Classification of Delayed Enhancement Scar Islands by Means of their Local Subendocardial Transmurality

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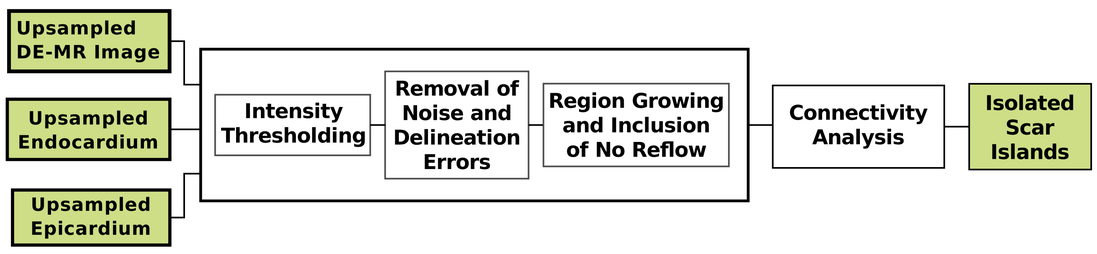
Motivation

- DE-MR detects infarcted tissue or fibrosis within the myocardium.
- In *ischemic cardiopathy* (ICM), there is a lack of blood supply which affects the endocardium first.
  - ⇒ Subendocardial or Transmural (S/T) scar configuration.
- The scar configuration on *nonischemic cardiomyopathies* usually provides qualitative insight into their etiology.
  - ⇒ Midwall or Subepicardial (M/E) scar configurations suggest a nonischemic origin for the cardiomyopathy.
  - *Hypertrophic Cardiomyopathy* (HCM) often presents midwall scar islands.
- No efforts towards the quantification of the scar intramural configuration have been carried out, to the best of our knowledge.

Island Identification



Local Subendocardial Transmurality (LSTM)

The current conception of the transmurality:

- is the ratio of the myocardial thickness covered by scar.
- is averaged by sectors ⇒ Loss of local detail
- does not take into account the intramural location of the scar.

The LSTM redefines the concept of transmurality so that [1]:

- It is defined as a dense local map the myocardium
- $t(\mathbf{x})$ is the transmurality computed between $\mathbf{x}$ and the endocardium.
- Contains information on the scar local and intramural configuration.
- At the *epicardium*, LSTM takes on the full transmurality value.

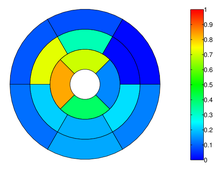


Figure: Bullseye of the transmurality of an ICM patient.

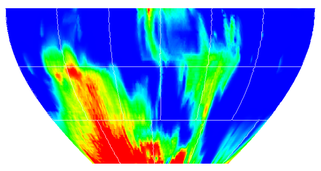


Figure: Epicardial LSTM (same patient).

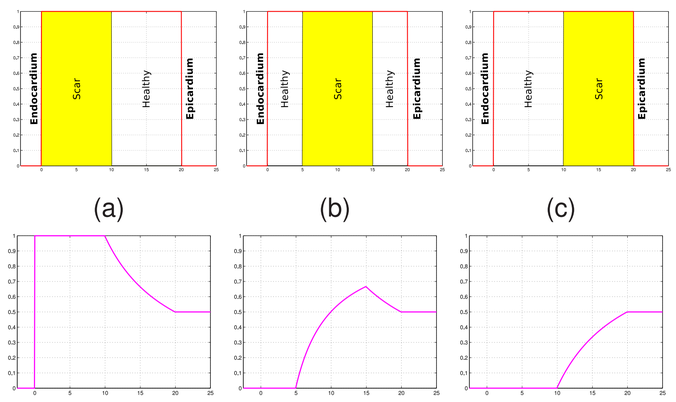


Figure: Theoretical 1D profiles of different scar configurations with a full transmurality value of 0.5.

[1] Merino-Caviedes S, Cordero-Grande L, Revilla-Orodea A, Sevilla-Ruiz T, Pérez MT, Martín-Fernández M, Alberola-López C. Multi-stencil streamline fast marching: a general 3D framework to determine myocardial thickness and transmurality in late enhancement images. IEEE Trans Med Imag. In press.

