Malignant Tumor Detection Using Finite Volume Time Domain

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INTRODUCTION

- There is considerable debate as to whether women under 50yrs should have X-ray mammograms.
- This arises from need to detect breast cancer in its earliest stage.
- While mammograms is recognized as the preferred method to detect breast cancer, it fails to detect 20% of malignant tumor.

- Mammograms are also uncomfortable or threatening many patients.
- There are other modalities such as ultrasound and magnetic resonance imaging (MRI) but they are either less effective or too costly.
- Pulsed confocal microwave technology can complement mammography by remedying most of above deficiencies.

Physical basis of the method

- The confocal, microwave breast cancer detection technology is based upon two fundamental properties of breast tissues at microwave frequencies.
- Microwaves interact with biological tissues primarily according to the tissue water content.
- Microwave attenuation in normal breast tissue is less than 4 dB/cm up to 10 GHz.
- This may permit existing microwave equipment having standard sensitivity and dynamic range to detect tumors located up to about 5 cm beneath the skin.

Breast tissue dielectric properties

- Relative dielectric permittivity ε_r, and conductivity σ, of high-water-content tissues are about an order of magnitude greater than those of low-water-content tissues.
- This contrast between high- and low-water-content tissues persists over the entire radio frequency (RF) spectrum from power frequencies through millimeter waves.

Malignant tumor properties

- Rogers et al. and Peloso et al. separately measured ε_r and σ of malignant tumors and found values above 1 GHz that are almost the same as for normal high-water-content tissues such as muscle.
- In some cases, ε_r and σ for malignant tumors were significantly greater than for normal muscle tissues, especially at frequencies below 1 GHz.

- Surowiec *et al.* performed measurements of cm-size malignant human breast tumors and adjacent tissues and found an increase in ε_r and σ of the normal breast tissue near malignant tumors.
- It could enlarge the microwave scattering cross-section and thereby aid in the confocal microwave detection of the tumor.

Finite Volume Time Domain Method

- The finite-volume time-domain (FVTD) technique solves partial differential equations of hyperbolic nature in conservative form.
- FVTD method is performed in unstructured conformal meshes it is very well suited for modeling structures including curved or oblique surfaces.
- Exploiting the geometrical flexibility of inhomogeneous meshes the FVTD method constitutes a powerful alternative to the classical FDTD Yee scheme that uses stair-casing approximations and sub-gridding to model complex structures.

- Modifications of the original Yee algorithm for irregular meshes exist at the cost of an increased complexity.

- The FVTD method in spite of the larger cost per cell saves memory resources in comparison to the classical FDTD algorithm by reducing significantly the number of cells necessary for accurate simulation of complex problems.

2-D Finite Difference Time Domain of a Pulsed Microwave System

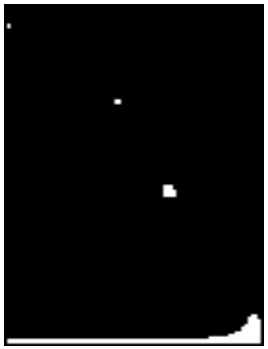
- The first step in the systems analysis, a fixed focus confocal microwave system employing a metal elliptical reflector was computationally modeled in two dimensions using the finite-difference time-domain (FDTD).
- The reflector was specified with one focal point at a monopole antenna element and one in a breast half-space 3.8 cm below the surface.

Results of the FDTD

Thresholding Original Image

Thresholding 3x3 Filtered Image

Thresholding 7x7 Filtered Image



Thresholding 25x25 Filtered Image

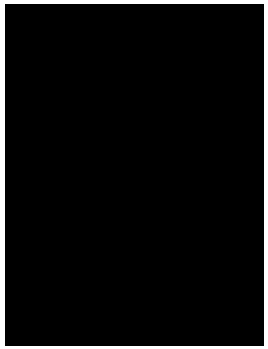
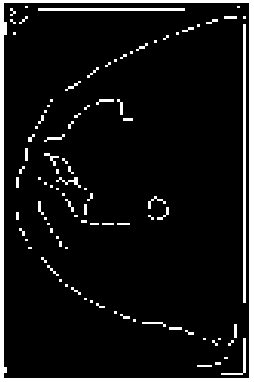


