Comparative Evaluation of Microwave Thermography and Mammography

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ABSTRACT
Mammography is widely used in early breast cancer detection and prevention although it constitutes ionizing radiation (X-ray) properties of which continuous exposure could lead to chances of cancer. On the other hand, thermography operates under infrared and microwave region consisting of non-ionizing radiation properties and is used not just for breast cancer detection and other special applications in medical services but also for Surface Month Technology (SMT) , Printed Circuit Board (PCB) evaluation and troubleshooting, etc. In the bid to design and develop modern technologies especially for testing and measurement systems in medical and engineering services with less false positive result, mammography and thermography are generally considered. Their applications, uses and limitations are presented in this paper with emphasis on design and development of multiple task engineering systems. The study shows that for breast cancer diagnosis, mammography has 96.1% accuracy while thermography has 97.1% accuracy. Mammography has high false positive result when compared with thermography leading to dangerous threat on the patients. Although mammography is very common and cost effective, it is recommended that thermography be further developed to increase its use and application in health services.

1.0 INTRODUCTION
Constant evolution of new technologies are meant to meet growing world population desires for smart cities, high quality of service (QoS), low cost of engineering products, control of climate change effect, dynamic systems, seamless operations of engineering systems, etc. These desires demand that researchers should endeavor to key into the framework whereby engineering system users could have access to a product that can handle multiple tasks with less skill. In ensuring that engineering systems meet critical human demands, design and development for the 21st century and beyond, there is need to evaluate the evolving microwave thermography and mammography technologies. The concentration should be on best for applications in medical services and engineering, and its capabilities for handling of multiple tasks just like as the mobile phones, laptops, Intelligent Enhanced Dynamic Cell Sectorization Scheme for Improved CDMA Traffic Capacity etc. does (Ohaneme et al, 2018).
Electromagnetic spectrum defined the range of frequencies or wavelength over which electromagnetic radiation extends (Quizlet). Mammography and thermography are in different regions of the electromagnetic spectrum. While mammography using X-rays is classified to have ionizing radiations, thermography uses microwave and infrared and has no ionizing radiation properties (Nwabueze and Jaja, 2017; Samartha et al, 2019).

Generally, the electromagnetic radiations which are waves of the electromagnetic field, propagating through space, carrying electromagnetic radiant energy are classified according to their ionizing properties (i.e. X-rays, Gamma rays and Extreme Ultraviolet) and non-ionizing radiation (i.e. visible light, Infrared, Microwave and radio waves). Studies show that the effect of ionization on human after continuous exposure is very hazardous,

hence the need for non-ionizing devices in health care system. Table 1 shows the electromagnetic spectrum of X-ray, Infrared and Microwave (Lexico).

The evolution, comparative evaluation, principles of operation, system techniques and applications areas of microwave thermography and mammography are presented in this paper.

Table 1: Electromagnetic Spectrum of X-ray, Infrared and Microwave.

Ionization Properties	Electromagnetic Spectrum	Frequencies	Wavelength Photon Energy	Photon Energy (eV)
Ionization	X-rays	30 EHz – 30 PHz	0.01 nm – 10 nm	124 keV – 124 eV
Non-ionization	Infrared	400 THz –300 GHz	750 nm – 1 mm	1.7 eV – 1.24 meV
	Microwave	300GHz-300MHz	$1mm - 1m$	1.24 meV – 1.24 μeV

2.0 MAMMOGRAPHY

2.1 Evolution of Mammography

Mammography is one of the oldest technologies commonly used by health workers for early breast cancer detection and possible prevention. In Mid 1950s, Jacob Gershon Cohen used mammography to screen healthy women for breast cancer. In the late 1950s, Robert Egan developed a new method of screening using mammography. Mammography became a widely used diagnostic tool in the 1960s (Brainkart)

Mammography is a technique using X-rays (i.e. electromagnetic spectrum with ionizing radiation) to diagnose and locate tumor of the breast. It can also be said to be a radiographic modality to detect breast pathology and cancer. A mammography exam, called a mammogram, aids in the early detection and diagnosis of breast diseases in women. A mammogram can detect breast cancer in its early formation. It is estimated that breast cancer accounts for 32% of cancer death incidences and 18% of cancer deaths in women. Approximately 1 in 8 or 9 women will develop breast cancer over their lifetime (Dascalos, 2017; Gwachha, 2013).

According to World Health Organization (WHO), every year, breast cancer kills more than 500,000 women around the world. In resource-poor settings, majority of women with breast cancer are diagnosed at an advanced stage of the disease; their five-year survival rates are low, ranging from 10-40% (WHO). Mammography is widely used to screen, monitor and detect cancer and other inflammatory tissue disorder but due to the ionization from X-ray radiations, medical personnel and patient are always at risk.

