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APPLICATION OF DISPERSION CORRECTION IN NUCLEAR RADIOLOGY BY STATISTICAL PROGRAMMING.

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Abstract:

Flash radiography distortions are caused by scattered photons, making image reconstruction difficult. Therefore, the effect of scattered photons must be considered at all times. The appearance of distortions generates iterative inferences about the scattered photons, so the scattering effect must be controlled to restore the true image without the influence of multiple scattering. The scattered photon flux is calculating by the summing of two principal variables and represents as components of these results. The single-scattered component is accurately calculated using the non-collisional photon flux along the characteristic beam. Previously obtained through a Monte Carlo simulation, which is based on most-likely-valued statistics and using matrices based on finite element variable analysis methods. The preprocessing procedures for stochastic geometry and ray tracing are based on a customized performance reporting tool. Using, IPORInter Protocol Over-Block Rate (IPOR), is developed. Numerical results show without dispersion correction with excellent computing and analytical accuracy.

Keyword: Application, nuclear physics, dispersion correction ,radiology, statistical program.

Introduction :

The techniques used to conduct tests using the Monte Carlo method have had an impact on the development of computational sciences based on analytical statistics, distinguished by their high accuracy and efficient results. Comparison with classical algebraic and analytical methods has demonstrated high accuracy in test results. Radiation based on the density and flux of quantum photons, representing beams of different energies and frequencies, has an impact on these studies today [1]. Controlling radiation parameters and parameters using a flowchart is the beginning of any computational work [2]. Using a flowchart representation, the actual exposure values can be calculated. This results in high-resolution, high-contrast images. Saving times ensure efficiency, determine the exposure time to the atomic radiation produced by X-rays, and complement the functions based on them [1, 2]. The relationship between material thickness, cathode voltage, and exposure time. Typical X-ray exposure is usually represented by a graph that plots the relationship as a function of exposure and material thickness for different X-ray tube voltage levels. The radiation exposure of materials can be determined and studied, and the effect of their thickness on radiation fluxes can then be calculated [3].

Methodology:

In radiation scanning, photons detected by detectors divided into two type colliding and non-collision components as represents by equation (1)

$$I(\vec{r}) = I^{(0)}(\vec{r}) + I_s(\vec{r}) \tag{1}$$

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The exponential law represent by Equation (2)

$$I^{(0)}(\vec{r},E) = \int_{-1}^{1}\int_{0}^{2\pi} I_0(\vec{r},E,\vec{\Omega})\exp\left(-\int_0^R \Sigma_t(\vec{r}-R'\vec{\Omega},E)dR'\right)d\mu d\omega \quad (2)$$

$$\sum_k d_k\Sigma_k = \ln\left(\frac{I_0(\vec{r_0})}{I^{(0)}(\vec{r})}\right) \quad (3)$$

The density of objects obtained by determined the following equation.

$$\rho = \frac{\Sigma m_{atomic}}{\sigma_{total}} \quad (4)$$

r represent distance between source of photon to detector.

Theoretical Model of Scattered Flux Calculation:

numerical coefficients represent as shown in eq.4.: [10].

$$I_s(\vec{r}) = I_s^{(1)}(\vec{r}) + \sum_{n=2}^{\infty} I_s^{(n)}(\vec{r}) \quad (4)$$

where $I(r)$ is the first scattered ray flux, and the multiple scattered ray flux.

$$\sum_{n=2}^{\infty} I_s^{(n)}(\vec{r}) \quad (5)$$

Spatial discretization:

The arbitrary geometry meshes represented by Figure (1).

