Patient Radiation Safety in Inetrventional X-Ray using Artificial Interligence

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Abstract:- Increased dose to patients was caused by imaging scientists repeatedly exposing patients to X-rays without justification during interventional X-ray procedures in Nigeria. The use of post-radiographic digital image processing equipment is limited by a lack of properly educated personnel and a culture of poor maintenance. The goal of this study is to use neck and chest radiographs from Kaggle to illustrate the functionality of the Magick package in Rstudio using R's programming language. All operating systems may run the package, and the R programming language is simple to learn and requires little upkeep. The neck and chest pictures underwent post-radiographic image processing in the following areas: color adjustment, transformation, segmentation, thresholding, noise management, and negation. The outcomes are favorable for patient radiation safety during radiological procedures.

Keywords:- *Radiation, Safety, Patient, Image Processing.*

I. INTRODUCTION

International organizations around the world, including the International Commission on Radiological Protection (ICRP),the World Health Organization (WHO), the International Atomic Energy Agency (IAEA) and international campaigns like Arab-safe [1], Euro-safe Imaging [2], Image Gently [3], Image Wisely [4], and Latin-safe [5], all agree that patient protection in clinical radiation exposure is a very crucial issue. The IAEA encourages initiatives to instruct and certify experts in all areas of patient related dosimetry and safety in radiation exposure. A dedicated International Action Plan for the Radiation Protection of Patients [6] also offers expertise and technical support. These efforts have been joined by several organizations, professional groups, nations, and individuals, resulting in the formation of the Bonn Call.

Studies have shown that Oyo,Lagos,Osun,Ogun, AkwaIbom, Niger and Ekiti state of Nigeria's diagnostic x-ray examination centers delivered the highest entrance skin dose (ESD) when compared with the established diagnostic reference levels in UK, other published work in Nigeriaand IAEA standard [28]. Patient exposures resulting from radiological procedures make up the majority of the population's exposure to artificial sources of radiation [7,8].

Proper monitoring of X-ray technical exposure parameters has not gotten much attention in underdeveloped nations like Nigeria, and this may have an impact on how staff adheres to best practices. Due to the government's inadequate budget, the Nigerian Nuclear Regulatory Authority's (NNRA) efforts to curb radiation usage in the nation are insufficient. There is a strong propensity to depart from customary procedures. [9]

Implementing post Artificial intelligent technique for general radiographic interpretation during interventional x-ray examination can reduce patience over exposure, which is the practice of repeatedly photographing the patient in an effort to obtain the desired image quality during conventional x-ray examination. Machine learning algorithms have recently made significant progress, and their potential applications in the future are exciting [9]. One of the important components of digital radiography is image processing, which significantly affects how the image looks [10]. Nonetheless, there is a chance of increasing radiation exposure up until adaptation to the new digital environment is complete, primarily because of the apparent lack of visual control [11]. The current optimization solutions for the best radiographic imaging include techniques for image processing and reduced noise algorithms [12].

In Nigeria, the majority of personnel working in conventional X-ray units do not follow the recommended guidelines for patient exposure, the majority of hospitals are unable to afford post-processing digital radiographic imaging equipment, and even where the equipment is available, there are issues with properly trained personnel and an ineffective maintenance culture that prevents use of the apparatus for any minor fault [28]. By showcasing the post-radiographic image processing capabilities of the Magick package in Rstudio, this study will aid in lowering the exposure dose to the patient by avoiding the unnecessary repeat exposure during radiographic diagnostic examination process.

II. LITERATURE

X-rays have become a crucial and necessary component of medical diagnosis and intervention, which exposes patients and medical staff to the risk of occupational radiation overexposure. Radiation shielding is a crucial part of hospital infrastructure [29]. The goal of radiation protection is to shield patients and medical staff from unnecessary radiation exposure. from subjecting patients and medical staff to excessive radiation exposure. The justification of the technique requiring radiation exposure and the use of a minimal radiation dose simply sufficient for diagnostic and interventional procedures should both be included in a radiation protection program [13].

