Chapter

Digital Image Processing and Its Application for Medical Physics and Biomedical Engineering Area

Nupur Karmaker

Abstract

The proper use of imaging modalities produces an image that aids in the detection of early stage abnormalities such as cancer, the identification of small precise lesions, and the presentation of internal illustration. A high-quality image can help doctors, radiologists, medical physicists, biomedical engineers, and scientists to make important decisions on ameliorate treatment planning that can reduce cancer mortality rates and provide life-saving results. This chapter outlines the features, attributes, and processing techniques of various medical imaging modalities utilized in the fields of radiation therapy and biomedical engineering. This study highlighted the significance of image processing in medical physics and biomedical engineering, characteristics of mammography, computed tomography (CT), ultrasound, magnetic resonance imaging (MRI), and positron emission tomography (PET) images. With their advanced application, various image processing approaches are distinguished. Images are collected through the journal, useful websites, the internet, or other sources. That can help teachers, students, researchers, scientists, and others comprehend and learn how to apply image processing techniques and which techniques will suit which modalities image. This chapter will provide a clear understanding of image processing techniques for medical physics and biomedical engineering participants, as well as an abundance of learning opportunities.

Keywords: mammography, ultrasound, computed tomography, positron emission tomography (PET), magnetic resonance imaging (MRI), image processing techniques, medical physics, biomedical engineering and importance

1. Introduction

Present status of the globe, special issue for the international community in this 21st century struggle against COVID-19 has been taken a tremendous place by the greatest health, economy, education, and food challenges that are denigrating normal process safety lifestyle of human, animal, agriculture, etc. [1]. Simultaneous global emergency situation handled by World Health Organization (WHO), policymakers, research center, institutions, universities, and scientific societies that are still finding affordable and practical solutions for prevention, diagnosis, treatment, and management to abate affected and death rate, manage patients in each stage of the disease control, secure quality and safety for patients, front liners, healthcare workers, and general people by accurate diagnosis kits, respirators, face shields,
ventilators, intensive care units (ICUs), personal protective equipment (PPE), medical devices, medicine, and vaccines [2, 3].

COVID-19 disrupted medical services more than half (53%) of the countries for hypertension treatment; 49% for treatment for diabetes and diabetes-related complications; 42% for cancer treatment, 31% for cardiovascular emergencies, and almost two-thirds (63%) for rehabilitation services [4].

In a devastating unexpected situation of COVID-19 hampered and increased higher risk for cancer patients, doctors, medical physicists, nurses, and other staff to ensure safe, sanitization, segregation, face/body shielding maintain social distance, and prepare radiotherapy infrastructures [5]. Clinical medical physicists approach who are working clinical services, education, informatics, equipment performance evaluation, quality assurance, treatment planning, brachytherapy, in vivo dosimetry, motion management, etc. mitigate infection risk to staff [6, 7]. Medical physicists formulated certain strategies based on published evidence to help to formulate their own protocols to carry out planning and treatment considering time, distance, and shielding it remains unchanged for COVID-19 [8].

Biomedical engineers are preserving life in different ways to fortify during COVID-19 pandemic for healthcare infrastructure, imaging modalities, medical equipment designed to avail contain the SARS-CoV-2 virus responsible for causing COVID-19 infections, rapid and reliable test kits, face mask, face shield, ventilator, oximeter, better nasal swabs, 3D printing, artificial intelligence applications, and vaccine development [9, 10].

On the other hand, human history has high death rate for some diseases per year. According to WHO report in 2019, the top 10 causes of death accounted for 55% of the 55.4 million deaths worldwide [11]. Leading causes of death globally are illustrated below (Figure 1).

The two fields of human health and medical imaging are inextricably linked one another. The use of high-quality imaging modalities is essential for accurate diagnosis [12]. Early detection and accurate assessment of lesions are the goals of various image modalities. The properties of imaging modalities and methodologies contribute to produce an image for clinical visibility [13]. The use of digital processing is a powerful tool to quickly analyze enhanced/intensified images [14]. Nowadays

![Leading causes of death globally](image)

**Figure 1.**
*Leading causes of death globally [11].*
artificial neural networks and deep learning applied for better understanding medical image analysis [15].

Significant image processing can assist to provide accurate anatomical information that can always play a vital role in early-stage detection, reducing death rates, and take better treatment decisions [16].

