Cluster and Quadrant Analysis for Thermographic Breast Cancer Detection

Aidan Murray, Shannon Toole, Pannie Xu, and Murray Loew

Department of Biomedical Engineering - George Washington University

Washington, D.C. USA

OBJECTIVE

This study aims to develop an algorithm that can effectively and accurately distinguish between tumor-affected and normal breast tissue. This is being achieved by performing cluster and quadrant analysis on the existing dataset to identify key characteristics of tumor-affected tissues.

INTRODUCTION

Thermographic Imaging utilizes an infrared thermal camera to capture the skin temperature and potentially indicate tumorous regions of interest based on skin temperature patterns. Prior research indicates that tumorous regions are warmer than normal breast tissue, and tumorous tissue cools at a slower rate than normal breast tissue [1].

MATERIALS & METHODS

- Patients were imaged over the course of 15 Minutes with an N2 Infrared Camera with Thermal Resolution of 50 mK / Digital Count.
- Image Processing and Algorithm Development completed in MATLAB.

Cluster Analysis was carried out with two mechanisms:

(1) Statistical Analysis of tumorous regions as indicated by truth data.

(2) Quadrant Analysis of general breast regions for statistical data. Quadrant Origin placed at nipple.

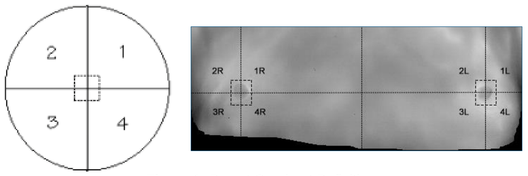

Figure 1: Breast Quadrant Definition

Statistical Analysis was carried out on the Tumorous and Normal tissue using a standard Z test. Based on the statistical data, a pixel intensity threshold was set and spatial clusters were formed using the DBSCAN Clustering Method [2]. Clusters were then isolated using a symmetrical analysis algorithm to identify clusters of clinical value.

RESULTS

Results displayed are for Patient IRST011, one of 14 patients imaged and one of three selected for the algorithm training set. Patient First and Last Images were used in Cluster Analysis Software.

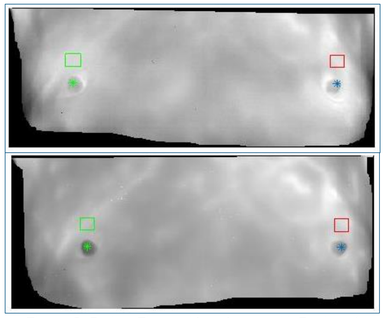

Figure 3: Patient First and Last Image with Region of Interest (Red) and Opposite Region (Green) highlighted.

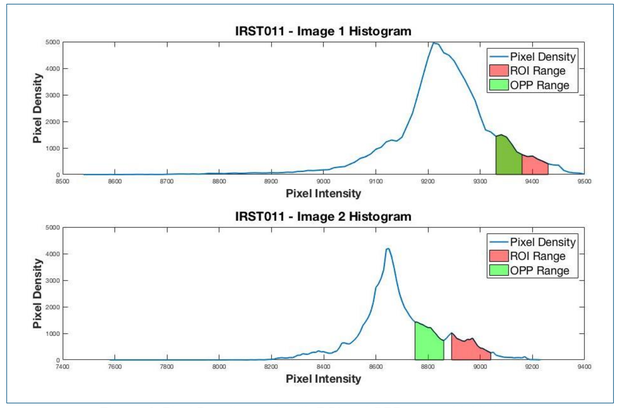

Figure 4: Pixel Density graph with ROI and OPP ranges highlighted

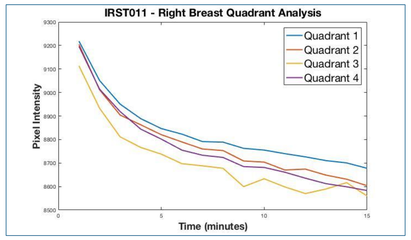

Figure 5: Right Breast Quadrant Analysis: Consistent cooling of normal tissue across all quadrants.

