Unsupervised localization of heart and lung region in EIT images: a validation study

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Unsupervised localization of heart and lung region in EIT images: a validation study

Goal

Propose and evaluate an unsupervised method to detect pixels in a sequence of EIT images depicting functional information of heart and lungs (H&L).

Plan

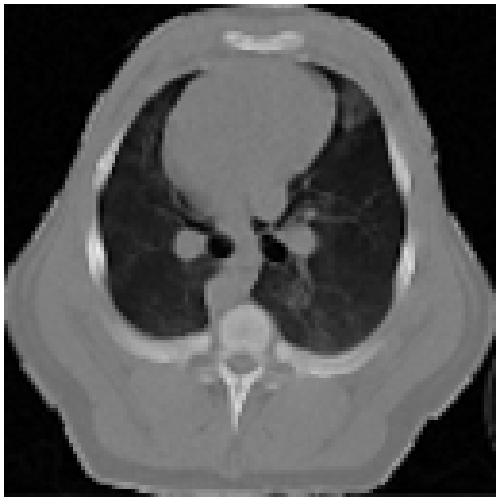
1. Database
2. EIT morphological reconstruction
3. Unsupervised localization of H&L on EIT images
4. Assessment of H&L localization
5. Results and conclusion

1. Database: simultaneous CT and EIT recordings

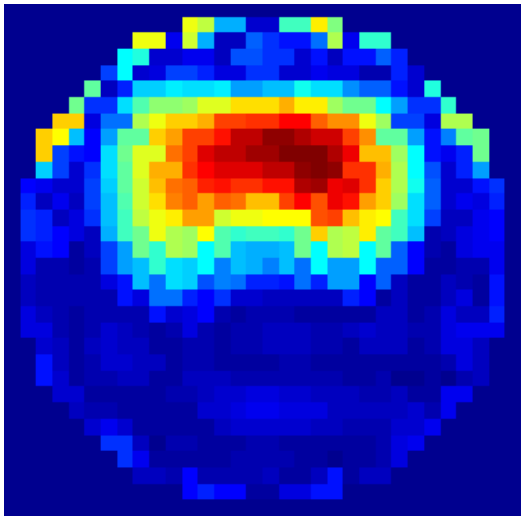
Retrospective analysis of CT and EIT

- Same pig
- Ventilated pigs: 5, 15 and 45 mbar

CT image



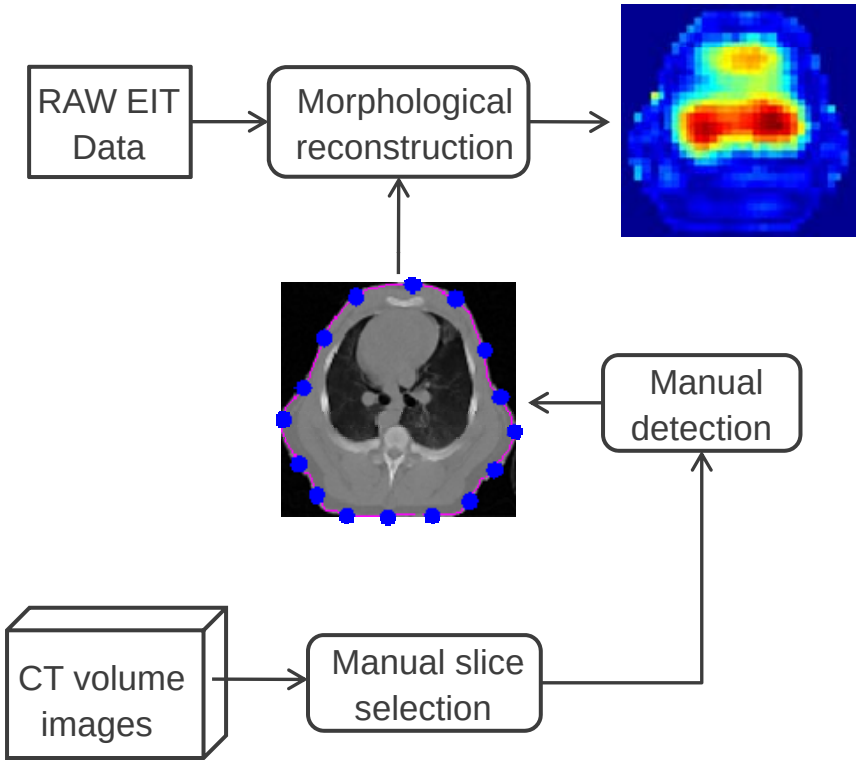
EIT image



How to compare CT and EIT images?

