Right Ventricle Segmentation Challenge
Performance assessment

A Matlab evaluation code is provided to participants. It is intended to help the participants assessing their segmentation method performance on the Training dataset, with the same evaluation tool that will be used by the organizers during Test1 and Test2 stages. This program code is compatible with Matlab version 6.1 and 7.8. It is provided "as is" without any warranty and cannot be guaranteed completely bug-free, despite great care and conscientious testing. Please report any bug to the RVSC organizers.

Which evaluation measures are computed?

The performance of a segmentation method will be analyzed both from a technical and a clinical point of view, via i) similarity measurements between the automated segmentation results and the manual result and ii) global RV function indices (volumes and mass)[1].

The following two standard **similarity measurements** are computed (*independently for the endocardium and for the epicardium)*:

- The overlap Dice metric (DM), based on the pixel labeling as the result of a segmentation algorithm, defined as 2*intersection of automatic and manual areas/(sum of automatic and manual areas);
- The Hausdorff distance (HD), defined as $\max(h_a, h_b)$, where h_a is the maximum distance, for all automatic contour points, to the closest manual contour point and h_b is the maximum distance, for all manual contour points, to the closest automatic contour point. The Hausdorff distance is computed in mm thanks to spatial resolution obtained from the PixelSpacing DICOM field..

Clinical performance is assessed via the following 4 indices:

- Endocardial volume at ED EDVol (ml),
- Endocardial volume at ES ESVol (ml),
- Ejection fraction EF = (EDVol_endo-ESVol_endo)/EDVol_endo,
- Ventricular mass vm (g) = density*(EDVol_epi-EDVol_endo), with density = 1.05g/cm^3

Volumes are computed as the sum of all areas multiplied by the SpaceBetweenSlices value[2]. This value is the absolute difference between SliceLocation DICOM fields in 2 adjacent images (SpaceBetweenSlices = 8.4mm for all patients).

What is generated with the evaluation code program?

After execution of the main program (`main_perf_assessment.m`), 3 text files are generated:

1. `ImageResults` contains technical parameters for all images of all patients;
2. `PatientResults` contains technical parameters averaged over slices and clinical parameters for all patients;
3. `StatsResults` contains technical parameters averaged over patients and clinical parameters compared to ground truth averaged over patients.

Below is a detailed description of the content of each text file.

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[1] The STACOM'11 Cardiac Left Ventricular Segmentation Challenge, http://cilab2.upf.edu/stacom_cesc11.
[2] J. Bogaert, S. Dymarkowski, A.M. Taylor. *Clinical Cardiac MRI: With Interactive CD-ROM*, Springer, 2005.

`ImageResults.txt` contains technical parameters for all images of all patients:

	Image1	DM (mm)	HD (mm)
Patient 1	…	DM (mm)	HD (mm)
	…	DM (mm)	HD (mm)

…

	Image1	DM (mm)	HD (mm)
Patient N	…	DM (mm)	HD (mm)
	…	DM (mm)	HD (mm)

Example:

```
P01-0080-i 0.8183 6.38
P01-0080-o 0.8413 6.38
P01-0100-i 0.8204 6.44
P01-0100-o 0.8532 4.91
```

This file is intended for detailed error analysis during the Training stage. It will be provided to the participants during the Test1 stage, upon reception of the participant's automatic contours obtained on the Test1database.

`PatientResults.txt` contains averaged technical parameters and clinical parameters for each patient:

	Mean$_{slices}$ DM Endo ED	Mean$_{slices}$ DM Endo ES	Mean$_{slices}$ DM Epi ED	Mean$_{slices}$ DM Epi ES				
Patient 1	Mean$_{slices}$ HD Endo ED	Mean$_{slices}$ HD Endo ES	Mean$_{slices}$ HD Epi ED	Mean$_{slices}$ HD Epi ES				
	Auto EDVol	Manual EDVol	Auto ESVol	Manual ESVol	Auto EF	Manual EF	Auto Mass	Manual Mass

…

	Mean$_{slices}$ DM Endo ED	Mean$_{slices}$ DM Endo ES	Mean$_{slices}$ DM Epi ED	Mean$_{slices}$ DM Epi ES				
Patient N	Mean$_{slices}$ HD Endo ED	Mean$_{slices}$ HD Endo ES	Mean$_{slices}$ HD Epi ED	Mean$_{slices}$ HD Epi ES				
	Auto EDVol	Manual EDVol	Auto ESVol	Manual ESVol	Auto EF	Manual EF	Auto Mass	Manual Mass

Example:

```
P01-dm 0.8902 0.6896 0.9038 0.7644
P01-HD 6.70 7.89 6.41 10.39
P01 112.16 121.83 32.12 39.58 0.71 0.68 53.06 52.84
```

If no automatic epicardium contour is provided, then epicardium DM and HD values, as well as mass measures are set to -1.

This file is intended for detailed error analysis during the Training stage. It will be provided to the participants during the Test1 stage.

