2.5D Lightweight Network Integrating Multi-scale Semantic Features for Liver Tumor Segmentation

Yilin You, Zhengyao Bai*, Yihan Zhang, Jiajin Du
School of Information Science and Engineering,
Yunnan University, Kunming, China
baizhy@ynu.edu.cn

1. Introduction

- One critical research area in the development of a computer-aided diagnosis system for liver cancer is efficient and automatic segmentation of lesion from CT scans.
- We enhance the information interaction between the input 2.5D stacked slice via introducing parallel convolution and increasing the knowledge weight of the lesion channel in different receptive fields.
- Based on the proposed method, the experimental results show that the use of deep learning can improve liver tumor segmentation tasks by 2.4%, while reducing amount of parameters by 57.5%.

3. Methodology

Encoder-decoder strcture

- In this paper, we propose a novel tumor segmentation framework, leveraging the hierarchical semantic features extracted from the encoder, with the goal to improve accuracy and robustness of the lesion segmentation task .

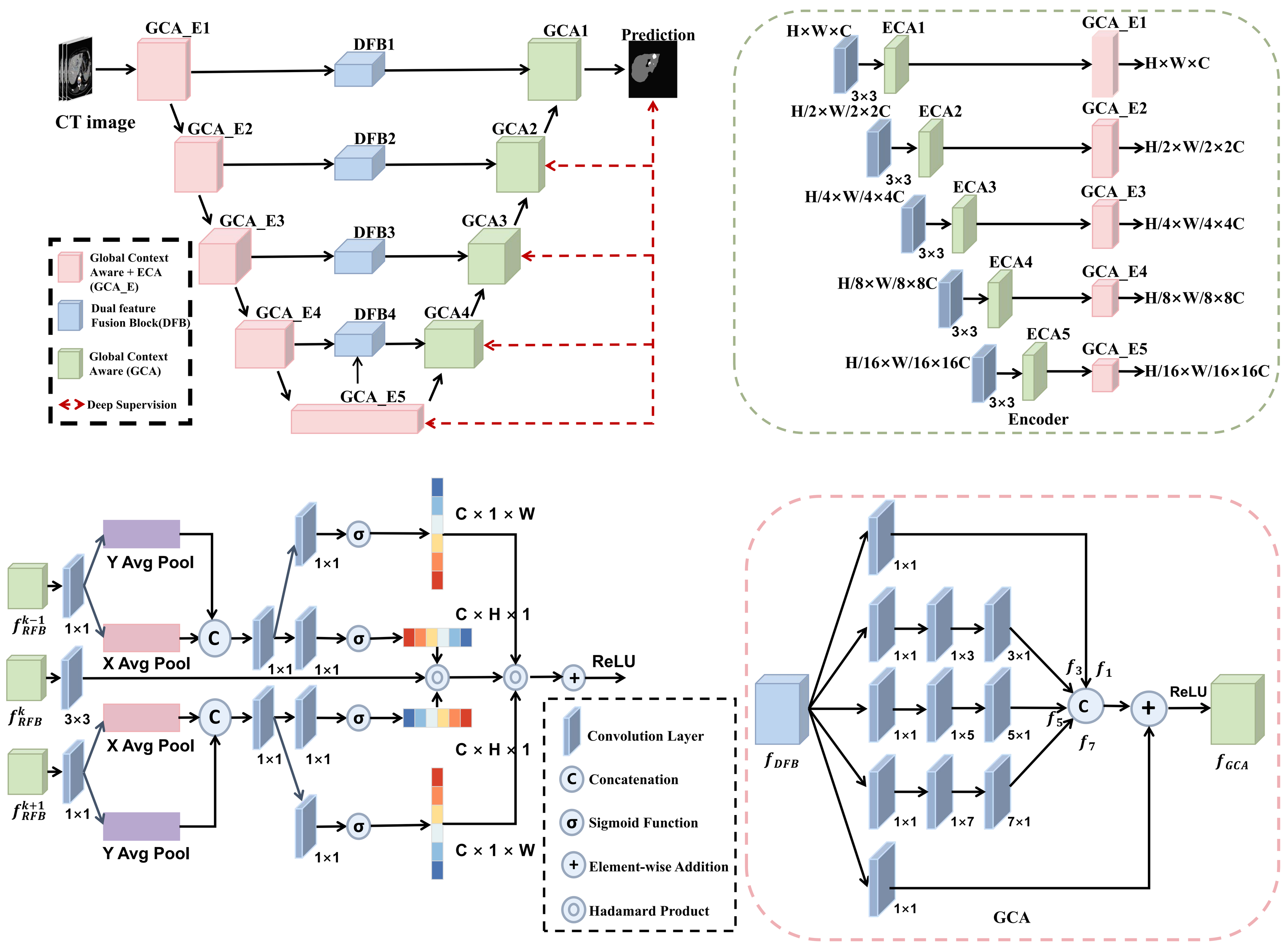


Fig. 1. The network structure of automated segmentation of Liver Tumor. In the framework, both high and low data flow are used for our task.

- We employ the Inception to build multi-scale features. And stack the annotated central slice and its adjacent slices carrying contextual information as the input of network.

Dual Feature Fusion

- We use the previously feature maps to concat along the spacial dimension, and transform the bottleneck layer then activate to achieve information interaction. After fusing the hierarchical features, we separate the shared layers along the spatial dimension and utilize the sigmoid function to obtain the sum of attention vectors. Ultimately, we operate on the vector and input with Hadamard product.
- The dual feature fusion first obtains long distance dependencies along one direction while retaining precise location information with the other spatial direction, which considered both high-to-low and low-to-high data flows to gain the cross channel relationship and location information. And we add the dual feature fusion in the skip connection of each layer to alleviate the loss of deep details and recovering spatial information.