2.2 Mammography Principle of Operation

X-rays are a form of radiation (i.e. light or radio waves) which pass through most objects, including the body. Once it is carefully aimed at the part of the body being examined, an x-ray machine produces a small burst of radiation that passes through the body, recording an image on photographic film or a special detector. Different parts of the body absorb the X-rays in varying degrees. Dense bone absorbs much of the radiation while soft tissue, such as muscle, fat and organs, allow more of the x-rays to pass through them. As a result, bones appear

white on the X-ray, soft tissue shows up in shades of gray and air appears black.
Most X-ray images are digital files that are stored electronically. These stored images are easily accessible for diagnosis and disease management. In conventional film and digital mammography, a stationery X-ray tube captures an image from the side and an image from above the compressed breast. In breast tomosynthesis, the X-ray tube moves in an arc over the breast, capturing multiple images from different angles (Radiologyinfo)

2.3 Method of Mammography

i. Conventional Mammography: Traditional mammograms create diagnostic images by applying a low-dose X-ray system to examine breasts. Mammograms are used to monitor the breasts and assist in the early detection and diagnosis of breast diseases in women. X-rays are the most frequently used form of medical imaging.

ii. Digital Mammography: Digital mammography replaced traditional X-ray film with a digital chip to record images of the breast. This process, also known as full-field digital mammography, makes it possible for the images of the breast to be viewed on a computer monitor or printed on a special film similar to traditional mammograms.

The advantages of digital mammograms include faster image acquisition, fewer total exposures and less patient discomfort. Breast health screenings that use digital mammograms have been proven to detect breast cancers better than conventional mammograms in three groups of women: those younger than 50, those with dense breasts and those who are pre-menopausal (SSM Health).

iii. 3D Mammography: The new 3D Tomosynthesis Mammography is the latest advanced array of technology that is in use. This revolutionary process allows physicians to better distinguish masses or tissues that might be cancerous. In traditional mammography, details of the breast are viewed in one flat image. 3D mammography allows the breast to be viewed in a series of layers, allowing the radiologist to more accurately interpret the images. The use of 3D mammography has proven to significantly reduce false positive callbacks and to be more accurate in detecting breast cancers early enough (Radiologyinfo and SSM Health).

2.4 Advantages and Disadvantages of Mammography

Advantages

i. Screening mammography reduces the risk of death due to breast cancer. It is useful for detecting all types of breast cancer, including invasive ductal and invasive lobular cancer.

ii. Screening mammography improves a physician's ability to detect small tumors. When cancers are small, the patient has more treatment options.

iii. The use of screening mammography increases the detection of small abnormal tissue growths confined to the milk ducts in the breast, called ductal carcinoma in situ (DCIS).

iv. No radiation remains in a patient's body after an X-ray examination.

v. X-rays usually have no side effects in the typical diagnostic range for this exam. (Radiologyinfo)

Risks/Disadvantages of Mammography

i. Risk of radiation leading to slight chance of cancer.
ii. Risk of false alarm.
iii. Difficulty to interpret result because of low contrast.
iv. Double reading of mammogram leads to increase in the cost of detection (Radiologyinfo)

2.5 Applications of Mammography

i. Highly effective means of detecting early-stage breast cancer.
ii. A typical mammographic screening examination consists of one or more commonly two views of each breast.
iii. Pre-surgical localization and guidance of biopsies.
iv. Mammography is used both for:

- Investigating symptomatic patients (diagnostic mammography)
- Screening of asymptomatic women (selected age groups) (American Collage of Radiography, 1999).

3.0 THERMOGRAPHY

3.1 Evolution of Thermography

Thermography operates under two distinct electromagnetic regions namely: infrared region and microwave region. In 1800, Frederick William Herschel discovered infrared radiation

While Microwave radiations were predicted in 1846 by James Clark Maxwell by the use of his renowned equations. Later in 1888, Heinrich Hertz proved the existence of microwave by building a device that produced and could detect microwave radiations (Halloween).

Outside the use of infrared and microwave radiations in the development of thermography systems, other areas of application includes: point to point communication link, wireless network, satellite communications, relay network, etc.

3.2 Principle of operations of Various Method of Thermography

Microwave thermography uses a microwave receiver of high precision and low noise to detect electromagnetic radiation from microwave spectrum. The system allows the detection of depth malignant structures because of the fact that microwaves has a greater wave length as compared with the infrared radiation and less absorbed by the tissue on which it covers from the tumour to the surface (Tipa and Baltag, 2004).