Yet, because ionizing radiation exposure during clinical procedures carries a stochastic risk of developing cancer, thus, it should be minimized and operated according to safety guidelines. Optimization in diagnostic and conventional clinical exposure is defined as "keeping the exposure of patients to the minimum necessary to achieve the required diagnostic or interventional objective" [14] according to the International Atomic Energy Agency's (IAEA) Radiation Protection and Safety in Medical Uses of Ionizing Radiation, Safety Standards Series No. SSG-46.

Electronic radiography Increased kV, decreased mAs, shorter exposure times, proper placement, and use of collimation are dose optimization techniques use in traditional radiographic imaging for each examination. These techniques are used to photograph only the body region necessary for the organ in focus. The advent of digital radiology has increased the risk of dosage.

Bright glare can be produced by light scattering from the X-ray viewing box illuminator,sunlight, room lighting, nearby illuminators and surface reflection. This glare can lead blindness of the observer's eyes, obstruct objective radiograph interpretation, and ultimately reduce the examiner's diagnostic performance. When the video being viewed is smaller compared to the illuminator's viewing screen, it occurs more frequently. The radiograph's surrounding light will appear to be blackened and will lessen the contrast of the film [15]. For diagnostically acceptable radiographs, the dosage per exposure is often lower in digital radiography (DR)compared to traditional film-based radiology [16]. Machine learning algorithms have made recent strides, and their prospects for the future make them attractive for use in clinical imaging. Machine learning has given rise to the ability of enhancing many radiology stages.

III. THE EVOLUTION OF FILM TO DIGITAL RADIOGRAPHY

When cellulose nitrate and emulsion photographic film were initially produced to work in place of glass plates, radiography showed its original use in medical diagnostics. Nonflammable cellulose triacetate materials, including polyester, were utilized for X-ray film instead of flammable cellulose nitrate [17,18]. Latent image creation and subsequent X-ray image development are the chemical steps involved in capturing an X-ray picture on radiographic film [19, 20]. Following the exposure of the X-ray film, it underwent chemical processing to produce a visible image that could be trans illuminated on an right view box for further analysis. Development, fixing, washing, and drying are steps in this process [21].

On a logarithmic scale, there is a substantial correlation between radiation exposure and X-ray film performance. The difference in color or luminance that allows an object to be distinguished is called contrast. The toe region (blue), the straight-line region (yellow), and the shoulder region (red) from bottom to top are the three distinct regions in the characterization curve for a given radiographic film. The contrast for a given film is determined by the film's design, exposure level, and chemical processing conditions. Shallow slopes in the toe and shoulder areas represent underexposure and overexposure, respectively. In contrast to the toe region, where the image will be underexposed and typically meaningless, the shoulder region's overexposed image suggests that the silver ions have been converted to silver atoms. [22].

Since its invention in 1895, conventional film-screen applications in radiography has greatly aided in medical diagnosis and industrial inspection. However, it was beset by a number of drawbacks, such as difficult chemical processing, inefficient automatic processing, expensive film materials, labor and time costs, awkward image storage and transmission, and environmental contamination. [23,24]. In order to do this, film-screen radiography was superseded by digital radiography. With this revolutionary technology, X-ray patterns are transformed into digital signals via a digital detector, which are then processed and shown on a screen for examination. picture acquisition, laser stimulation, electric signal processing, picture display, postprocessing, storage, and communication components make up the majority of its components. [25]. Furthermore, computed radiography exhibits an enhanced linear exposure range (10^4:1) in comparison to film-screen radiography (FSR, blue dotted line), indicating a broad spectrum of radiation exposure. [26,27, 30].

IV. MATERIAL AND METHODS

The approach used in this work is computer vision with the R programming language package (Magick), which enables radiologists to execute some simple iterations on the already acquired radiographic image during routine conventional x-ray examinations. These iterations are listed in table 1. The program is capable of processing images obtained from any body part during interventional x-ray exams. The study uses radiographic images of the neck and chest that were obtained from Kaggle to show how reliable the algorithm is. The Magick program is simple to use on any radiographic image and may be installed on any operating system in the rstudio cran archive.

