Deep Learning-based Colorectal Cancer Detection in Endoscopic Images

Tariq Rahim, Arslan Musaddiq, Dong Seong Kim*
tariqrahim@ieee.org, arslan@kumoh.ac.kr, dskim@kumoh.ac.kr

Kumoh National Institute of Technology, Gumi-si, South Korea

Abstract

Colorectal cancer (CRC) is the most prevalent cancer found in the small bowel of the human gastrointestinal (GI) tract. Polyps are antecedents to CRC and are detected in approximately half of the people at age 50 within the GI. In this paper, an improved version of You Only Live Once (YOLO) is presented for the detection of polyp within the endoscopic images. We have improved the YOLOv3-tiny model by adding more convolutional layers to extract enriched and deeper features. For fair benchmarking, the efficacy of the proposed model is evaluated against the default version of YOLOv3-tiny in terms of recall, precision, F1-score, and F2-score.

Ⅰ. Introduction

Early diagnosing of different diseases inside the gastrointestinal (GI) tract is a tumultuous and time-taking process for physicians. This has led to the introduction of technologies such as colonoscopy and wireless capsule endoscopy. Colorectal cancer (CRC) is the second-highest reason for death by cancer across the world [1]. CRC is treatable in 90.0% situations upon timely detection. Early detection approaches employed conventional image processing techniques followed by deep learning (DL) models, yet there is more to explore for timely diagnosis [2].

DL performs a significant part in several areas, including image recognition, self-driving cars, and healthcare, etc. Computer vision and ML-based methods have emerged over many decades and are being exercised for the detection of polyps [2], [3]. Recently, regression-based efforts are conducted by using a single-shot multi-box detector and You Only Look Once (YOLO) for the detection of natural [4] and polyps within the GI tract [1].

Despite computerized detection procedures that can efficiently classify and recognize, the detection of polyp dwells challenging due to its notable size, features, and intensity fluctuations inside the GI tract and sequential image. Looking into such issues faced while detecting the polyp in endoscopic images, we have improved YOLOv3-tiny model using different *convolutional* filters in their respective layers. This ensures to extract enriched features both at local and global position of the frame. Benchmarked results are presented against the default model to show the efficacy of the improved YOLOv3-tiny model.

Ⅱ. Proposed Improved YOLOv3-tiny Model

Figure. 1 shows the proposed improved YOLOv3-tiny model for the detection of polyp within endoscopic images. The model is improved by adding different

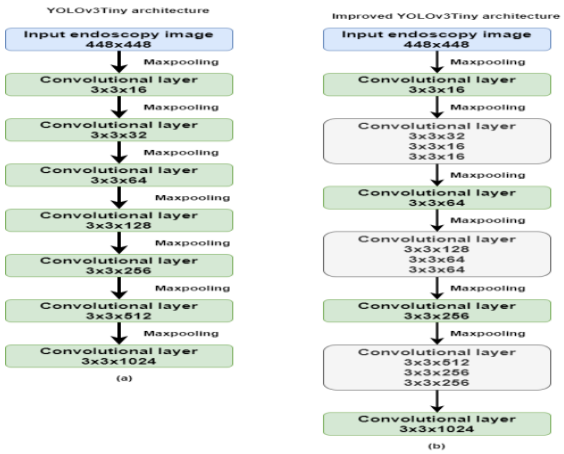

Figure 1. Proposed model, where (a) default YOLOv3-tiny model, and (b) Improved YOLOv3-tiny model.

sizes of *convolutional* filters i.e., 16, 32, 128, 256,512, and 1024 having kernel size 3×3. Different *convolutional* filters ensure the extraction of deeper local and global feature required for the localization of polyp. For the labeling, RectLablel tool is used producing a bounding box "B" that consisted of five predictions. Intersection over union is used to compute the distance between predicted and ground truth. The dataset is acquired from the Kvasir-SEG dataset consisted of 1000 polyp images [5]. The dataset is split into 70% and 30% for training and testing purpose. The parametric configuration for training both models can be referred to [1].

