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INESC TEC and **Faculdade de Engenharia, Universidade do Porto**, Portugal

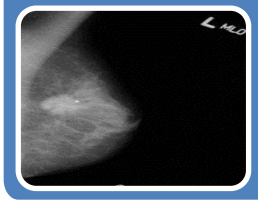
VISUM 2018 Challenge

July 7th, 2018
Porto, Portugal

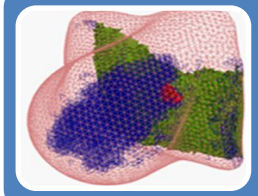
Management of Breast Cancer

image processing

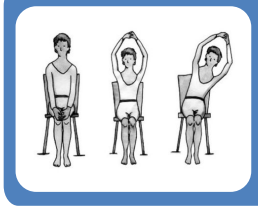
machine learning



Screening and diagnosis



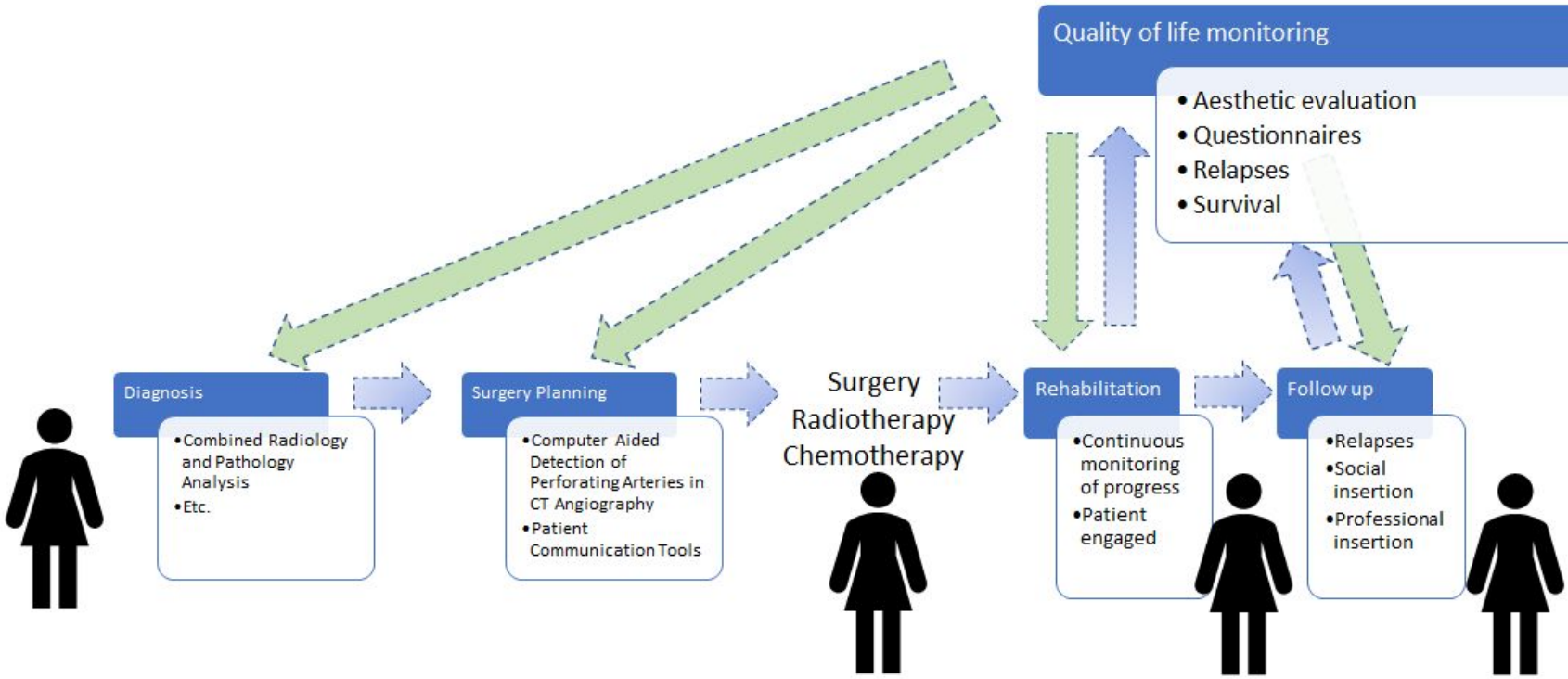
Surgery planning



Rehabilitation

Quality of Life Monitoring

Quality of life monitoring

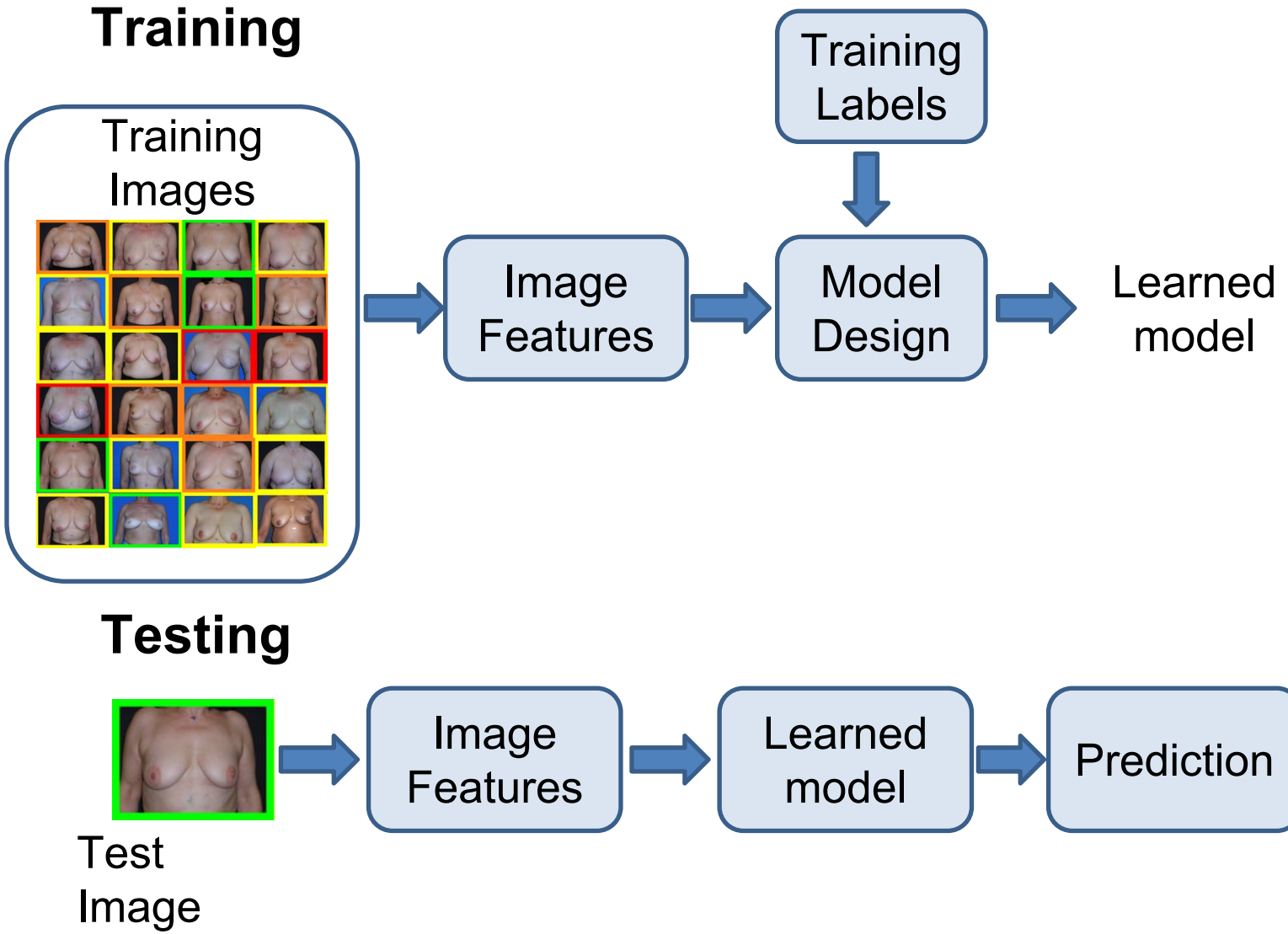


Aesthetic Evaluation

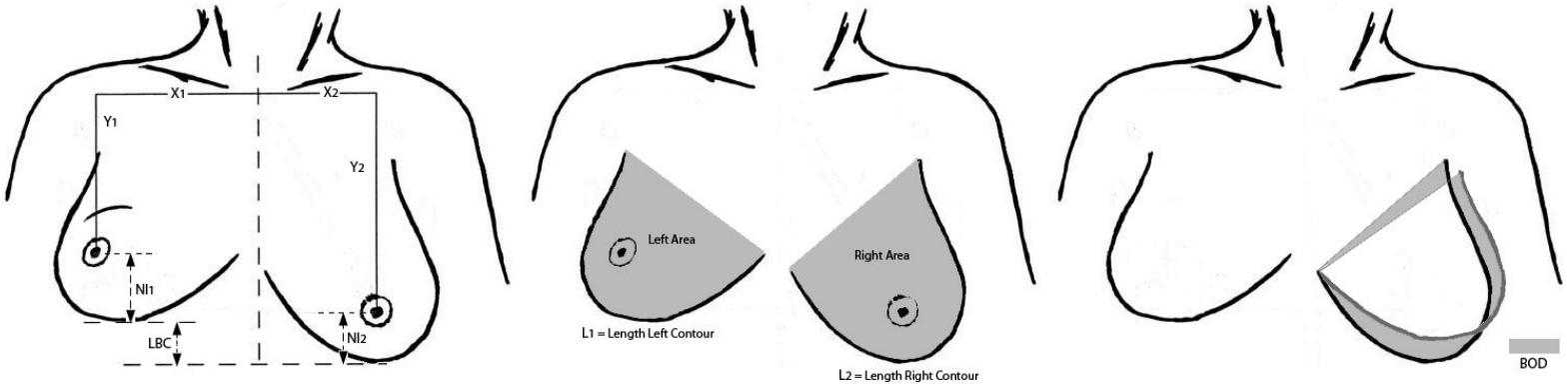
The Clinical Need

In breast-conserving surgery, there is evidence that approximately 30% of women receive a suboptimal or poor aesthetic outcome; however there is currently no standardised method of identifying these women.

Aesthetic Evaluation

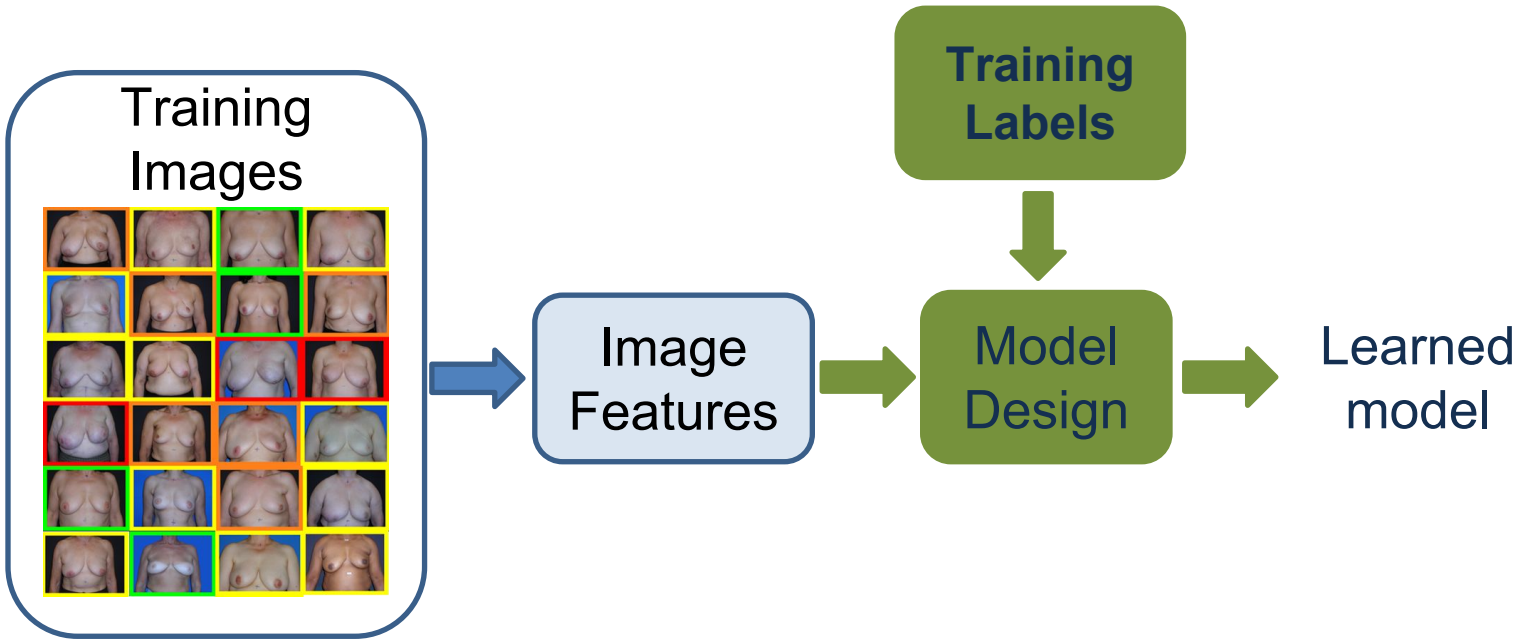


Asymmetry Features