DB provided by Marc Bodenstein, Mainz University

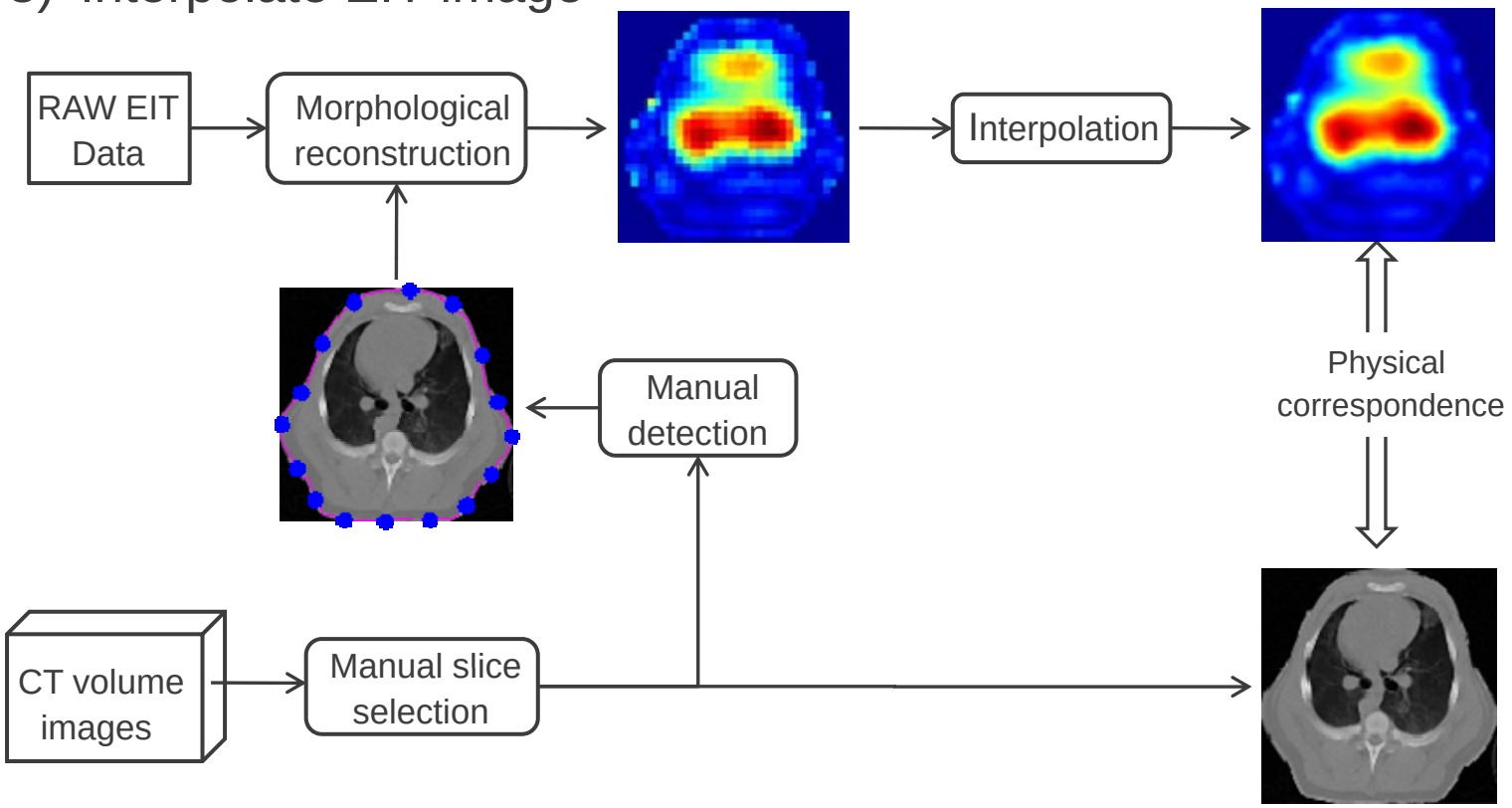
2. EIT morphological reconstruction



✓ EIT and CT images have now the same shape

2. EIT morphological reconstruction

3) Interpolate EIT image

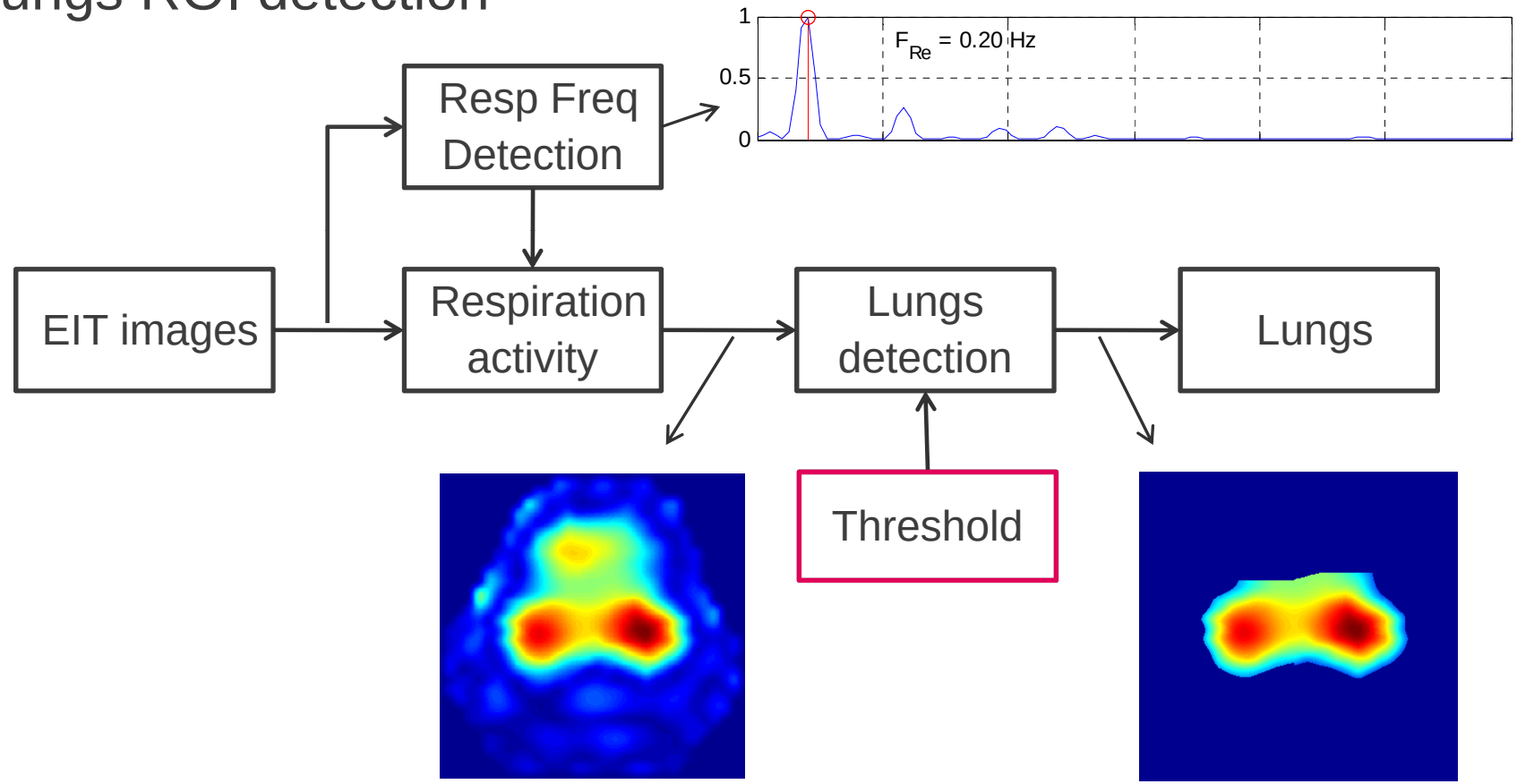


