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A FULLY AUTOMATED COMPLETE SEGMENTATION SCHEME FOR MAMMOGRAMS

Summary

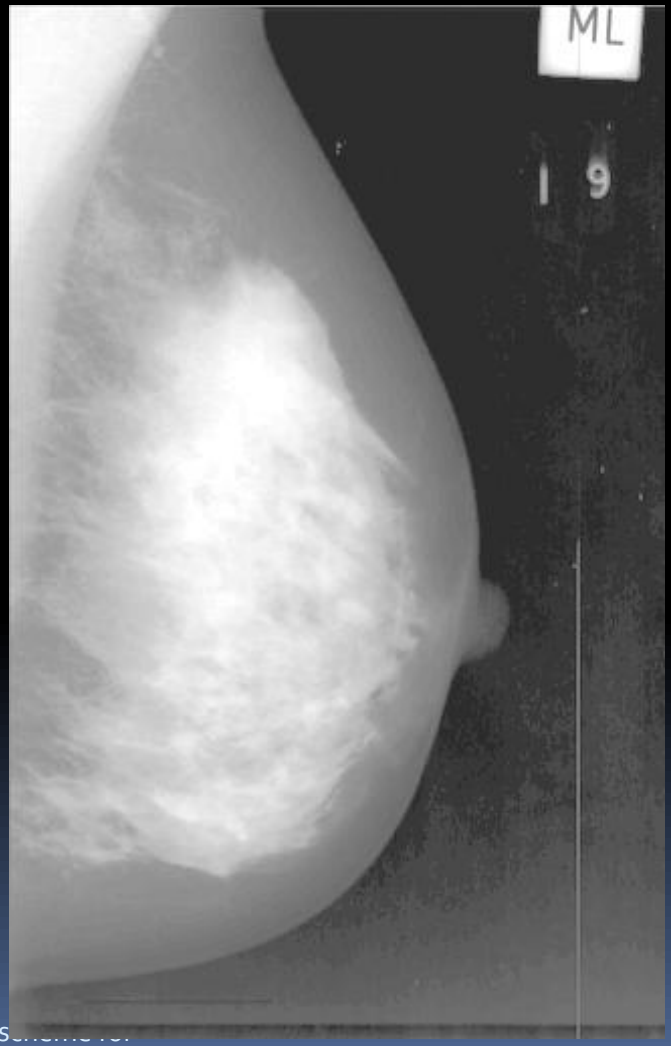
- Fully-automated procedure (i.e. no manually defined thresholds are used)
- Improved technique for pectoral muscle segmentation
- New proposed technique for nipple detection

Why mammography?

- Breast cancer :
  - The 2nd most common type of cancer
  - The 5th most common cause of cancer-related death
- Mammography :
  - Proved to be the most effective and reliable screening method for early breast cancer detection

Typical Mammogram

- Medio-lateral oblique view



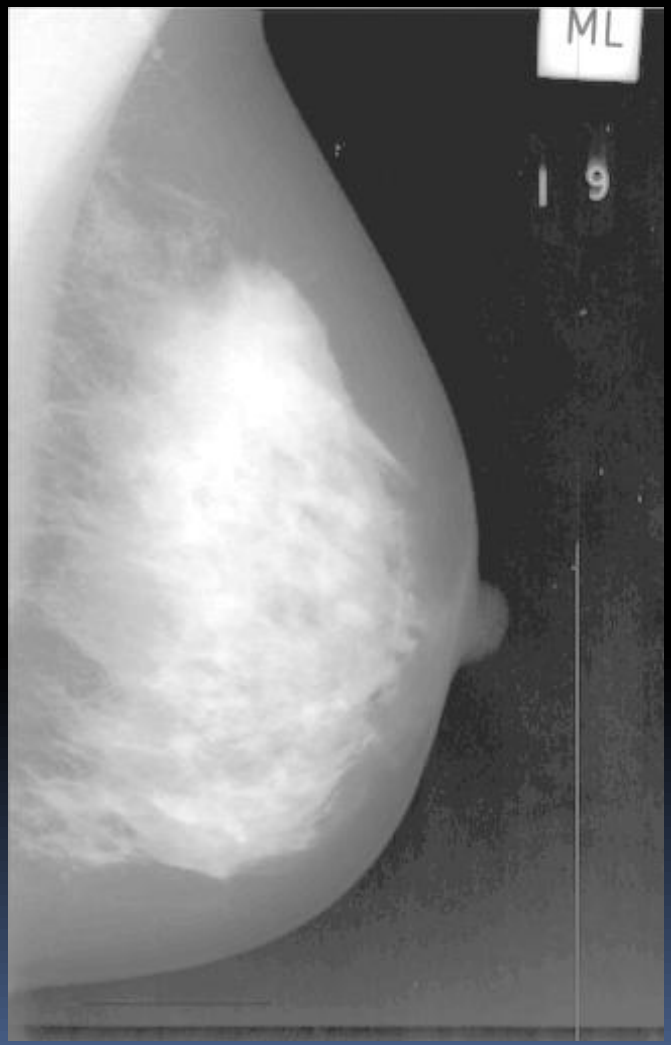
But :

