A Benchmark Dataset for Segmenting Liver, Vasculature and Lesions from Large-scale Computed Tomography Data

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Introduction

- How to build a high-performance liver-related computer assisted diagnosis system is an open question of great interest. However, the performance of the state-of-art algorithm is always limited by the amount of data and the quality of the label.

- To address this problem, we propose the biggest treatment-oriented liver cancer dataset for liver surgery and treatment planning.

- This dataset provides 216 cases (total about 268K frames) scanned images in contrast-enhanced computed tomography (CT).

Related work

Dataset:

- 3D-IRCADb-01: There are 20 3D CT volumes in this dataset. 75% of these images have hepatic tumors. The liver edges, liver vessels and liver tumors are labeled out for segmentation tasks. Besides, these image characteristics, such as the liver size and the location of tumors, are listed in a table on the web page.

- Sliver07: This dataset is provided by the Segmentation of the Liver Competition 2007. 30 CT cases are available for the public. 20 cases are randomly chosen as the training set, and the remaining 10 cases for testing. Only the segmentation reference of the training set is downloadable.

Related work

Dataset:

- ImageCLEF: This dataset belongs to the ImageCLEF Liver CT Image Annotation Challenge. It includes 50 training cases and 10 testing cases. Each case data consists of the raw image, the liver lesion bounding box and the liver mask. In addition, the CT features of the liver, vessels and lesions are listed.

- LiTs: This dataset is from the Liver Tumor Segmentation Benchmark. It contains 131 CT cases in the training set and 30 CT cases in the test set. Only these images in the training set are labeled with liver contour and liver tumor area.
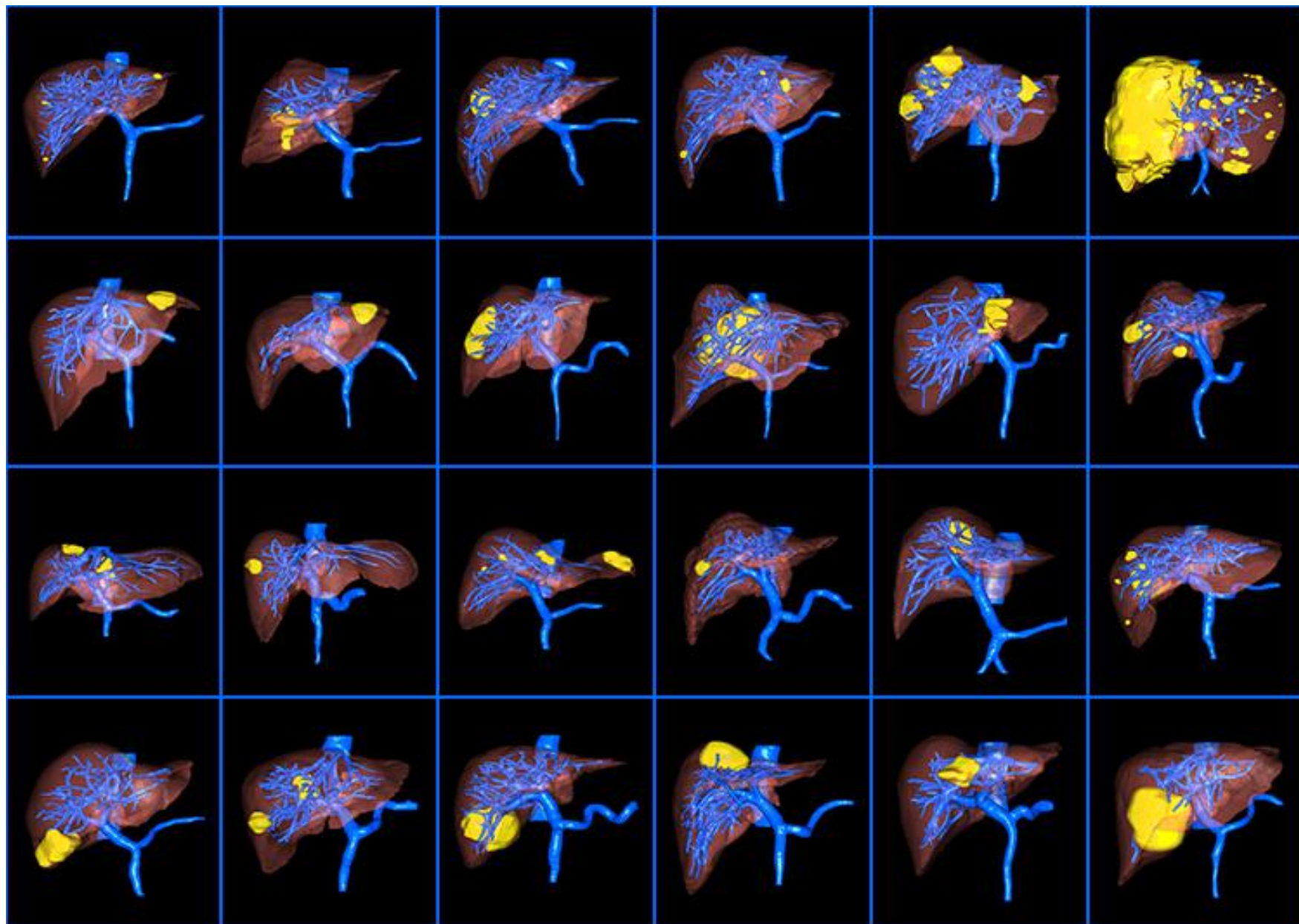
Related work