✓ EIT and CT images have same resolution

Can be compared pixel by pixel

3. Unsupervised detection of H&L activity

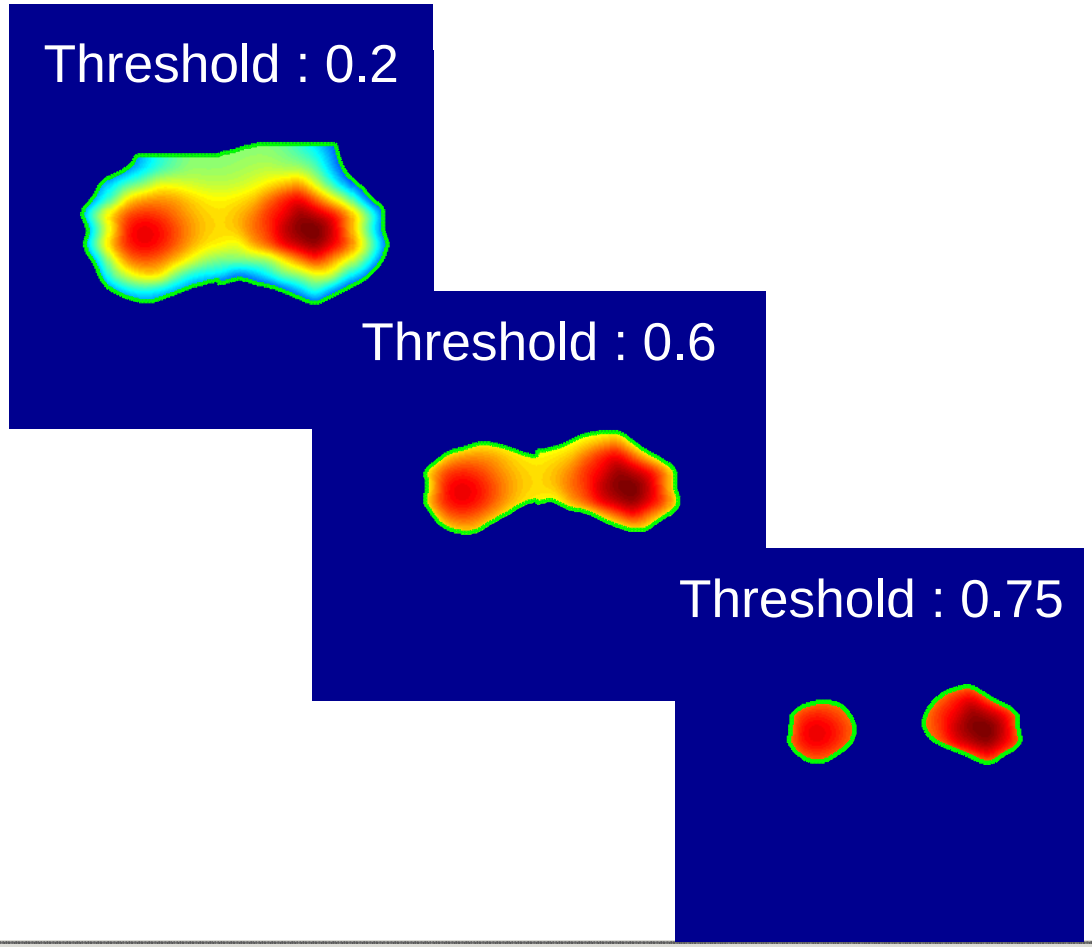
Lungs ROI detection

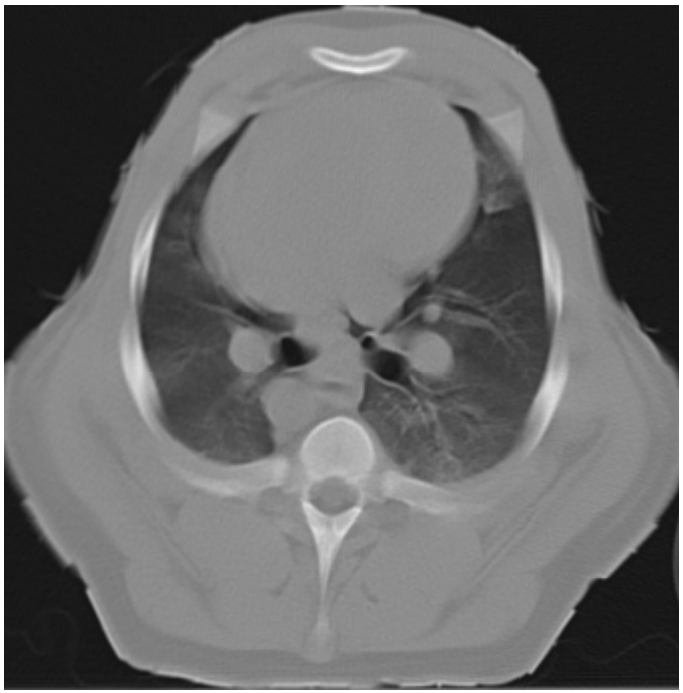


⇒ The threshold allows to choose the size of the lungs ROI

3. Unsupervised detection of H&L activity

