A Shape Constrained Parametric Active Contour Model For Breast Contour Detection

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Outline

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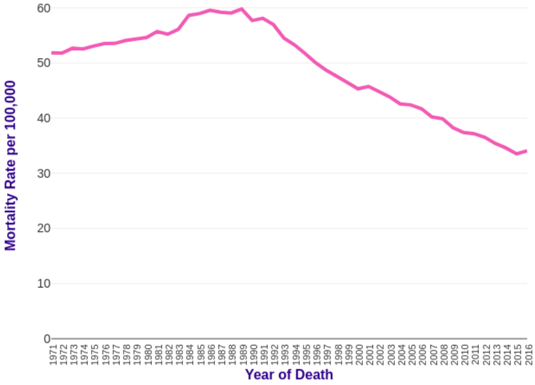
Breast Cancer (C50), European Age-Standardised Mortality Rates per 100,000 Population, Females, UK, 1971-2016



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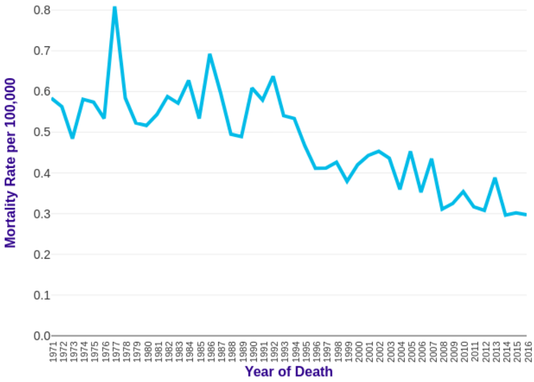
Breast Cancer (C50), European Age-Standardised Mortality Rates per 100,000 Population, Males, UK, 1971-2016



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Importance

- Restoring breast cancer survivors' quality of life
- Save patient from Confusion

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Previous algorithm limitations

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Previous algorithm limitations

- strong gradient changes like nipple/areola

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Previous algorithm limitations

- strong gradient changes like nipple/areola
- not validated with clinical photographs

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Defenition

An active contour is a parametric curve $v(s) = [x(s), y(s)]^T, s \in [0, 1]$ that evolves to minimize the following energy functional

$$\int_0^1 \left[\frac{1}{2}(w_1 v_s(s) + w_2 v_{ss}(s))^2 + E_{ext}\right] ds \qquad (1)$$

where

- $v_s(s)$ & $v_{ss}(s)$ *are first and second derivative*
- w_1 & w_2 are associated weights to continuity and curvature of the contour
- E_{ext} is the external forces that influence the curve evolution.

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- an image with oriented structure enhanced
- obtained by a quadrature pair comprized of the steerable forth derivative of a 2D gaussian and its Hilbert transform
- embeded within the VFC framework to make E_{ext} robust to noise

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- to incorporate the prior knowledge:
  $F_{shape} = (V(s) - v_c(s))^2, s \in [0, 1]$,where

$$\mathbf{v_c(s)} := \begin{pmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{pmatrix} \begin{pmatrix} \alpha \cdot 2(s-1) + b \\ -\alpha \cosh(2(s-1)) + c \end{pmatrix} \quad (2)$$

  represents the rotated catenary curve which captures the overal curvature of the breast contour reliably.
- to prevent the contour from evolving towards a trivial local optima:
  F_{baloon} := the unit normal vector of each vertex in the active contour

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The resulting Euler-Lagrange equation To minimize energy functional E is :

$$w_1 v_{ss}(s) - w_2 v_{sss}(s) - \nabla Eext(v(s)) - \lambda F_{shape} + \tau F_{balloon} = 0 \quad (3)$$

which represented as $F_{int} + F_{ext} = 0$ where F_{int} is the internal forces to retain the continuity and F_{ext} is the external force needed to attract the contour to the breast contour.