The continuous in each mesh of the source with hypothesis as scattering form, so equation (3) represent as equation (6)[4].

where $$I_s^{(1)}(\vec{r}) = \sum^{NM} Q^{(0)}(\vec{r_i},E',\vec{\Omega})\exp\left(-\int_0^{R'} \Sigma_t(\vec{r}-R''\vec{\Omega},E')dR''\right) \quad (6)$$

$$Q^{(0)}(\vec{r_i},E',\vec{\Omega}) = Q^{(0)}(\vec{r_i},E)\cdot p(\theta)$$

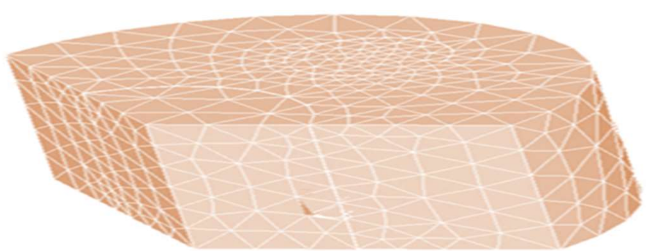

Fig. 1. Spatial Discretization

The integration of equation (6) by using infinite numerical method can be represented by the following expression:

$$I_s^{(1)}(\vec{r}) = \sum_{i=1}^{NM} Q^{(0)}(\vec{r_i},E)\cdot p(\theta)\cdot e^{-\sum_j \Sigma_t(E',j)d_j} \quad (7)$$

From equation [4] can be expressed as:

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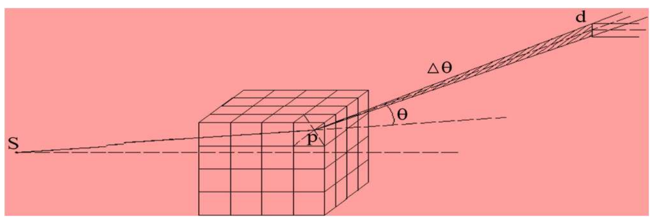
(1) This state shown in figure (2) then can be expressed by equation (8).

$$P_c(\theta) = \frac{\int_{d\Omega_d} \frac{d\sigma_s(E,\theta)}{d\Omega}}{\sigma_c} \tag{8}$$

$\frac{d\sigma_s(E,\theta)}{d\Omega}$

Equation (9) is the definition of the well -known Klein-Nishina[6].

$$\frac{d\sigma_s(E,\theta)}{d\Omega} = \frac{r_e^{\,2}}{2}\left(\frac{E_{\gamma'}}{E_\gamma}\right)^2\left(\frac{E_\gamma}{E_{\gamma'}} + \frac{E_{\gamma'}}{E_\gamma} - \sin^2\theta\right) \tag{9}$$



Figure(2): Schematic Diagram for Compton Scattering

(2) Angular scheme for pair production:
The production of two particles as results of inhalation of electron an d positron with lose energy as they travel through matter [7]. These two photons have an energy of 0.511 MeV, and their travel directions are diametrically opposite. Equation (10) represent
The whole operation. $p_{spp}(\theta) = \frac{1}{4\pi r'^2}$ (10)

<u>Source scheme:</u> Scattered source with the first step $Q^{(0)}(\vec{r}_i, E)$represents by equation(7) then the results appear as equation (11).

$$Q^{(0)}(\vec{r}, E) = d\phi(\vec{r}, E)\cdot\Sigma_s(E)\cdot n \tag{11}$$

equation (12)below represents

$$d\phi(\vec{r}, E) = \frac{I_0(\vec{r_0}, E)}{4\pi r^2} e^{-\sum_i \Sigma_{ti}(E) d_i} dV \tag{12}$$

$$Q_{pp}^{(0)}(\vec{r}, E) = \frac{I_0(\vec{r_0}, E)}{4\pi r^2} e^{-\sum_i \Sigma_{ti}(E) d_i} dV \Sigma_{spp}(E)\cdot 2 \tag{13}$$