Table 1: Iterations

Sn	Feature	Function
1.	Color adjustment	Adjusts the image's brightness, contrast, and colors.
2.	Image transformation	Simple changes like flipping, resizing, rotating, and cropping. The areas and sizes are specified using the geometry syntax.
3.	Image segmentation	Simple picture segmentation techniques include fuzzy C-means, blob extraction, and related components labeling.
4.	Image thresholding	Segmenting images can be done easily and simply by thresholding the image. While image lat conducts local adaptive thresholding, the function image threshold enables black and white thresholding.
5.	Image noise control	Improves an image's quality by eliminating extraneous visual elements like spots, flecks, or pixels.
6.	Image negation	Read, write, and integrate pictures. Since every image function is vectorized, it can function on a single frame or a sequence of frames.

V. RESULT AND DISCUSSION

The outcome of this investigation is displayed utilizing radiographic images along with the impact of each of the six (6) functions used for the analysis using algorithm from Rs Programming. Each of the functions aids in preventing the needless repetition of patient exposure during interventional x-ray procedures when the required image is not obtained. Following each of the six roles was a brief explanation of its significance as a complement to the static mode light viewing box during radiography report.

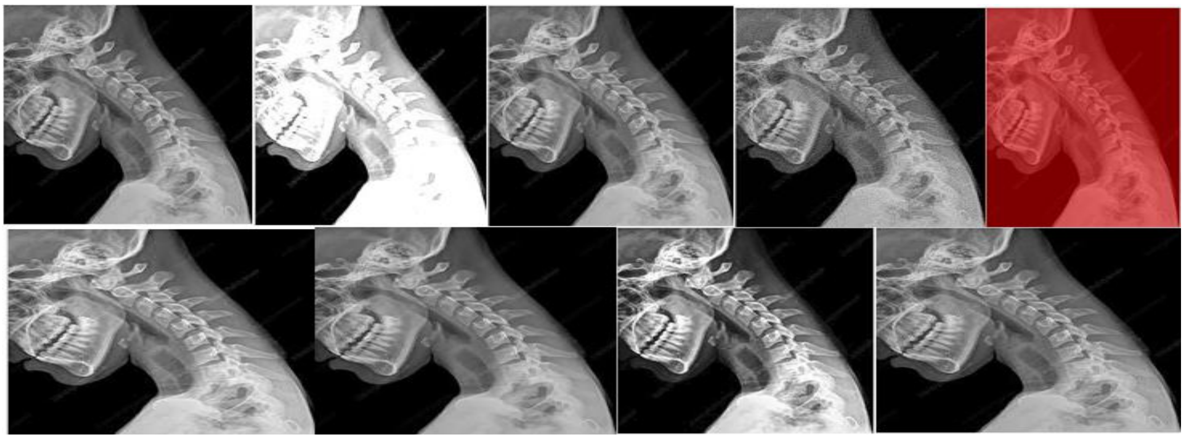

Fig. 1(a): part of neck radiographic basic color adjustment: from left, original image, modulated image to brightness of 200, modulated image to saturation of 150, modulated image to hue value of 150, quantized image to maximum value of 10 and colour-space gray, colorized image with 50% red, enhanced image, median curve image and equalized image.