The goal of this empirical study is to show that there is a significant link between medical physics and biomedical engineering with digital image processing, as well as how to apply image processing techniques in this area and what types of benefits can be obtained. So, this is the fundamental concern for introducing the medical physics and biomedical engineering working field, what sorts of modalities are used here for diagnosis and treatment reasons, what essential features can be seen in various modalities images, and which image processing techniques are preferred.

2. Medical physics

The application of physics to medicine is known as medical physics which encompasses therapeutic radiological physics, medical, nuclear physics, and medical health physics [17]. A fundamental component of medical physics is the requirement for broad imaging facilities and accurate explanations [16]. The journey of medical physics and imaging began with the discovery of X-ray that is known as medicine in radiation [18]. Radiation therapy (RT) was first used to treat cancer over a century ago. Since then, enormous progress has been made to improve the effectiveness of this modality and minimize side effects [19]. Radiation therapy is a form of radiation medicine that consists of external beam radiation therapy and brachytherapy that is used to treat a variety of cancer cases. Radiation therapy (also called radiotherapy) is a cancer treatment that uses high doses of radiation to kill cancer cells and shrink tumors [20].

Various machines have been used to produce radiation beams throughout the history of radiation therapy [21]. High-energy X-ray or electron beams used for cancer treatment that is known as external beam radiation therapy (EBRT) [22]. Brachytherapy is a treatment in which radioactive material is implanted into patient body.

One type of radiation therapy used to treat cancer is brachytherapy or internal radiation therapy [23].

Stereotactic irradiation, total body irradiation, total skin electron irradiation, intraoperative radiotherapy, endocavitary rectal irradiation, conformal radiotherapy, image guided radiotherapy, adaptive radiotherapy, respiratory gated radiotherapy, and PET/CT scanners and PET/CT image fusion are some special techniques used for treated cancer to achieve better outcome [24].

2.1 Importance of digital image processing: Medical physics in radiation therapy

Medical imaging, tumor localization, skin reference marks, treatment planning, virtual simulation are key parts of radiation treatment [25].

Medical diagnosis for detection, staging, grading, treatment planning before radiation therapy, treatment guidance and verification, evaluation of response to therapy, and treatment follow-up is involved with imaging of tumors and surrounding normal tissues [26].

2.1.1 Tumor localization

In oncology, benign, pre-malignant, and malignant tumors are the most prevalent forms. Early imaging techniques aid in the reduction of cancer-related
morbidity. Pre-processing, segmentation, and morphological operation are the three stages of tumor image processing [27]. The goal of this image processing is always to determine tumor location [28]. The main concern of segmentation, detection, and extraction of tumor area from imaging modalities images that helps to perform radiologists or clinical experts for treatment planning [29].

2.1.2 Treatment planning

Treatment planning is a computerized procedure that employs a variety of technologies to update treatment outcomes [30]. Image datasets are required by treatment planning systems in order to construct a detailed plan for each beamline route for delivering radiation. The complex programming for multi-leaf collimator (MLC) leaf is sequencing to shape the beam around critical structures during dose delivery [31]. From the initial characterization of tumor volumes through the development of digitally reconstructed radiographs for patient treatment setup and treatment verification, medical images such as CT images are used in the treatment planning process. CT enables tumor imaging as well as the reconstruction of three-dimensional (3D) anatomical information, which is then utilized to create patient models with all of the relevant anatomic, geometric, and electron density data. CT has become the method of choice for 3D treatment planning due to these characteristics, as well as its widespread availability and inexpensive cost [32].

2.1.3 Virtual simulation

The virtual simulator is a software program that helps with the geometric component of 3D radiation treatment planning [33]. After completion of treatment planning, the patient is directly placed at the LINAC. The actual position is registered by the LINAC-based imaging units [34]. It is obvious that without a high-quality image, all radiation treatments will proceed incorrectly, potentially increasing cancer mortality. As a result, image processing is becoming increasingly important in radiation oncology.

3. Biomedical engineering

The application of engineering ideas and design concepts to medicine and biology for healthcare reasons is known as biomedical engineering (BME) or medical engineering (e.g., diagnostic or therapeutic) [35]. BME's areas of expertise include bioinstrumentation, biomaterials, biomechanics, cell, tissue, and genetic engineering, clinical engineering, medical imaging, orthopedic, and rehabilitation engineering [36].

3.1 Importance of digital image processing in biomedical engineering

The concern of BME is the acquisition of images for diagnostic and therapeutic applications where use advanced sensors and computer technology [37]. A set of anatomical information structures provide by a biomedical images helps to investigate and visualize for treatment [38]. Accurate implant, prepare the biomedical device, joint, and other organ replacement is required good quality images.