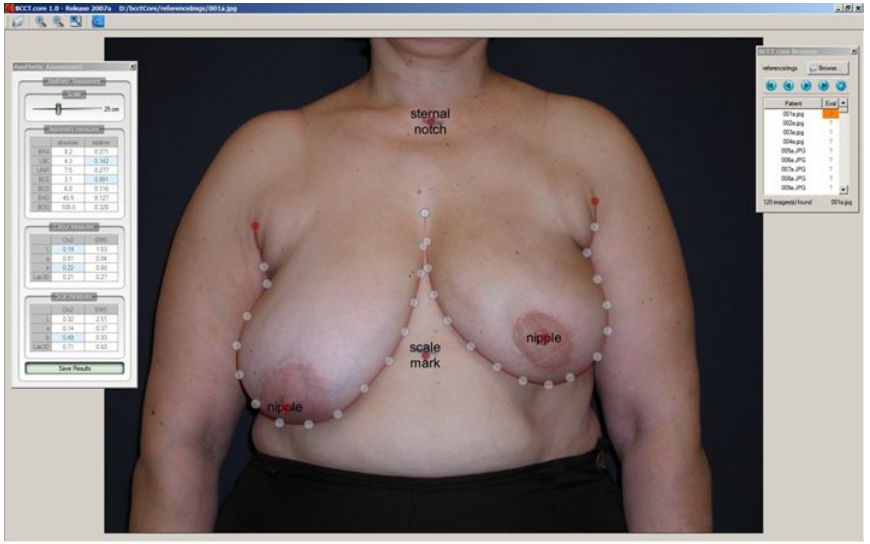
Objective Criteria in 2D and 3D Images

- Define **quantities** ('features' or 'attributes') in the image 'correlated' with the factors identified by the panel of experts
  - 2D and 3D features
- **Automate** the measurement
  - Automatic detection of fiducial points



The task

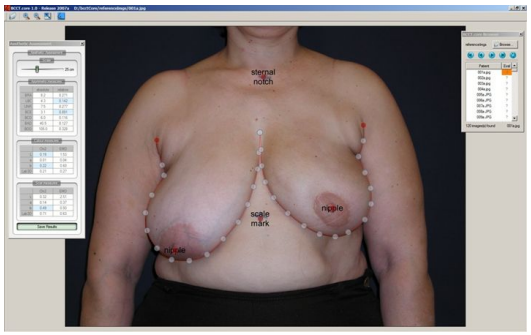
- automatically detect anatomical points / structures (to facilitate the automatic evaluation)
- **Input**: frontal image of a patient after breast cancer surgery



- **Output**: position of
  - breast contours
  - nipples
  - sternal notch

The task

- automatically detect anatomical points / structures



- To help you design your algorithms, we make available
  - A dataset of 154 images with ground truth annotation by experts
  - Two baseline solutions (one based on deep learning, another in conventional pipelines)
  - A working environment in the google cloud platform

