

Echocardiogram video analysis using speckle and feature tracking methods

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In collaboration with



Introduction

- Echocardiogram is a commonly used method to detect heart malfunctions
- In other medical-imaging methods, there are functions which help the doctor to extract medical data from the image
- The speckles which can be seen in an echo-cardiac videos, can often be used to extract medical data



A typical echo-cardiac image

Goals

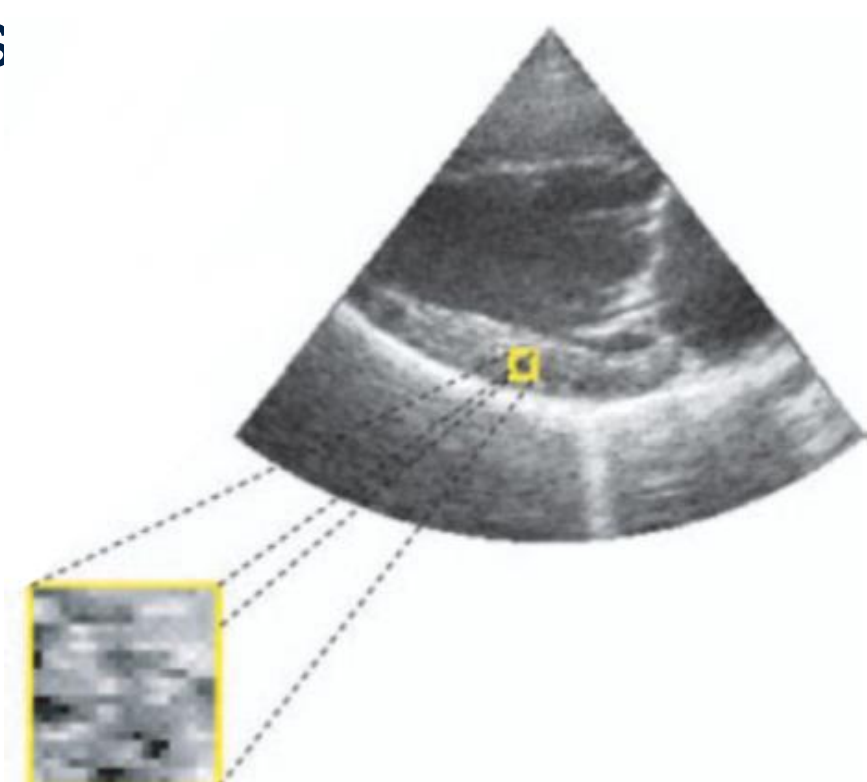
- Create an automatic or semi-automatic product which can extract the following medical data:
 - Ejection fraction (EF)
 - The existence of regional wall motion abnormalities (RWMA)

Challenges

- Achieve the chosen goals solely by using a previously unused speckle tracking method and basic image processing methods
- Make the product intuitive for Doctors
- Obtain echo-cardiac videos for testing

The chosen speckle tracking method

- Each frame is divided to semi-congruent regions of interest. Each ROI is symbolled by its top left corner indexes