3.1.1 Bioinformatics

The growing usage of medical equipment has resulted in a tremendous amount of data being generated, including image data. Bioinformatics solutions give an
effective way to picture data processing in order to recover information of interest and combine several data sources for knowledge extraction; additionally, image processing techniques aid scientists and physicians in diagnosis and treatment [39]. Some bioimage informatics are mentioned here: high-throughput and high-content analysis of cellular phenotypes, Atlas building for model organisms, understanding the dynamic processes in cells and living organisms, joint analysis using both bioimage informatics and other bioinformatics methods [40].

3.1.2 Biomechanics

Medical imaging is crucial in the construction of anatomically realistic, cutting-edge finite element models that can be employed in biomechanical research [41]. In the discipline of biomechanics, Digital Image Correlation (DIC) is being used. However, because DIC is based on a number of key assumptions, it necessitates rigorous optimization to provide accurate and precise findings [42].

3.1.3 Biomaterial and tissue engineering

Repair, replacement, restoration of hard and soft tissues continue to grow as the population ages using biomaterials require to investigate internal anatomy so imaging has been taken a crucial role in this field [43].

3.1.4 Genetic engineering

Molecular imaging offers a novel way to observe cellular and molecular phenomena such as cell survival, migration, proliferation, and even differentiation at the whole-organism level without causing harm. For monitoring cell grafts in vivo, a variety of imaging methods and methodologies used for investigating the condition [43].

3.1.5 Biomedical optics

Techniques, equipment, instruments, probes, computer algorithms and software, and clinical trials make up the discipline of biomedical optical imaging [44]. Without medical imaging modalities, image processing medical physics and biomedical engineering is impossible.

4. Imaging modalities for cancer diagnosis

Different types of imaging modalities are utilized in diagnosis. How to get an image from modalities is a popular inquiry for the audience. Some imaging modalities are given below:

4.1 Mammography

One of the most frequent diagnostics for detecting breast tissue abnormalities is mammography, which uses X-rays to create images of the breast that is known as a mammogram [45]. The two-dimensional image that relies on the identification of morphologic findings for breast cancer these findings include masses, grouped calcifications, asymmetries, and areas of architectural distortion. Spot compression, magnification, rolling, extended views, and genuine lateral views are some of the diagnostic mammographic views that can be used to describe and locate abnormalities [46]. When a high-energy X-ray photon with a low dose interacts
with tissue, the photon is attenuated. The reconstruction method captures and
images changes in attenuation. In terms of identifying cancer, it has a high specific-
ity sensitivity and temporal response of a portable gadget (about 1 minute). When
employing mammography, good resolution means higher accuracy in thick breasts.
The number of false-positive predictions is considerable. When compared to CT
and MRI, the contrast is poor [47].

Worldwide breast cancer screening programs, digital mammography (DM)
use as a standard imaging technique. The primary benefit of DBT is that it
provides depth information about the breast, allowing for improved imaging of
possible concealed lesions and demonstrating a difficult reconstruction pro-
dure to build a pseudo-3D representation of the breast from a small number of
projection images [48]. The image quality of digital breast tomosynthesis (DBT)
 volumes depends greatly on the reconstruction algorithm [49]. DBT images have
the acquisition of several low-dose planar X-ray projections of the compressed
breast over a limited angular range, which is then reconstructed into a pseudo-
3D volume. The inherent challenges of this acquisition approach degrade image
quality. The limited angle acquisition gives rise to out-of-plane artifacts and low
vertical resolution, the low dose per projection increases the impact of noise,
and X-ray scatter decreases contrast. The reconstruction algorithm is one of the
main aspects of image creation that could ameliorate these technical drawbacks
and therefore can greatly affect the final quality of DBT images [50]. DBT has
been demonstrated to help with two-dimensional (2D) mammography breast
tissue overlapping concerns. However, contemporary DBT technologies are still
limited in comparison to mammography. Statistical image reconstruction (SIR)
approaches have the ability to reduce DBT through-plane artifacts, and hence
could be utilized to reduce anatomical clutter even more [51].

Galactography can detect a variety of breast abnormalities, including pathologi-
cal nipple discharge, which is described as bloody, serous, or clear single-orifice
nipple discharge [52]. The GL technique is essential for diagnosing and finding
intraductal lesions. GL has been shown in several trials to be ineffective in distin-
guishing benign from malignant tumors [53].

