Cardiac structures segmentation in 2D echocardiography using deep learning

500 patients project

CREATIS — Olivier Bernard, Sarah Leclerc

CHU Saint-Étienne — Florian Espinoza

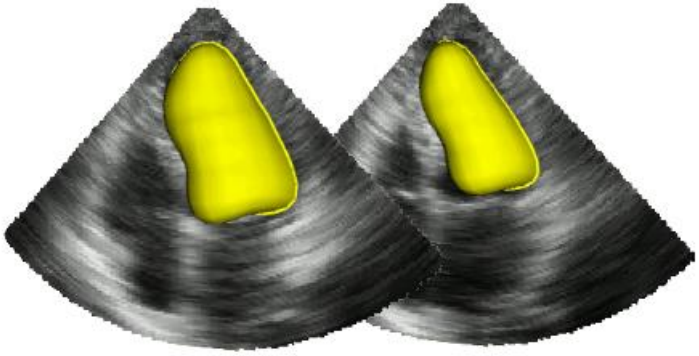
NTNU — Lasse Lovstakken, Erik Smistad, Andreas Ostvik

KATHOLIEKE UNIVERSITEIT LEUVEN — Jan D'hooge, Joao Pedrosa

VITAL — Pierre-Marc Jodoin, Clément Zotti

Medical context

- **Assessment of cardiac pathologies in clinical routines**
  - **One classical index: Ejection Fraction (EF)**
  - **Still needs the expert manual annotation / correction in clinical routine**



End diastole (ED) *End systole (ES)*

$$EF(\%) = \frac{Vol_{ED} - Vol_{ES}}{Vol_{ED}} * 100$$

Strong needs to have robust, reproducible and accurate fully-automatic extraction of the EF in clinical routines

Medical context

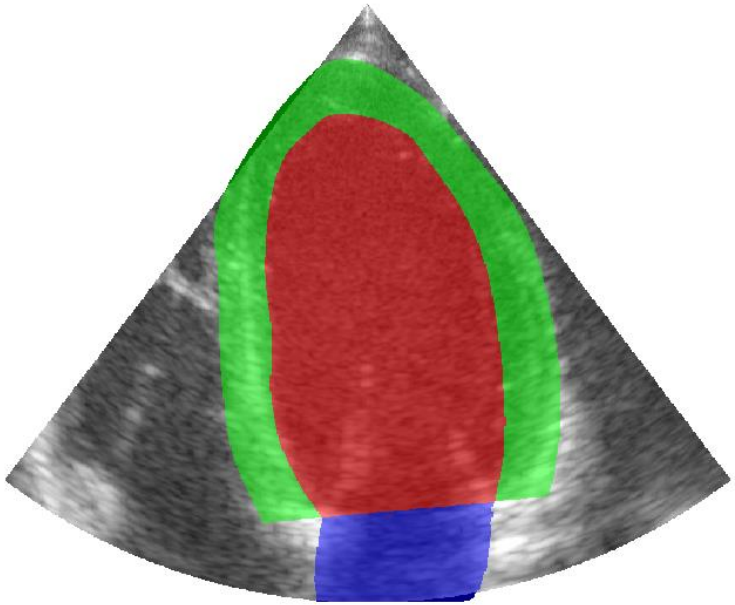
- **How to estimate volumes from 2D images ?**
  - **Acquisition of two orthogonal planes: apical four-chamber view and apical two-chamber view**

