Enhancing Cervical Lesion Detection through Instant Segmentation: Analyzing Colposcopic Images with DeepLabv3+ Model

Yi-Hung, Sun[1,2,3,4], Chien-Teng Liao[1], Yu-En Chou[5], John Y. Chiang[5]

1. Department of Obstetrics and Gynecology, Chi-Mei Foundation Medical Center, Tainan, Taiwan
2. Institute of Medicine, Chung Shan Medical University, Taichung, Taiwan
3. School of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
4. School of Medicine, National Defense Medical Center, Taipei, Taiwan
5. Department of Computer Science & Engineering, National Sun Yat-sen University

Introduction

Female cervical Pap smear screening and subsequent colposcopic examinations for suspicious dysplasia identification are crucial for the early detection of precancerous lesions on the uterine cervix. A comprehensive colposcopic examination could give reliable guidance for tissue proof by biopsy. In our study, we utilized machine learning to analyze colposcopic images to improve the accuracy of detecting cervical lesions. The ultimate aim is to empower clinicians, making them more integral in effectively identifying lesions.

Methods

This study utilized machine learning techniques and analyzed 1,758 patients' colposcopic images to segment cervical lesions. The dataset included 700 patients who underwent cervical conization. We employed data augmentation to address the segmentation dataset's small size. We segmented four types of lesion characters in colposcopic acetic acid-stained images: acetowhite areas, punctate vascular abnormality areas, mosaic vascular abnormality areas, and atypical vascular abnormality areas. After comparing training results for DeepLabv3+, PSP-Net, and HRNet segmentation models on the same training dataset, we selected the DeepLabv3+ model. Our evaluation metrics assessed our model's performance, including MIoU, Recall, and Hit Rate.

Results

The DeepLabv3+ model performed better on larger targets than on smaller counterparts. The overall MIoU was 0.773. The study conducted a multi-label classification evaluation, showing a Subset Accuracy of 0.588, an Accuracy of 0.710, a Precision of 0.992, a Recall of 0.713, an F1-score of 0.754, and a Hamming Loss of 0.180.

Conclusion

In conclusion, the multi-label classification results indicate that the model exhibits a certain level of performance in identifying and categorizing the four types of lesion characters in colposcopic acetic acid-stained images. This model demonstrates a few-shop learning with instant segmentation, making it applicable in a clinical setting. It involves conducting annotation training on different features within the same image and applying the concept of instance segmentation to practical detection in colposcopic image interpretation.

Table 1 Comparison of Training Results (MIoU) for DeepLabv3+, PSP-Net, and HRNet Segmentation Models on the Same Training Dataset

Model	Training Set (MIoU)	Validation Set (MIoU)
DeepLabv3+	0.972	0.773
PSP-Net	0.916	0.685
HRNet	0.961	0.734

Table 2 Multi-label classification for DeepLabv3+[1], PSP-Net[2], HRNet[3] Models

Multi-label classification		Training set			Validation Set			Test set		
Accuracy		1	2	3	1	2	3	1	2	3
Complete	***Subset Accuracy***	0.672	0.607	0.593	0.590	0.554	0.558	0.588	0.566	0.543
Partial	***Accuracy***	0.761	0.738	0.732	0.734	0.703	0.71	0.710	0.698	0.674
	Precision	0.999	0.999	0.999	0.991	0.984	0.988	0.992	0.987	0.987
	Recall	0.761	0.738	0.733	0.739	0.709	0.717	0.713	0.695	0.681
	F1 − score	0.801	0.778	0.755	0.784	0.755	0.761	0.754	0.735	0.721
	Hamming Loss	0.143	0.168	0.169	0.175	0.198	0.19	0.180	0.198	0.2

Table 3 Evaluation Results of MIoU[1], Recall[2], HitsRate[3] in DeepLabv3+ for Each Class on the Training Set, Validation Set, and Test Set

Characteristics	Training set			Validation Set			Test set		
	1	2	3	1	2	3	1	2	3
Acetic white stating	0.965	0.988	0.992	0.874	0.936	0.93	0.881	0.942	0.931
Punctuation	0.767	0.825	0.868	0.525	0.659	0.721	0.501	0.624	0.718
Mosaic	0.932	0.96	0.868	0.831	0901	0.914	0.802	0.88	0.9
Atypical vasculation	0.855	0.923	0.965	0.649	0.746	0.834	0.676	0.778	0.837

Figure. Segmentation Results of DeepLabv3+ in the Presence of Four Types of Lesions