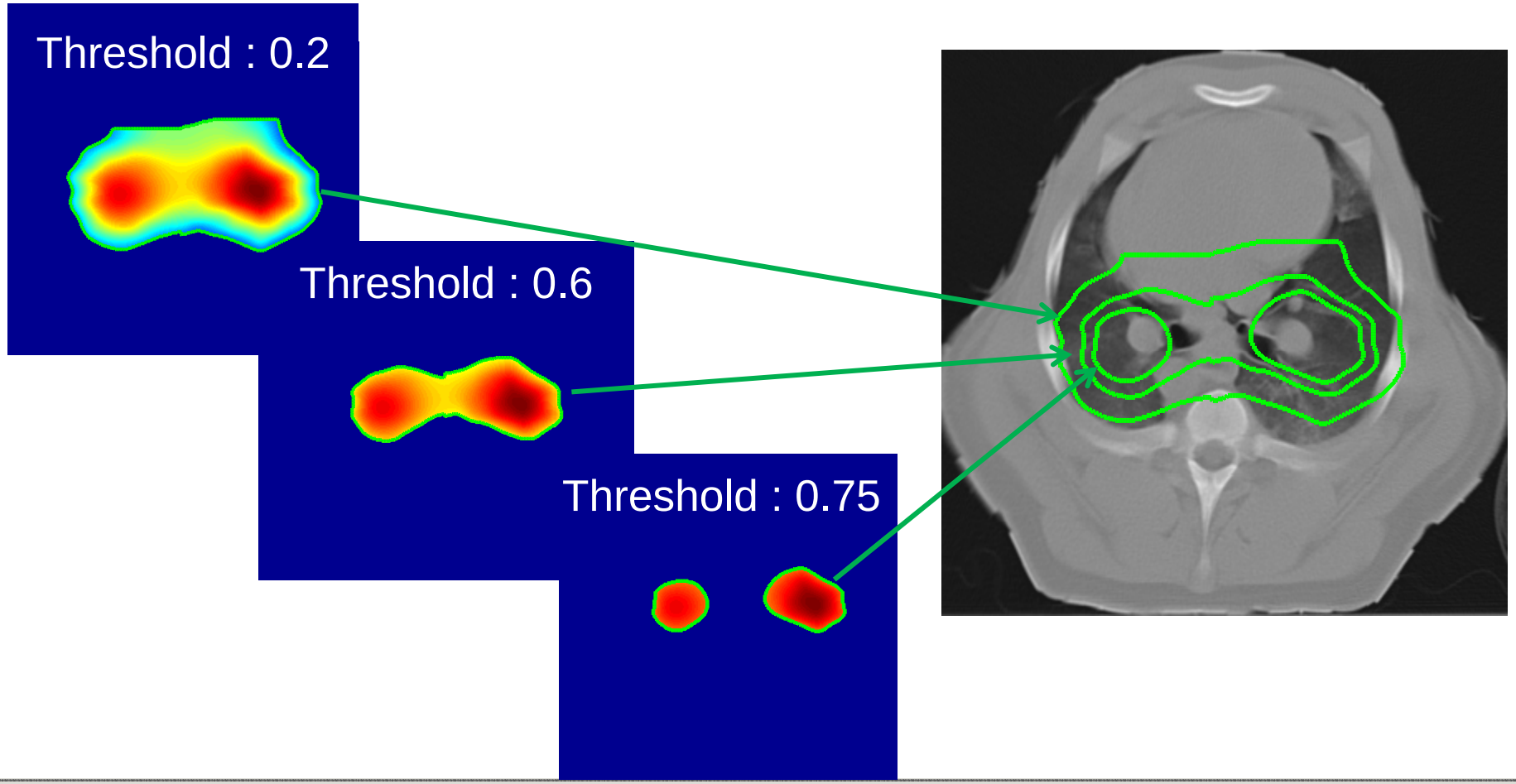
Allowing to zoom on pixels with more respiration





3. Unsupervised detection of H&L activity

Allowing to zoom on pixels with more respiration



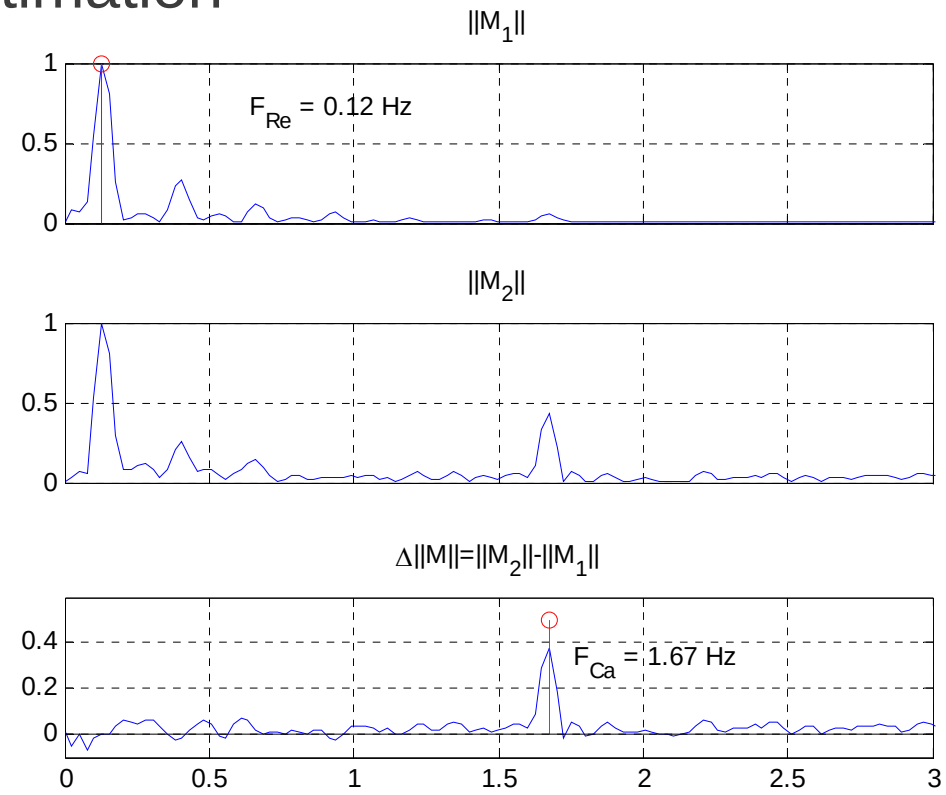
3. Unsupervised detection of H&L activity

