A deep learning approach for the segmentation of myocardial diseases

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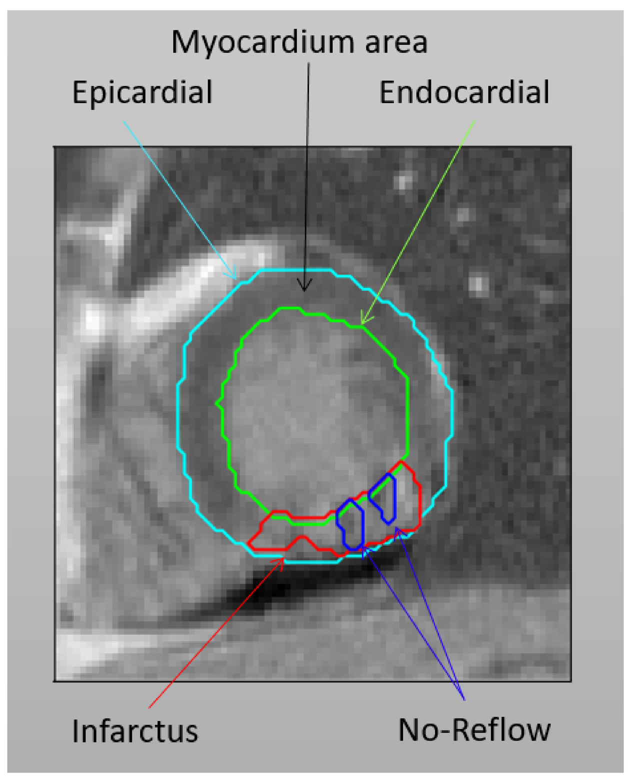
1. Introduction

According to the World Heart Organization, Myocardial Infarction (MI) is a severe silent killer in the world. Indeed, MI is a life-threatening condition that occurs when blood flow to the heart is abruptly stopped. Thus, a patient with acute myocardial infarction needs an emergency revascularization therapy to restore perfusion as soon as possible. However, an extensive damage which consists in an obstruction called permanent microvascular obstruction (MVO, also called no-reflow) can appear in infarcted tissue. MVO indicates the lack of reperfusion of some myocardial region even after the ending of the ischemic event. The use of magnetic resonance contrast agents based on gadolinium-chelates for visualizing the scarred myocardium is considered as the most clinical relevant references for better MI and non-ischemic cardiomyopathies diagnosis.

