonoscopy, an endoscopic modality is the most recommended and efficient method for the diagnosis of colonic polyps. In most cases an expert endoscopists may miss about 20% to 30% of polyps. Artificial intelligence (AI) and deep learning (DL) techniques has made remarkable progress in the medical field. These modern techniques may offer real time diagnosis of colonic polyps and enhance the performance of the system. Convolutional Neural Network (CNN) with efficient feature extractors enables better prognosis of polyp. The transfer learning techniques with CNN can extract more feature set, for the automated classification of colonic polyps. In this paper, a survey on various deep learning techniques for the detection and classification of colorectal cancer are enumerated.

Keywords: Colorectal Cancer, Colonic Polyps, Artificial Intelligence, Convolutional Neural Network, Transfer Learning, Deep Learning

INTRODUCTION

Globally 1,360,000 people are diagnosed and about 694,000 people die with CRC every year [1]. Colonoscopy is the golden standard for screening CRC [2]. The small protrusions in the inner lining of Colon or rectum lead to CRC [4]. These protrusions are termed as polyp, if missed or neglected can lead to CRC. 90% of CRC are due to the unnoticed growth of adenomatous polyps [5] [6]. So the early diagnosis of the colonic polyps using colonoscopy is essential .CRC is one of the worst cancer in the world affecting both the men and women. [4]. Colonoscopy screening enabled early diagnosis and excision of the polyps. The excision of the visible protrusion has reduced the mortality rate of CRC. Studies have shown that the increase in the adenoma polyp detection rate may reduce the morality rate by 25% [1].Artificial analysis

of polyps may lead to high missed diagnosis rate [5]. For improving the polyp detection rate it is always better to have a second expert assistance [2]. The accurate classifications of polyp features are highly desirable [4] .The CNN based detection systems learn highly significant features for the automated classification [6]. When combined with high performance feature extractor and transfer learning techniques the overall performance of the CAD system is improved.

OBJECTIVE

The purpose of this work is to review on the phenomenal progress achieved in the medical field over the last few years. The advancements in the field of Artificial Intelligence (AI) have led to the development of high performance Computer-Aided Polyp Detection systems [2]. The CAD system act as a second eye for the colonoscopy diagnosis. The performance level of real time diagnosis have potentially improved. Over a decade of study and research have resulted in the formulation of many advanced algorithms, hybrid networks and enhanced computational powers [3]. The deep-learning methods using convolutional neural networks (CNNs) offered the best performance [2]. This work intend to put forth the Deep Learning approaches and enumerate the various challenges in medical image processing applications in for the researchers [8][9].

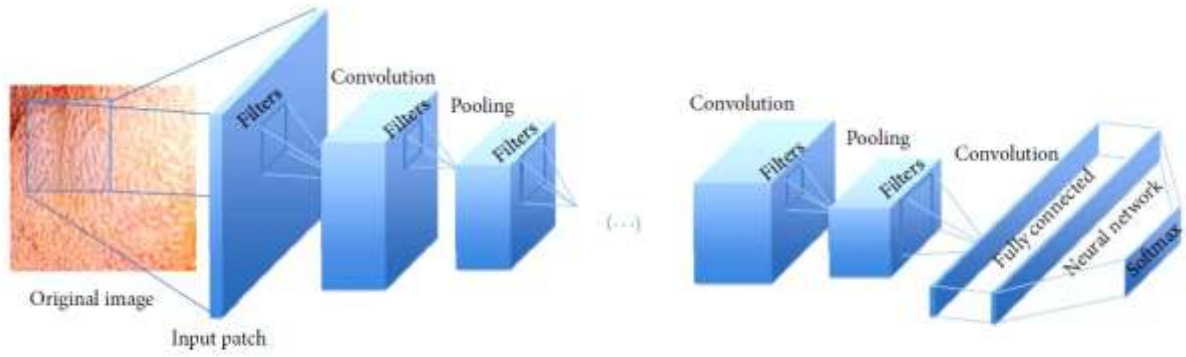

FIGURE 1 : An illustration of the CNN architecture for colonic polyp classification.[8]

Paper Title	Dataset	Proposed Work	Result
Zhanga.et.al 2018 Pattern recognition [1]	ASU-MAYO VIDEOSET-18no MICCAI2015-20	A novel regression-based Convolutional Neural Network (CNN) architecture is utilized for the polyp detection. Here a fast object detection network YOLO with a residual is used to extract the spatial	precision of 88.6%, recall of 71.6% processing speed 6.5 frames per second, Specificity