Cardiac frequency estimation

lungs pixels:

not lungs pixels:

difference:

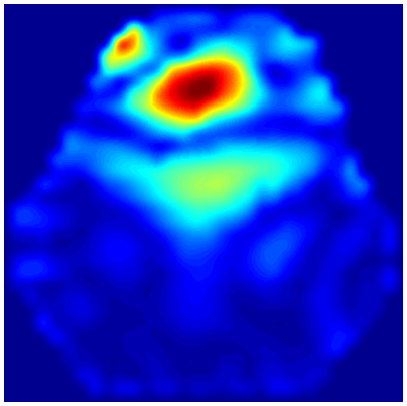


⇒ Cardiac frequency is then the frequency with the biggest amplitude

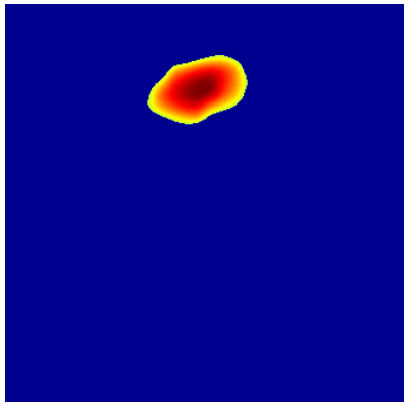
3. Unsupervised detection of H&L activity

Heart ROI detection

- Compute harmonic energy at cardiac frequency for each pixel



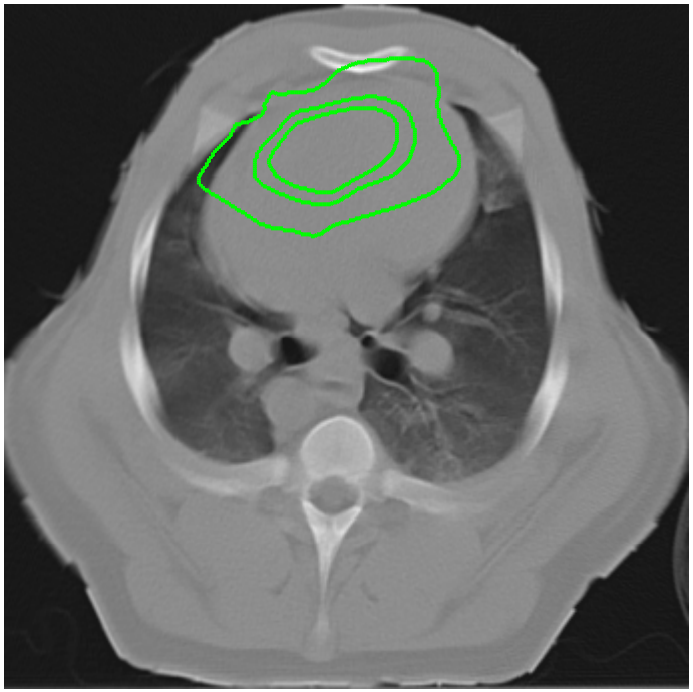
- Heart ROI is detected similarly to the lungs detection



⇒ The threshold allows to choose the size of the heart ROI

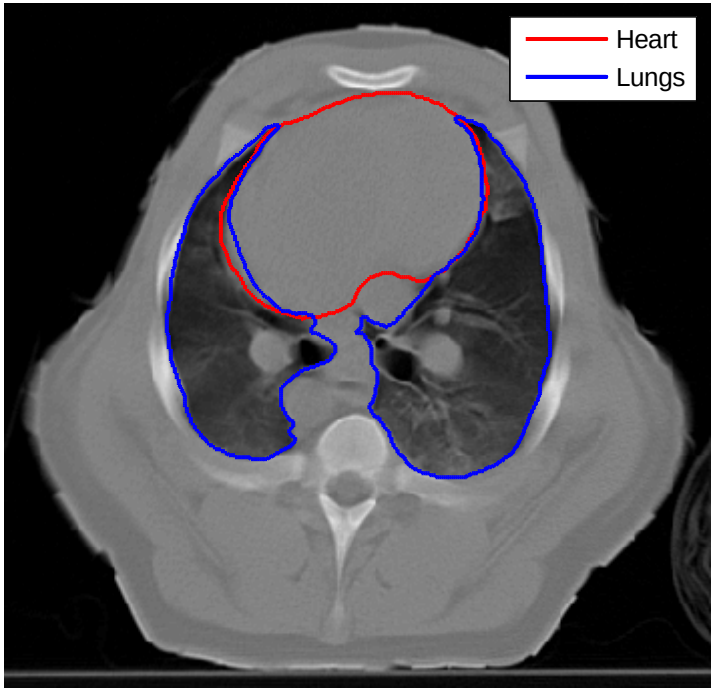
3. Unsupervised detection of H&L activity

Allowing to zoom on pixels with more cardiac activity



4. Assessment of H&L detection performance

Reference CT images were manually segmented by an expert:

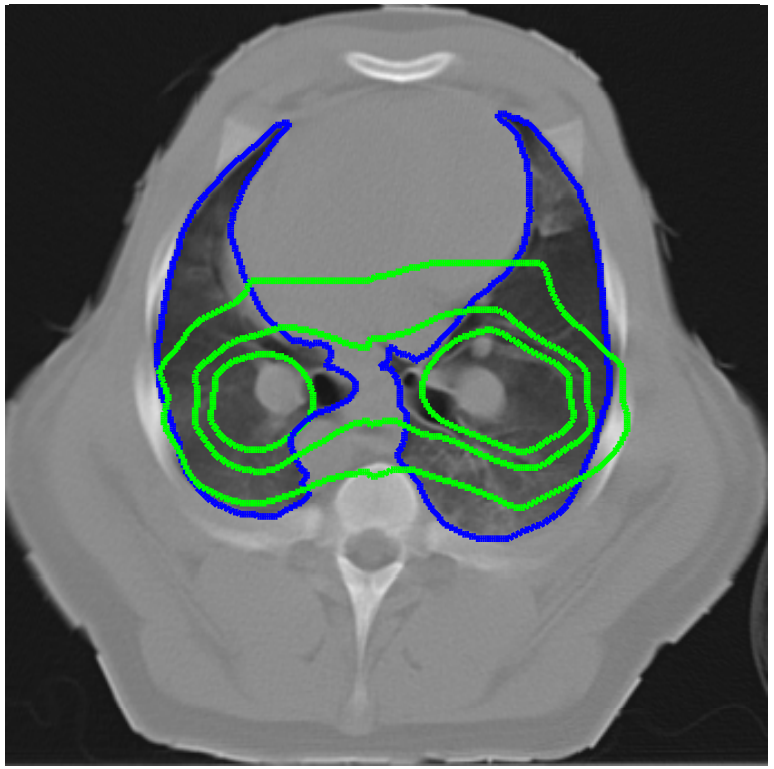


4. Assessment of H&L detection performance

Are pixels with high activity in the corresponding organ?

Precision: $$precision = \frac{TP}{TP + FP}$$

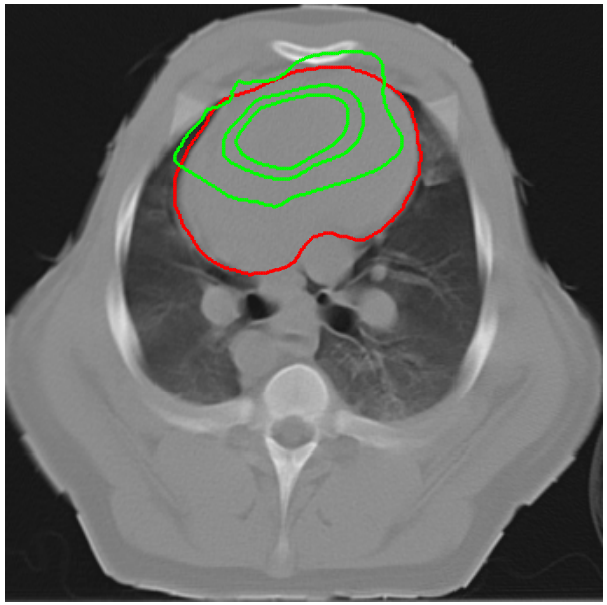
If all pixels are in the segmented organ precision is 100%

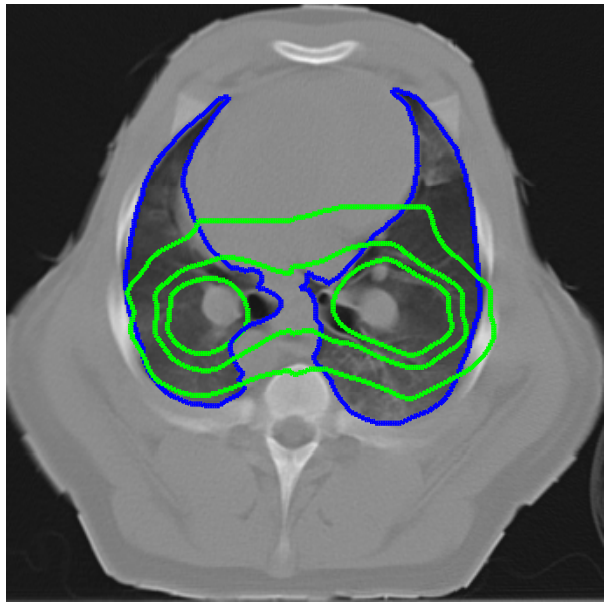


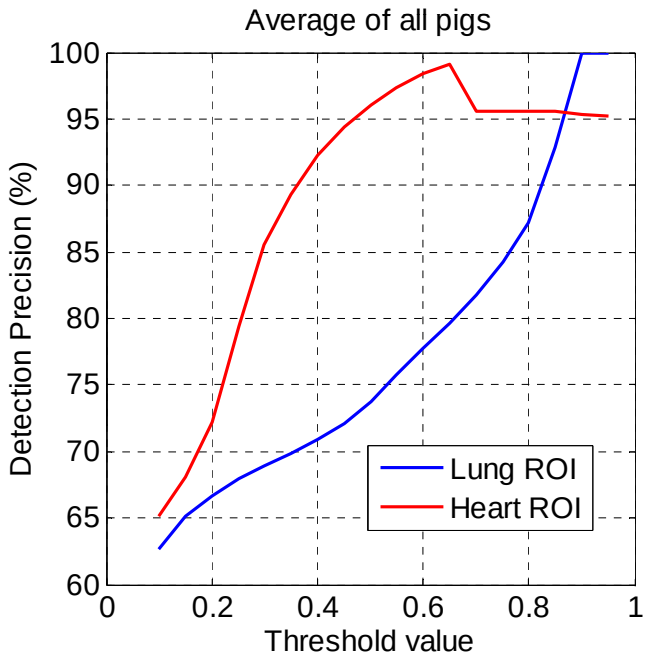
5. Results

In total:

- 7 pigs at 3 PEEP conditions (5, 15, 45 mbar): 21 test.
- 20/21 tests were *precise* for the heart and 21/21 for lungs.