`StatsResults.txt` includes:

- Mean and standard deviation values of DM and HD over all patients at ED, ES and over both phases, for both the endocardium and epicardium contours.
- Comparison of manual vs. automated clinical parameters via:
    - Correlation coefficient R and coefficients of linear regression fit (y = ax+b) for:
        - Endocardium and epicardium areas,
        - ED and ES volumes,
        - EF and mass.
    - Mean and standard deviation of relative error for EF and ventricular mass (vm): $|EF_{auto} - EF_{manual}|/EF_{auto}$ and $|vm_{auto} - vm_{manual}|/vm_{auto}$

Example:

```
Mean (std) endo DM: ED: 0.8982 (0.03), ES: 0.7993 (0.21)
Mean (std) endo HD: ED: 7.63 (2.29), ES: 6.95 (4.40)
Mean (std) epi DM: ED: 0.9117 (0.02), ES: 0.8497 (0.20)
Mean (std) epi HD: ED: 7.69 (2.76), ES: 8.91 (5.78)

Total mean (std) endo DM: 0.8535 (0.15)
Total mean (std) endo HD: 7.32 (3.38)
Total mean (std) epi DM: 0.8836 (0.14)
Total mean (std) epi HD: 8.24 (4.38)

Endo area: R = 0.9923, a = 0.9139, b = 0.0513
Epi area: R = 0.9940, a = 0.9529, b = -0.6426
ED vol: R = 0.9992, a = 0.9168, b = 0.7175
ES vol: R = 0.0783, a = 0.4012, b = 19.8901
EF: R = 1.0000, a = 1.2803, b = -0.1545, mean (std) error = 0.0361(0.02)
vm: R = 0.9968, a = 1.0434, b = -3.1248, mean (std) error = 0.0527(0.06)
```
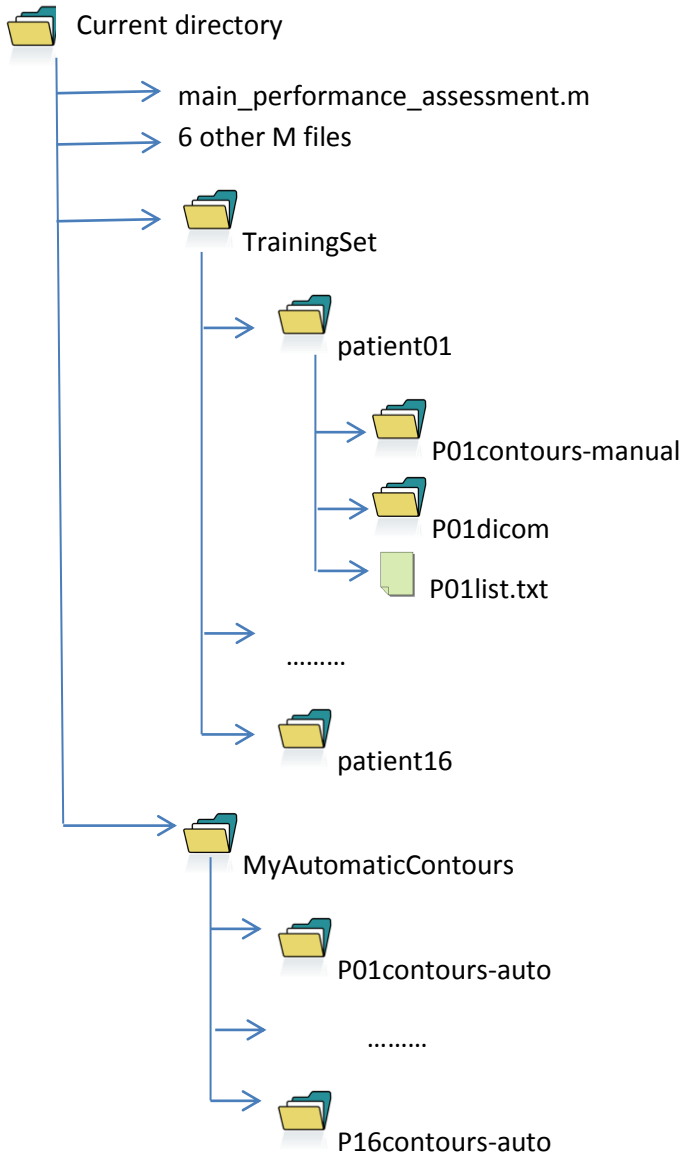
This file contains results to may be included in the paper to be submitted. It will be provided to the participants during the Test1 stage.

How to launch the main evaluation program

Matlab programs for performance assessment are provided to the participants (7 M-files: `main_perf_assessment.m`, `compare_rv_contours.m`, `corrcoef_regression.m`, `edgelist2mask.m`, `intline.m`, `mypoly2mask.m`, `poly2edgelist.m`). They have been tested with Matlab 6.1 and Matlab 7.8.

Before executing the main program (`main_perf_assessment.m`), the participant *should set the EPI variable* to 1 if automatic epicardium contours exist, or set EPI to 0 otherwise.

Regarding the location of the automatic contour files, the `main_perf_assessment` program is based on the following file hierarchy:

📁 Current directory
- → main_performance_assessment.m
- → 6 other M files
- → 📁 TrainingSet
  - → 📁 patient01
    - → 📁 P01contours-manual
    - → 📁 P01dicom
    - → 📄 P01list.txt
  - → ………
  - → 📁 patient16
- → 📁 MyAutomaticContours
  - → 📁 P01contours-auto
  - → ………
  - → 📁 P16contours-auto

This can be easily changed in the `main_perf_assessment` program.