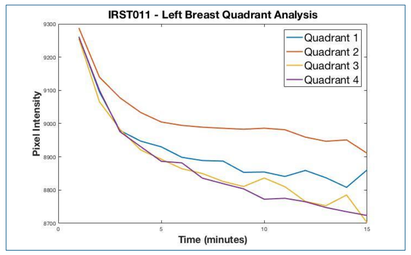

Figure 6: Left Breast Quadrant Analysis: ROI falls between Quadrants 1 and 2, which remain warmer than the other quadrants over time.

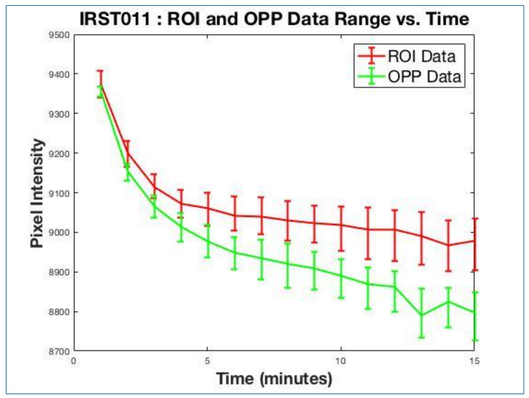

Figure 7: Mean Intensity of ROI and OPP over time. Intensity range shown at each data point.

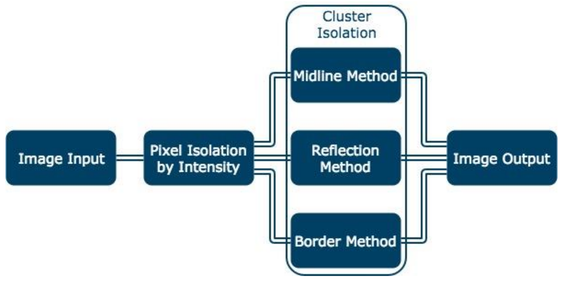

Figure 8: Block Diagram for Cluster Isolation Algorithm

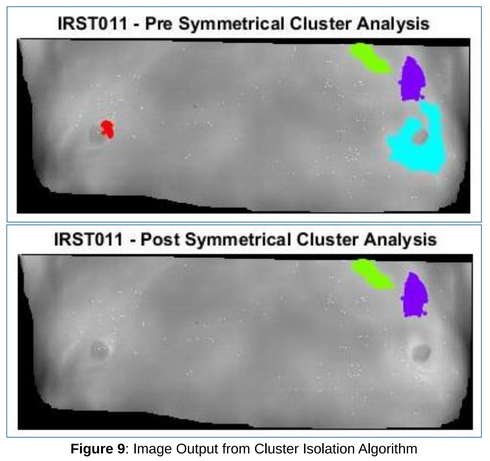

Figure 9: Image Output from Cluster Isolation Algorithm

DISCUSSION & FUTURE WORK

Results confirm findings from prior research that tumor-affected breast tissue is warmer than normal tissue.

For each of the patients evaluated, the tumor region identified by the truth data was significantly warmer than the corresponding region on the opposite (unaffected) breast with a 95% confidence level. This result was confirmed by the Quadrant Analysis, which found that the quadrant containing the tumorous tissue is significantly warmer than the surrounding quadrants and the corresponding quadrant on the opposite breast.

Given these results, the cluster isolation algorithm becomes more significant due to its ability to isolate unilateral regions that are warmer than the surrounding tissue. As more patients are added to the data set, we will continue to train the algorithm. The goal is to provide information for adjunct usage with mammography that may improve the overall accuracy of early breast cancer diagnosis.

CONCLUSION

Given the available data from the 14 patient images thus far, our research indicates that the tumorous breast tissue is noticeably warmer than normal breast tissue. This is evident through the comparison of the tumor-affected tissue with the corresponding region on the opposite breast, which acts as patient-specific baseline. Additionally, these results allow us to train the Cluster Isolation algorithm to identify regions of clinical importance.

REFERENCES

[1] Li Jiang, et al., Phys. Med. Biol. 56 (2011). 187–202

[2] Yarpiz (2015). DBSCAN Clustering Algorithm, MATLAB Central File Exchange. Retrieved July 2017.