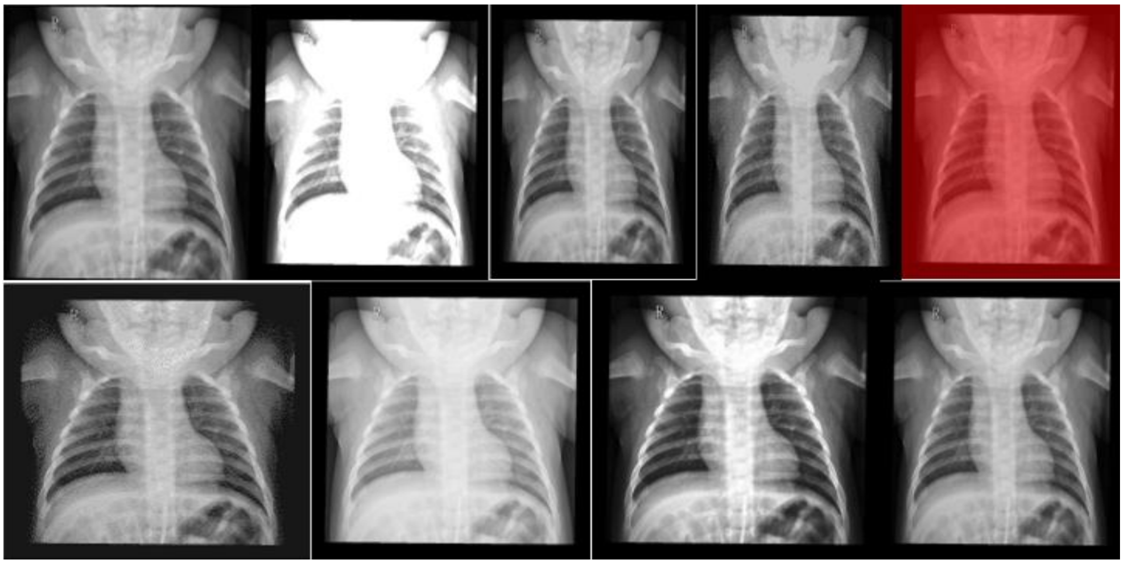

Fig. 1(b): chest radiographic basic colour adjustment; from left, original image, modulated image to brightness of 200, modulated image to saturation of 150, modulated image to hue value of 150, quantized image to maximum value of 10 and colour-space gray, colorized image with 50% red, enhanced image, median curve image and equalized image.

Regardless of the image quality, the color view of the gray-scale radiographed image and the red background allow radiologists, radiographers, and imaging scientists to access more patient-related information from the acquired image. As a result, fewer needless repeat exposures are required to fix low-quality images.

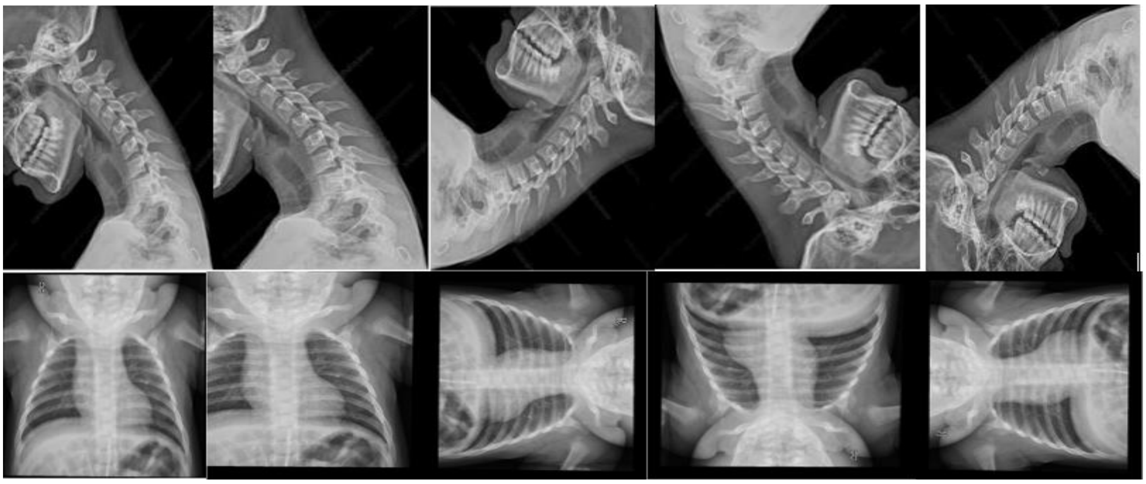

Fig. 2: neck and chest radiographic basic resize and transformation; from left, original image, resized image to 100 x 20, 900 rotated image, 1800 rotated image and 2700 rotated image.

The ability to resize and morph an image during a report allows an imaging scientist or radiologist to zoom in or out and rotate the image to get a full perspective of the taken radiograph. This is opposed to employing a light viewing box that does not permit zooming in or out.