Apical four-chamber view

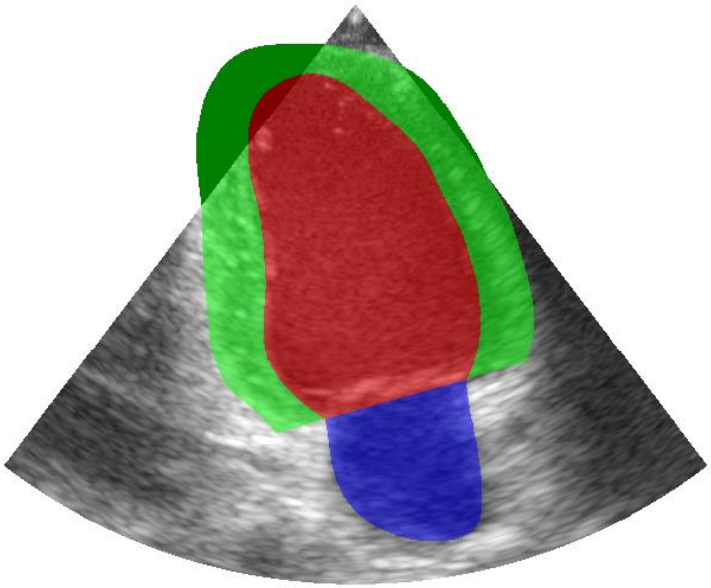
Apical two-chamber view

Medical context

- Segmentation of the left-ventricle structures on the corresponding image planes
- Use of an approximation from the 2D segmentations to roughly estimate the corresponding volume



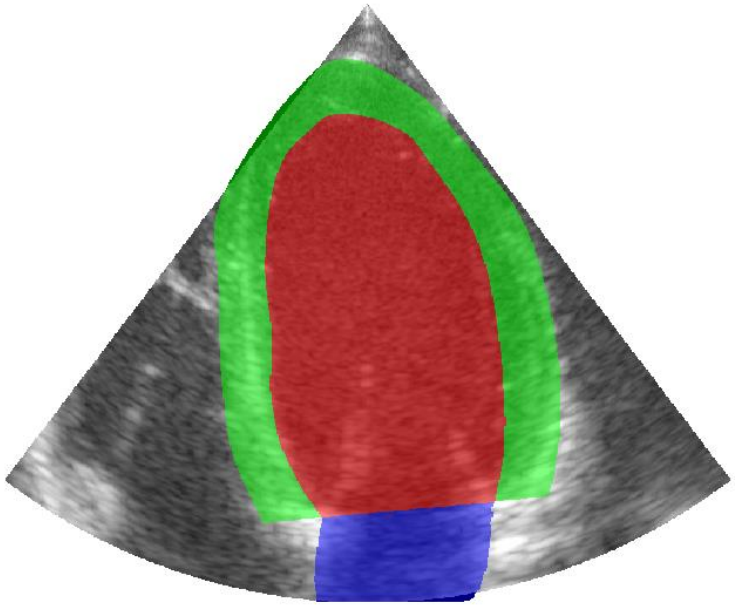
Apical four-chamber view



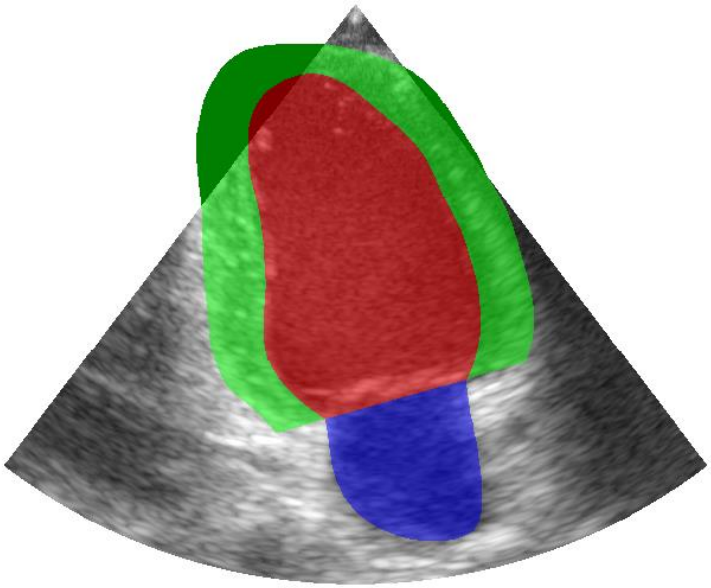
Apical two-chamber view

Medical context

- **How to estimate volumes from 2D images ?**
  - **Segmentation of the left-ventricle structures on the corresponding image planes**