2. Objective

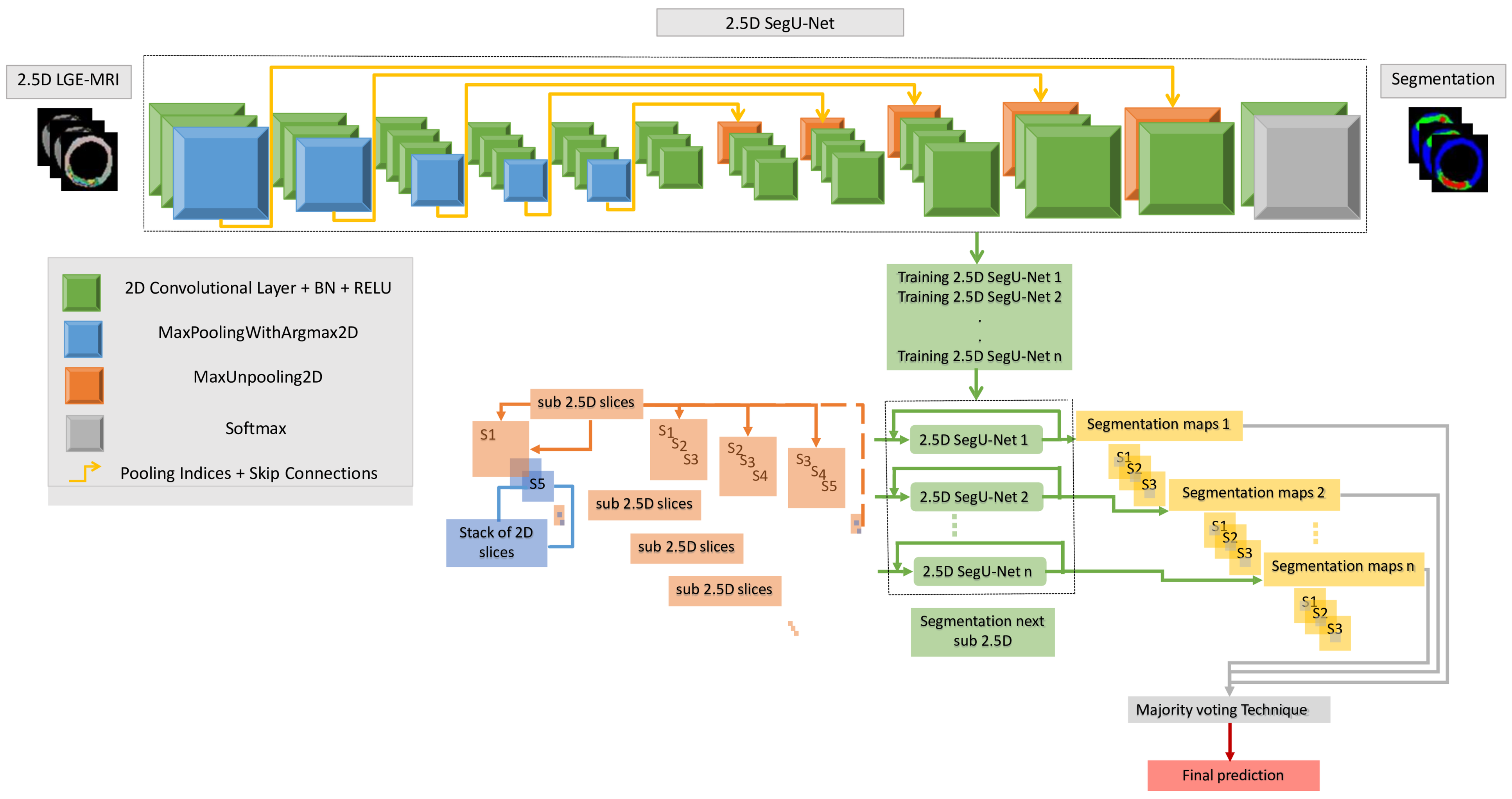
In this work, we aim to effectively identify over-enhanced and non enhanced region on LGE-MRI in subjects with MI. Infarct core may contain hypo-enhanced zones as a consequence of the MVO phenomenon as presented below.