	VIDEOS	features. The temporal	= 97.0%, F1 score = 79.2%,

	8169 images with polyp 28307 images non polyp	Features are extracted d using a discriminative Correlation Filter(DCF) based tracker Efficient Convolution Operators (ECO) tracker. The RYCO (ResYOLO) will locate the polyp at a much faster rate. The tracker will ensure a stable navigation towards the polyp thus making the system more robust.	F2 score = 74.4%
Chen.et.al 2018 [5]	20000 samples from 100 patients	The author proposes a Deep Learning based polyp detection method. The video frames are subject to a series of pretreatment with CNN based image segmentation and image cutting. The pretreated image frames are fed to a multi class detection network. Three detection networks proposed are, Faster R-CNN, Retina Net and RefineDet .When compared, the multiple classification provided better accuracy, recall rate and mean average precision. Refine Det performs well. When compared with the labeling method of classification the multiple classification method has an improved accuracy mean average precision and precision rate.	Average execution time 18 fps for Retina Net.

Kang.et.al 2019 IEEE Access [6]	CVC-ClinicDB , ETIS-Larib , MICCAI 2015 polyp detection challenge CVC-Colon DB	Here the author proposes a Mask RCNN based object detection neural network for identifying and segmenting the polyps in the colonoscopy images. Mask RCNN in addition to the detection it provides an instance segmentation also. In these work two Mask R-CNN models with ResNet50 and ResNet101 is integrated to improve the performance of the model. The model proposed have three components: 1) data augmentation, 2) two Mask R-CNNs with different backbone structures (Resnet50 and 101) pre-trained on the COCO dataset, 3) the bitwise combination of two masks to enhance the segmentation performance as our ensemble method. The outcome of the bitwise combination of the two Mask RCNN architecture is used to enhance the segmentation.	For ETIS-Larib dataset mean pixel precision (PR)= 73.84% mean pixel recall (RC)=74.37% interception over union (IU)=66.07% For CVC-Colon DB dataset mean pixel precision (PR)= 77.92% mean pixel recall (RC)=76.25% interception over union (IU)= 69.46%
Tajbakhsh.et.al 2015 IEEE [7]	From the 40 short colonoscopy videos , the polyp database, consists of approximately 7,000 frames with polyps and 28,000 frames with no polyps	Here the author proposes a new polyp detection method where the polyp features such as color & texture (P_C), shape (P_S), temporal (P_T) information are extracted initially for accurate polyp localization. The 3 unique patches obtained are then fed as the input to 3 Corresponding CNN architecture. A probabilistic score of each pattern is generated and the maximum score of each pattern is calculated. Then these scores along the CNN are averaged to identify the presence of a polyp or a non-polyp candidate.	Method significantly decreases polyp detection latency. False positives per frame = .002 at 50% sensitivity

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Billah. et.al 2017 Hindawi IJBI [10]	http://www.depeca.uah.es/colonoscopy_dataset. CVC-Clinic DB , ETIS-Larib, ASU- Mayo colonoscopy videos	An automated model is proposed here to identify and segment the colonic polyp. The Color wavelet (CW) features and convolutional neural network (CNN) features of video frames are extracted from the colonoscopy video. These features are combined to train a linear support vector machine (SVM) for the automatic classification of the image. The proposed system provides better accuracy and sensitivity.	Accuracy of 98.65%, sensitivity of 98.79%, specificity of 98.52%.
Ribeiro .et.al 2017 IEEE[11]	NBI1-563 IMAGES NBI2387 IMAGES CELIAC-612 IMAGES	For achieving better feature extraction, detection and classification a large dataset is essential. For medical images the larger datasets are not available. In order to overcome this barrier the concept of Transfer Learning is applied. In this work the author explores the transfer learning techniques on to the Convolutional Neural Networks (CNN's) for better classification of colonic polyp images. The analysis infer that the performance of the model with transfer learning framework can extract more relevant feature set than the CNN based model.	