Scintimammography using 99mTc-sestamibi is a non-invasive and painless
 diagnostic imaging method where a variety of radiopharmaceuticals create planar
and tomographic pictures as well as provide information on tumor cell viability and
cellularity that is used to detect breast cancer when mammography is inconclusive
[54]. In the presence of cancer tissue, the radiopharmaceutical accumulates in the
breast, which may be seen clearly in the photographs [55]. It is the most widely used
agent for this purpose because of the advantages of 99mTcsestamibi tagging and its
great efficiency in detecting carcinomas [56].

4.1.1 Image processing techniques

- Contrast stretching, histogram processing, spatial filtering (mean filter and
median filter) [57]

- Adaptive histogram equalization (AHE), brightness preserving bi-histogram
equalization (BPBHE), recursive mean separate histogram decomposition
(RMSHD), multi-decomposition histogram equalization (MDHE), minimum
mean brightness error bi-histogram equalization (MMBEBHE), and adaptive
smoothing [58]

- Low pass filtering: Butterworth low pass filter and Gaussian low pass filter.
High pass filtering: ideal high pass filter and Butterworth high pass filter [58]
• Enhancement based upon wavelet transform and morphology, morphological operations (enhancement of image using multi-scale morphology) [59]

• Direct contrast enhancement techniques [60]

• Adaptive neighborhood contrast enhancement [61]

• Removal of noise using wiener function [62]

• An intuitionistic fuzzification scheme based on the optimization of intuitionistic fuzzy entropy and contrast limited adaptive histogram equalization (CLAHE) [63]

• Mammogram enhancement, non-subsampled pyramid (NSP), low pass filter (LPF), high pass filter (HPF), directional filter bank (DFB), 2D-directional edge filter (HTDE), combining directional and scale features, adaptive histogram equalization (AHE), one-dimensional spatial profile of difference of Gaussian and HTDE filter, detection of microcalcification (MC) [64, 65]

4.2 Ultrasound

A hand-held transducer transmits and receives pulsed acoustic waves, which are used in medical ultrasound imaging. This is a well-established technique that is widely used throughout the world. Its benefits include cost-effectiveness, flexibility, and the absence of ionizing radiation [66]. Generally, the morphology, orientation, internal structure, and margins of lesions from multiple planes with a high resolution both in predominantly fatty breasts and dense, glandular structures find out from ultrasound [67]. Ultrasound electrography, contrast-enhanced ultrasound, three-dimensional ultrasound, automated breast sonography, computer-aided detection for breast ultrasound use for better outcome of image quality [68].

The biggest disadvantage of ultrasound is its restricted penetration, which is due to the fact that sound waves cannot pass through bone or air, limiting its usage in the brain, lungs, and abdominal region [69].

4.2.1 Image processing techniques

• Modern beamforming techniques, dynamically focused transmission and reception, apodization, limited diffraction beams, pulse compression, compounding, spatial compounding, frequency compounding, strain compounding, harmonic imaging, pulse inversion, filtering, adaptive filters, anisotropic diffusion, wavelets, and deconvolution [70]

• Gray-level normalization, image fuzzification, and fuzzy histogram computation, histogram partitioning and equalization, and image defuzzification [71]

• Contrast limited adaptive histogram equalization (CLAHE) [72] block size, histogram bins, max slope, 3D discrete wavelet transform (3D DWT), wavelet thresholding, and bilateral filter [73]

4.3 CT

The CT scanner displays several slices of bodily tissues in various directions [74]. Due to more informative CT images so it is more effective than X-ray [75].
The resolution, noise, and contrast are the three key elements that influence image quality [76]. Contrast materials are frequently injected into the body during CT scans to improve visibility of certain organs, blood arteries, or tissues by increasing contrast between these locations and surrounding structures in CT images. Contrast enhanced CT (CECT) is a technique that provides useful anatomical information that is not acquired by standard non-enhanced CT (NECT) imaging [77]. Modern micro-CT- and X-ray-based scanners allow the acquisition of three-dimensional (3-D) images of core samples with a resolution as fine as 0.1 μm per voxel; these images can be used to construct 3-D digital models of core samples in extremely fine detail [78].

4.3.1 Image processing techniques

- Noise filter, watershed segmentation, thresholding, image acquisition, and image pre-processing (smoothing, enhancement, image segmentation, feature extraction, and classification) [79]

- Data analyze and interpretations: histogram, particles analyze, and profile plot [80]

4.4 MRI

Magnetic resonance imaging (MRI) is a noninvasive imaging tool for examining anatomic features, physiological functions, and tissue molecular composition [81]. MRI is known as a non-invasive, radiation-free imaging technology for detecting and diagnosing small lesions, with significant implications for various kinds of cancer diagnosis, prognosis, and treatment [82].