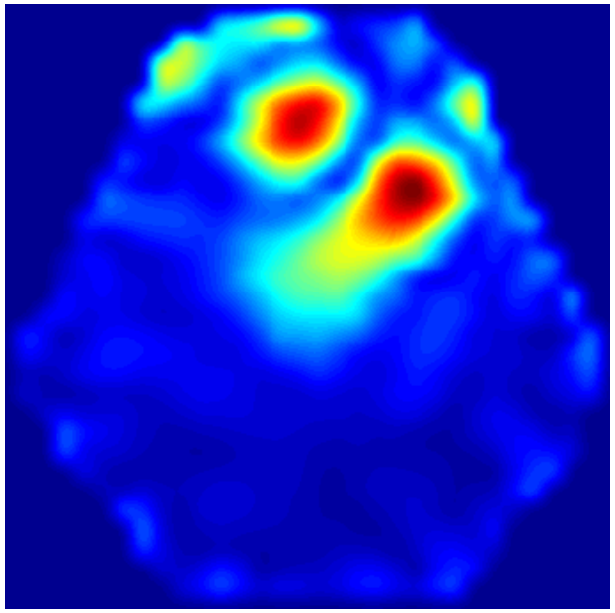


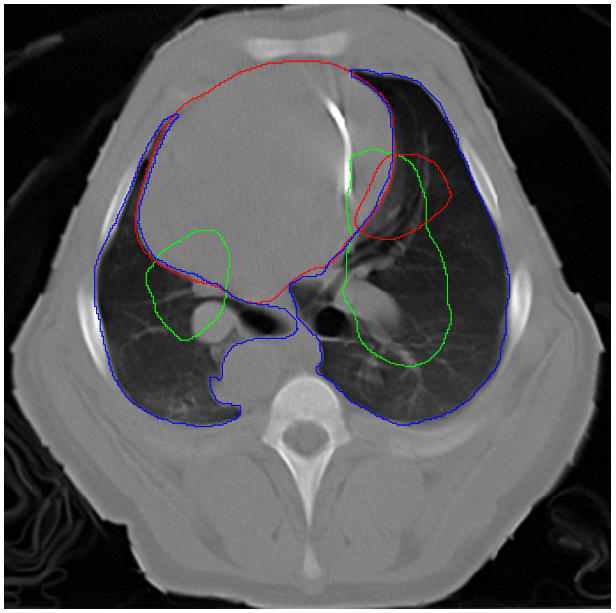




5. Results

One single animal showed unsuccessful heart detection





5. Conclusion

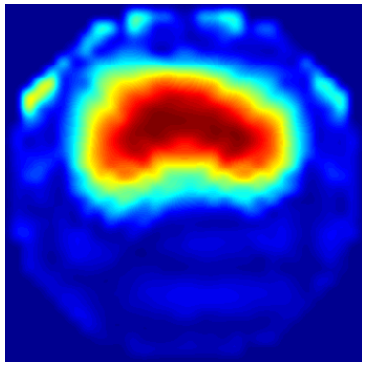
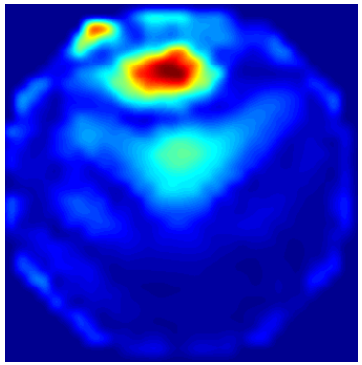
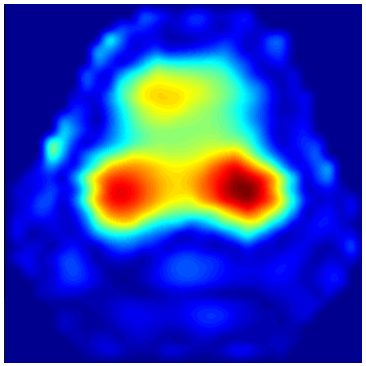
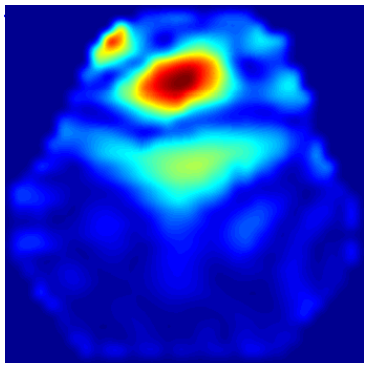
- Proposed automatic algorithm to detect H&L regions in EIT images was evaluated and showed a performant detection in almost all cases.

- Validates EIT images as an accurate representation of physiological activity in the thorax.

- Show the potential of EIT to specifically monitor organs or regions of interest.