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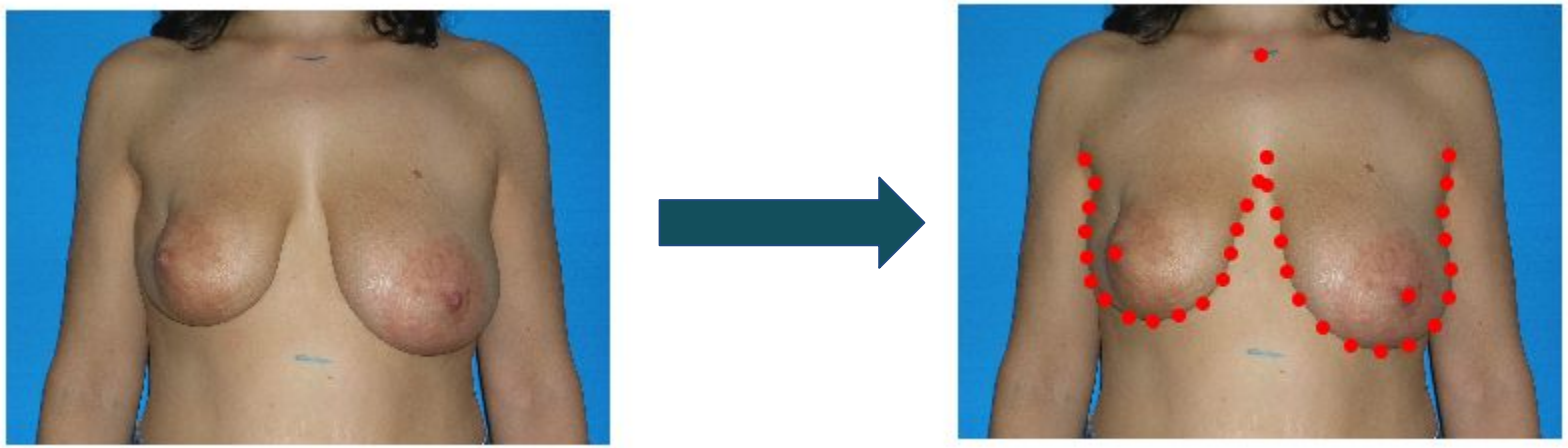
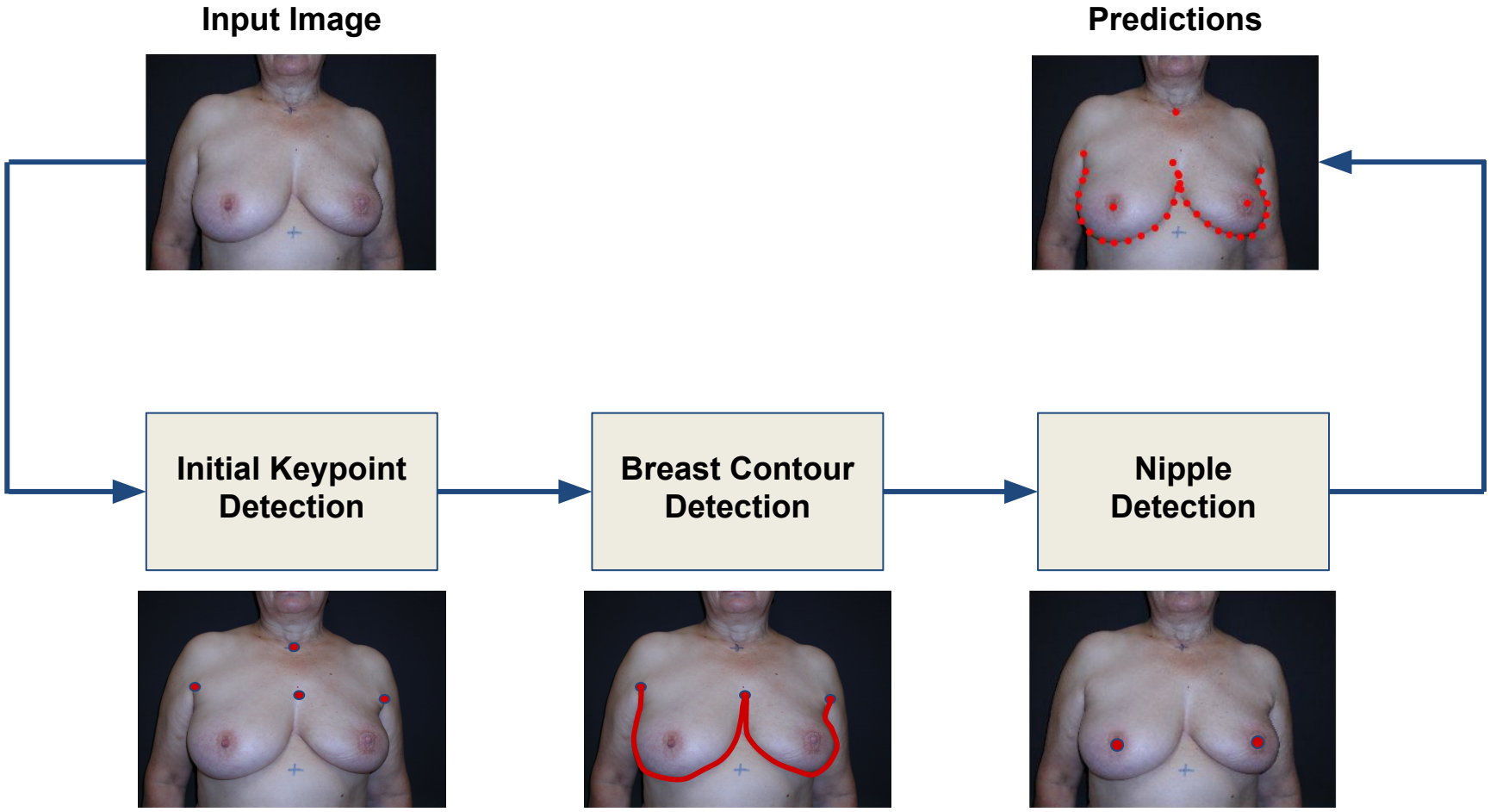
Baseline 1 - A Conventional Computer Vision Pipeline



Pipeline


Input Image
Predictions
Initial Keypoint Detection
Breast Contour Detection
Nipple Detection

Initial Keypoint Detection

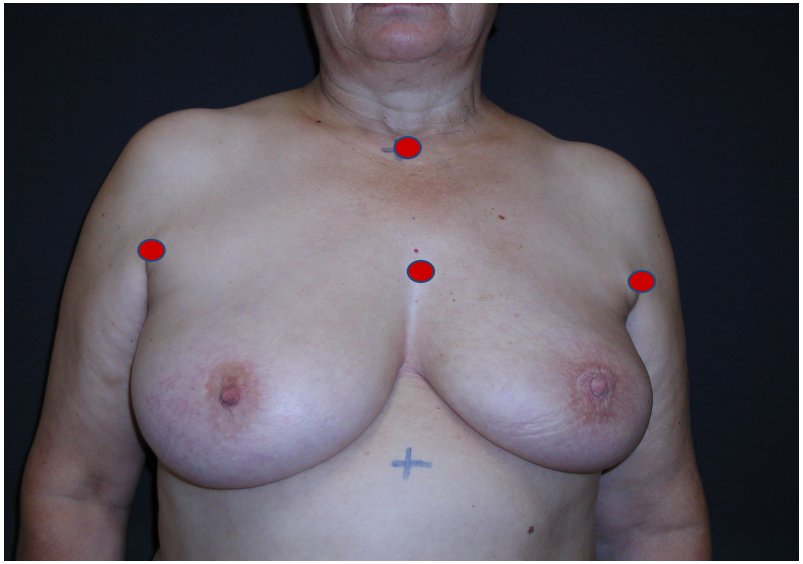
1. Find left and right points p_l and p_r