- **Short-axis view of LGE-MRI**



3 Methods

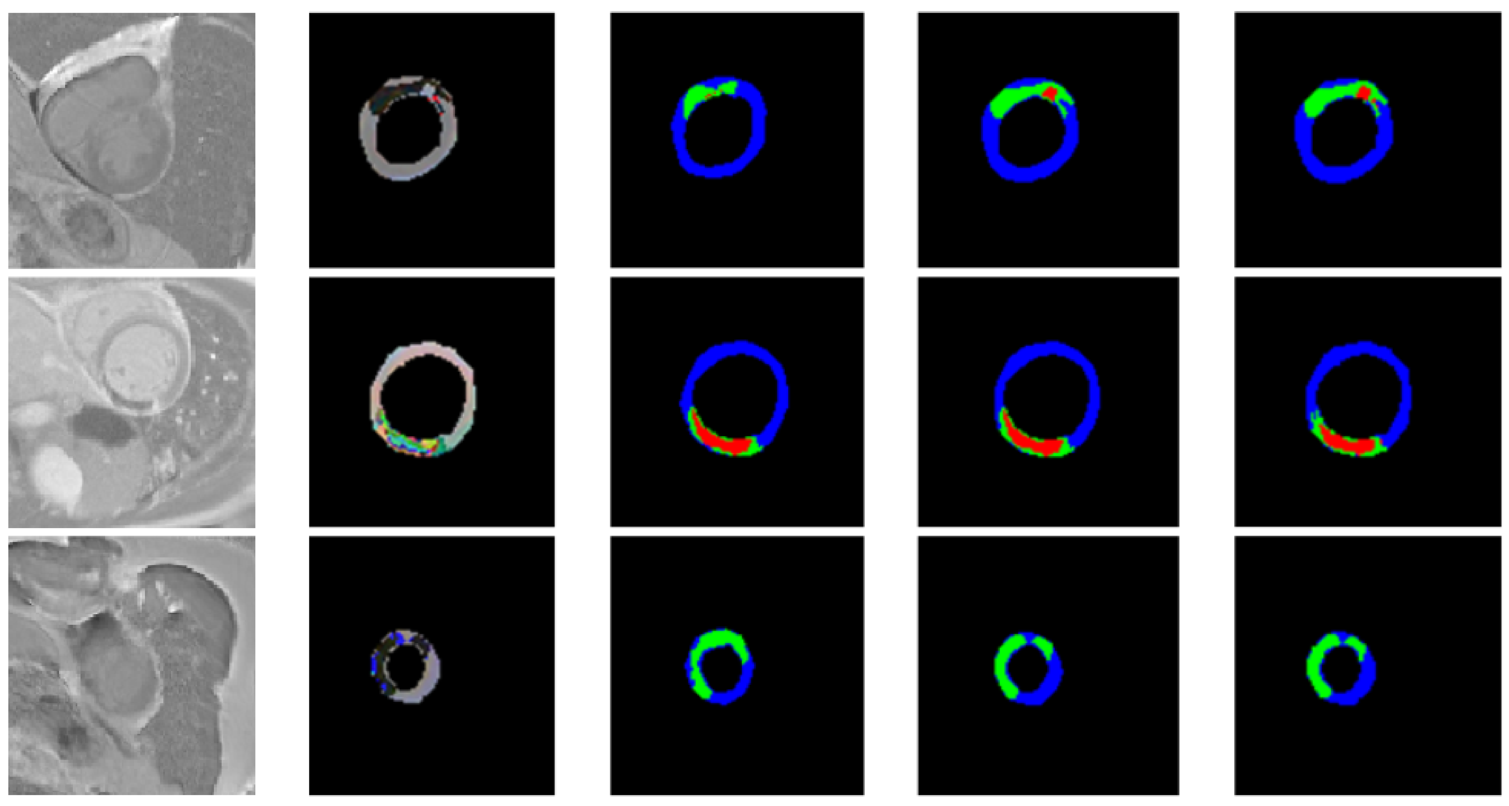
- **Built based on a typical Convolutional Neural Network (CNN) with 29 conv2D layers and 3 × 3 convolutional kernels and an incremental number of filters from 64 to 512.**
- **Fine and coarse feature preservation through concatenation of layers.**
- **Skip connection [1] and Max Pooling Indices [2] are integrated for restoring spatial pixel information of the image.**
- **The network output for each input of sub 2.5D was one segmentation map with a size of 224 × 224, representing the predicted class label of each pixel corresponding to the region type.**



4. Results

- **Three slices from three different input patients. From left to right: LGE-MR images, 2.5D Input images, First intra ground-truth, Second intra ground-truth and 2.5D SegU-Net generated-result (Myocardium area (blue), MI area (green), and MVO area (red))**

  We tested our 2.5D SegU-Net approach in 16 diverse exams taken from the EMIDEC database (**http://emidec.com/**), to evaluate its power to identify myocardial regions.



- **Quantitative study for myocardial segmentation on EMIDEC Dataset.**

  (**http://emidec.com/downloads/papers/paper-17.pdf**)

Method	Metrics	Structures		
		Myocardium	Infarctus	No-reflow
3D U-Net	DSC %	95.71	74.98	68.61
	AVD mm3	295.50	474.12	55.75
	HD mm	4.57	-	-
	AVDR %	-	9.06	0.97
Our 3D approach	DSC %	96.29	76.56	93.12
	AVD mm3	270.00	234.1	26.69
	HD mm	3.77	-	-
	AVDR %	-	4.92	0.59

5. Conclusions

Automated MI segmentation is important for disease diagnosis and analysis. In this work, a 2.5D deep learning based model has been presented for quantification of LGE-MRI myocardium diseases. We have evaluated the effectiveness of our framework on two different datasets (EMIDEC and MS-CMRSeg). Our innovative approach worked best in comparison with some previously proposed methods and yielded the highest DSC over all segmented myocardial regions. As compared to the intra-observer variability, the proposed model perfectly segments damaged myocardial areas of subjects with chronic myocardial infarction and hence, can be a valuable clinical tool for diagnosis of MI.

6. fundings

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7. References

[1] Olaf Ronneberger, Philipp Fischer, and Thomas Brox. U-net: Convolutional networks for biomedical image segmentation. In *International Conference on Medical image computing and computer-assisted intervention*, pages 234–241. Springer, 2015.

[2] Vijay Badrinarayanan, Alex Kendall, and Roberto Cipolla. Segnet: A deep convolutional encoder-decoder architecture for image segmentation. *IEEE transactions on pattern analysis and machine intelligence*, 39(12):2481–2495, 2017.