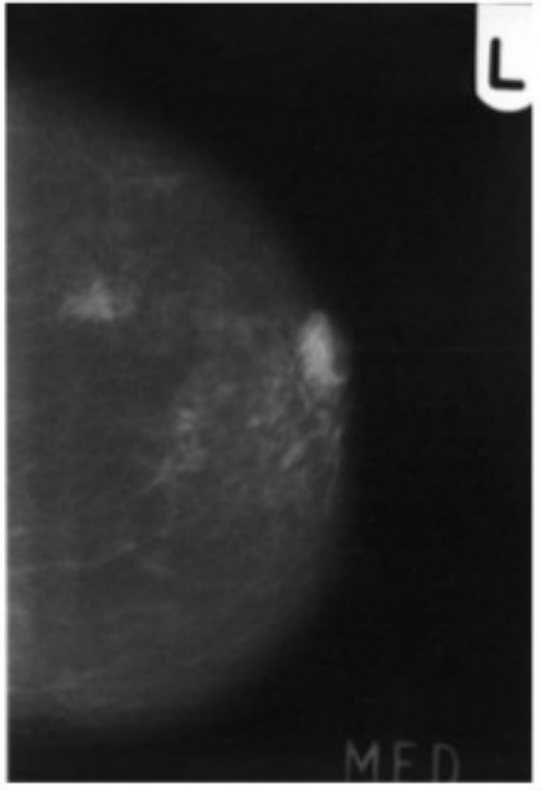
[AIM1.T2]

Extracting glandular tissue thickness from mammographic images: a possibility for multi-site harmonization

Introduction

Conventional mammogram:

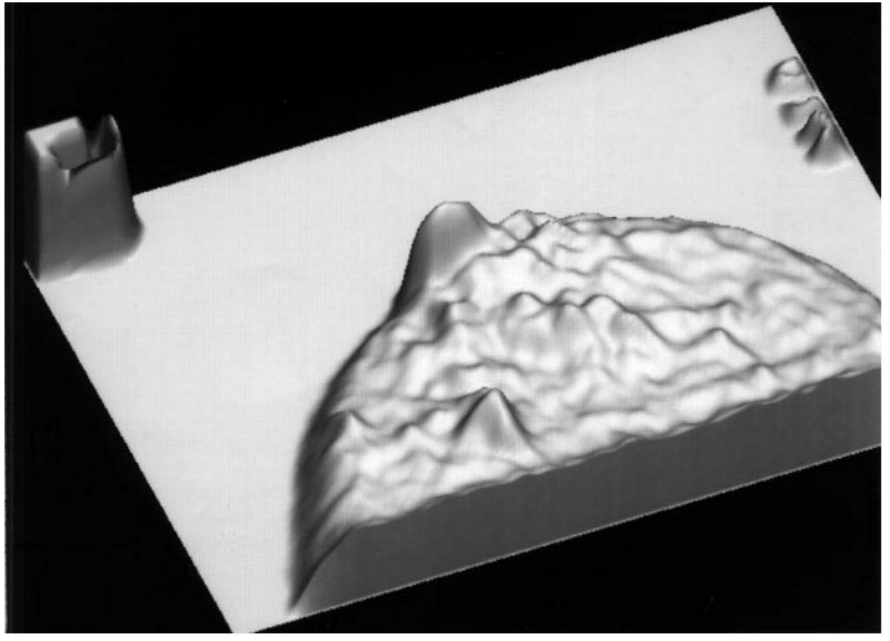
- Images highly dependent on the acquisition system
- No direct physical meaning of the gray levels of the image
- Pixel values depend on:
  - All the materials and thicknesses encountered along the path
  - Energy and fluence of the beam
  - Detection system



Thickness of equivalent glandularity

We are looking for a representation that:

- Is based on a physical quantity
- Allows to remove several degrading factors (i.e. scatter)
- Generate images that are independent from the acquisition system
  - Normalization for multisite databases



Breast model

$$h_{int} = H - h_{fat}$$

- *h_int*: thickness of *interesting* material (glandular, fibrous cancerous) ;
- *H*: total thickness of the (compressed) breast;
- *h_fat*: fat thickness.