2. Find middle point:

$$p_m = (p_l + p_r)/2$$

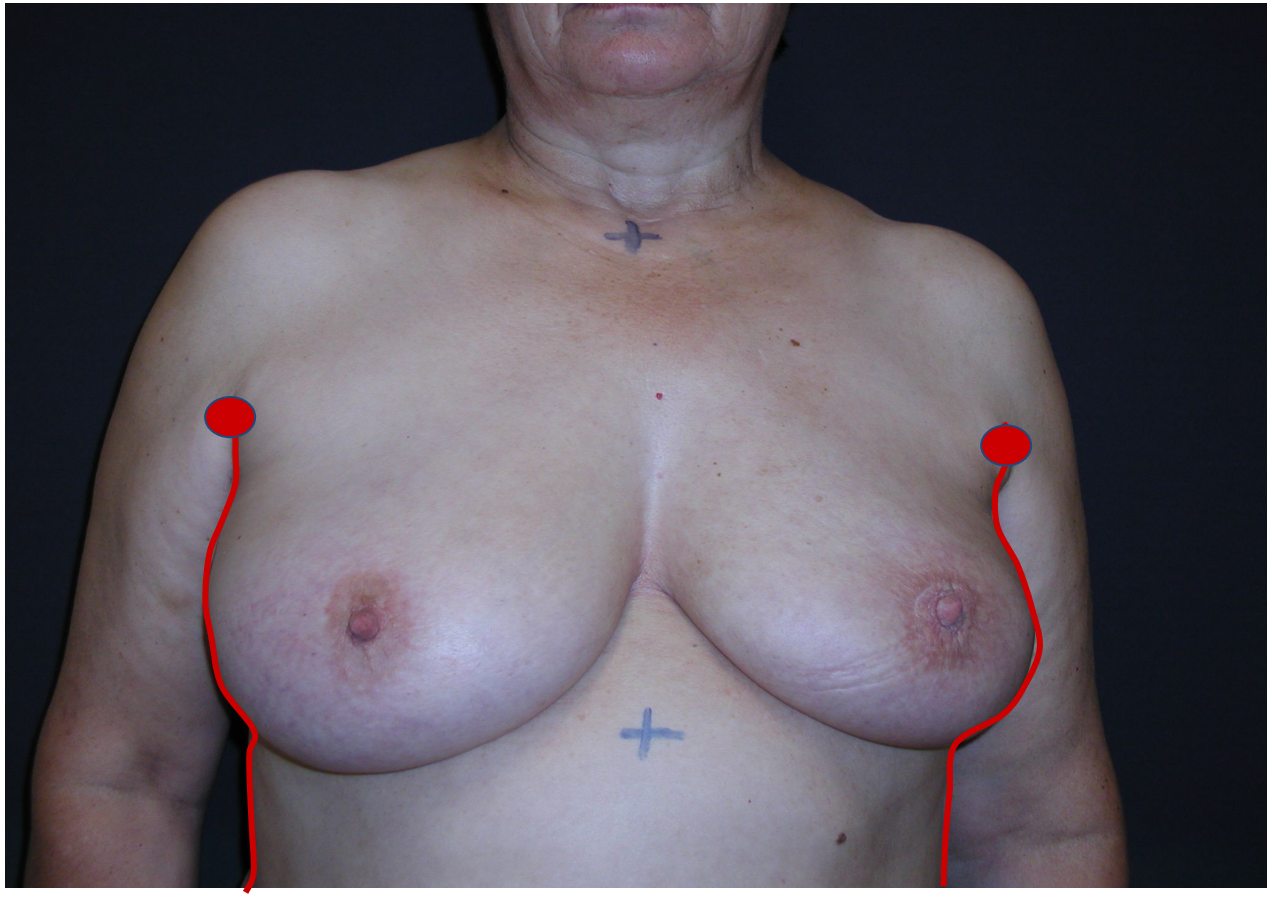
3. Find suprasternal notch:

$$p_t = (p_m[0]/2,\ p_m[1])$$

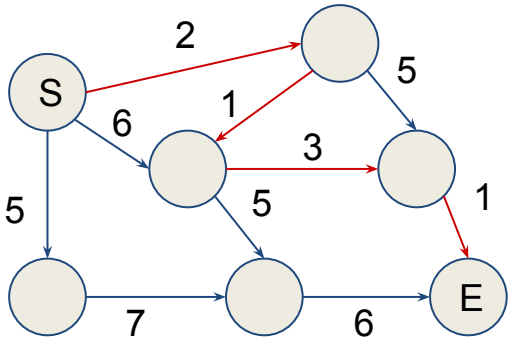


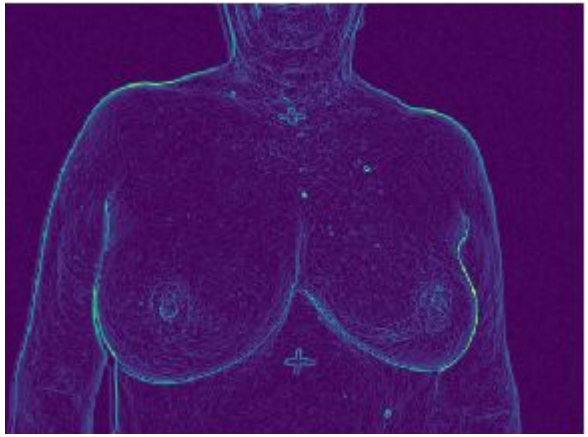
baseline1.image_processing.find_extrema_points2()

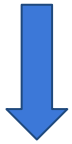
Initial Keypoint Detection

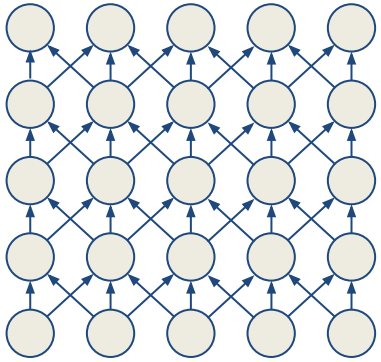


Shortest Path







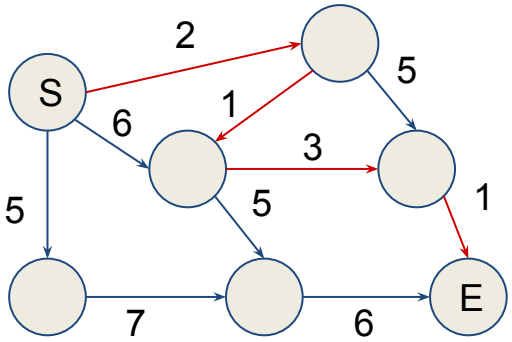


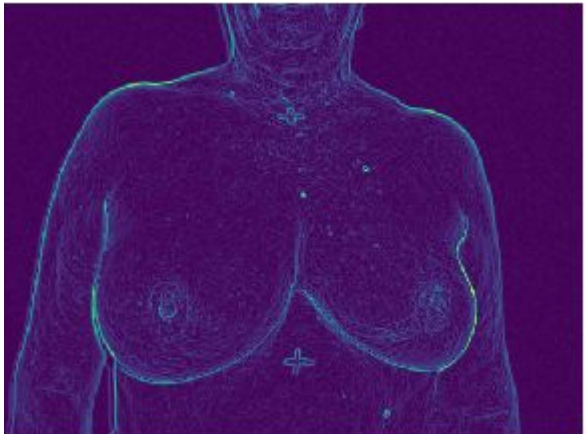
Find path $P=\{v_1, v_2, \ldots, v_n\}$ so that

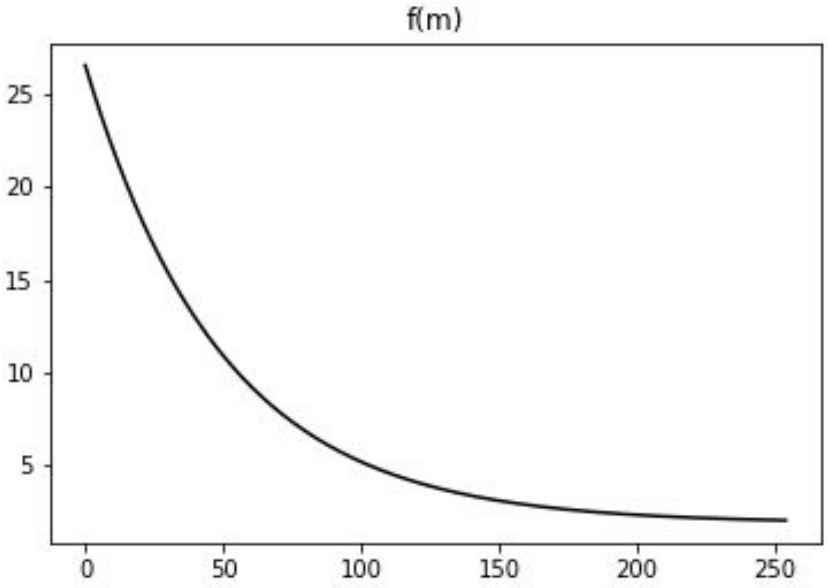
$$\Sigma_{i=0:N-1} f(e_{i,i+1})$$

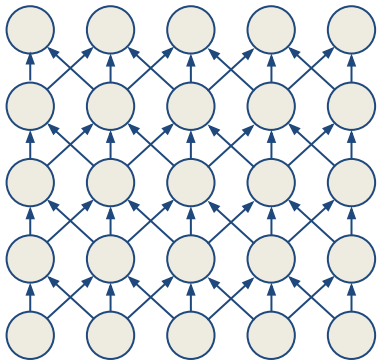
is minimized.