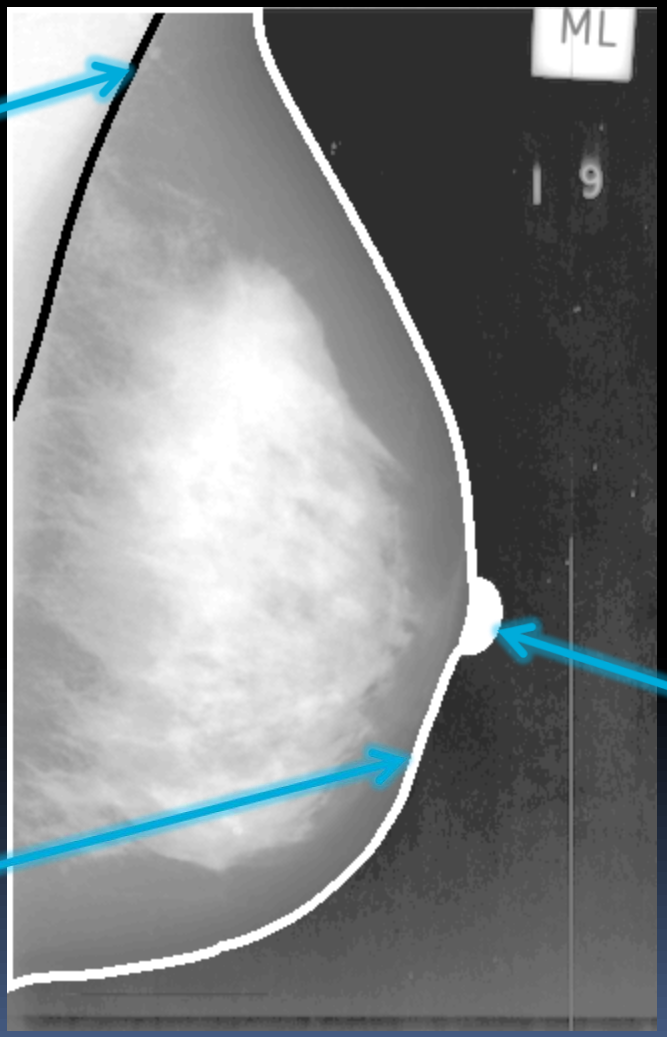
- Too many mammograms generated by population screening must be interpreted by a small number of radiologists
- Abnormalities are often camouflaged
- All the above lead to significant rate of missed breast cancer

Role of the CAD systems

- Computer Aided Diagnosis (CAD) systems
  - Reduce increasing workload
  - Improve accuracy
- CAD systems :
  - Perform computerized mammographic analysis
  - All of them require as a first stage the segmentation of each mammogram into its representative anatomical regions
    - Breast border
    - Pectoral muscle
    - Nipple