Total attenuation is:

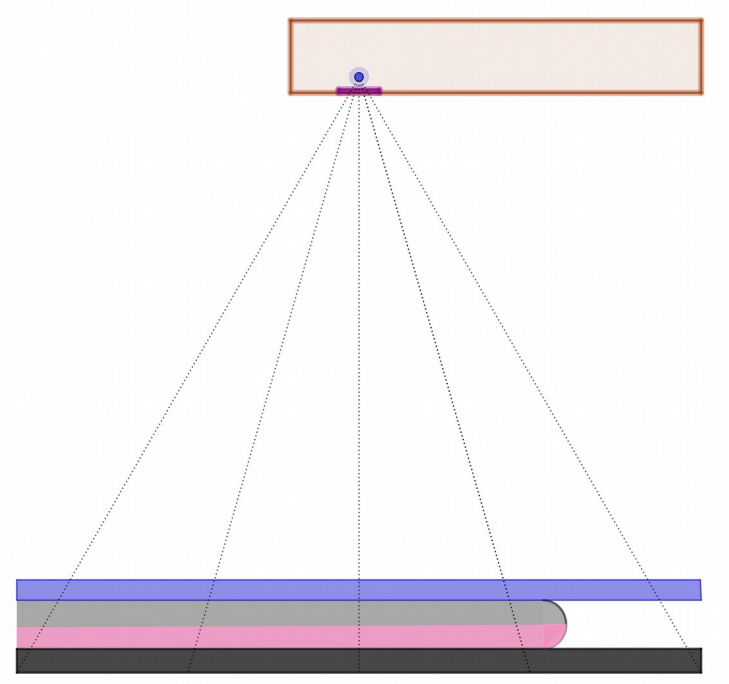
$$h\mu = h_{int}\mu_{int} + (H - h_{int})\mu_{fat}$$

- The idea is to express the breast glandularity in terms of h_{int}
- This representation is independent of the acquisition system

Deposited energy

$$E_p(x,y) = \Phi(KVp_{tube}) A_p t_s \sum_E N_0^{rel}(E) E \cdot S(E) \cdot e^{-\mu(E)h}$$

- E_p: deposited energy by primary photons;
- Φ: photon flux;
- A_p, t_s: pixel area and exposure time;
- $N_0^{rel}(E)$: photon spectrum;
- S: photon fraction passing through the antiscatter grid;
- μ, h: breast attenuation coefficient and thickness



Calculation of h_{int}

Mono-energetic photons:

$$h_{int} = \frac{H\mu_{fat}}{\mu_{fat} - \mu_{int}} + \frac{ln(E_p - ln(A_p t_s ES)}{\mu_{fat} - \mu_{int}}$$

Polychormatic spectrum:

$$\frac{E_p}{\Phi A_p t_s} = \sum N_i^{rel}(E_i) E_i \cdot S(E_i) \cdot e^{-\mu(E_i)h}$$

Measurements

- Dark image
- Flat-Field (per each *Kvp and mAs)*
- MTF (Slanted-Edge)
- Step wedge (PMMA)
- Relation between Kerma and mAs
- Tube spectra (from catalogs)
  - Data from DICOM file

Required corrections

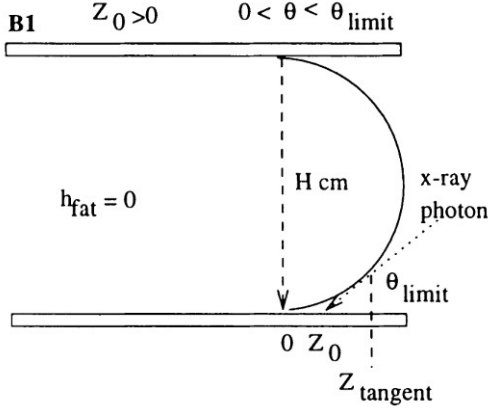
$$E_p = E_{pse} - E_s - E_e$$

Scattering:

- Model for scatter PSF
- Measure of *s/p*

Extrafocal Radiation:

- Study of the effect of the *Breast-Edge*



Validation of the model

- Acquisition of breast-equivalent phantoms
- Monochromatic breast-CT of complete mastectomy (Syrma3D project)

Aims

- Multisite harmonization
  - Reduce the high variability in the data-sets
- Data Enhancement
  - Possibility to generate synthetic images
  - Possibility to simulate additional structures in the image
- Applications for machine learning
  - Extraction of quantitative features from normalized images