The Integration of all equations with respect to the flux influence

$$I_{sc}^{(1)}(\vec{r}) = \sum_{i=1}^{NM} Q_c^{(0)}(\vec{r}_i, E)\cdot p_c(\theta)\cdot e^{-\sum_j \Sigma_t(E', j) d_j} \tag{14}$$

$$I_{SPP}^{(1)}(\vec{r}) = \sum_{i=1}^{NM} Q_{PP}^{(0)}(\vec{r}_i, E)\cdot p_{SPP}(\theta)\cdot e^{-\sum_j \Sigma_t(E', j) d_j} \tag{15}$$

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where $I_{sc}^{(1)}(\vec{r})$ is the first scattered photon flux produced by Compton scattering, $I_{spp}^{(1)}(\vec{r})$ is the first scattered photon flux produced by pair production. The detector equation represents as:

$$I_s^{(1)}(\vec{r}) = I_{sc}^{(1)}(\vec{r}) + I_{spp}^{(1)}(\vec{r}) \tag{16}$$

1) Ray tracing

The mean free path of the photon regarded to the theoretical model, the transport track of each region represent as:

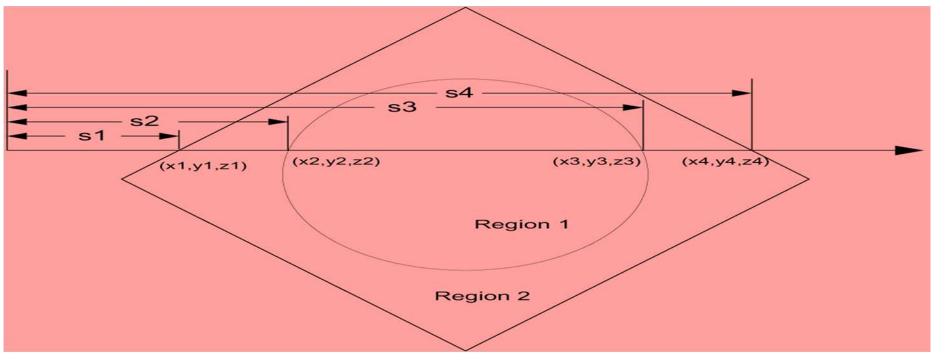
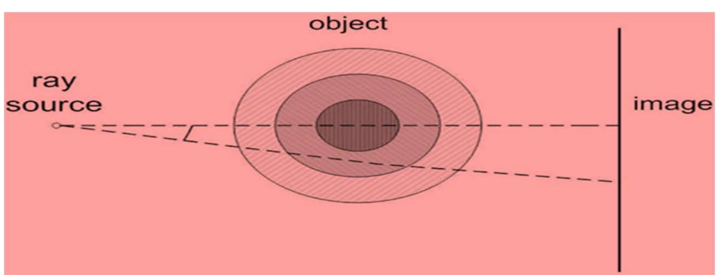


Figure (3):Theoretical Calculation for several trace zone .

<u>Theoretical Model of the Multiple Scattered Ray Flux:</u>

The second term on the right-hand side of Eq.(7) is the contribution of multiple scattered photons.



Figure(4): Spherical Shell Geometry Object representation.

Table (1). The objects with several densities

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Densities	Aluminum	Uranium	Copper
c1	2.7	18.9	8.9
c 2	3.2	21.60	10.21
c3	3.9	26.90	12.7
c4	4.5	31.30	14.8
c 5	580	40.10	18.95
c 6	7.55	52.64	24.79
c 7	955	63.70	30.14