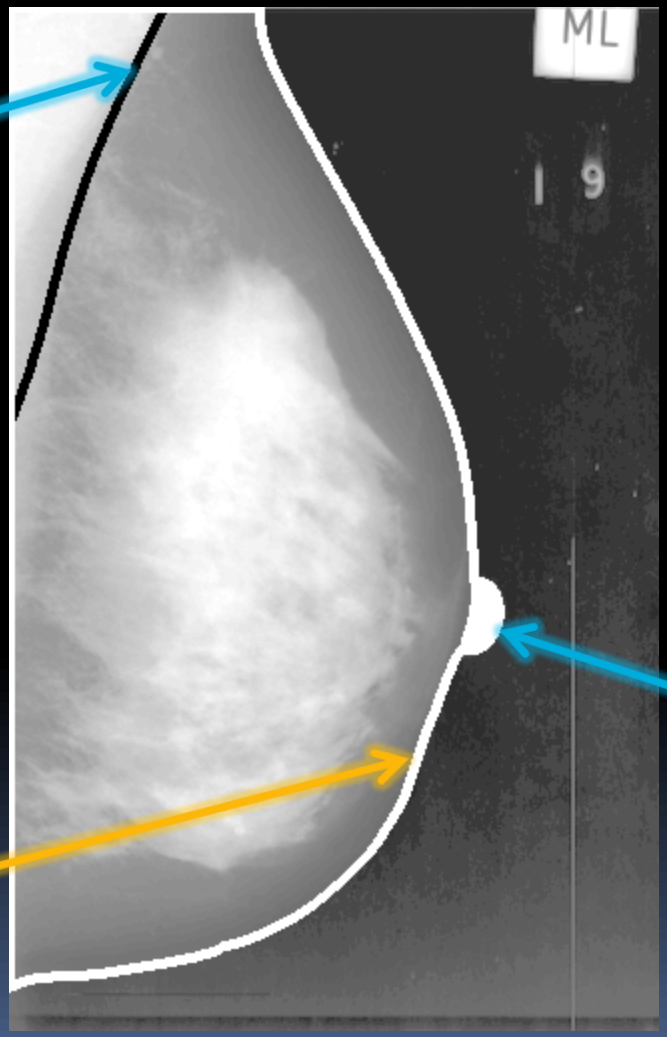
Mammogram segmentation (1)





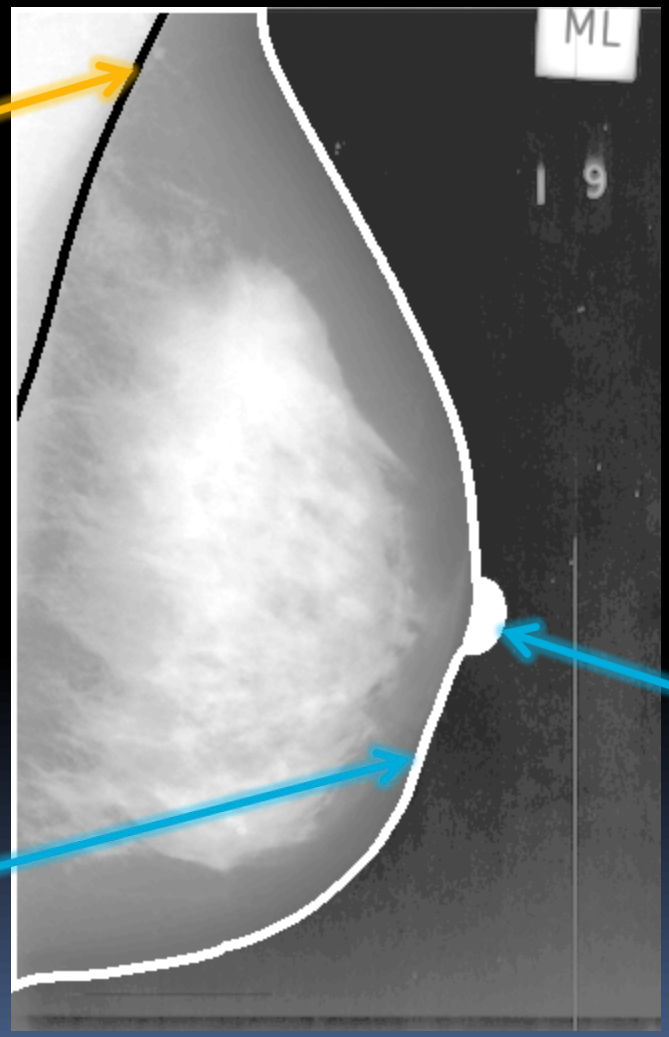
Mammogram segmentation (2)