4.4.1 Image processing techniques

- Histogram equalization techniques, typical histogram equalization (HE), brightness preserving bi-histogram equalization (BBHE), recursive mean separated histogram equalization (RMSHE), and dynamic histogram equalization (DHE) [83]

- Dynamic block coding [84]

- Median filter, Wiener filter [85]

- Local area histogram equalization (LAHE) [86]

4.5 Positron emission tomography (PET)

PET and combined PET/computed tomography (CT) is increasingly used for oncologic imaging [87]. Fluorodeoxyglucose (FDG) PET demonstrates abnormal metabolic features associated with malignancy that often precedes morphologic findings demonstrated with anatomic imaging [88]. Combined PET/CT systems are increasingly available and currently account for almost all of the new whole-body PET installations [89]. In these systems, the CT and PET images are fused and provide combined anatomic and physiologic imaging [90]. Typically, the CT portion is used to provide attenuation correction as well as an anatomic correlation for the PET imaging component [91]. This modality allows more precise anatomic localization of PET abnormalities and in general has been shown to improve diagnostic accuracy compared with FDG PET alone [92].
4.5.1 Image processing techniques

- Gauss filter, high order derivatives of Gauss filter [93]
- Shock filter, Bettahar’s image filtering model, speckle reducing anisotropic diffusion [94]
- Coherence enhancing filter [95]
- Stationary wavelet transform (SWT) and Discrete Wavelet Transform (DWT) [96]

5. Limitation

This chapter has lots of information on the role of digital image processing in medical physics and biomedical engineering areas that can be a little bit confused for the reader. It was challenging to place image processing in this area and popular in the non-medical environment.

6. Future direction

This chapter enriches by multi-disciplinary research area. This is offering lots of research information for the audience. The audience can be able to carry on individual research based on each topic.

7. Conclusion

Overview of medical imaging with their modalities, application, and outcome stated here. The combination of medical physics and biomedical engineering area is a vast and worldwide recognized field. Both areas fight against global health challenges. History from human, this is the main concern for ensuring safety for human, animal, plant, and other living matter. In this planet suffers a lot in various time hit living system but always these areas highly contributing lifesaving. This chapter is given an inspirational message for the young because lots of do wait for their contribution to change the future world. Especially women can highly contribute to gynecological health challenges because all corners of the cannot be developed in this area equally. So, some conservative environment always prefers women for gynecological challenges. This chapter highlighted to significance role of image and image processing for this area, imaging modalities for various images, image processing techniques. Various kinds of image processing techniques are mentioned here for growing creative interests.

Acknowledgements

Thanks to all who are associated and contributed to this book.

Conflict of interest

Not Applicable
Learning outcomes

The reader will be able

• to expatiate the role of medical physics and biomedical engineering area
• to identify the known image of image processing
• to characterize various modalities images
• to outline that image processing can contribute to medical science
• to apply image processing techniques
• to find out lots of reading materials and exhort to study in this area

Useful learning materials

• https://github.com/sfikas/medical-imaging-datasets
• https://www.cancerimagingarchive.net/primary-data/
• https://datacommons.cancer.gov/repository/imaging-data-commons
• https://nucmedicine.iaea.org/home

Mammography

• https://www.rsna.org/education
• http://www.sprawls.org/resources/MAMMO/module.htm
• https://venturebeat.com/2019/03/21/nyu-open-sources-breast-cancer-screening-model-trained-on-over-200000-mammography-exams/
• http://www.eng.usf.edu/cvprg/Mammography/Database.html

Ultrasound

• http://www.med.umich.edu/dipl/research.html

CT

• http://www.sprawls.org/resources/CTIMG/module.htm
• https://www.kaggle.com/kmader/siim-medical-images
MRI

• https://radiology.ucsf.edu/research/labs/quantitative-image-processing-a#accordion-ct-angiography
• https://uwaterloo.ca/vision-image-processing-lab/research-topics
• https://www.aylward.org/notes/open-access-medical-image-repositories

PET

• https://www.petimagingresources.com/
• https://cai2r.net/resources/pet-mr-dataset/

