STACKED BCDU-NET WITH SEMANTIC CMR SYNTHESIS: APPLICATION TO THE MYOCARDIAL PATHOLOGY SEGMENTATION CHALLENGE

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MYOPS Challenge

Automatically segment scar tissue and edemic regions from multi-sequence cardiac magnetic resonance images (bSSFP, LGE and T2).

- Training data: 25 patients from Shanghai Renji Hospital with registered and interpolated multi-sequence MRI [1].
- Testing data: 20 unseen patients

Background

- Accurate segmentation of scar tissue and edema from CMR is fundamental to the assessment of the severity of myocardial infarction and viability.
- Automatic segmentation is particularly challenging due to:
  - Variability in texture of infarcted and edemic areas
  - Limited input data to train models
  - Imaging acquisition protocol & inter-observer variability

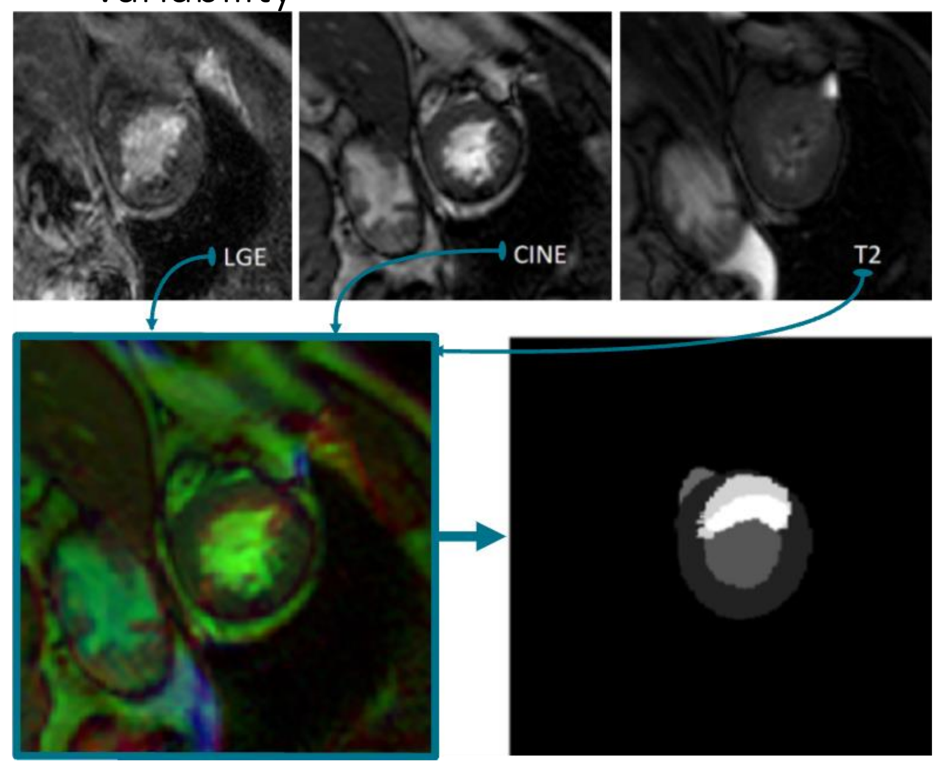


Fig. 1. LGE, bSSFP, T2, their combination, their manual segmentation

The solution

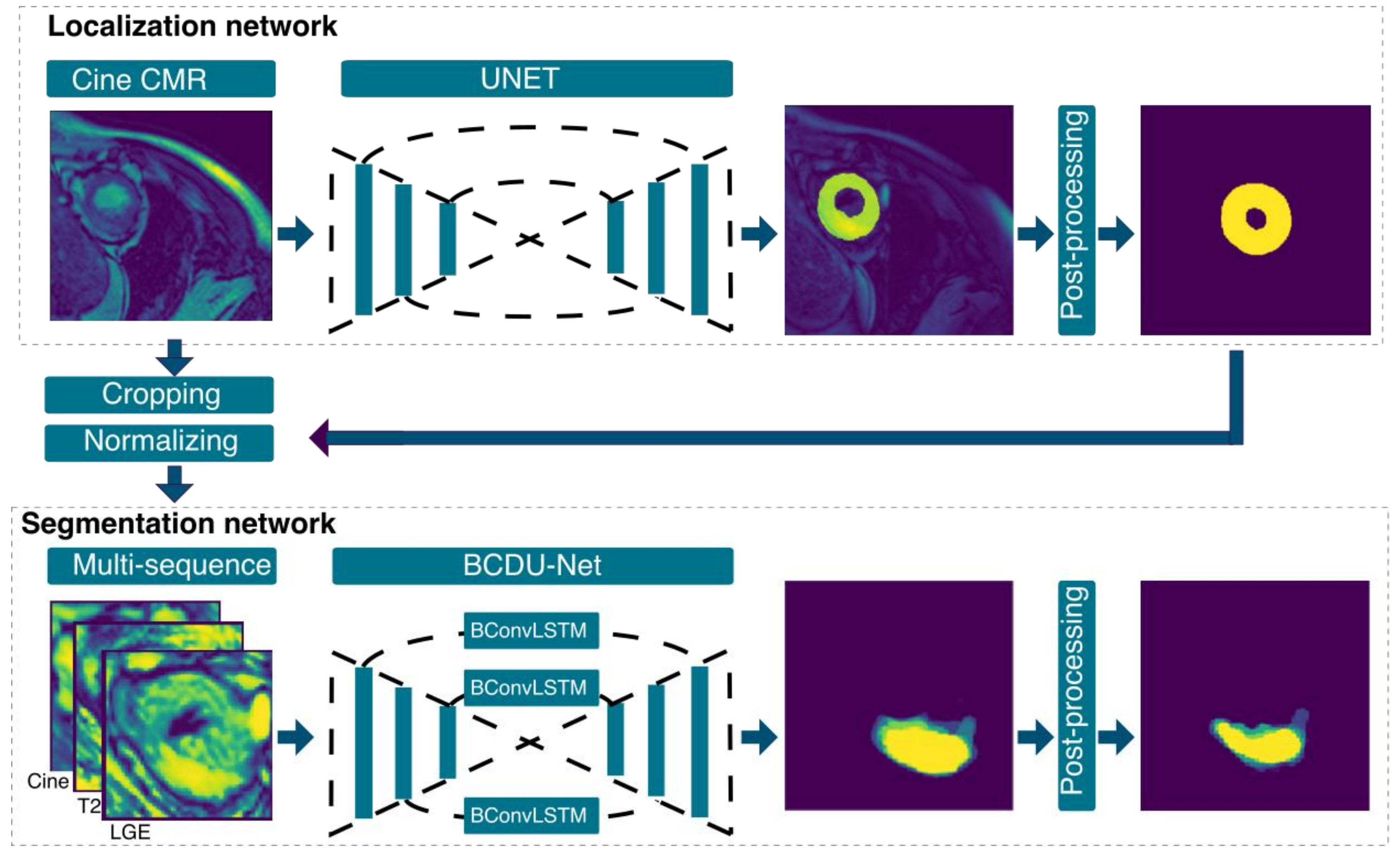
- To address these challenges, we propose:
  - Deep learning stacked BCDU-NET architecture
  - Localisation and segmentation stages
  - Multi-modal Semantic Image Synthesis with Spatially-Adaptive Normalization (SPADE) [2]

Proposed architecture & augmentation strategy

Proposed 2-stage architecture based on BCDU-Net

- STEP 1: LOCALIZATION
  - Binary segmentation network to localize the myocardium
  - Cine-MRI as input modality
  - U-net architecture
- STEP 2: SEGMENTATION
  - BCDU-Net [3] to segment the scar and edema
  - Normalized myocardium of the three input modalities
  - Averaging the confidence maps of an ensemble of 15 models.

Fig. 2. Overview of the proposed stacked localisation – segmentation network.



Data augmentation strategy

- New multi-modality images with multi-styles from altered versions of real annotations
- Morphological operations: 1. contour warpings between pairs of annotations, 2. scar tissue and edema rotations, and 3. dilations/erosions over the original