A ROI with Speckles

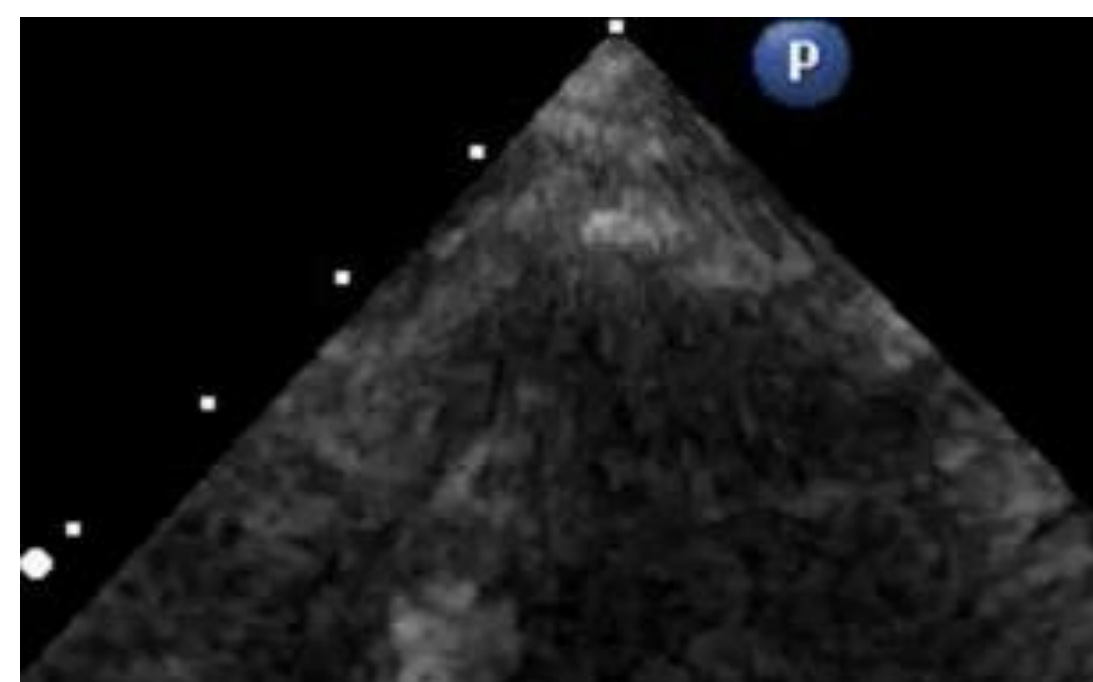
- To determine where a specific ROI moved to between frames to an other ROI the following error matrix is calculated :

$$\epsilon_{m,n} = \sum_{i=1}^l \sum_{j=1}^k |X_{i,j} - Y_{i+m,j+n}|$$

- X – the original frame, Y – the following frame
- l X k – the ROI size
- The ROI with the lowest error value is chosen as the ROI's new position
- This method contains 8 time less calculations than currently used methods.

Image manipulations

- After several simulations, and according to past researches, we decided to extrapolate from each frame a binary mask of the heart's inside.
- The automatic product failed to fully recognize the inside of the heart, mostly due to lack of difference in some areas between the inside and the walls of the heart



Example to the lack of difference

- Thus, the extrapolation flow is:
 - The user chooses a frame which showing the end-diastolic volume
 - The user marks the ventricles
 - An image processing methods are used to extrapolate solely the heart's inside