Figure 1: Binary images created by thresholding

Edges in Original Image

Edges in 3x3 Filtered Image

Edges in 7x7 Filtered Image



Edges in 25x25 Filtered Image

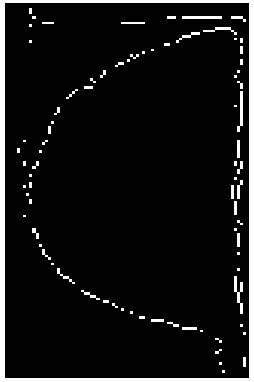


Figure 2: Detecting Edges in Images

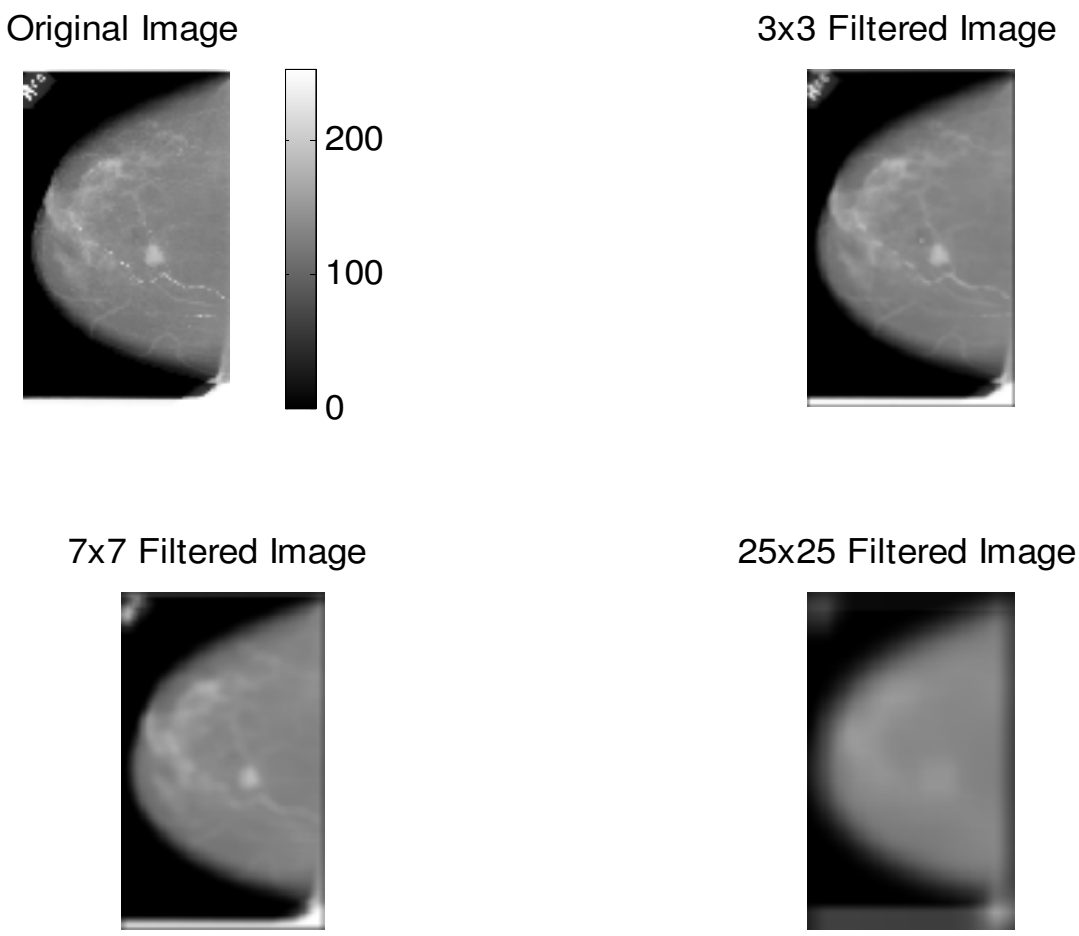


Figure 3: Images after removal of Noise