Results – Ablation study

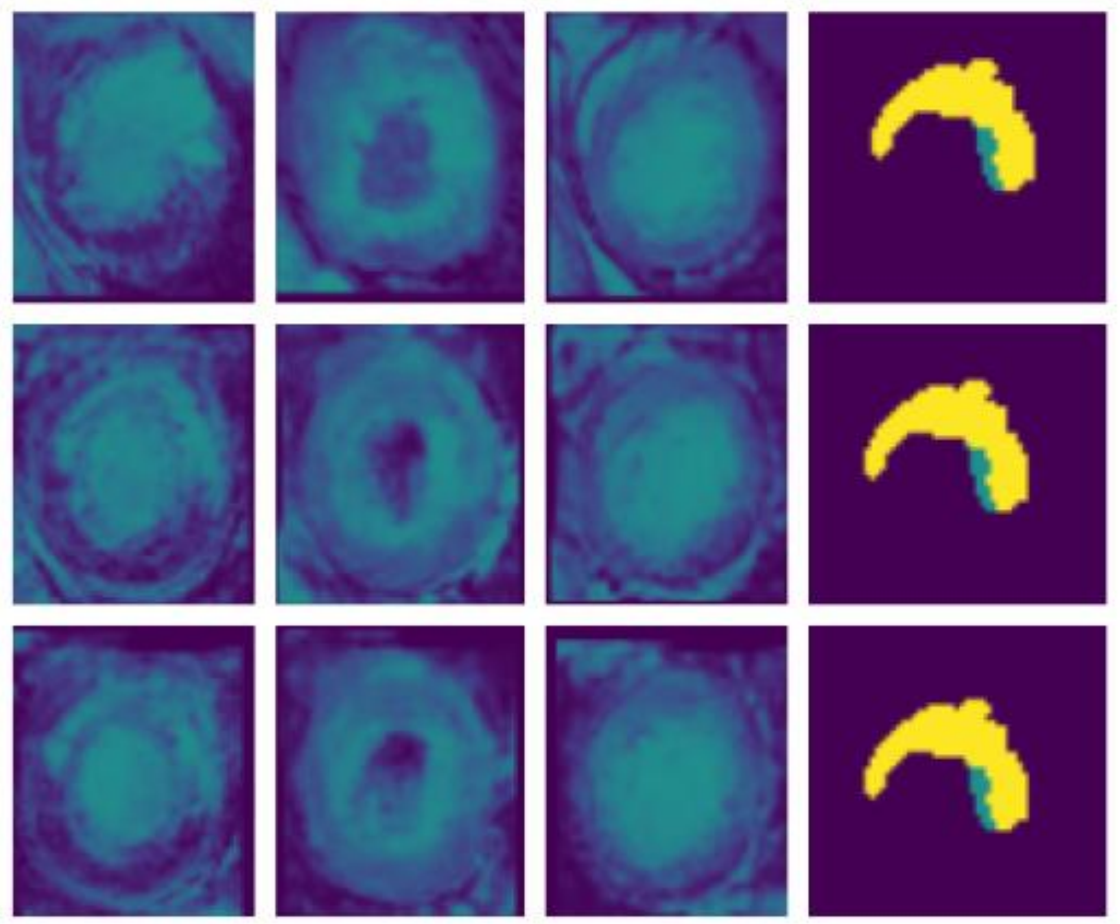


Fig. 3. Example style modifications. The proposed data augmentation strategy allows us to generate realistic images with different styles.

Table 1. 2D Dice score (mean ± standard deviation) of the proposed method for scar and scar+edema using different training data.

Training data	Scar	Scar + Edema
Original data	0.202 ± 0.286	0.170 ± 0.253
Original data + cropping + normalizing	0.449 ± 0.261	0.508 ± 0.243
Style transfer	0.548 ± 0.250	0.640 ± 0.192
Epicardium warping	0.490 ± 0.260	0.586 ± 0.222
Scar + edema rotation	0:466 ± 0:241	0:554 ± 0.224
Scar + edema dilation + erosion	0:458 ± 0.299	0:600 ± 0.224
All spade	0.518 ± 0:286	0:617 ± 0.253

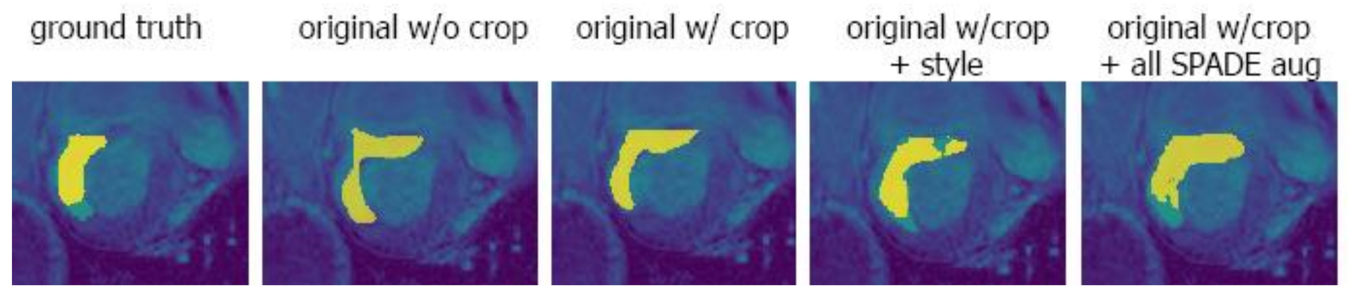


Fig. 4. Example of improvement offered by the proposed data augmentation technique

Results – Test set

- Post-processing based on unconnected components deletion and convex hull merging was applied to ensure segmentations satisfy anatomical constrains
- Two ensembles with and without such process are evaluated

Table 2. 3D Dice score for the final testing set of 20 subjects.

Approach	Scar	Scar + Edema
5 models ensemble	0.625 ± 0.255	0.677 ± 0.146
5 models ensemble + post-processing	0.635 ± 0.281	0.692 ± 0.143
15 models ensemble	0.636 ± 0.243	0.687 ± 0.131
15 models ensemble + post-processing	0.665 ± 0.241	0.698 ± 0.128

Conclusions

- Larger ensemble results in improved performance (larger training sizes).
- The effect of the low validation size was noticeable as a noisier validation curve, and attenuated by means of a greater regularization power, with an overall improved accuracy.
- Consistent results across the different semantic manipulations and their respective synthesis, indicate the potential of this set of transformations for improving generalization of multi-modality cardiac pathology segmentation algorithms.

References

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Acknowledgements

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