Shortest Path



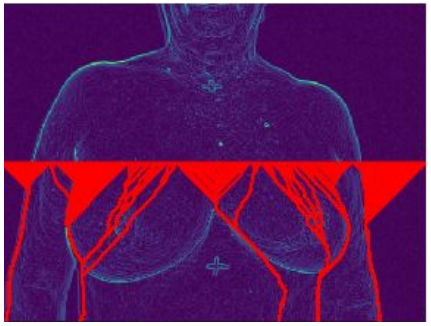




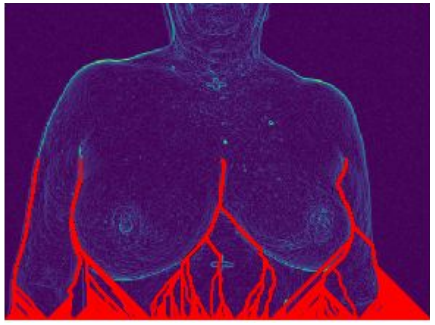


Shortest Path

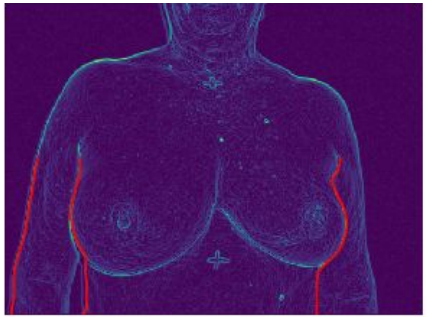
Shortest paths from mid to bottom



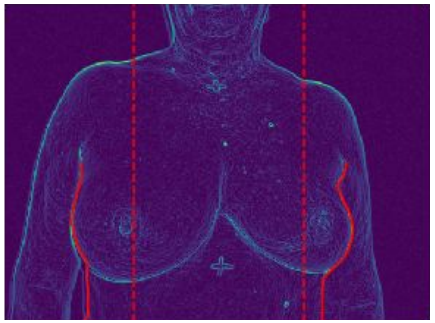
Shortest paths from bottom to mid



Strong paths between mid and bottom.



Selection of body edges.

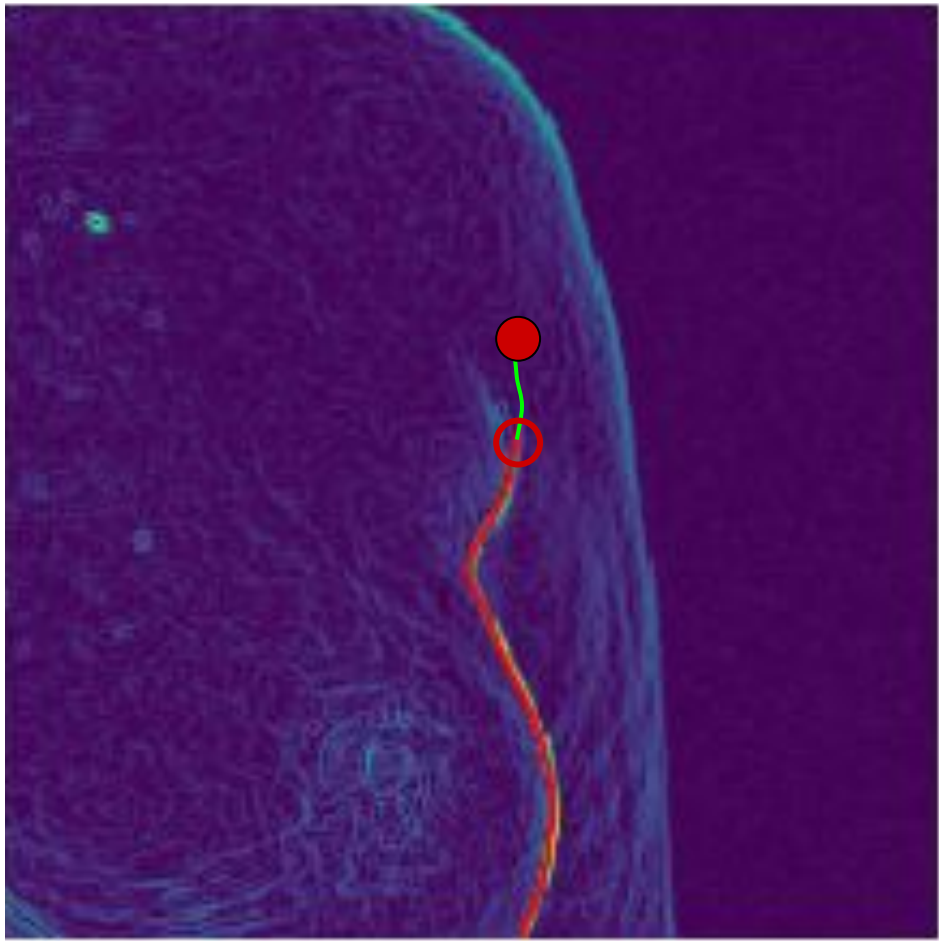


baseline1.image_processing.select_start_points()
baseline1.image_processing.find_extrema_points2()

Refinement

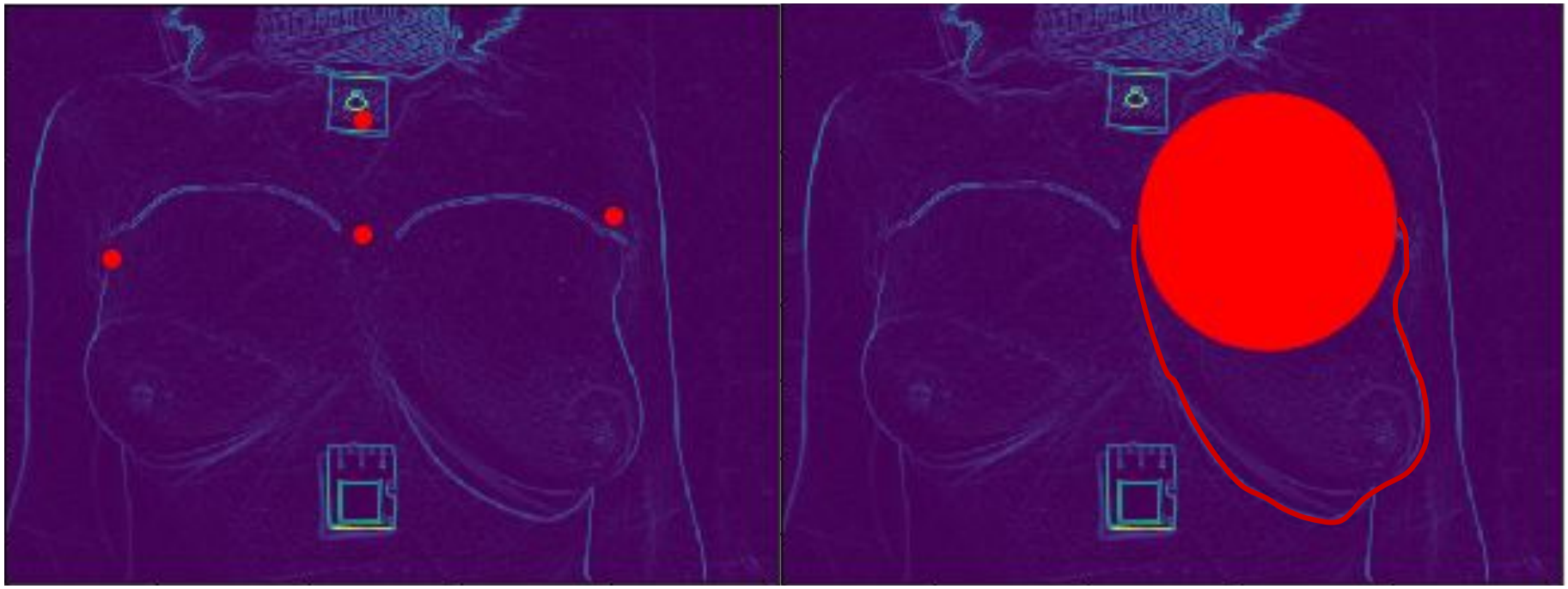
```
M - Gradient image
Th1 - Threshold (parameter)
maxLEN - Maximum length (parameter)

len = 0
p = p_r
while len<maxLEN:
      p = argmax(north_neighboors(M, p))
      if M[p]<Th1:
            len+=1
      else:
            len=0
```



baseline1.image_processing.grow_segment()

Breast Contour



baseline1.image_processing.breast_contour()

Nipple Detection

We followed a probabilistic approach:

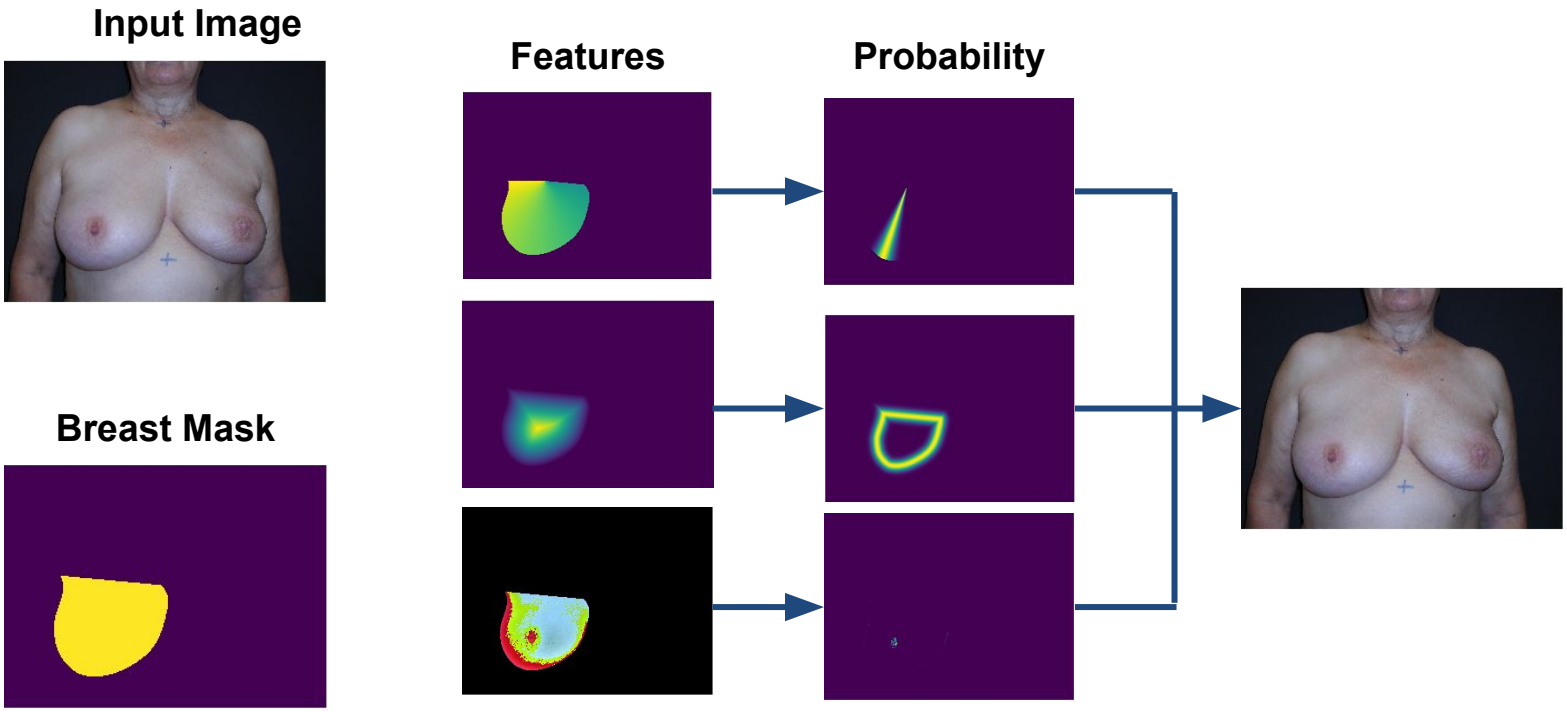
$$argmax_{x \in X}\{P(x)\} \qquad x = [\alpha; d, c]$$

Assumptions:

- The angle, distance and color features are independent.
- The angle, distance and color can be modelled by a Gaussian distribution.

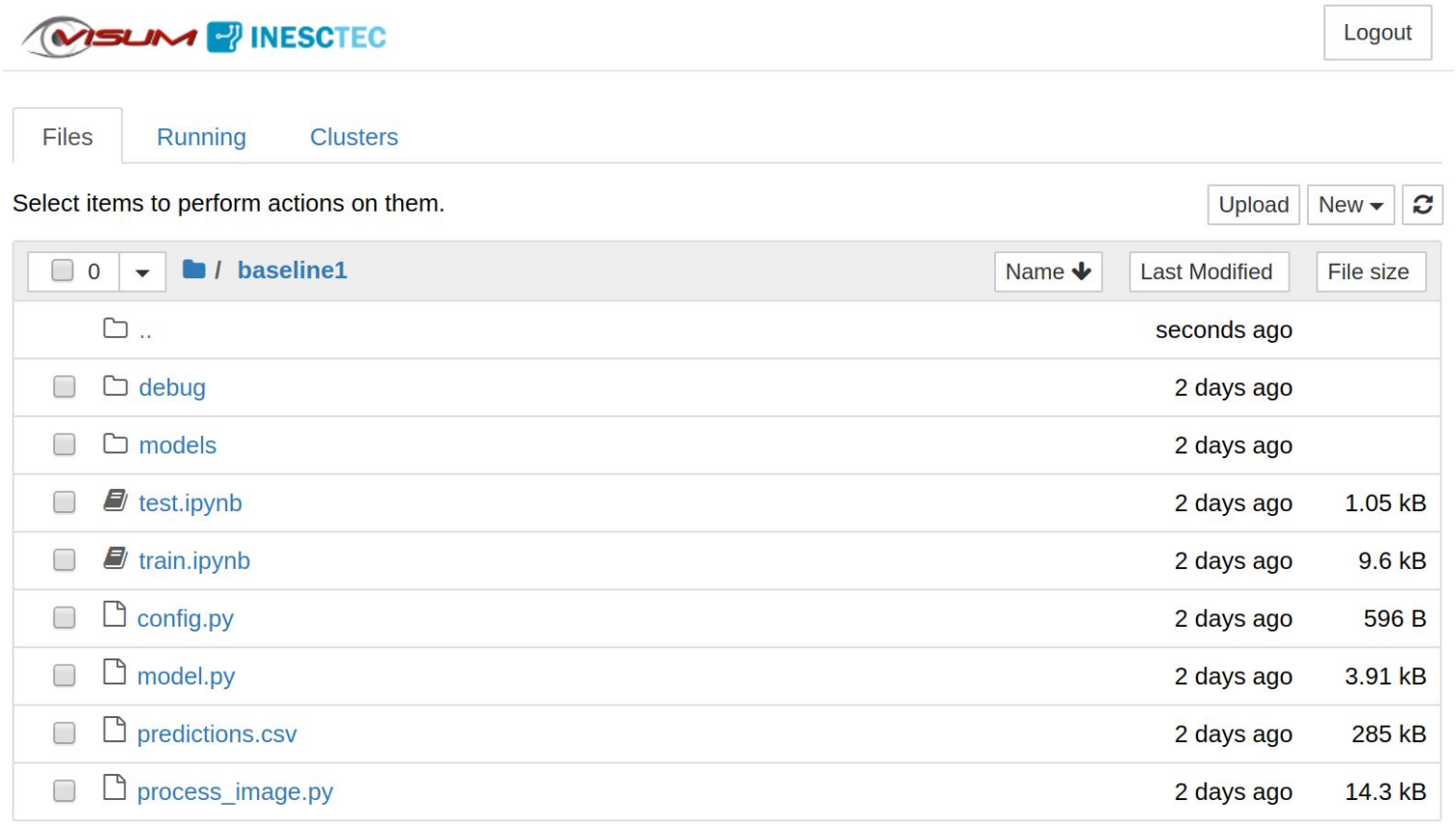
$$P(x) = \mathcal{N}(\alpha|\mu_\alpha, \sigma_\alpha) \times \mathcal{N}(d|\mu_d, \sigma_d) \times \mathcal{N}(c|\mu_c, \sigma_c)$$

Nipple Detection



baseline1.image_processing.nipple()