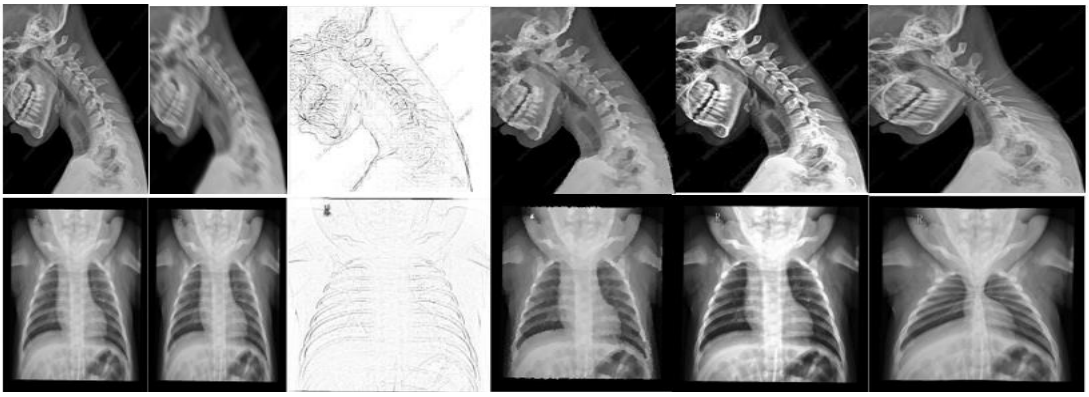

Fig. 3: Neck and chest radiographic noise control; from left, original images,despeckled images, reduced noise images, transformed charcoal view images, embossed images and imploded images.

The statistical variation in the quantity of x-ray photons detected and grain size in the film screen system combination are the two most significant sources of noise in radiography images. Image resolution and contrast are decreased as a result of noise's impact on the visibility of image details. The radiologist or imaging scientist can report at the best level using the multiple views of the radiographic image based on the noise level, which is not achievable with a light viewing box. This prevents the patient from being overexposed inexplicably.

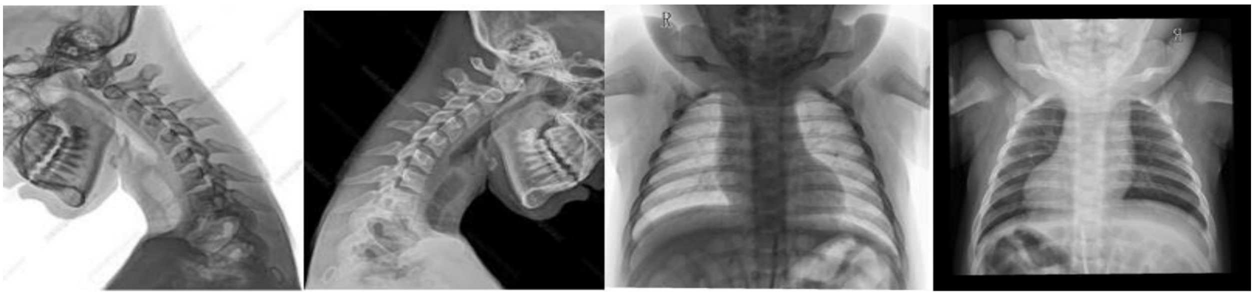

Fig. 4: Neck and chest radiographic basic negations; from left, neck negated image, neck flopped image, chest negated image and chest flopped image.

The negate function assures the radiologist that all radio-opaque structures visible in the radiograph are present by making the bright portions of the radiographic image subject seem dark and its dark areas appear bright.