- Breast Border
  - Necessary for a typical CAD system
  - Identify also noisy regions (artifacts)



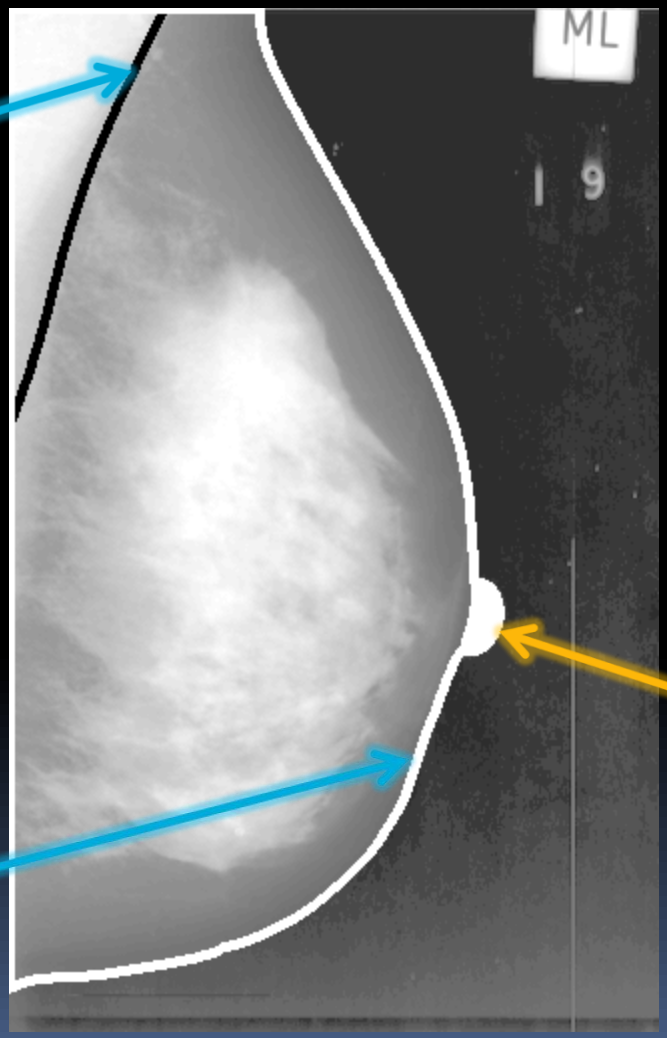
Mammogram segmentation (3)

- Pectoral Muscle
  - Visible only in MLO mammograms
  - False Positive reduction in automatic mass detection
  - Excluded for further processing (density estimation)



Mammogram segmentation (4)

- Nipple Location
  - It can serve as a key-point
  - Registration point for comparison (asymmetries)
  - Starting point for cancer detection