SPECT

• http://www.people.vcu.edu/~mhcrosthwaite/clrs322/SPECTimagingparameters.html

Radiology organizations

• https://en.wikipedia.org/wiki/Category:Radiology_organizations

Organization/society of medical physics

• The American Association of Physicists in Medicine (AAPM)
  • https://www.aapm.org/
• International Organization for Medical Physics (IOMP)
  • https://www.iomp.org/
• Institute of Physics and Engineering in Medicine (IPEM)
  • https://www.ipem.ac.uk/
• European Federation of Organizations For Medical Physics (EFOMP)
  • https://www.efomp.org/
• Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM)
  • https://www.acpsem.org.au/Home
• Asia-Oceania Federation of Organizations for Medical Physics
  • https://afomp.org/
• Middle East Federation of Medical Physics (MEFOMP)
• https://www.mefomp.com/

• South East Asian Federation of Organizations for Medical Physics (SEAFOMP)

• http://seafomp.org/home/

**Organization/society of biomedical engineering**

• IUPESM

• https://2018.iupesm.org/about/

• IFMBE

• https://ifmbe.org/

• https://guides.libraries.psu.edu/c.php?g=318448&p=2258484

• https://guides.library.uab.edu/c.php?g=386396&p=2621393

**Useful Video Links**

**Mammography**

• https://www.youtube.com/watch?v=B_LASa80l8I

• https://www.youtube.com/watch?v=FJl_yf5Au68

• https://www.youtube.com/watch?v=H3wrzoV_Ksk

• https://www.itnonline.com/videos/
  video-how-contrast-enhanced-mammography-will-impact-breast-imaging

• https://www.youtube.com/watch?v=WJKhehpFxow

**Ultrasound**

• https://www.youtube.com/watch?v=X8ab6NAIV5I

• https://www.youtube.com/watch?v=b1Eh4a1umdw

• https://www.youtube.com/watch?v=4aXEmVCf9HM

• https://www.youtube.com/watch?v=h1S1xJ0qxSk

• https://www.youtube.com/watch?v=VSjTK_R8e3A

**CT**

• https://www.youtube.com/watch?v=l9swbAtRRbg

• https://www.youtube.com/watch?v=bgjkJfBHKxg
Digital Image Processing and Its Application for Medical Physics and Biomedical Engineering Area
DOI: http://dx.doi.org/10.5772/intechopen.100619

- https://www.youtube.com/watch?v=wdY9gcjVsNY
- https://www.youtube.com/watch?v=9eeiKhyysLU
- https://www.youtube.com/watch?v=UeFRo7uALhM

MRI

- https://www.youtube.com/watch?v=nFkBhUYynUw
- https://www.youtube.com/watch?v=akuQWr8q9Qs
- https://www.youtube.com/watch?v=G2YsuVzg-Gg
- https://www.youtube.com/watch?v=mBAIWAyNdz0
- https://www.youtube.com/watch?v=ur6pi3L98kk

PET

- https://www.youtube.com/watch?v=k2jnSmpHqzg
- https://www.youtube.com/watch?v=GHLBcCv4rqk
- https://www.youtube.com/watch?v=nnS0YPWuwLY
- https://www.youtube.com/watch?v=64ALTpmtxUw

Author details

Nupur Karmaker
Medical Physics and Biomedical Engineering (MPBME), Gono Bishwabidyalay (University), Dhaka, Bangladesh

*Address all correspondence to: moonnkbe@gmail.com: nupurmpbme@gmail.com

IntechOpen

© 2022 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
References


[52] Berná-Serna JD, Torres-Alés C. Galactography: An application of the galactogram imaging classification system (GICS). Acta Radiologica. 2009. DOI: 10.3109/02841850903436659


[55] Schillaci O, Danieli R. Scintimammography for the detection of breast cancer. Published online: [Jan 09]. 2014:191-196. DOI: 10.1586/17434440.2.2.191


[58] Surya Gowri D. A review on mammogram image enhancement techniques for breast cancer detection. In: 2014 International Conference on
Intelligent Computing Applications. 6-7 March 2014; Coimbatore, India: IEEE; 2014. DOI:10.1109/ICICA.2014.19


[80] Seleþchi ED, Duliu OG. Image processing and data analysis in computed tomography. In: 7th International Balkan Workshop on Applied Physics. 5-7 July 2006; Romania: Constanþa; 2006


Arabi H, Allaf AA. The promise of artificial intelligence and deep learning in PET and SPECT imaging. 2021;83:122-137. DOI: 10.1016/j.ejmp.2021.03.008


Hanán MB, Hala ME, Gamal IS. Enhancement of positron emission tomography (PET) image based on thinning algorithm and shocking filter. Egyptian Computer Science Journal, ECS. 2013;37(4):64-79. ISSN: 1110-2586