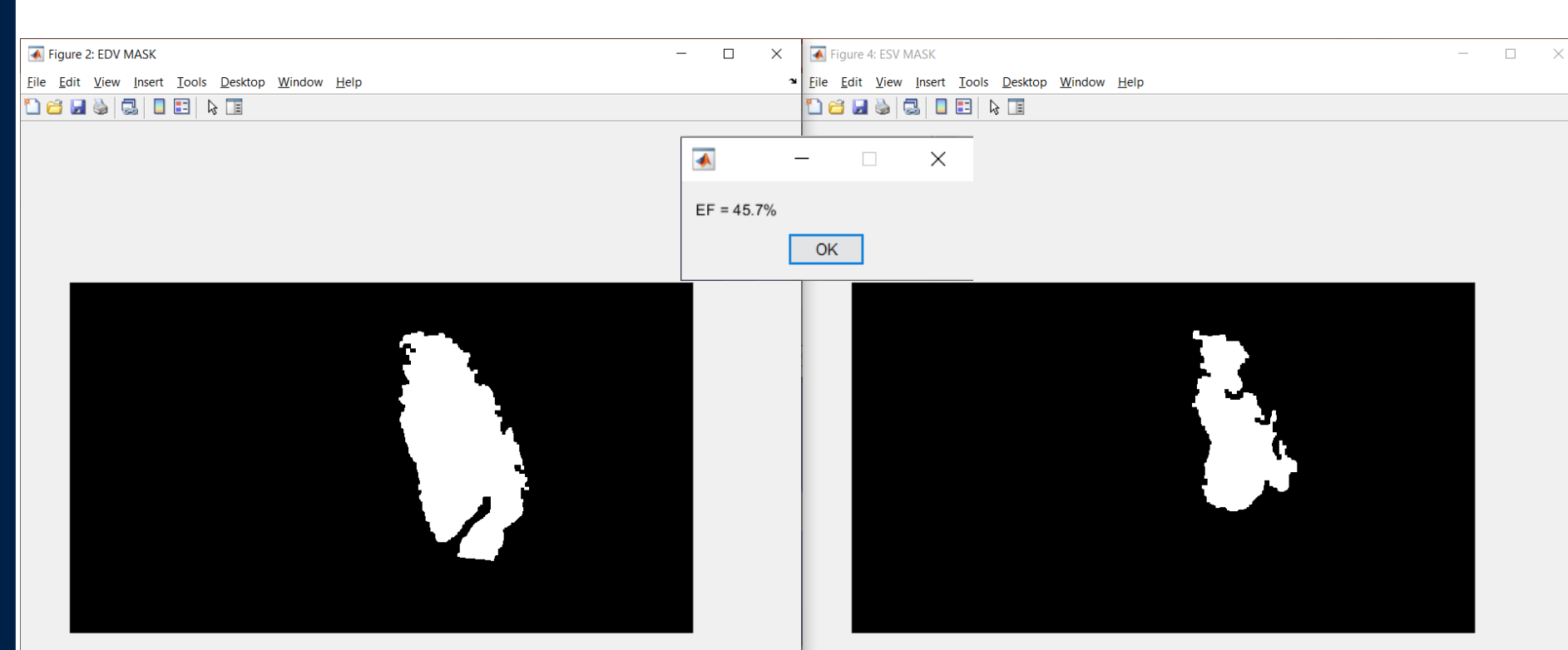


Extrapolated heart's mask

Ejection fraction extraction

- Ejection fraction (EF) is a measurement, expressed as a percentage, of how much blood the left ventricle pumps out with each contraction.
 - $EF(\%) = \frac{SV}{EDV} \cdot 100$
 - $SV = EDV - ESV$
- According to studies, the calculation of the EF by using the left ventricle area, instead of volume, gives a good approximation to the EF.
- The ejection fraction extraction flow is:
 - The left ventricle area is extracted from all the chosen frames
 - The maximum and minimum areas are selected
 - The ejection fraction is calculated as:

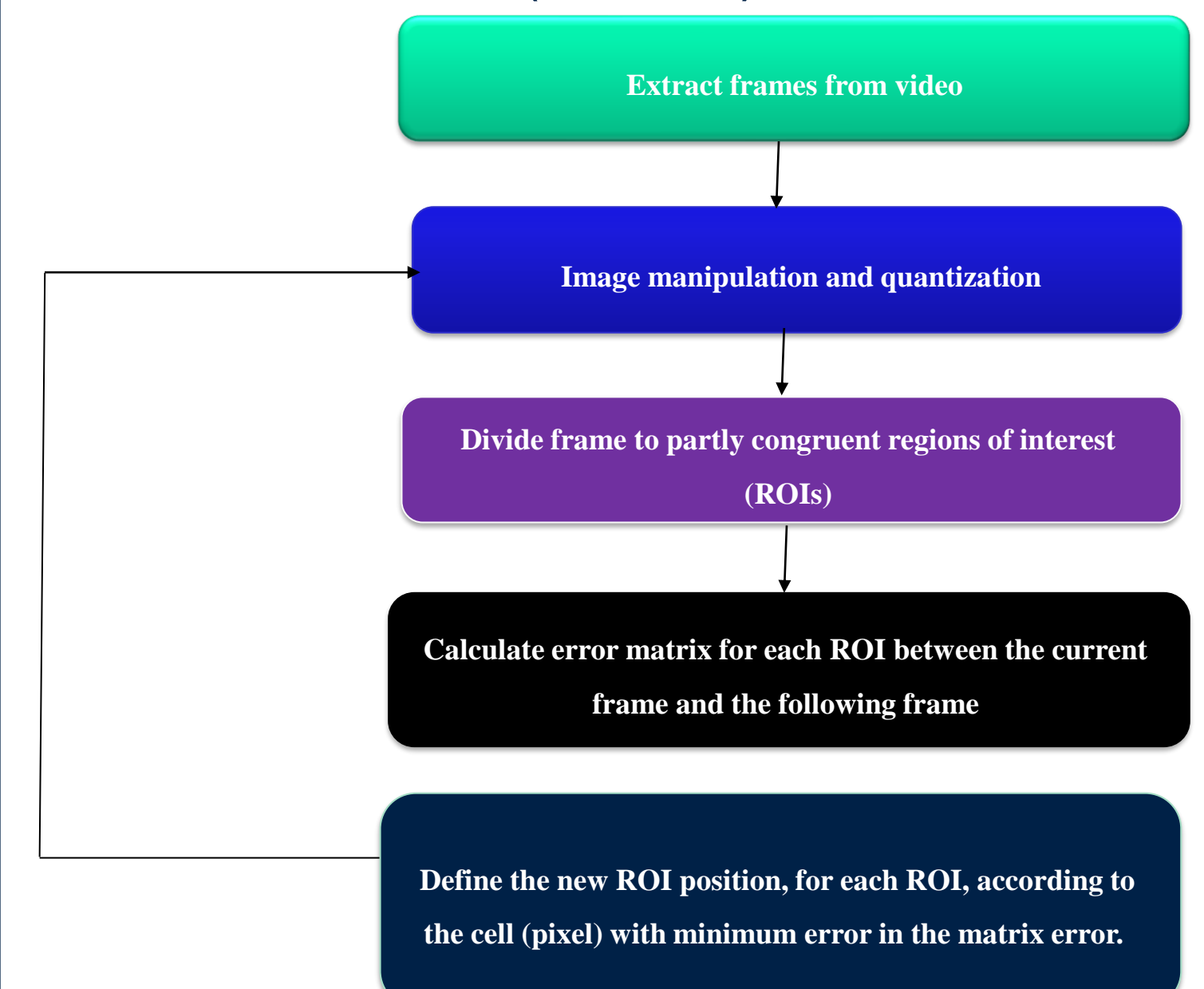
$$EF(\%) = \frac{\max\{area\} - \min\{area\}}{\max\{area\}} \cdot 100$$
- The output is shown as follows:



A typical output for the EF extraction tool

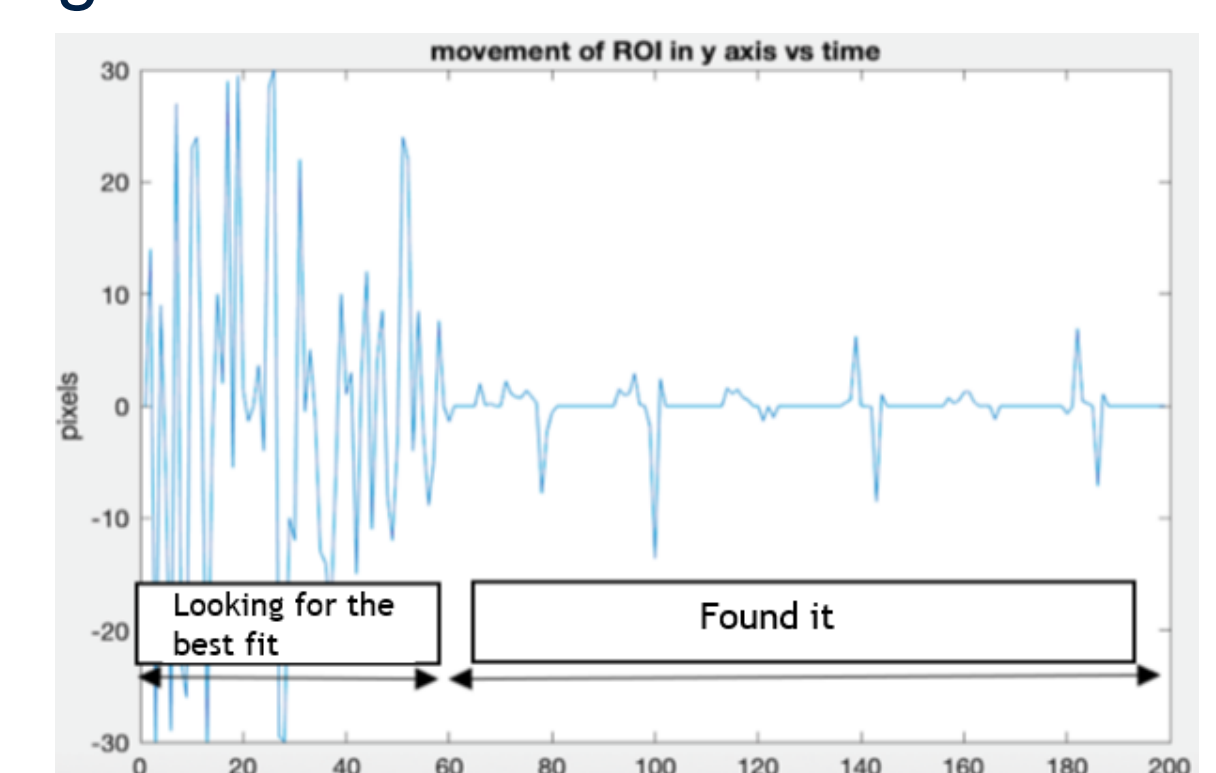
Regional wall motion abnormalities detection