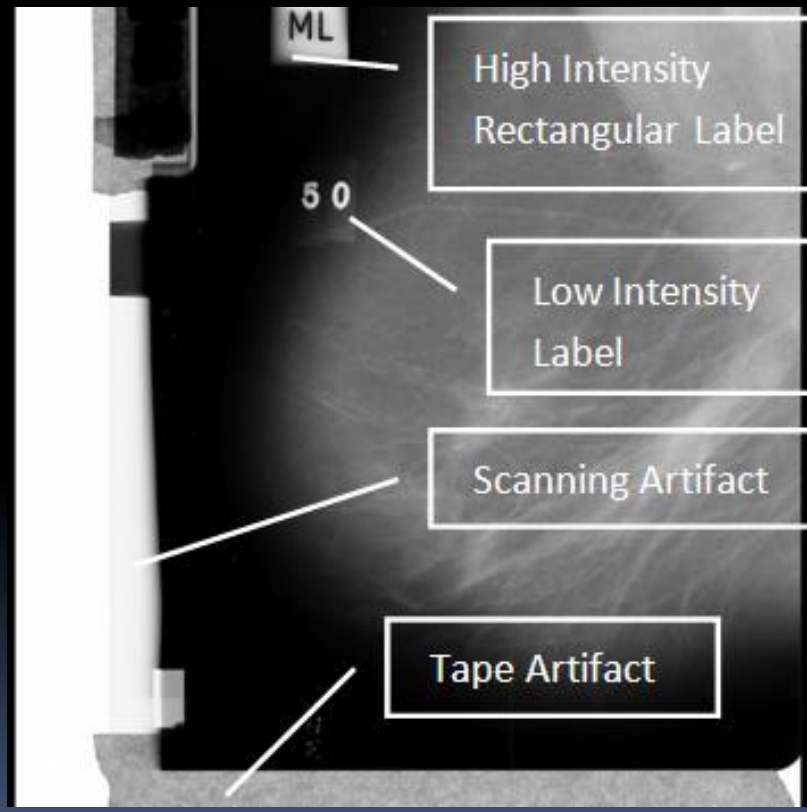


Dataset used

- Mini-MIAS database
  - Available freely online
  - 161 pairs of MLO mammograms
  - Spatial resolution : 0.4mm/pixel
  - Bit depth : 8 bits, 256 gray levels

Image Preprocessing

- Image orientation
- Noise estimation
  - High intensity noise
  - Tape artifacts
- Image filtering
  - Median filtering

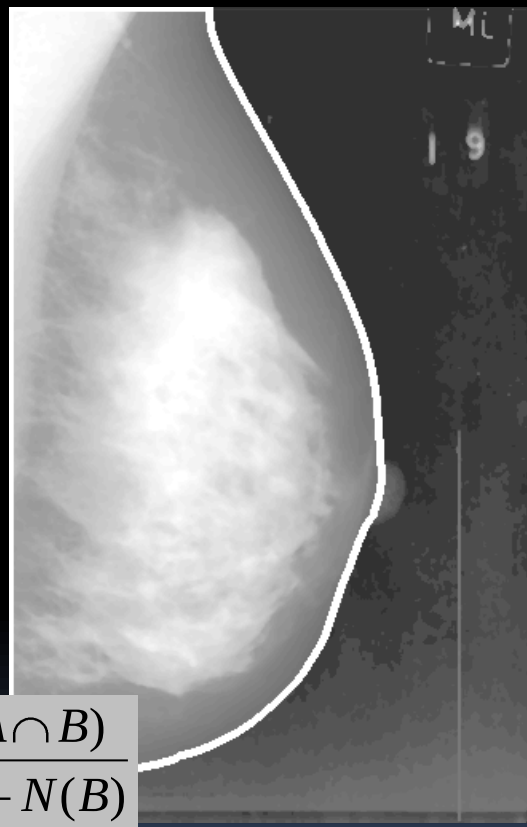


Breast Boundary (1)

- Existing method, relying on the idea that the skin-air boundary is the smoothest section of identical pixels near the breast edge
- Method
  - Threshold the image
  - Extract boundary region
  - Fit a polynomial
  - Estimate the fitting error
  - Final estimate automatically chosen is the one producing the least error
- Divide whole image to zones and use different threshold values for each zone

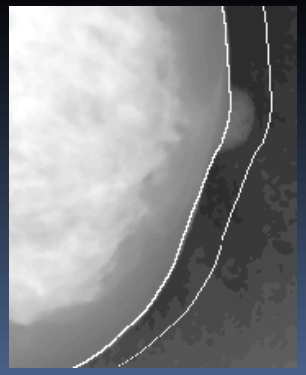
Breast Boundary (2)

- Evaluation
  - Manual segmentation ground truth [Wirth 05]
  - Compare it with the automatic method
  - Metrics used
    - Tannimoto Coefficient $TC = \frac{N(A \cap B)}{N(A \cup B)}$
    - Dice Similarity Coefficient $DSC = \frac{2N(A \cap B)}{N(A) + N(B)}$