Baseline1 Files



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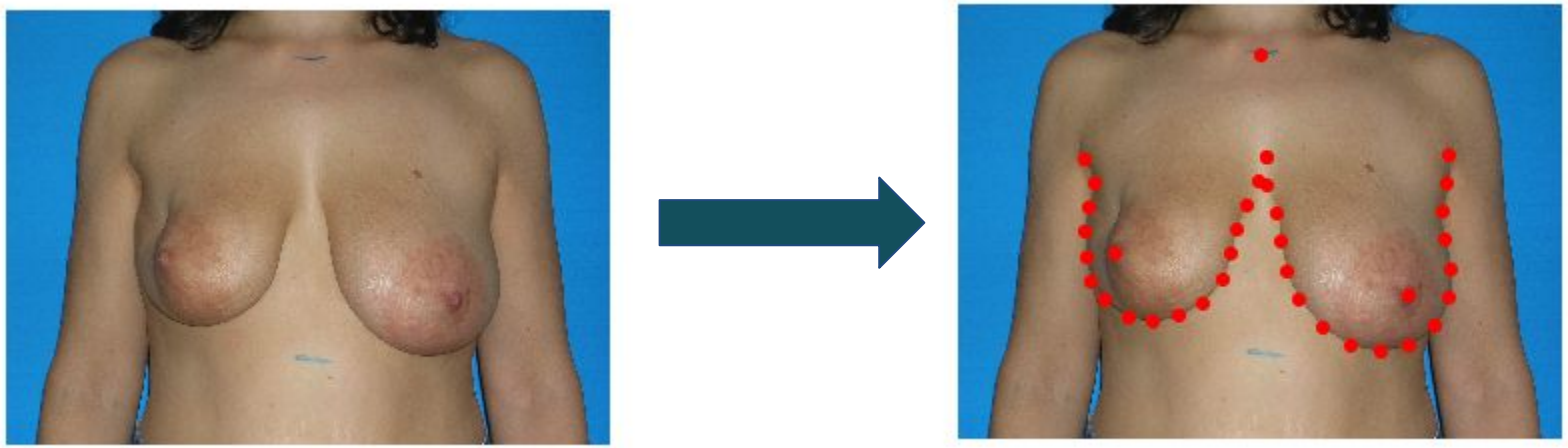
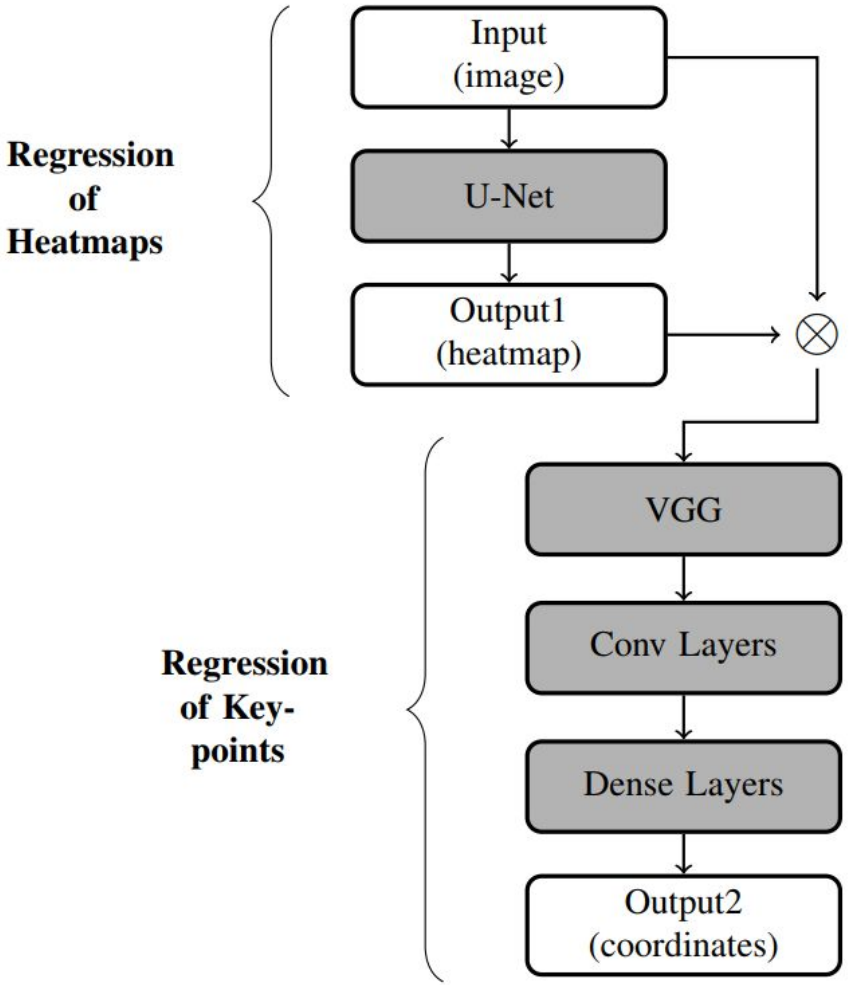
Baseline 2 - A Deep Learning Approach



A Deep Learning Approach

- How to deal with overfitting?
  - Learn an Intermediate Representation
  - Transfer Learning



A Deep Learning Approach

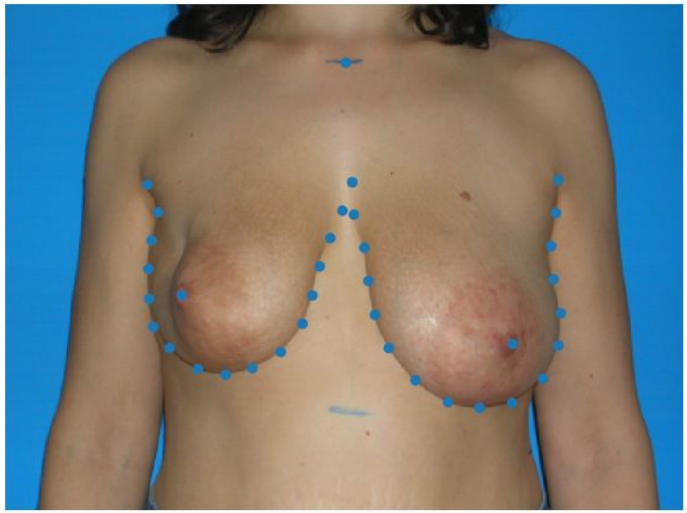
Heatmap Regression

$$\mathcal{L}_{heatmap} = \frac{1}{N_p} \sum_{\forall p} (x_p^{target} - \hat{x}_p)^2$$

A Deep Learning Approach

Keypoints Regression

$$\mathcal{L}_{keypoints} = \frac{1}{N_k} \sum_{\forall k} (x_k^{target} - \hat{x}_k)^2$$

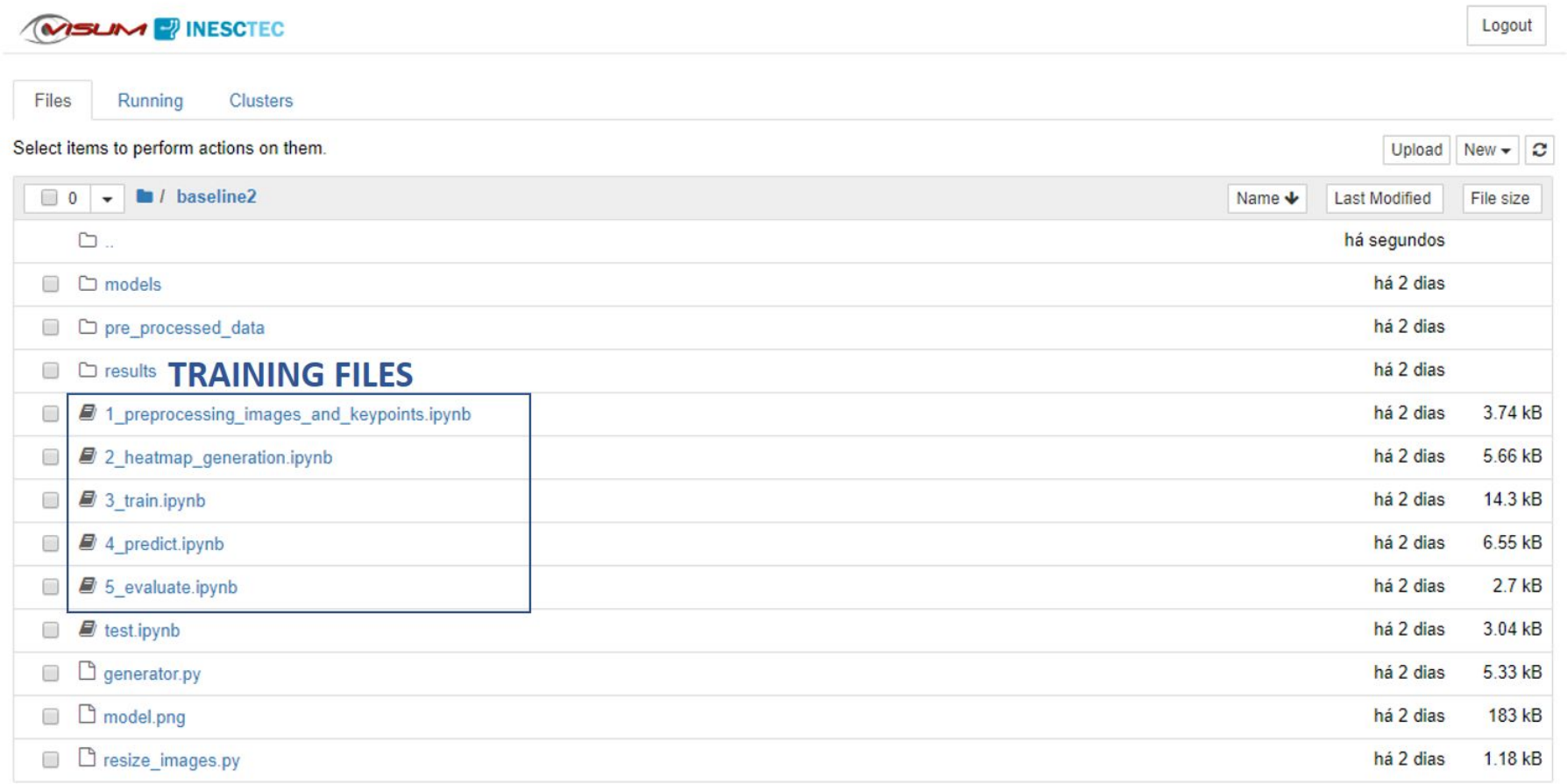


A Deep Learning Approach

Learning Process

$$\mathcal{L} = \lambda_h \mathcal{L}_{heatmap} + \lambda_k \mathcal{L}_{keypoints}$$