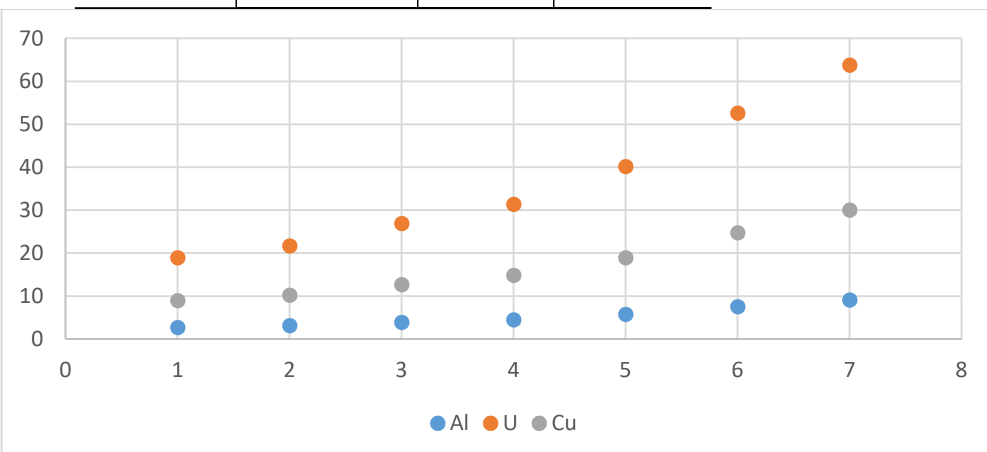

Figure (5): Representations densities for U, Al and copper.

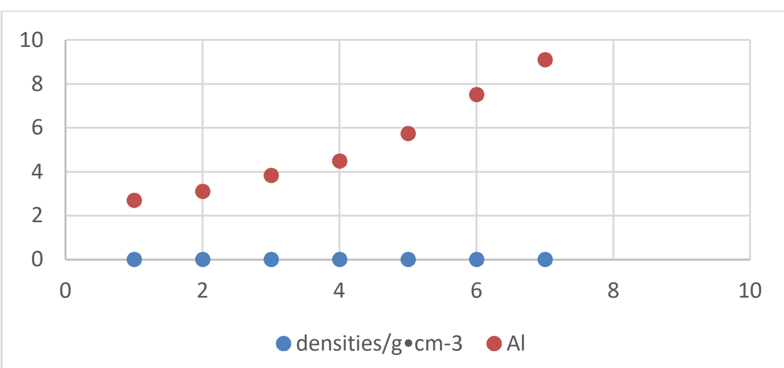

Figure (6): Representations densities for U and Al.

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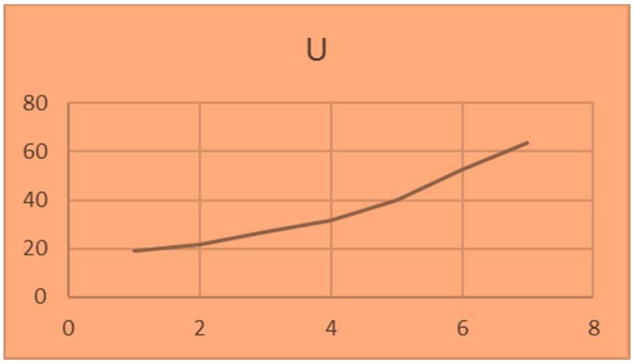

Figure (7): Representations densities for U.

CONCLUSIONS:

The scattering applications and dispersion corrections in medical radiography, especially for photons emitted and interacting with exposed materials, guarantee the correction or reduction of distortions. The improvement of accuracy and reconstruction depends on continuous iteration. This study demonstrated that the accurate calculation of non-collisional beam fluxes and single scattered beam fluxes is achieved using this method, which is primarily based on relevant statistics and includes the Monte Carlo method. The multi-scattered beam fluxes are calculated using pre-calculated numerical parameters. Compared to Monte Carlo simulations, this method supports and is characterized by very high computational efficiency and accuracy. Adapted to a custom AutoCAD program, it performs geometric characterization and ray tracing of random geometries, significantly expanding the ability to handle complex geometric shapes... The accuracy and efficiency observed in this method confirm the dispersion correction method for a comprehensive and extended treatment of random three-dimensional geometric shapes, whether regular or irregular, homogeneous or heterogeneous. Providing the optimal dispersion correction method is good for imaging flash beams, whether cylindrical, spherical or conical, which include three dimensions.

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