Apical four-chamber view

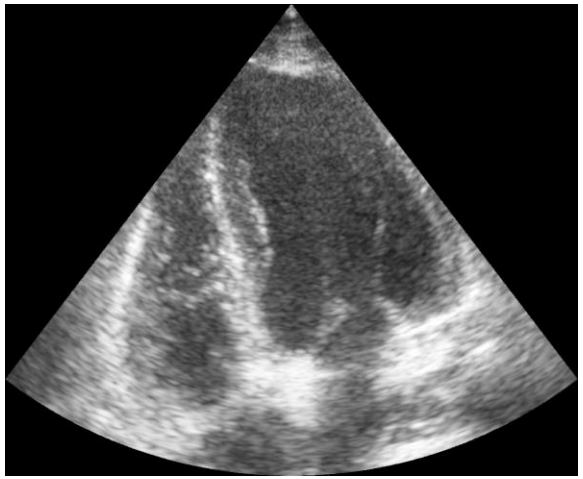


Apical two-chamber view

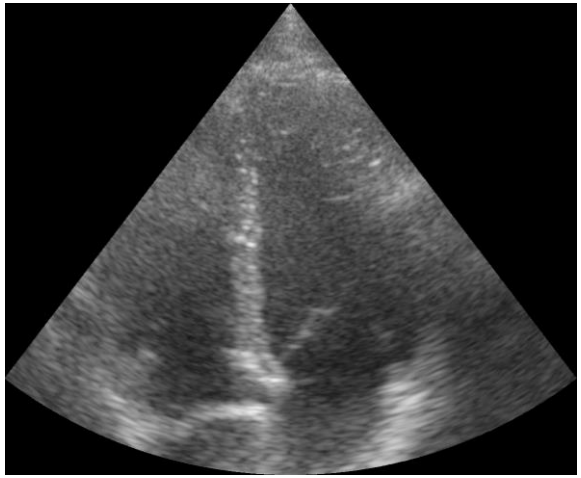
Medical context

- **What are the difficulties ?**
  - **Strong variabilities in the quality of images**
  - **The boundaries of the structures of interest are not clear**
  - **Presence of different artefacts inherent from ultrasound imaging**