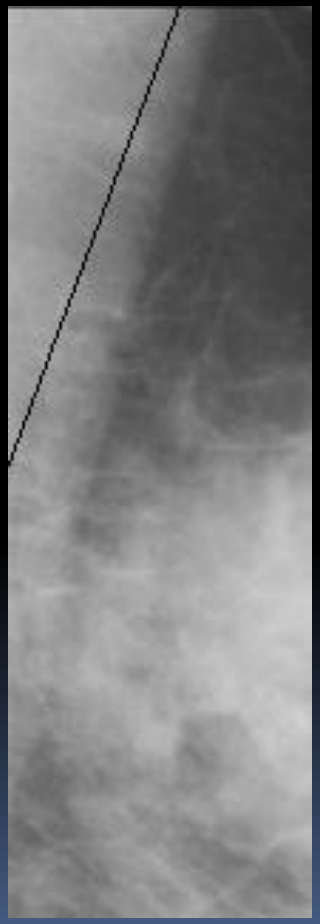
Breast Boundary (3)

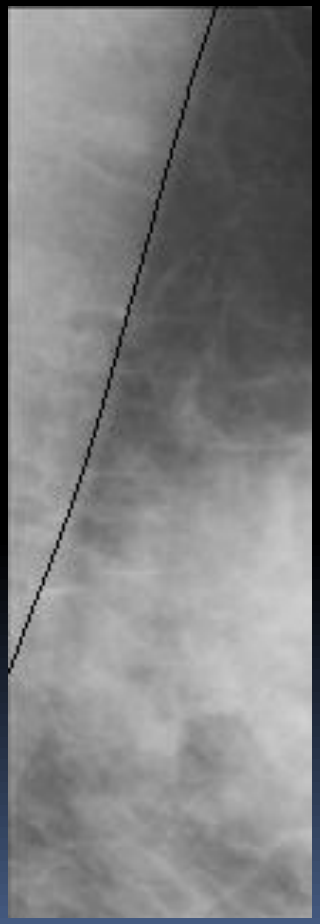
- Comparing ground truth segmentation with the detection algorithm :
  - Comparison region : 10mm's around ground truth boundary
  - Mean values : TC 0.900 , DSC 0.945 (optimal : 1)
- But : Inefficient detection of nipple, when in profile, because of sharp corners



Pectoral Muscle (1)

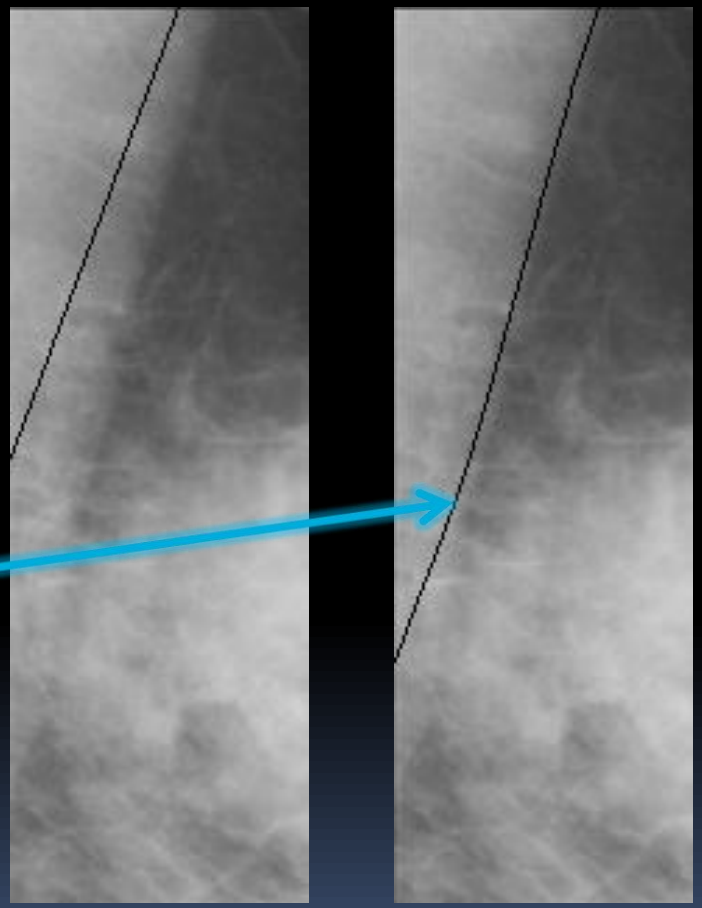
- 2 basic steps procedure [Kwok 04]
  - Straight Line Estimation
  - Iterative Cliff Detection