2. Major Contributions

- Extract features through the InceptionV3 with enhanced channel attention and acquire the inter-slice spatial information via 2.5D network structure.
- We employ a dual-feature fusion block in the skip connections to focus on the tiny features and suppress irrelevant information.
- Extensive experiments are conducted on the benchmark dataset, and the proposed framework provides superior performance, which demonstrated the effectiveness of proposed method.

4. Results

Evaluation metrics

- We adopte six common evaluation indicators to measure the performance of our network, consisting Dice, jaccard, volume overlap error(VOE), Hausdorff distance(HD), and average symmetrical surface distance(ASD).

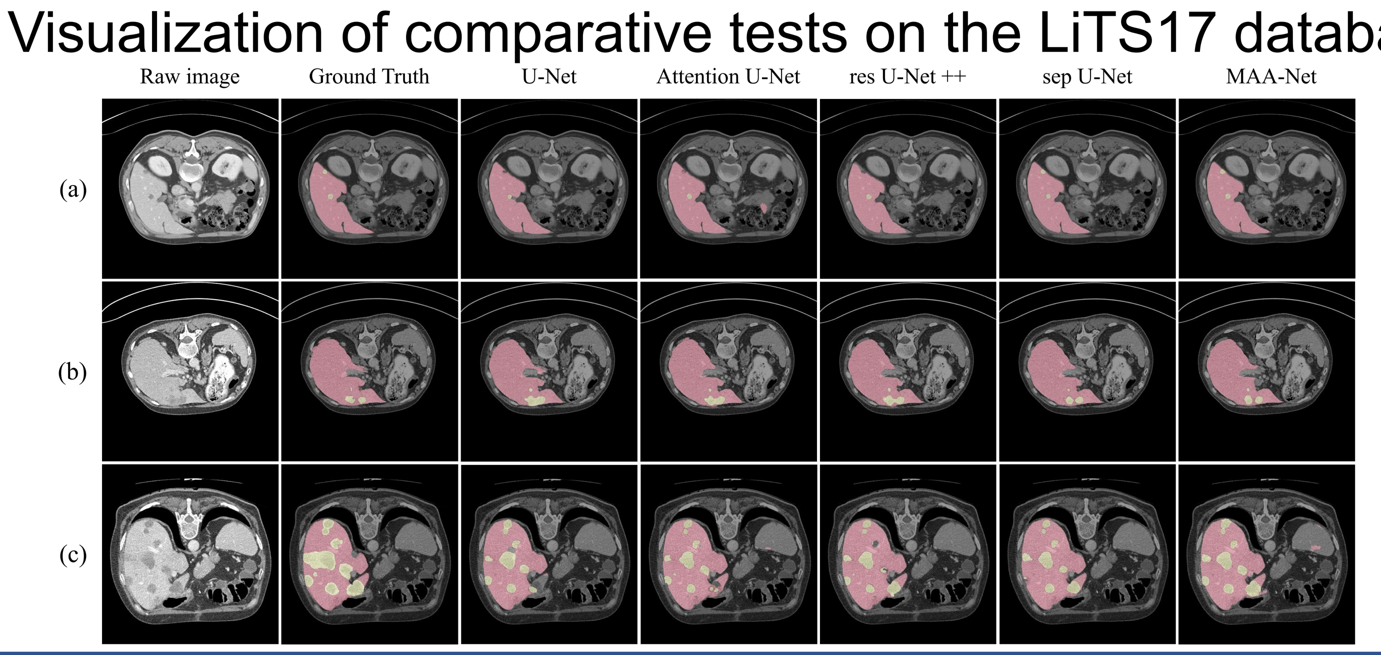
Quantitative evaluation

- Results of liver tumor comparative experiments on the LiTS2017 and 3DIRCADb datasets in Table 1.

Datasets	Model	Dice	Jaccard	VOE	HD	RVD	ASD
LiTS17	U-Net [2]	0.613	0.634	0.366	56.25	-0.076	15.89
	Res U-Net ++ [21]	0.660	0.693	0.307	57.16	-0.073	13.63
	Attention U-Net [22]	0.639	0.621	0.379	55.90	**-0.067**	13.37
	sep U-Net [23]	0.600	0.614	0.386	52.77	-0.091	12.26
	MAA-Net	**0.698**	**0.694**	**0.306**	**48.31**	0.071	**10.08**
3DIRCADb	U-Net [2]	0.599	0.625	0.375	62.20	0.111	13.26
	Res U-Net ++ [21]	0.644	0.662	0.338	57.19	-0.075	14.60
	Attention U-Net [22]	0.627	0.653	0.347	57.42	-0.049	13.90
	sep U-Net [23]	0.608	0.648	0.352	53.17	-0.029	12.83
	MAA-Net	**0.692**	**0.679**	**0.321**	**50.45**	**-0.028**	**11.30**

Qualitative evaluation

- Visualization of comparative tests on the LiTS17 database.



5. Conclusion

- In this paper, we propose a 2.5D lightweight structure for segmenting liver and lesion in abdominal CT scans.
- Our framework includes a multi-scale encoder-decoder framework, which is based on the global context aware and bidirectional feature fusion.
- We train our model using the novel form of input, and it realized the information interaction between different levels. Extensive experiments on the public two databases show our approach can reduce the amount of calculations by 57.5% when the evaluation indicators are not much different.