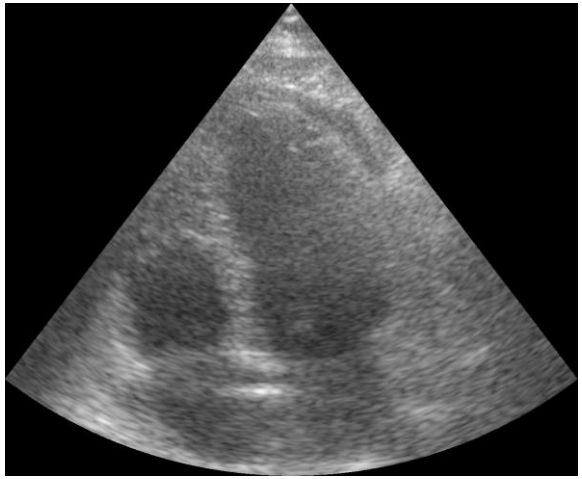
Database – 4CH



Good

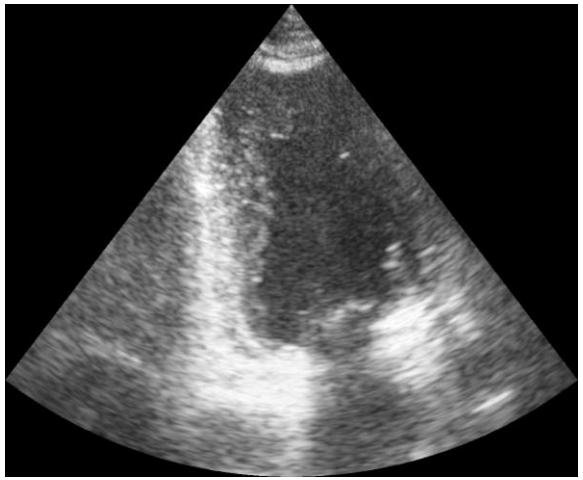


Medium



Low

Database – 2CH



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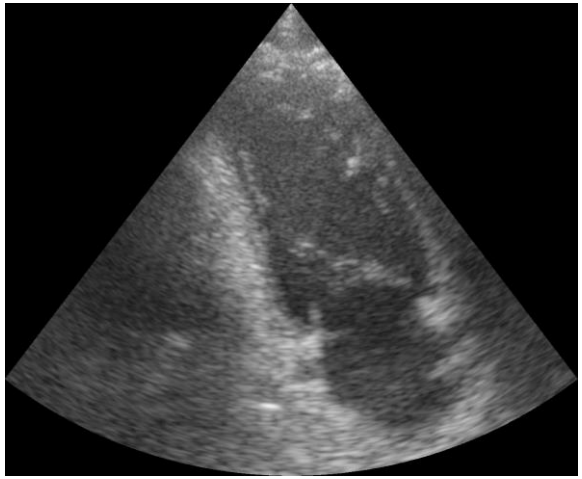

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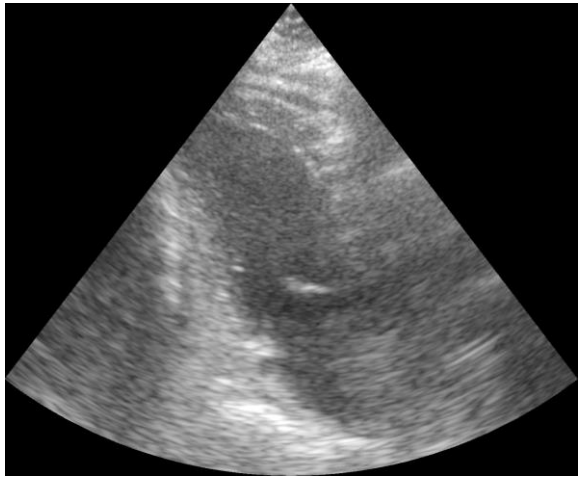


Low

Objectives of the CAMUS project

- **Answer to the following questions:**
  - **How accurate are the current best performing deep learning techniques to perform endocardium, myocardium and left atrium segmentation ?**
  - **What are the performances of the deep learning techniques compared to the best state-of-art methods ?**
  - **How accurate are deep learning techniques in estimating the EF ?**
  - **Is there a convergence for the deep learning methods in terms of accuracy according to the number of patients used in the training phase ?**
  - **How many patients do we need to obtain accurate deep learning results ?**