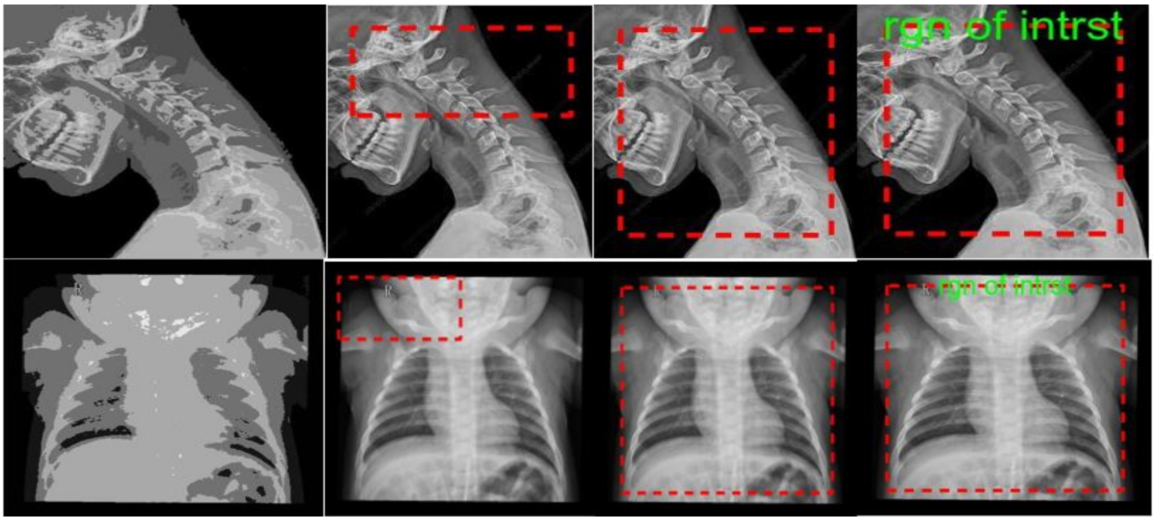

Fig. 5: Neck and chest radiograph basic segmentation; from left, oiled view image, small area segmented image, large area segmented image and labeled area of interest.

Picture segmentation makes it possible to choose particular radiograph regions of interest (ROI) to concentrate on while reporting, allowing for zooming in and out of the chosen region of interest.

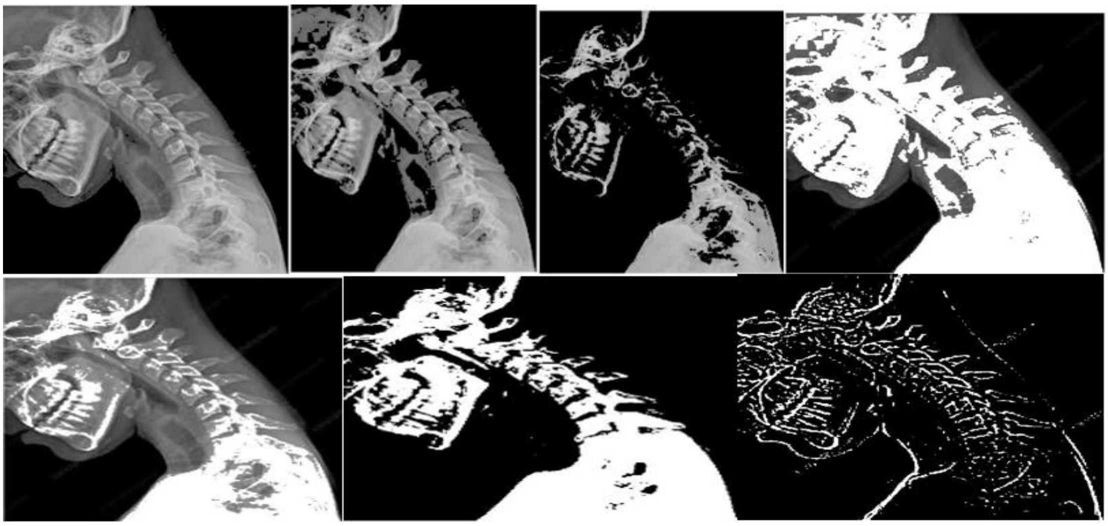

Fig. 6(a): neck radiograph basic thresholding; from left, threshold image with black reduced to 20%, threshold image with black reduced to 40%, threshold image with black reduced to 60%, threshold image with white reduced to 40%, threshold image with white reduced to 60%, threshold image with black and white reduced to 50% each and adapted threshold image