Acknowledgements

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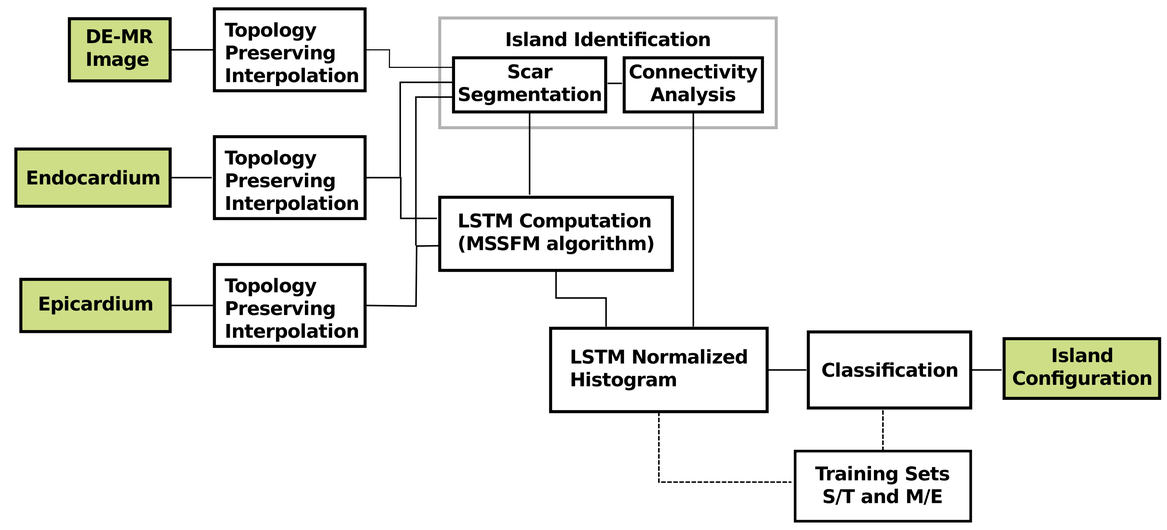
General Computational Framework



Classification

- The normalized histogram of the LSTM values within each island are computed.
- Noticeable difference between:
  - S/T configuration: LSTM mostly unitary.
  - M/E configuration: wider value range for LSTM.
- The classifier linearly correlates the input histogram against a training set of S/T and M/E histograms.
- The input histogram is assigned the class of the training histogram which yielded the highest correlation.

Experimental Results

- 20 short-axis DE-MR from HCM and ICM patients were employed.
- From them, a total of 30 islands were identified and annotated as S/T and M/E.
- Training set: 2 S/T islands and 3 M/E islands. Test set: 25 islands.
  - Paired Mann-Whitney U-test: training S/T and M/E islands have different medians ($p < 10^{-65}$).
  - Classification success of 95%. Only one S/T island was misclassified as M/E.

Table: Classifier performance.

	S/T_{exp}	M/E_{exp}
S/T_{class}	12	0
M/E_{class}	1	12

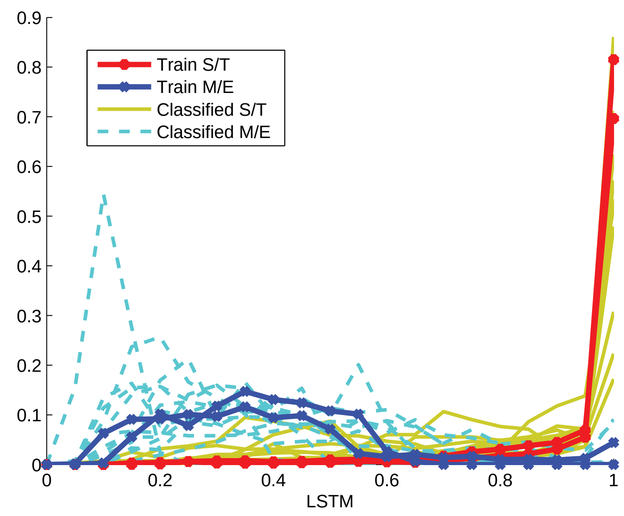


Figure: LSTM normalized histograms of the island set.

Conclusions

- A computational framework for the classification of myocardial scar configurations was developed.
- The scar intramural configuration can be extracted from the Local Subendocardial Transmurality (LSTM).
- Inspection of local measures on islands provides complementary information to the sector average approach.
- This work is a step towards a computer-aided tool for the diagnosis and risk stratification of nonischemic cardiomyopathies.

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