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to solve later equation the contour $v(s)$ is considered as a function of time t and the steady state solution of it can be found using the gradient descent equation as follows

$$\frac{\partial v(s,t)}{\partial t} = F_{int}(v(s,t)) + F_{ext}(v(s,t)) \tag{4}$$

the initial value is defined as $v(s,0) = v_c(s, a_0, b_0, c_0, \theta_0)$ as an approximate to the breast contour.

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Initialization

- let $S_p = [w_1, w_2, \lambda, \tau]$ denotes the static parameter set and let $S_p = [0.05, 0.15, 0.1, 0.2]$
- let $D_p = [a, b, c, \theta]$ denotes the dynamic parameters set.
- let $[a, \theta]$ be [70, 20] for for the patient's right breast contour and [70, -20] for patient's left breast contour
- the initial values for [b,c] will computed from the location of *Anterior Axilliary Point* ***(AAP)*** *so one end of the active contour will be located in* ***AAP***

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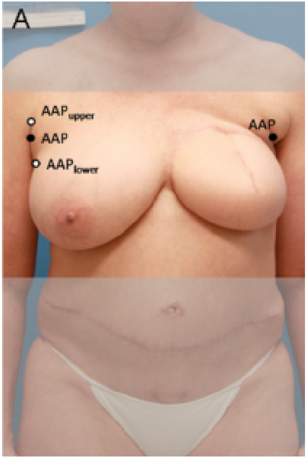
the location of **AAP**



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Data: S_p, D_p
Result: v_s
while $\sum_i |v(i,t) - v(i,t-1)| < \lambda$ **do**
    Update $v(i,t)$ by solving (4) ;
    Update $[a, b, c, \theta]$ from $v(i,t)$ by solving (2) in least square sence ;
end

Algorithm 1: computing active contour

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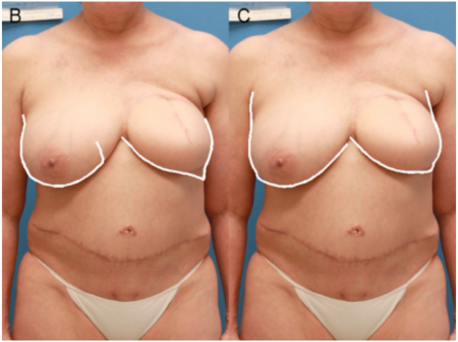
traditional balloon model wthout shape constrained (B) **VS** proposed approach (C)



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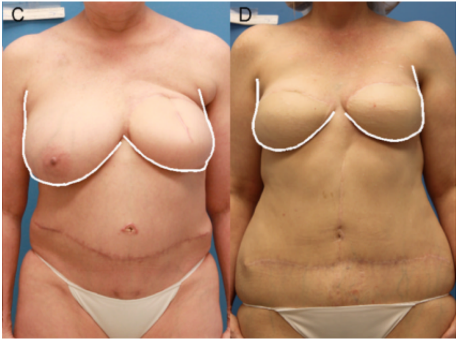
Example of success cases



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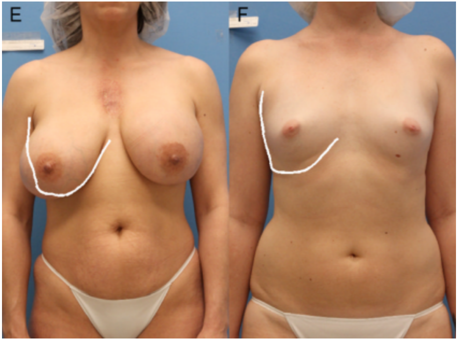
Results
failed cases

Example of failure cases



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Q&A

"Ask, and it shall be given you!"
Matthew 7:7

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References

- https://www.cancerresearchuk.org
- Lee, J., Muralidhar, G. S., Reece, G. P., & Markey, M. K. (2012). A shape constrained parametric active contour model for breast contour detection. In Conference proceedings:... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference (Vol. 2012, p. 4450). NIH Public Access.

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Thank you for your attention.