Dataset:

- Jiang et al.: In this dataset, 83 DCE-MRI images are scanned from 83 patients with liver cancer. The training set and the test set contain 62 and 21 cases, respectively.

- Ouhmich et al.: The authors used an in-house database (Db) containing ground truth 2D annotations for three classes, namely the healthy parenchyma, the active and the necrotic parts of the lesions. This database is composed of data from seven patients suffering from hepatocellular carcinoma (HCC) that underwent from one to three contrast-enhanced computed tomography (CECT) examinations, resulting in a total number of 13 CT sequences.

Our Dataset

TABLE I
COMPARING THE PROPOSED DATASET WITH OTHER LIVER IMAGING DATASETS.

Dataset	D-IRCADb [11]	Sliver07 [12]	ImageCLEF [13]	LiTs [14]	Jiang [15]	Ouhmich [16]	Our
Slices(/case)	2,823(70-260)	6,427(64-502)	41-588	58,638(42-1026)	4,283(42-84)	104(8)	**268,431(205-1,207)**
Cases	20	30	60	201	117	13	**216**
Thickness(mm)	1.25-4mm	1-3mm	0.399-2.5mm	0.45-6mm	1.25-5.0mm	0.7-1.25mm	**0.62-1.25mm**
Resolution	0.56-0.87mm	0.55-0.8mm	0.674-1.007mm	0.56-1mm	0.71-1.17mm	0.66-0.97mm	**0.55-0.76mm**
Liver label	✓	✓	✓	✓	None	None	✓
Vessel label	✓	None	None	None	None	None	✓
Tumor label	✓	None	(bounding box)	✓	✓	✓	✓
Diagnose report	None	None	None	None	None	None	Li-Rads

Our Dataset

Experiments

Metrics	FCN	UNet	UNet++	Attention UNet	VNet	3D UNet	3D Attention
Precision	0.9612	0.9670	0.9652	0.9667	0.9661	0.9662	0.9667
Recall	0.9631	0.9762	0.9759	0.9798	0.9661	0.9745	0.9772
Accuracy	0.9702	0.9824	0.9865	0.9873	0.9868	0.9887	0.9894
Specificity	0.9658	0.9684	0.9697	0.9735	0.9728	0.9737	0.9798
DICE	0.9756	0.9824	0.9853	0.9871	0.9862	0.9876	0.9899

Metrics	FCN	UNet	UNet++	Attention UNet	VNet	3D UNet	3D Attention
Precision	0.8031	0.9257	0.9576	0.9601	0.9637	0.9677	0.9724
Recall	0.7671	0.8637	0.8646	0.8651	0.8111	0.8922	0.9021
Accuracy	0.7564	0.8033	0.8557	0.8629	0.8517	0.8723	0.8779
Specificity	0.7351	0.7990	0.8207	0.8619	0.8147	0.8787	0.9001
DICE	0.6243	0.7522	0.8166	0.6887	0.8453	0.8665	0.8907

Experiments

TABLE IV
COMPARING DIFFERENT METHODS WITH THE PROPOSED DATASET ON THE LIVER TUMOR SEGMENTATION TASK.

Metrics	FCN	UNet	UNet++	Attention UNet	VNet	3D UNet	3D Attention
Precision	0.3824	0.4425	0.4006	0.4356	0.4531	0.3787	0.3784
Recall	0.3092	0.3513	0.3423	0.3698	0.3471	0.3661	0.3545
Accuracy	0.3612	0.3670	0.3652	0.3667	0.3663	0.3652	0.3627
Specificity	0.3579	0.3607	0.3618	0.3629	0.3606	0.3787	0.3801
DICE	0.3097	0.3265	0.3693	0.3896	0.3370	0.4021	0.4133

Conclusion

To remove the limitation of the amount of data and quality of the label, we propose the biggest treatment-oriented liver cancer dataset for the liver surgery and treatment planning. The dataset labels all the CT images with the liver, liver vasculature and liver tumor for train and tune segmentation algorithms in advance. Furthermore, we evaluate several recent and state-of-the-art segmentation algorithms, including 7 deep learning methods and 4 interactive methods, on CT sequences.