Shin .et.al 2017 IEEE Access[12]	ASU-MAYO VIDEOSET-10no CVC-Clinic DB-612 Images ETIS-Larib, 196 images	In this work the author proposes a RCNN concept for an improvised detection and segmentation of colonoscopy polyp images and videos. In addition to the RCNN, there is a post learning scheme which consist of 2 schemes- a FP and offline learning. Image augmentation strategies for training deep networks are performed and the images are applied on to an Inception Resent network for better classification .Every time a part of the outcome is fed back through the post learning schemes. The proposed system is the superior detection performance in terms of precision, recall and reaction time (RT) in both image and video databases. Since the model consist of deep CNN framework the detection processing	detection processing time in each frame is about 0.39 sec
		Time in each frame is about 0.39 sec.The only drawback of the proposed model.	
Yuana.et.al 2017 SPIE[13]	Mayo Clinic Arizona Videos 6 Cases-4 Patients with polyp 2 non polyp 37196 images with polyp 35985 images no polyp	A 2 stage model is proposed by the author. Candidate generation and candidate classification based on CNNs. The polyp frames are obtained from the real time colonoscopy videos. The frames are are pre-processed and with the help of ground truth the images are grouped as polyp and non-polyp. In the classification stage the system is operated with Alex Net CNN architecture. The proposed system gives a better accuracy and sensitivity.	accuracy 91.47% sensitivity 91.76%,

Zhang.et.al IEEE[14]	PWH DB-215 polyp,65 hyper plastic ,150 adenomatous	The polyp detection and classification model may result in 2 outcomes, hyper plastic polyps (benign) and adenomatous polyp. The adenomatous polyp is a malignant which is to be removed whereas the hyper plastic polyp is left out. In this paper the author initially train the CNN with images from non-medical domain. A novel transfer learning concept is applied on to the initial CNN features learned, along with the polyp database; fine tunes the network for classification. The classification is done by SVM algorithm. The results of this study showed that transferring low-level CNN features gives better transfer learning performance for both target tasks. The proposed method have almost the same precision rate but higher recall rate and accuracy	precision 87.3% recall rate 87.6% accuracy 85.9%
Wimmer.et.al 2018 SPIE[15]	CVC-ClinicDB , ETIS-Larib , CVC-Colon DB	The author proposes an automated diagnosis of celiac disease (CD) and colonic polyps (CP) based on applying Fisher encoding to the activations of convolutional layers. This makes the model the most effective endoscopic image classifier. In this work, three different convolutional neural network (CNN) architectures (Alex Net, VGG-f, and VGG-16) are applied to three endoscopic image databases (one CD database and two CP databases).The CNN architecture is initially pertained on the ImageNet database, and then with an	classification results up to 92.5% for the CD database, 91.2% for the HD database, and 93.7% for the HM database

		endoscopic database. The combined Fisher representations of convolutional	
		Layer activations are classified using support vector machines. Additionally, experiments are performed by concatenating the Fisher representations of several layers to combine the information of these layers. The proposed CNN-Fisher model clearly surpass all the other CNN and non-CNN-based approaches	
Liu.et.al 2019 IEEE. Access [16]	CVC-Clinic DB,ETIS-Larib, and CVC-Colon DB	The single shot detector (SSD), a faster and highly accurate object detection network is investigated for detecting polyps in colonoscopy videos. For improving the efficiency of the proposed model multi scale feature extractor are integrated in to the SSD framework. An analysis of three different feature extractors, ResNet50, VGG16, and InceptionV3 were done. The SSD with InceptionV3 based method achieved excellent detection performance in polyp detection and can potentially improve diagnostic accuracy and efficiency. **LIMITATIONS:** It is still difficult for them to identify intestinal content, plica and hemorrhagic foci, also there is a chance to miss small, flat and distant polyps	The proposed SSD method is 12.x times faster than Faster RCNN. The accuracy of the system is much higher than the same one-stage method YOLOV3.

Table 1: Over view of the various Deep Learning techniques

CONCLUSION

In this paper we explore on to the various Deep Learning techniques for the detection and classification of polyps. The Deep Learning approach using the CNN and the transfer learning techniques have brought huge impact in the medical image processing arena. The

advancement in the Artificial Intelligence has led to a phenomenal increase in the number of research and publication in this field. Often in the medical field we lack the availability of large datasets for image analysis. With the advancements like data augmentation the available dataset can be expanded and the network can be trained from the scratch so as to get better performance. The development of the CNN framework has transformed the scenario to a higher level of learning. With the application of the Transfer Learning concept many new pertained networks were developed for learning more significant features thereby improving the performance of the system. The Deep Learning approach led to further improvisations in the CNN resulting in the increase in the depth of the network. For this many new pretrained networks were developed and new architecture was built to make precise classification. Here in this work we are looking in to the various aspects of the deep learning strategies, CNN architecture, and hybridmodelling of the network for the detection, segmentation and classification of the polyps from the colonoscopy videos. Further investigations are to be carried out to improve the performance of Deep Learning models for successful real- time diagnosis

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