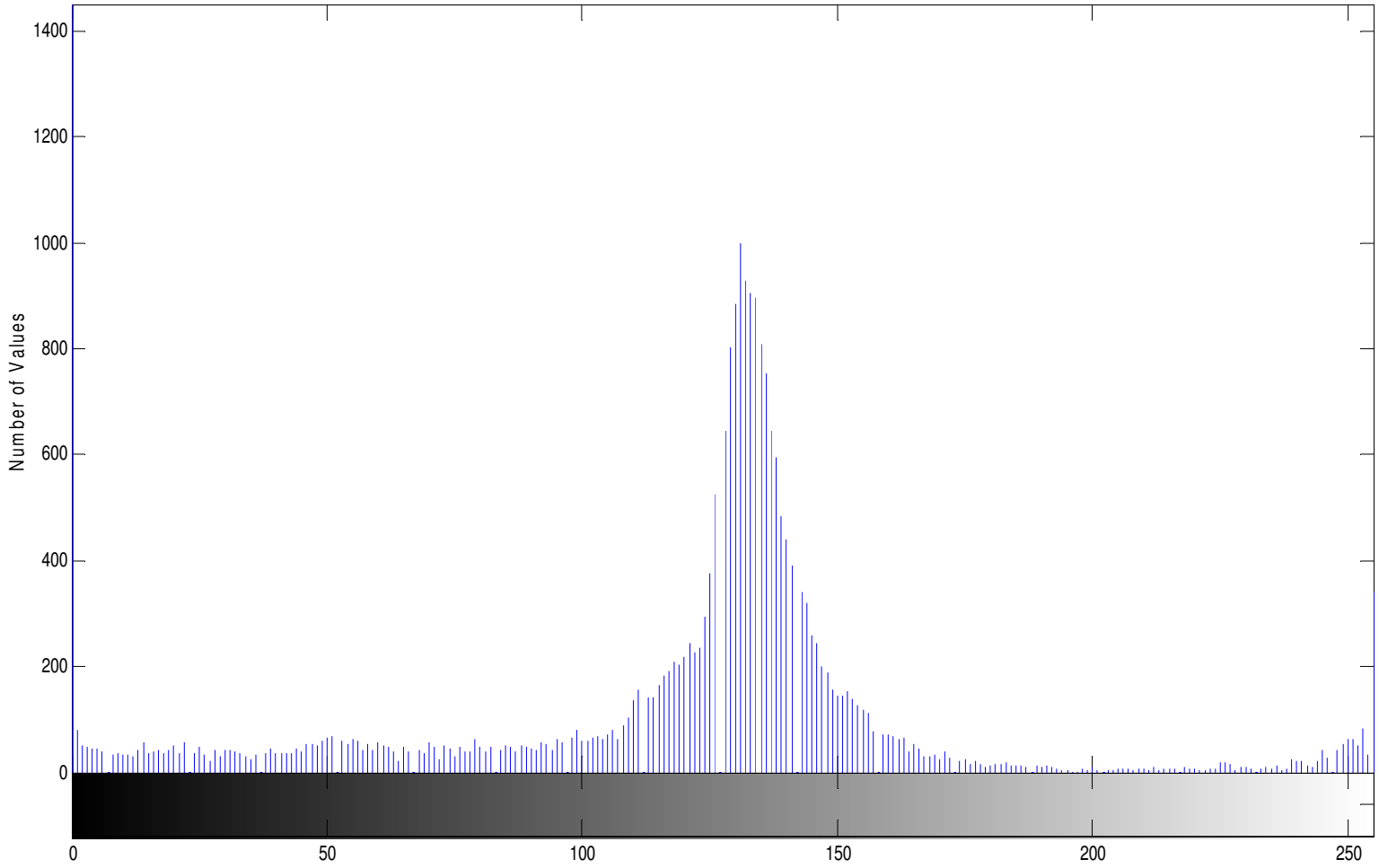


Figure 4: Histogram of the original image

Preliminary result using FVTD

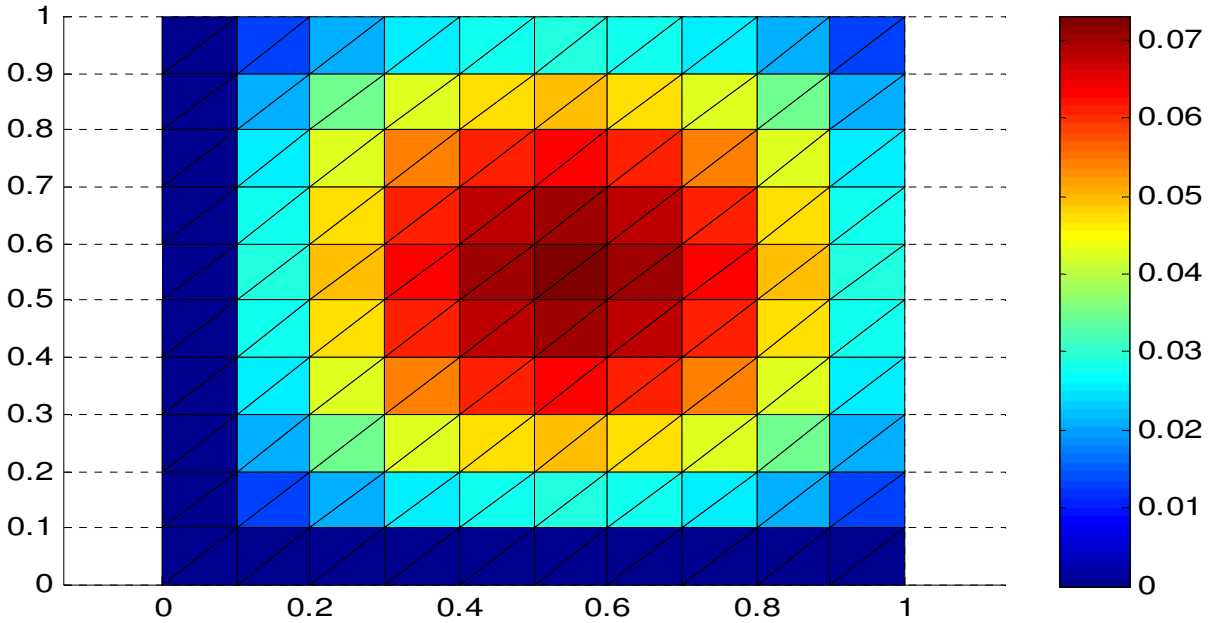


Figure 5: Image reconstruction using FVTD

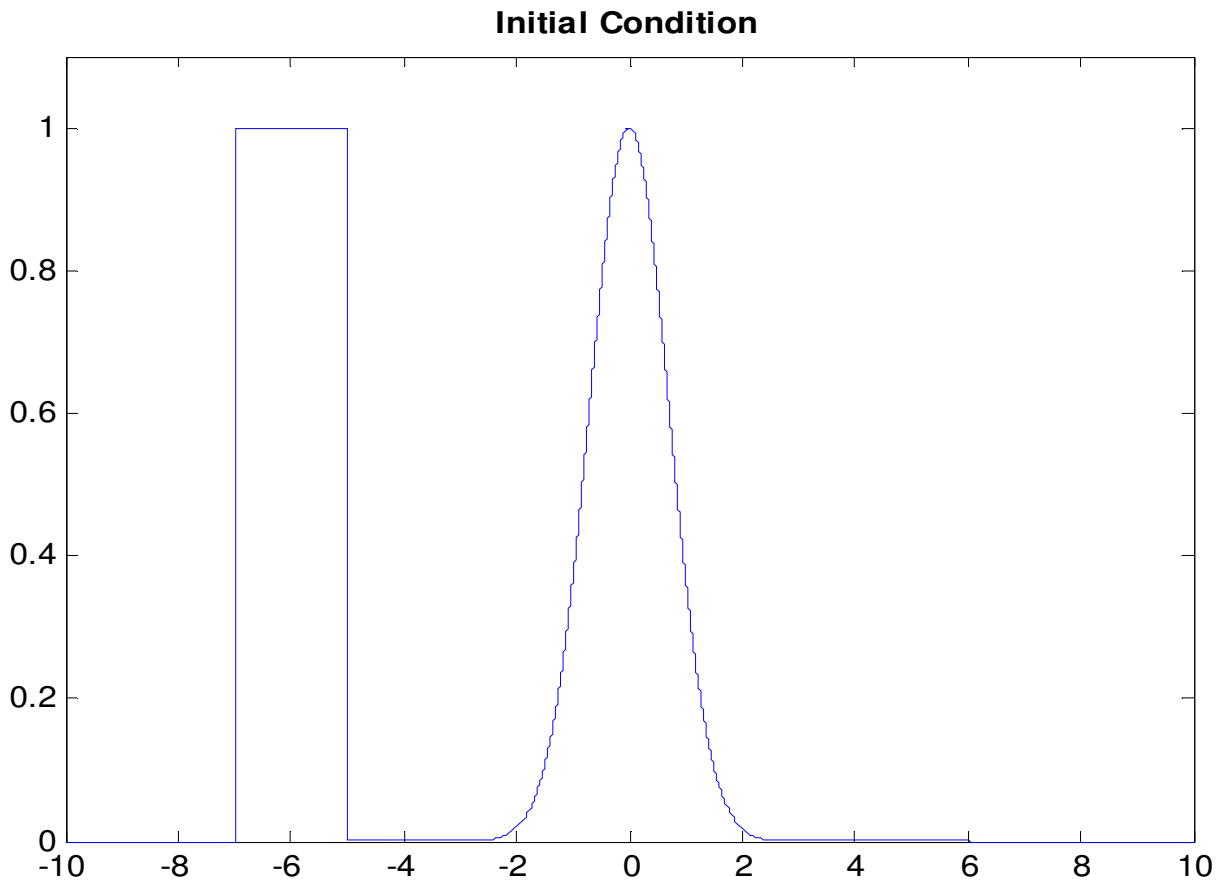


Figure 6: Histogram of Image using FVTD

Conclusion

- The finite volume technique seems to be an interesting approach for the study of breast cancer detection.
- The preliminary result is encouraging but more refinement need to be undertaken to make the images and detection to be more clear.
- Rigorous boundary conditions need to be developed to improve accuracy.

THANK YOU !!!