- The algorithm for regional wall motion abnormalities (RWMA) detection is as follows:



RWMA detection Results

- We got 3 types of results:
 - No homing*
 - Semi homing
 - Full homing
- In every homing case, it took several frames for the algorithm to fix on a ROI



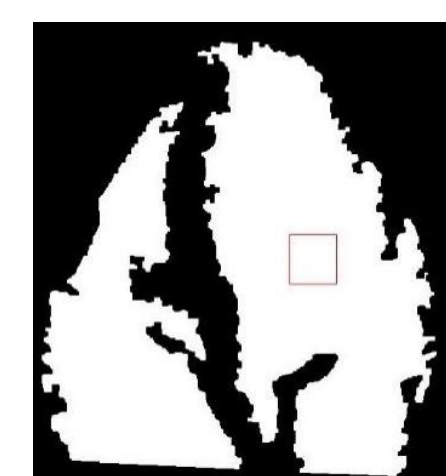
ROI's homing process

- All the results of type 2 were fixed in the following area:

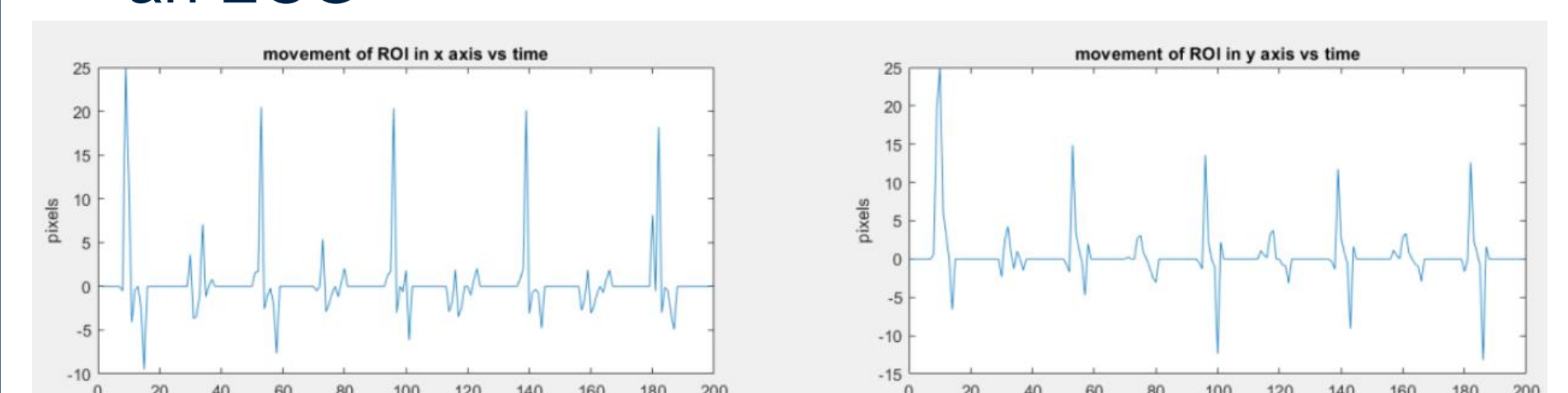
:



- All the results of type 3 were fixed on a specific ROI:



- When getting type 3 results, the ROI movement along the cardiac cycle resembled the results of an ECG



Type 3 results ROI's movement

*Homing = The algorithm fixed on a specific ROI

Conclusions

- The speckle tracking method weren't useful in RWMA detection
- By using image processing methods, we manage to extrapolate the EF with an intuitive and informative tool