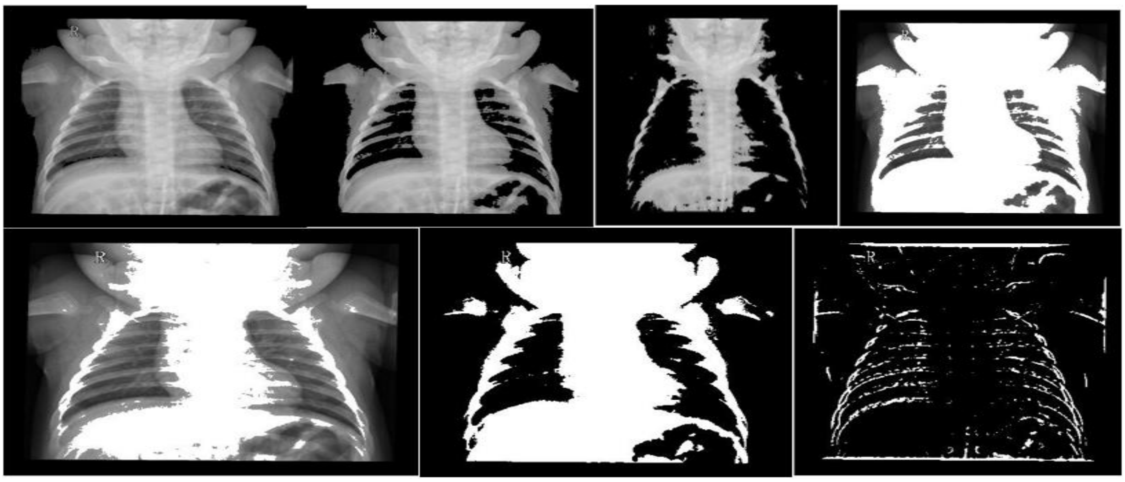

Fig. 6(b): chest radiograph basic thresholding; from left, threshold image with black reduced to 20%, threshold image with black reduced to 40%, threshold image with black reduced to 60%, threshold image with white reduced to 40%, threshold image with white reduced to 60%, threshold image with black and white reduced to 50% each and adapted threshold image

Image thresholding, also known as picture layer segmentation, is the technique of separating foreground and background pixels into binary images to help in image processing. Additionally, this provides the radiologist or imaging scientist with access to more accurate patient information that is not possible with a light viewing box.

VI. CONCLUSION

Inadequate proper supervision of the conventional x-ray facilities in Nigeria makes strict adherence to international patient radiation safety practices and recommendations is ineffective. In an effort by imaging scientists and radiologists to get high-quality images, many routine x-ray diagnostic examinations subject the patient to unwanted additional dose over the minimal and reasonable requirement for the examination. This study demonstrates to all parties involved in radiographic imaging the use of artificial intelligence through computer vision as an alternative for post-imaging processing with the first acquired image that is user-friendly, therefore maximizing the patient's lower dose during interventional radiography exams.

REFERENCES

[1]. Tsapaki, V. (2020). Radiation dose optimization in diagnostic and interventional radiology: Current issues and future perspectives. *PhysicaMedica*, *79*, 16-21.

[2]. The European Society of Radiology Eurosafe Imaging initiative. Available at: http://www.eurosafeimaging.org/, last assessed 17th February 2023.

[3]. The Image Gently Alliance. Image Gently. Available at: https://www.imagegently. org/, last assessed 10th December 2023.

[4]. The American College of Radiology and the Radiological Society of North America Joint Task Force on Adult Radiation Protection. Available at: https://www. imagewisely.org/, last assessed 20th December, 2022.

[5]. Latinsafe initiative. Available at: http://latinsafe.org/espanol/, last assessed 4th January 2023.

[6]. Tsapaki, V., Balter, S., Cousins, C., Holmberg, O., Miller, D. L., Miranda, P., ... &Vano, E. (2018). The International Atomic Energy Agency action plan on radiation protection of patients and staff in interventional procedures: Achieving change in practice. *PhysicaMedica*, *52*, 56-64.

[7]. Hamza, Hamza Abubakar. (2022). ASSESSMENT OF ENTRANCE SKIN DOSE IN ROUTINE X-RAY EXAMINATIONS AT FEDERAL TEACHING HOSPITAL, GOMBE, NIGERIA. https://www.researchgate.net/publication/358857585

[8]. Samaila, Buhari& A, Bello. (2021). Estimation of Entrance Skin Dose to Patients undergoing Diagnostic X-rays Examinations in some states of Nigeria: Review. 8. 20-27. https://www.researchgate.net/publication/354153871

[9]. Choy, G., Khalilzadeh, O., Michalski, M., Do, S., Samir, A. E., Pianykh, O. S., ... & Dreyer, K. J. (2018). Current applications and future impact of machine learning in radiology. *Radiology*, *288*(2), 318-328.

[10]. ICRP, A. (2007). Managing patient dose in multi-detector computed tomography (MDCT). *Ann. ICRP*, *37*(1), 1-79.

[11]. World Health Organization. (2015). Worldwide Implementation of Digital Imaging in Radiology. A Resource Guide. In Cooperation with the World Health Organization.

