A YOLO-based Model for Breast Calcification Areas Detection in Screening Mammography

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***Abstract*— Breast cancer remains one of the most prevalent and life-threatening diseases among women worldwide. Early diagnosis of breast cancer is pivotal in improving patient outcomes and survival rates. The earliest signs of non-palpable breast cancer are calcifications. This paper proposes a deep learning network for breast calcification areas detection based on YOLO with self-attention mechanism. By using Bi-Level Routing Attention (BRA) mechanisms, the model's performance can be significantly enhanced. Later, the modified Bi-directional Feature Pyramid Network (BiFPN) technique was used. The advanced model architecture is a modification of the YOLOv8 framework. In order to improve the instances detection of breast calcification, we applied several image preprocessing steps. The contrast of each input image was enhanced and standardized, and the images were resized to a fixed resolution. Utilizing k-fold cross-validation, multiple supervised machine learning techniques were compared. The model demonstrated effective performance across various metrics in the task of calcification detection, achieving a precision rate of 99.32%, a recall rate of 85.0% and an F1-score of 91.59% at the IoU threshold of 0.6. Based on these experimental results, the model is shown to reliably detect areas of breast calcification.**

I. Introduction

Breast cancer is a global health concern that affects millions of women and their families each year. In recent years, there has been a trend toward an earlier age of onset for breast cancer. When breast cancer is detected early and is in the localized stage, the 5-year relative survival rate is higher than 99% [1]. This shows the importance of early detection of breast cancer, especially for the earliest signs of non-palpable breast cancer often manifesting as calcifications. The development of a detection model for breast calcification areas can assist physicians in the early diagnosis of breast cancer, thereby improving clinical decision-making and patient care. In this study, we utilized 1,806 craniocaudal images from the recognized benchmark dataset CBIS-DDSM [2] focused on calcification areas, comprising 1,514 single tumors and 292 multi-tumor images. The dataset was partitioned into three subsets: 1,280 images for training, 320 images for validation, and 206 images for testing. Our goal was to improve the instance detection of breast calcification based on machine learning and deep learning architectures.

II. Detection Model for Breast Calcification Areas

Each input image underwent preprocessing, including contrast enhancement and standardization, and resizing to a fixed resolution. Using YOLOv8 framework as foundation, the proposed model was modified by incorporating Bi-Level Routing Attention (BRA) and Bi-directional Feature Pyramid Network (BiFPN).

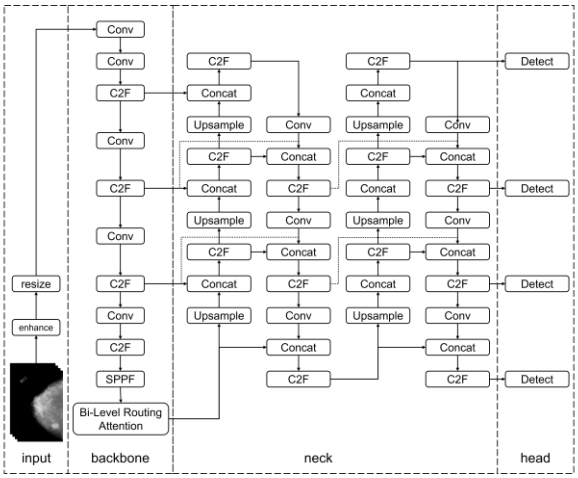

Fig.1. YOLO-based Framework with BRA and BiFPN

III. Experimental Results

Experiments are conducted to evaluate machine learning models and validate their generalization ability on independent test datasets. In this K-fold cross-validation experiment, five-fold samples were collected. The experimental results are shown in Table 1.

TABLE I. Result of the K-fold Cross Validation (K=5)

Fold Number	Precision	Recall	mAP50	mAP50-95	F1-score
1	**1.0000**	0.8140	0.8730	0.7570	0.8975
2	0.9870	0.8550	0.8970	0.7780	0.9163
3	0.9910	**0.8780**	**0.9210**	**0.8200**	**0.9311**
4	**1.0000**	0.8620	0.9130	0.8050	0.9259
5	0.9880	0.8410	0.8890	0.7760	0.9086
Average Value	0.9932	0.8500	0.8986	0.7872	0.9159
Standard Deviation	0.0064	0.0241	0.0191	0.0251	0.0135

Conclusion

This paper proposes a novel multi-scale model upon YOLOv8 embedding a self-attention guidance mechanism. Experiments show that the model can detect breast calcification more efficiently while satisfying the real-time requirements of medical inspection.

References

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