CAMUS project

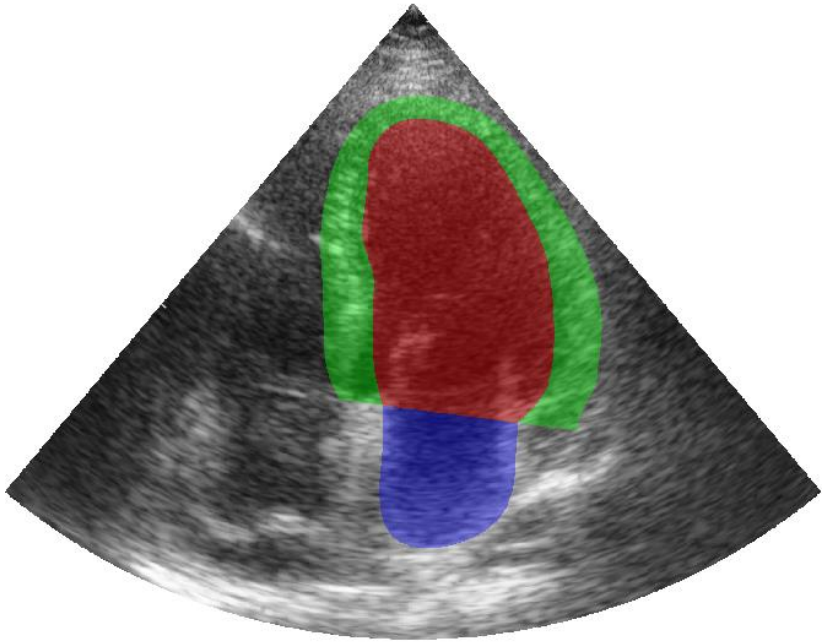
Database

Database

- 500 patients from the Hospital of St Etienne, France
  - Corresponds to 2/3 weeks of scans in the hospital
  - For each patient, acquisition of one 4CH and one 2CH sequence (to assess the EF from the Simpson formula)
  - No assumption on potential disease (clinical conditions)
  - High heterogeneities in the image quality
    - Good = 35 %
    - Medium = 46 %
    - Poor = 19 %

Manual annotations from cardiologists

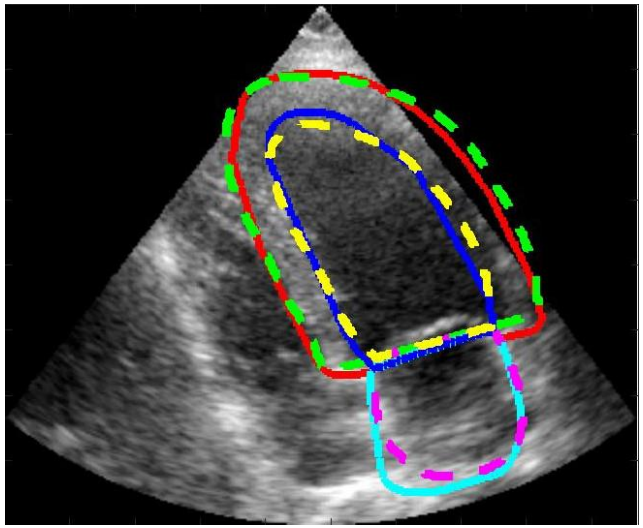
- Manual delineation by one cardiologist of the left ventricle, the myocardium and the left atrium for both ED and ES time instances and for both 2CH and 4CH views
- Accurate segmentation of 500 patients => 8 months of work

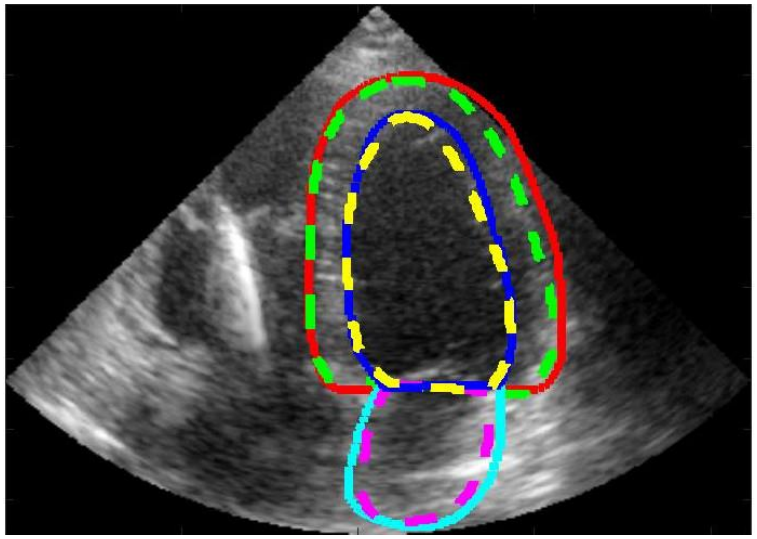


Database

- **Manual annotations from cardiologists**
  - **For a subset of 50 patients, manual delineation by 2 cardiologists from two different centres to assess the inter-experts variability**

Some typical results





	LV	MYO	LA
Dice	0.93	0.85	0.9
MAD (mm)	1.7	1.8	2.0
Haus (mm)	4.7	4.6	8.8

	LV	MYO	LA
Dice	0.96	0.84	0.89
MAD (mm)	1.1	2.1	2.3
Haus (mm)	4.2	5.4	3.9