A Deep Image Segmentation Approach to Breast Keypoint Detection

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Introduction

- The main aim of breast cancer conservative treatment is the optimisation of the aesthetic outcome and women's quality of life.
- Recently, a deep learning algorithm, used in conjunction with a shortest-path algorithm that models images as graphs, has been proposed and achieved state-of-the-art results.
- We propose a novel algorithm based on the interaction of deep image segmentation and deep keypoint detection models, which is capable of improving both performance and execution-time on the breast keypoint detection task.

Deep Keypoint Detection

- Based on [1] and [2], Silva et al. [3] proposed a novel deep neural network (DNN) capable of automatically detecting keypoints in photographs of patients after being subjected to BCCT.
- The architecture of the proposed DNN contains two principal modules: regression and refinement of heatmaps, and regression of keypoints.

Deep Image Segmentation

- It should be easier to detect breast contours if one is capable to detect breasts first [4].
- If it is possible to perform the segmentation of both breasts with high precision, one could proceed to an algorithm of contour detection and then accurately extract the keypoints related to the breast contours.
- With segmentation, the goal is to learn a single solution (i.e., one image corresponds to one mask), instead of learning multiple solutions (i.e., keypoints' coordinates).

Implementation and Results

- The U-Net++ model is trained and used to generate segmentation masks.
- Contours were extracted from masks and the Silva et al. DNN predicted keypoints were projected onto to the mask contours through the minimization of the Euclidean Distance between the mask contour keypoint and the predicted keypoint.
- The execution time of each algorithm on CPU was measured on the test set of each cross-validation fold, to assess which one would fit better into a web-version of BCCT.core.

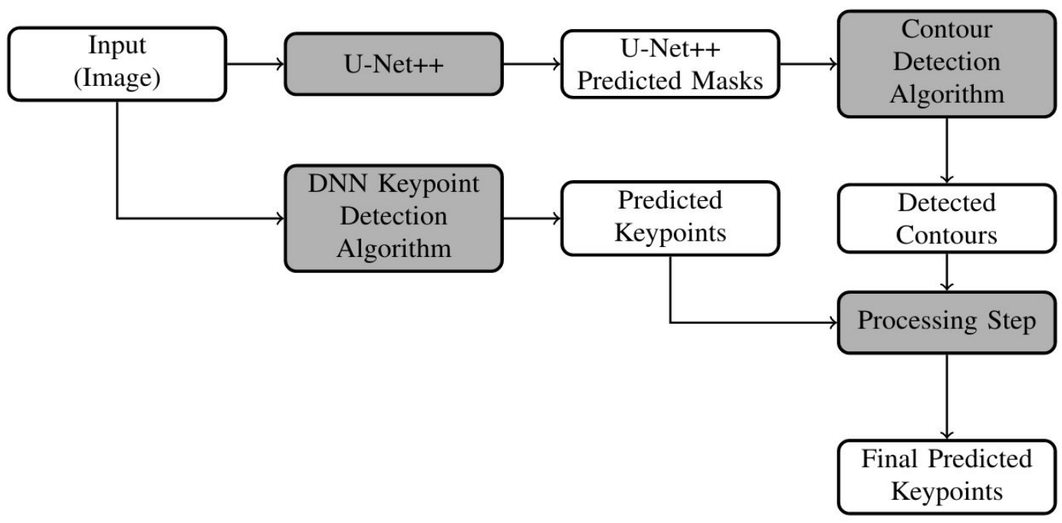

Figure 1 - Scheme of the deep image segmentation algorithm for breast keypoint detection.

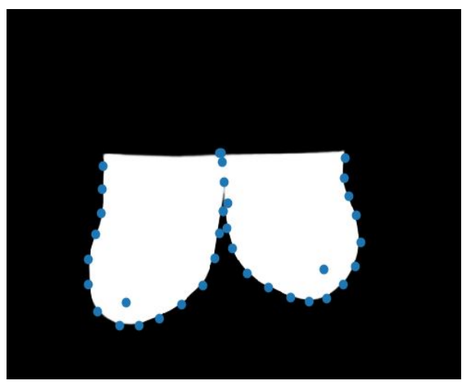

Figure 2 - Results obtained with the proposed method.

Table 1 - Average error distance for endpoints, breast contours and nipples, measured in pixels and average execution time of the models' inferences. Best results are highlighted in bold. Note: STD stands for standard deviation and Max stands for maximum error.

Model	Endpoints			Breast Contour			Nipples			Time (s)
	Mean	STD	Max	Mean	STD	Max	Mean	STD	Max	
DNN	40	**33**	**182**	21	8	72	**70**	**39**	**218**	**150**
Hybrid	40	**33**	**182**	13	14	104	**70**	**39**	**218**	1704
Ours	**38**	34	195	**11**	**5**	**34**	**70**	**39**	**218**	280

Conclusions & Future Work

- In this work, we presented a novel algorithm based on the interaction of segmentation and keypoint detection models.
- A comparative study of algorithms performance was performed to assess which one would fit better a web-based application for the aesthetic assessment of BCCT.
- Future work will be devoted to improving results on nipples detection task and to modify this novel algorithm by integrating all the tasks of its pipeline into a unique DNN with a combined loss function.
- The integration and full deployment of this algorithm in a web-application are also planned.

Acknowledgements

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References

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[3] Wilson Silva, Eduardo Castro, Maria J. Cardoso, Florian Fitzal, and Jaime S. Cardoso. Deep Keypoint Detection for the Aesthetic Evaluation of Breast Cancer Surgery Outcomes.

[4] Tiago Gonçalves, Wilson Silva, Maria J Cardoso, and Jaime S Cardoso. A novel approach to keypoint detection for the aesthetic evaluation of breast cancer surgery outcomes.