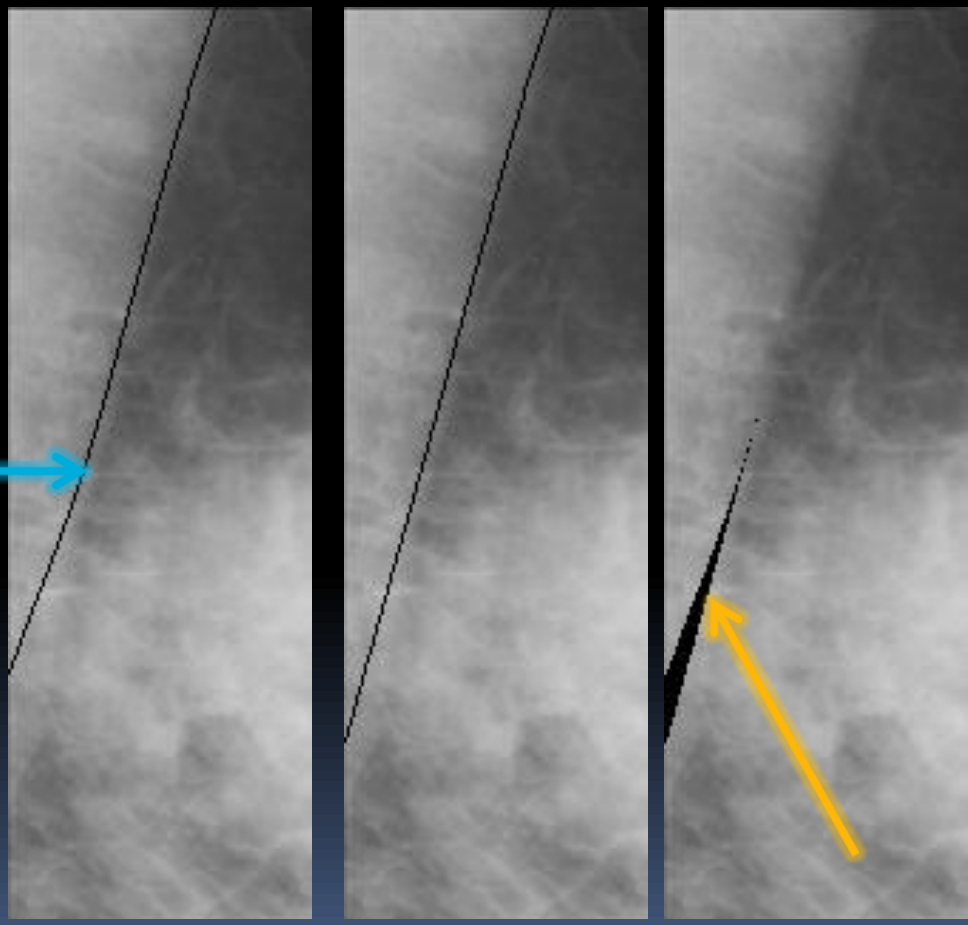
Pectoral Muscle (2) - Improvements

- Region enclosing :
  - Performed at the end of the process, if the bottom end is not aligned with the left edge of the image
  - Existing : extend the bottom end by a straight line parallel to the initial straight line estimation