5. Conclusion

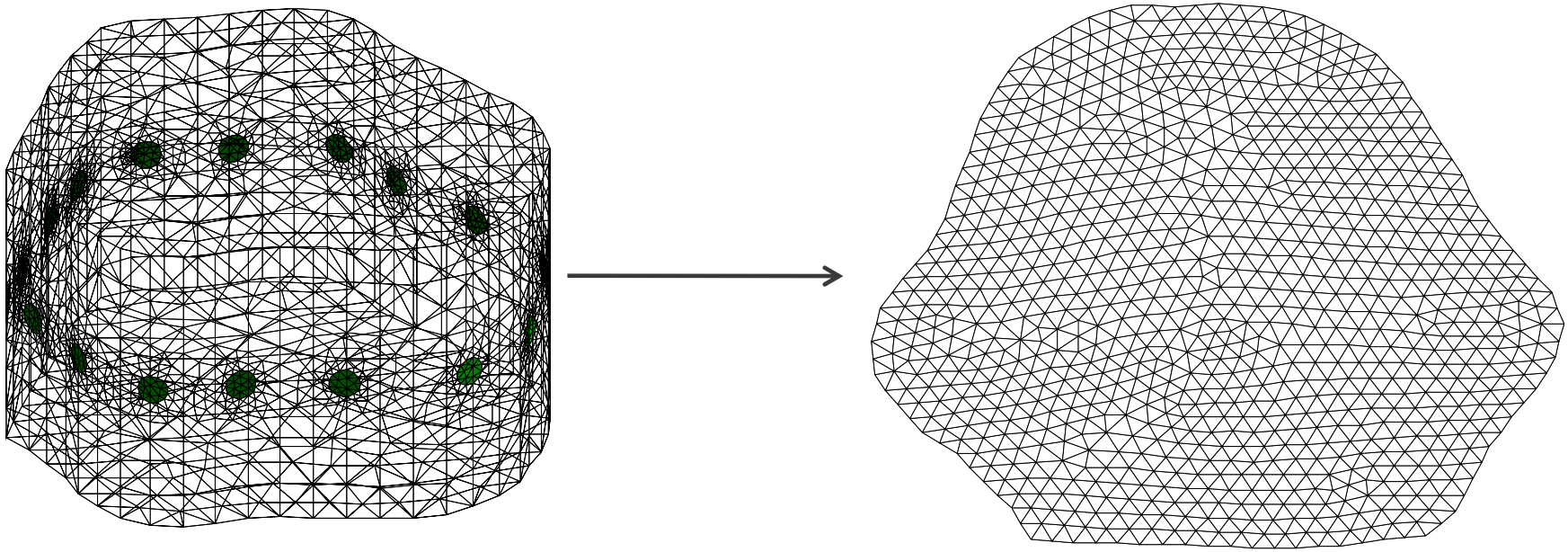
Importance of accurate anatomical models for EIT reconstruction!

	Respiration activity	Cardiac Activity
Round shape		
Pig shape		

Questions

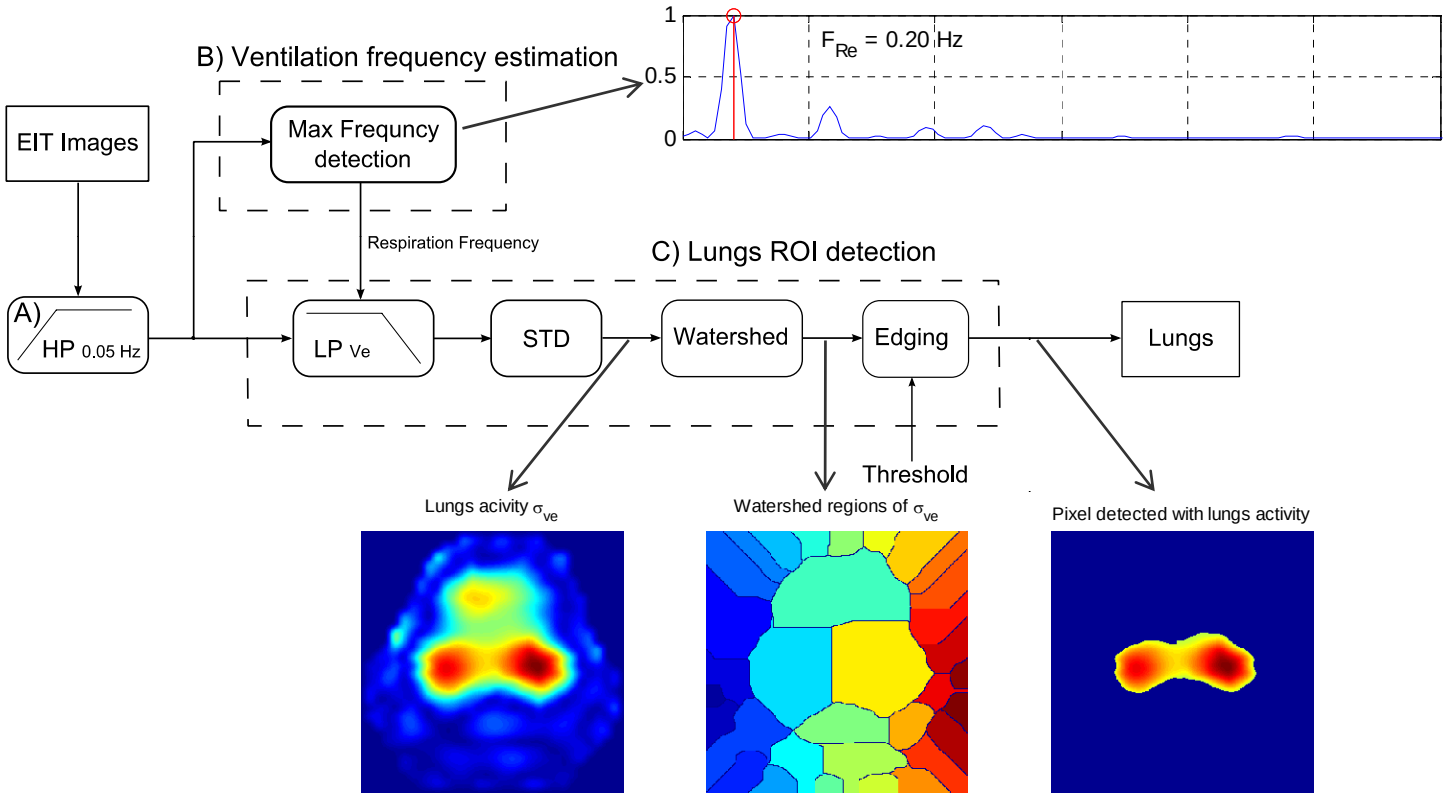
Thank you!

2. EIT morphological reconstruction



3. Unsupervised detection of H&L activity

Lungs ROI detection



⇒ changing the size of the threshold allows to choose the size of the lungs ROI