[12]. Takagi, S., Yaegashi, T., & Ishikawa, M. (2020). Dose reduction and image quality improvement of chest radiography by using bone-suppression technique and low tube voltage: a phantom study. *European Radiology*, *30*, 571-580.

[13]. Bello, A &Samaila, Buhari. (2022). THE UNREGULATED USE OF X-RAY DOSE AND THE ASSOCIATED CANCER RISK TO PATIENTS UNDERGOING SOME DIAGNOSTIC X-RAY PROCEDURES IN KEBBI STATES. https://www.researchgate.net/publication/359768949

[14]. Protection, R. (2018). Safety in Medical Uses of Ionizing Radiation. Specific Safety Guide No SSG-46. Jointly Sponsored by the International Atomic Energy Agency (IAEA), International Labour Office (ILO). *Pan American Health Organization(PAHO) and World Health Organization (WHO). International Atomic Energy Agency*, *Vienna*, 140-145.

[15]. Hussainy A.L, Haydar A.J and Smeeter W (2006). Validated simple tip to aid eliminating light scatter in viewing overexposed radiographs. Royal College of Surgeons of England. 88:136-139. doi 10.1308/003588406X94995

[16]. Wer B, Beuger D.A and Van D. S (2004). The dynamic range of digital radiographic systems: dose reduction or risk of overexposure? The British Institute of Radiology 33: 1-5. retrieve from http://dmfr.birjournal.org

[17]. Seeram, E., &Seeram, E. (2019). *Digital radiography: an Overview* (pp. 1-19). Springer Singapore.*Research.*

[18]. Ou, X., Chen, X., Xu, X., Xie, L., Chen, X., Hong, Z., ... & Yang, H. (2021). Recent development in x-ray imaging technology: Future and challenges.

[19]. Oborska-Kumaszyńska, D., &Wiśniewska-Kubka, S. (2010). Analog and digital systems of imaging in roentgenodiagnostics. *Polish journal of radiology*, *75*(2), 73.

[20]. Pai, S., Das, I. J., Dempsey, J. F., Lam, K. L., LoSasso, T. J., Olch, A. J., ... & Wilcox, E. E. (2007). TG-69: radiographic film for megavoltage beam dosimetry. *Medical physics*, *34*(6Part1), 2228-2258.

[21]. Dondelinger, R. M. (2011). X-ray film processors. *Biomedical Instrumentation & Technology*, *45*(5), 395-400.

[22]. Seeram, E., &Seeram, E. (2019). *Digital radiography: an Overview* (pp. 1-19). Springer Singapore.*Research.*

[23]. Cole, R., &Hespel, A. M. (2020).

[24]. Prummel, M. V., Muradali, D., Shumak, R., Majpruz, V., Brown, P., Jiang, H., ... & Chiarelli, A. M. (2016). Digital compared with screen-film mammography: measures of diagnostic accuracy among women screened in the Ontario breast screening

program. *Radiology*, *278*(2), 365-373.Digital radiography. *Feline Diagnostic*

[25]. Konstantinidou, K., Strekopytov, S., Humphreys-Williams, E., & Kearney, M. (2017). Identification of cellulose nitrate X-ray film for the purpose of conservation: Organic elemental analysis. *Studies in Conservation*

[26]. Oborska-Kumaszyńska, D., &Wiśniewska-Kubka, S. (2010). Analog and digital systems of imaging in roentgenodiagnostics. *Polish journal of radiology*, *75*(2), 73.

[27]. Cowen, A. R., Davies, A. G., &Kengyelics, S. M. (2007). Advances in computed radiography systems and their physical imaging characteristics. *Clinical radiology*, *62*(12), 1132-1141.*Imaging*, 1-11.

[28]. European Alliance for Medical Radiation Protection Research (EURAMED): https://www.euramed.eu/ last assessed 1st December, 2022

[29]. Tsapaki, V. (2020). Radiation dose optimization in diagnostic and interventional radiology: Current issues and future perspectives. *PhysicaMedica*, *79*, 16-21.

[30]. Cousins, C., Miller, D. L., Bernardi, G., Rehani, M. M., Schofield, P., Vañó, E., ... & Sim, K. H. (2013). ICRP publication 120: radiological protection in cardiology. *Annals of the ICRP*, *42*(1), 1-125.