Breast Cancer Detection by an Infrared Imager: Evaluating the Thermal Resolution

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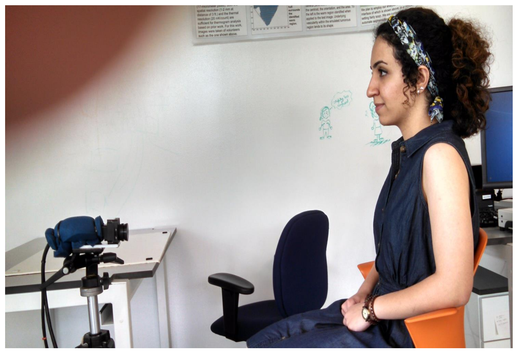
OBJECTIVE

This study assesses the suitability for breast thermography of the N2 Imager thermal infrared camera by measuring its thermal resolution and spatial uniformity and determining the effect of automatic gain control (AGC).

BACKGROUND

- We are investigating infrared thermography as a noninvasive adjunct to mammography for breast cancer screening. Thermography detects elevated skin temperatures that arise from increased blood flow as a consequence of the angiogenesis that accompanies tumor growth.
- Previous work indicates that differences of as little as 0.1 K can be clinically important [1].
- **Thermal resolution** is the minimum temperature difference the camera can detect repeatably.

IMAGE ACQUISITION



The camera used for this study is N2 Imager that has a 640x480 array of 17-micrometer pixels. The stated thermal resolution is 18.6 mK and spatial resolution is 1-2mm at distance 3 ft.

METHOD AND MATERIALS

- We imaged a blackbody (BB) radiator at temperatures 32ºC to 42ºC in intervals of 1ºC. The BB model is OMEGA BB703.
- The line of best fit between temperature and count value for each pixel was computed, repeated with AGC OFF and ON.
- The thermal resolution was calculated by dividing the mean standard deviation (across all pixels) by the mean slope.
- A cup of water at 44ºC was imaged as it cooled to room temperature.
- Two adjacent BBs: one fixed at 42ºC and the other increased from 32ºC to 40ºC in intervals of 2ºC. This was repeated with one BB fixed at 44ºC and a cup of water at 44ºC that was allowed to cool.

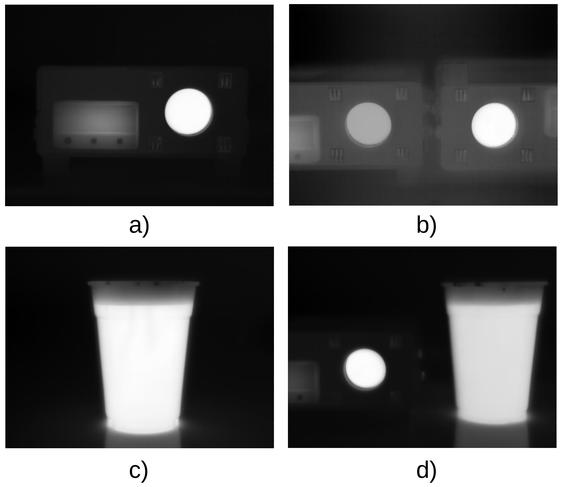


Figure 1: Experimental Setup. a) 1 BB with AGC OFF. b) 2 adjacent BB's with AGC OFF, the right BB's temp was constant while the left BB's temp was varied. c) 1 cup of hot water with AGC OFF. d) 1 BB at fixed temperature and a cup of water with AGC ON

RESULTS

The thermal resolution calculated is 47.5 mK/digital count, using a 95% ($\pm 2\sigma$) confidence interval derived from the mean line of best fit.

AGC must be kept OFF; otherwise valuable data related to the cool-down of breast tissues would be lost [1]. AGC maintains a fixed gain by spreading the detected temperature range over the entire grayscale.