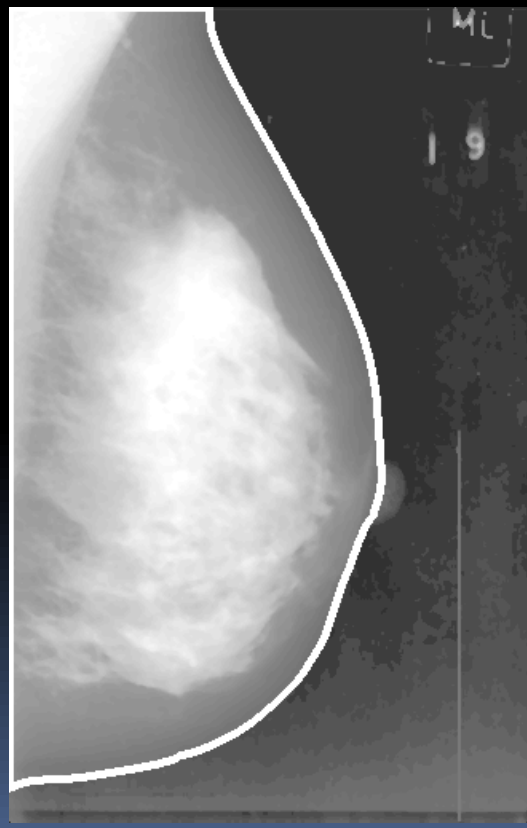
Pectoral Muscle (3) - Improvements

- Region enclosing :
  - Proposed : extend the bottom end by a straight line parallel to the straight line, that best fits the already detected estimate
  - Idea : use the updated estimate, not the initial one



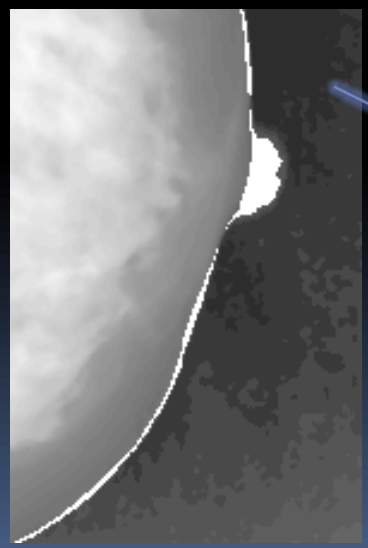
Nipple Detection (1)

- Motivation :
  - Nipple not detected, when in profile
- Use the already detected boundary, in order to find the nipple, if visible



Nipple Detection (2)

- Define a search area of 10mm's width
- Threshold using values derived by the breast boundary detection procedure



Threshold value : 1

Threshold value : 3

DSP09 - Tzikopoulos et al. - A fully automated complete segmentation scheme for mammograms

Nipple Detection (3)

- Try to fit an ellipse
  - Moving center across the boundary detected
  - Variable semi-major and semi-minor axis (2mm's - 10mm's)
- False-positive reduction :
  - Mask derived by maximum value of thresholds (contains no noise) should contain at least one pixel of the nipple

Nipple Detection (4)

- Evaluation
  - Truth Table

Nipple	Not Visible	Visible
Not Detected	189	30
Detected	15	88

  - Manual annotation by an expert radiologist
  - 118 mammograms with a visible nipple
    - Nipple correctly detected in 88 of them
    - In 30 of them no nipple detected
      - 25 of them was partly in profile, already detected by breast boundary algorithm
  - 204 mammograms with no nipple in profile
    - In 15 of them was nipple detected, due to high level of noise

Nipple Detection (5)

- Evaluation
  - Estimate new values of metrics
  - Mean values :
    - TC : 0.900 (0.079) -> 0.903 (0.078)
    - DSC : 0.945 (0.055) -> 0.947 (0.055)
  - The increase may not be large, but :
    - The boundary changes only when nipple detected (103 images)
    - The area, where the boundary changes is too small compared to the whole boundary of the image

Final Conclusions (1)

- Preprocessing :
  - Successful
- Implemented breast boundary detection :
  - Acceptable results, according to
    - Specific measures
    - Careful observation by radiologist
- Pectoral muscle segmentation :
  - Acceptable and further improved through the modification we propose
- New nipple detection technique
  - Serves as an improvement for the already known breast boundary
  - Serves as a key-point for the further processing of the image

Final Conclusions (2)

Acknowledgements

- The research was funded by the Greek Secretariat of Research and Technology (GSRT) in the context of the project MedAS

Discussion

- Thank you for your interest

- Questions ?