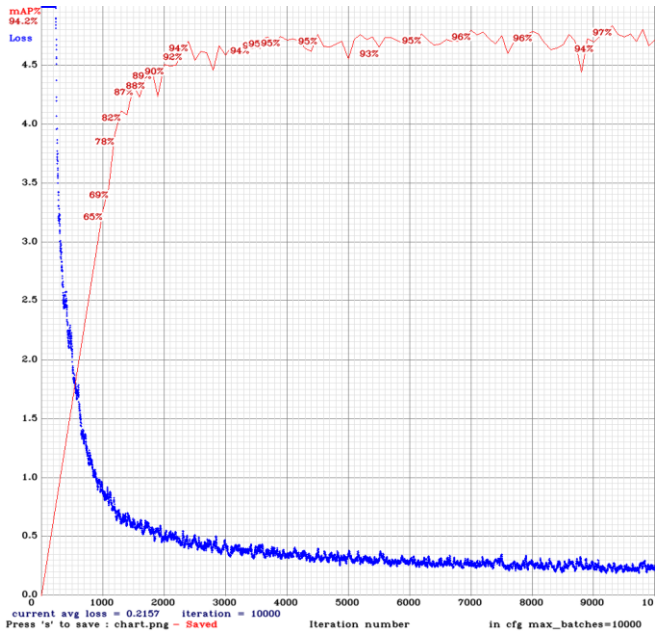

Figure 2. Training phase for the proposed improved YOLOv3-tiny model.

Table 2. Performance evaluation of the proposed model.

Performance metrics	YOLOv3-tiny	Proposed improved YOLOv3-tiny
Recall	87.37	90.51
Precision	86.18	87.06
F1-score	87.02	90.44
F2-score	86.41	88.27

Ⅲ. Result and Discussion

For the experimental evaluation, the performance metrics opted to reflect the efficacy of the proposed improved YOLOv3-tiny model are recall, precision, F1-score, and F2-score. The training phase is shown in Fig. 2 where it can be observed that a high mean average precision (mAP) of 94.20% with mean square loss of 0.2157 is achieved. From this computed the true positive, true negative, false positive, and false negative which are used in the final computation of the performance metrics. Table. 2 shows the performance evaluation of the default and proposed improved YOLOv3-tiny model. Clearly, it can be seen that the proposed improved YOLOv3-tiny model outperforms the default YOLOv3-tiny model in terms of performance metrics.

Ⅲ. Conclusion

An improved version of YOLOv3-tiny model for the detection of CRC i.e., polyp within the GI tract of human being is presented. The model uses different convolutional filters in different ensuring better detection performance. The results are benchmarked with the default model of YOLOv3-tiny model.

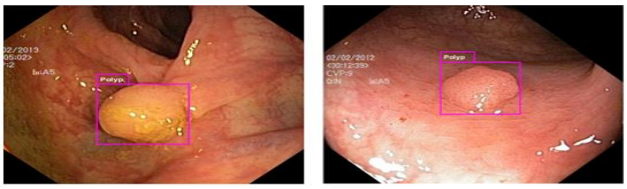

Figure 3. Results from the proposed improved YOLOv3-tiny model for the accurate detection of polyp.

ACKNOWLEDGMENT

This research was supported by MSIT (Ministry of Science and ICT), under the Grand Information Research Center support program (IITP-2021-2020-0-01612) supervised by the IITP (Institute for Information & Communication Technology Planning & Evaluation).

References

[1] Rahim, Tariq, Syed Ali Hassan, and Soo Young Shin. "A deep convolutional neural network for the detection of polyps in colonoscopy images." Biomedical Signal Processing and Control 68 (2021): 102654.

[2] Rahim, Tariq, Muhammad Arslan Usman, and Soo Young Shin. "A survey on contemporary computer-aided tumor, polyp, and ulcer detection methods in wireless capsule endoscopy imaging." Computerized Medical Imaging and Graphics (2020): 101767.

[3] Hassan, Syed Ali, Tariq Rahim, and Soo Young Shin. "Real-time uav detection based on deep learning network." In 2019 International Conference on Information and Communication Technology Convergence (ICTC), pp. 630-632. IEEE, 2019.

[4] Farhadi, Ali, and Joseph Redmon. "Yolov3: An incremental improvement." Computer Vision and Pattern Recognition, cite as (2018).

[5] Jha, Debesh, Pia H. Smedsrud, Michael A. Riegler, Pål Halvorsen, Thomas de Lange, Dag Johansen, and Håvard D. Johansen. "Kvasir-seg: A segmented polyp dataset." In International Conference on Multimedia Modeling, pp. 451-462. Springer, Cham, 2020.