Infrared thermography:- Although infrared radiation (IR) is not detectable by the human eye, an IR camera can convert it to a visual image that depicts thermal variations across an object or scene. IR covers a portion of the electromagnetic spectrum from approximately 900 to 14,000 nanometers (0.9 μm–14 μm). IR is emitted by all objects at temperatures above absolute zero and the amount of radiation increases with temperature. Thermography is a type of imaging that is accomplished with an IR camera calibrated to display temperature values across an object or scene. Therefore, thermography allows one to make non-contact measurements of an object's temperature. IR camera construction is similar to a digital video camera (New World Encyclopedia)

3.3 Types of Thermography

i. Passive thermography : Inspection of object or body at higher or lower temperature than the background
ii. Active thermography: An energy source is required to produce a thermal contrast. The detection can occur either hot (active) or cold (passive) on the surface of the body.

3.4 Advantages and Disadvantages of Thermography

Advantages of Thermography

i. It is a non-contact type technique.
ii. A large surface area can be scanned in no time.
iii. Images can be presented in visual and digital form.
iv. Software back-up for image processing and analysis.
v. Requires very little skill for monitoring.

Disadvantages of thermography

i. Cost of instrument is relatively high.
ii. Unable to detect the inside temperature if the medium is separated by glass/polythene materials etc.,
iii. Difficult to interpret even with experience.
iv. Training and staying proficient is time consuming (Maintworld).

3.5 Method of Thermography

There are three basic method deployed in thermography technology (Brainkart):

i. Infrared Thermography
ii. Liquid Crystal Thermography
iii. Microwave Thermography

Applications of Thermography

a. In Diagnosis of electronic system and parts
b. Diagnosis of Electrical system
c. In medical thermography
d. Level detection
e. Industrial roof moisture detection

a. Areas of thermography application in electronic system diagnosis

i. Surface Mount Technology (SMT)
ii. PCB evaluation and trouble shooting
iii. Thermal mapping of semiconductor devices
iv. Circuit board components evaluations
v. Inspection of hybrid microcircuit
vi. Inspection of soldered joint
vii. Production type inspection of bonded structure

b. Areas of applications of thermography in medicine

i. Oncology: Thermography deals with cancerous disorder

ii. Tissue viability : Thermography deals with vitality of tissue
iii. Surgery : Deals with invasive procedure done in order to treat patient
iv. Respiratory disorder : Thermography deals with respiratory disorder , an so many other areas in medicine which include ,Vascular disorder, Neurology, Orthopedics Occupational medicine ,Ventinary medicine ,Pain management, Dentistry etc (The Construction and Slideshare).

4.0 ANALYSIS

4.1 Comparative Evaluation of Mammography and Thermography

In summarizing the comparative evaluation of mammography and thermography, the interest is mainly on application areas, advantages and disadvantages and other useful techniques as shown in table 2. (Yao et al., 2014; Fletcher & Elmore, 2003; Hoekstra, 2001; Berrington de González & Reeves, 2005, and Omranipour et al., 2016).

Table 2: Comparative Analysis of Thermography and Mammography

S/N	Conditions	Mammography	Thermography
1	Early diagnosis	Better for early cancer detection	Less accurate for early cancer detection
2	Risk from radiation	High	Very low
3	False-positive results	High	Low
4	Design complexity	Hard	A bit simple
5	Handlings/Reading	Hard to interpret and need more experience personnel to handle	Easy to interpret and handle
6	Size	Bulky	Small
7	Energy level	Better energy level than thermography	Low level of the energy of the signal produced by tumors (10-13-10-16)W.
8	Overall Efficiency /Accuracy	96.1%	97.1%
9	Compression	Rupture risk	No rupture risk as no contact during test
10	Breast density	Not well suited for women with dense breasts, implants, fibrocystic breasts, or those on hormone replacement therapy	Well suited
11	Treatment Monitoring	Non monitoring of treatment through hypothermia	Allows the monitoring of some treatment through hypothermia
12	Age	Less efficient cancer detection in younger children	Scalable in both old and young people with better efficiency
13	Area of Application	More prominent in Medical applications	Widely used for medical , electronic engineering design and other applications
14	Cost	Expensive	Less expensive when compared to mammography
15	Contact	Contact technique when in used	Non-contact technique when in used

CONCLUSION

In the bid to design and develop modern technologies especially for testing and measurement systems in medical and engineering services with less false positive result, mammography and thermography are generally considered. Their applications, uses and limitations are presented in this paper with emphasis on design and development of multiple task engineering systems. The study shows that for breast cancer diagnosis, mammography has 96.1% accuracy while thermography has 97.1% accuracy. Mammography has high false positive result when compared with thermography leading to dangerous threat on the patients. Although mammography is very common and cost effective, it is recommended that since thermography has the capabilities to handle multi-task applications, it should be further developed to increase its use and application in health and engineering services.

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