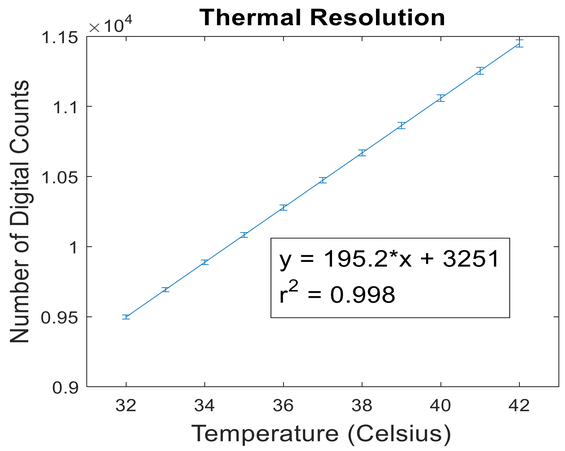


Figure 2: Number of counts vs. Temperature with the mean slope and y-intercept of all pixels. AGC OFF. The mean standard deviation of count at each temperature is 4.64.

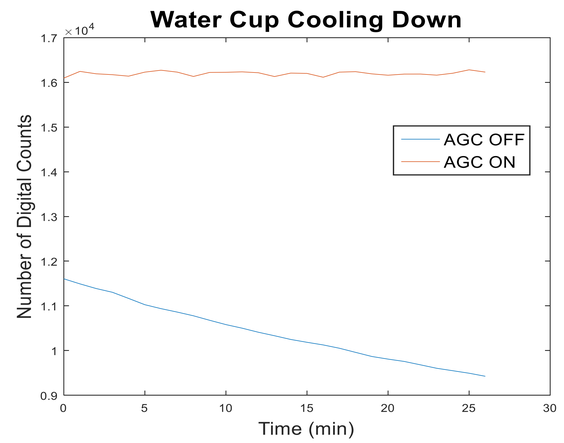


Figure 3: Water cool down - number of counts vs. Time. Comparison of AGC OFF and ON.

DISCUSSION & FUTURE WORK

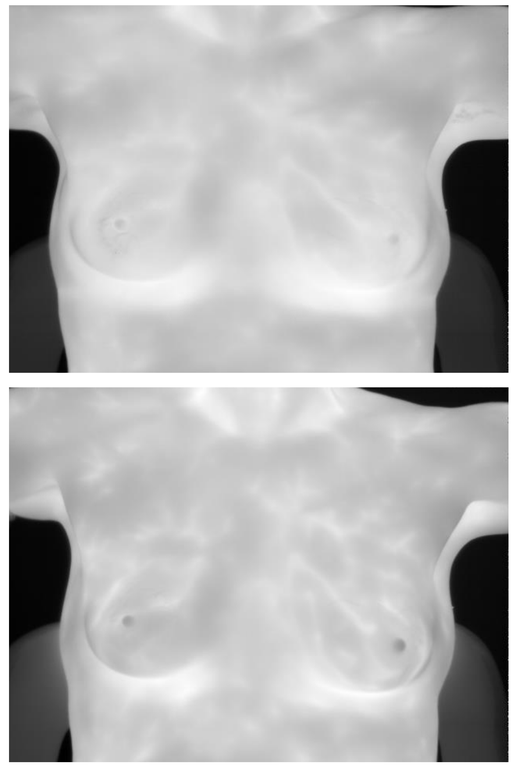


Figure 4: Infrared images of one breast cancer patient. The top image is at time t=0, and the bottom at 15 minutes after imaging started.

The results show that the N2 Imager camera is suitable for clinical trials, which began in September 2016. Patients diagnosed with breast cancer are imaged for total time of 15 minutes to observe the cool-down pattern of breast tissues[1]. Current work involve image analysis and segmentation to locate warm regions on the breast.

ACKNOWLEDGMENT

We thank the U.S. Army Night Vision Laboratory for loaning us the N2 Imager camera.

REFERENCES

[1] L. Jiang, W. Zhan, and M. H. Loew, "Modeling static and dynamic thermography of the human breast under elastic deformation," *Phys. Med. Biol.*, Vol. 56, No.1, 2011, pp. 187-202.