Baseline 2 Files



Baseline 2 Files

1_preprocessing_images_and_keypoints.ipynb

Image Size: (1539, 2133)

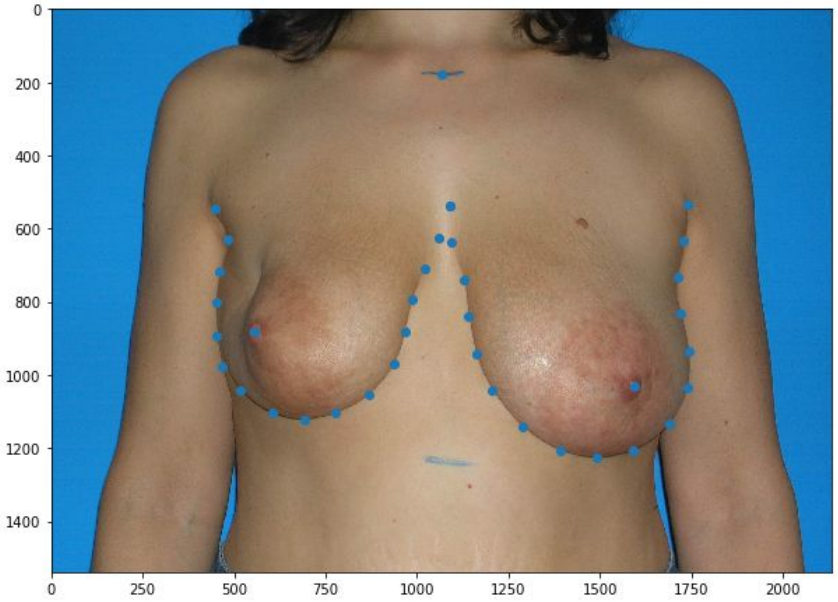
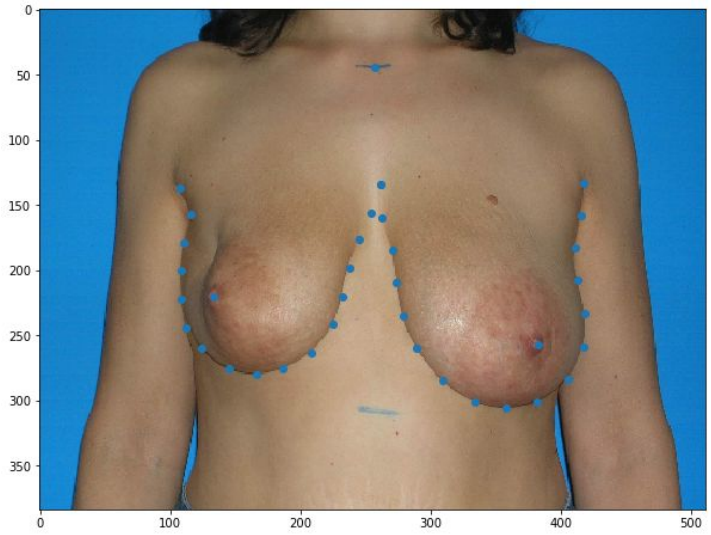


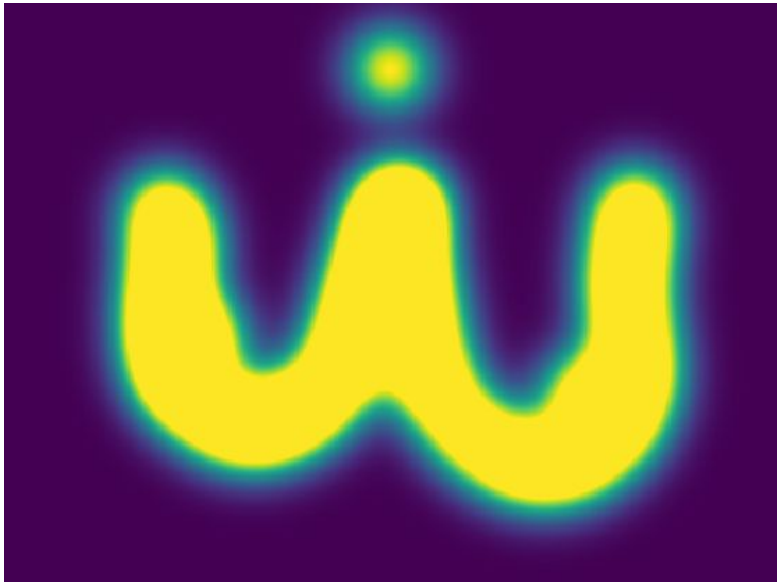
Image Size: (384, 512)



Baseline 2 Files

2_heatmap_generation.ipynb

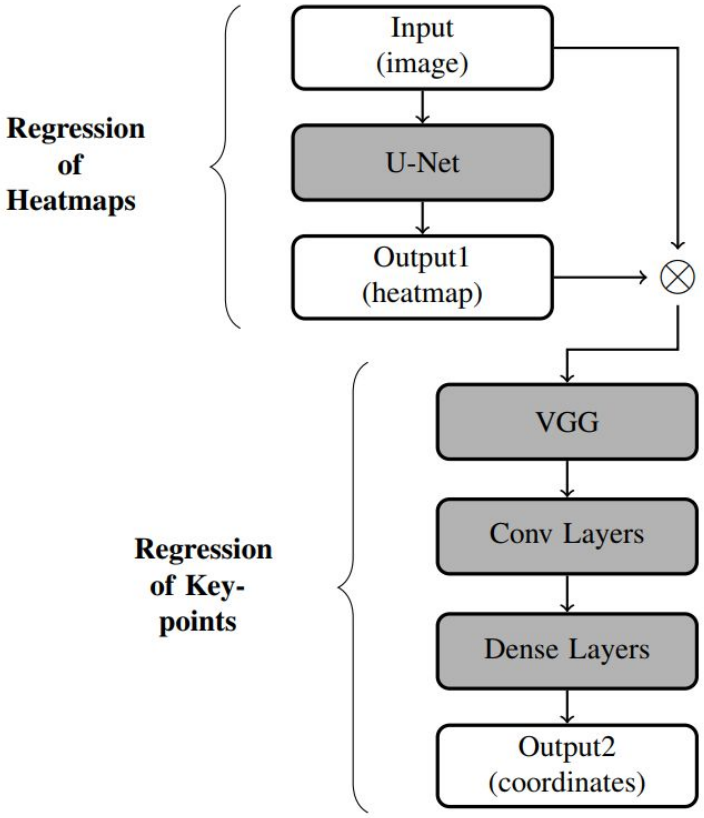
Image	Heatmap



Baseline 2 Files

3_train.ipynb

KERAS IMPLEMENTATION



Baseline 2 Files

4_predict.ipynb

Trained Model

Baseline 2 Files

5_evaluate.ipynb

Predictions:

Evaluation:

- **Breast Contour Score (BC)**
- **Nipples Score (N)**
- **Suprasternal Notch Score (SN)**

Score = 0.45 BC + 0.35 N + 0.20 SN

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The Platform

Google Cloud Platform

Final Remarks

-You are **forbidden** from downloading the challenge dataset.

  -It can only be used within the google platform provided for the challenge.

-You are **allowed** to use additional data, collected from other sources.

-You are **allowed** to integrate ‘third party’ code.

Final Remarks

-**Objective Evaluation**: an weighted combination of the errors in the breast contour, nipples and sternal notch

-**Subjective Evaluation**

-Statistical mismatch between training and testing data

-Daily leaderboard

-Top runners will be invited to present their solutions in 5 min pitch

Enjoy the Challenge!

Good Luck!!