*Available online www.jocpr.com*

**Journal of Chemical and Pharmaceutical Research, 2013, 5(12):409-412**

**Research Article**

**ISSN : 0975-7384**
**CODEN(USA) : JCPRC5**

# Diffuse reflectance detection based on Monte Carlo simulation for the diagnosis of breast cancer

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**ABSTRACT**

*In this paper, the Monte Carlo simulation was used to simulate the diffuse reflectance of four breast tissues, which includes the normal breast tissue and three diseased human breast tissues (the breast fibroadenoma, the mastopathy and the breast cancer). The simulation was made in the wavelength of 633nm. To verify the simulations, experiments were done to measure the diffuse reflectance. The measurement system is made up of a CCD and phantom of tissue which made from aqueous suspension of Intralipid-20% and ink. The relation between the light intensity and the distance from the light source were obtained after the data processing. The results of the simulation and the experiments both showed that the differences of the diffuse reflectance in the four kinds of tissues were significant. This method may be useful in the clinical diagnosis of the breast diseases.*

**Keywords:** Monte Carlo simulation, CCD, diffuse reflectance detection, breast cancer

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## INTRODUCTION

Breast cancer has become the health killer of women, and millions of women are suffering the pain of the disease. At present, there is no non-destructive and effective method for the diagnosis of breast cancer. So the early diagnoses of breast cancer become particularly important in the prevention of the disease. Now the common detection methods include X-ray, CT, MRI and ultrasound, and the frozen pathological examination [1, 2]. While a non-destructive, costless and more accurate method is needed to improve the current methods.

Recently ,the use of the near-infrared wavelengths has been introduced in the detection of some diseases, and which makes it possible to provides a low risk, low cost, real-time and non-destructive method for the detection of diseases. Many scholars have began to study the detection of the breast cancer using the near-infrared spectroscopy method, the Fourier transform infrared(FTIR)and a attenuated total reflectance(ATR)methods were used in the Jin Zhao's experiment [3] , and Yiwen Zhang provided the image reconstruction of time-domain diffuse optical tomography for breast tumor diagnosis [4] . These methods were both complex and expensive. The purpose of this experiment is to find a simple and rapid way to differentiate the different kinds of breast tissues.

Monte Carlo simulation of photon propagation provides an effective approach toward photon transport in turbid tissues. The input to the Monte Carlo program includes the absorption coefficient mua, the scattering coefficient mus, the anisotropy factor g, the thickness of the tissue, the refractive index and so on. The Monte Carlo simulation result was input to the Conv program with some specific parameters based on our experiment to get the convolution results. The output of the convolution consists of the distribution of diffuse (Rd), the distribution of absorption (A) and the distribution of transmittance (Tt) of the light [5, 6]. In order to yield acceptable results the number of the photons was 1000000 in the simulation. The radial distribution of diffuse light was used to plot the light intensity with the change of the distance from the light source.

In order to verify the results of the simulation, a CCD non-destructive measurement system was used to get the

diffuse image of the tissue equivalent phantom. A tissue-similarity phantom consisted of Intralipid and ink can be made by using the similar diffuse reflectance equation [7].

## EXPERIMENTAL SECTION

Monte Carlo simulation was made by running the Mcml and the Conv program. The number of the photons was 100 0000 in the simulation. In the wavelength range of 600nm-1100nm, the absorption coefficients of the four kinds of breast tissues were similar and were set to be 0.1 $mm^{-1}$ [8]. The mean cosine of the scattering angle was in the range of 0.945-0.985 for different kinds of breast tissues [6], and g=0.95 were used in the simulation. The parameters of the breast tissues in 633 nm were listed in the Table 1.

**Table 1 The parameters of the breast tissues in 633nm**

| | mua(/$mm^{-1}$) | mus(/$mm^{-1}$) | g | n |
|---|---|---|---|---|
| Normal | 0.1 | 1.6 | 0.95 | 1.33 |
| Mastopathy | 0.1 | 1.75 | 0.95 | 1.33 |
| Breast cancer | 0.1 | 2.15 | 0.95 | 1.33 |
| Fibroaden | 0.1 | 2.25 | 0.95 | 1.33 |

The parameters, n, mua, mus and g were input into the Mcml program, and then the output of the simulation was input to the Conv program. The radial distribution of the diffuse light was obtained from the convolution results of Conv. And the relative intensity of light can be gotten by the normalization method. The plots of the intensity with the change of the distance were drawn with the MATLAB.

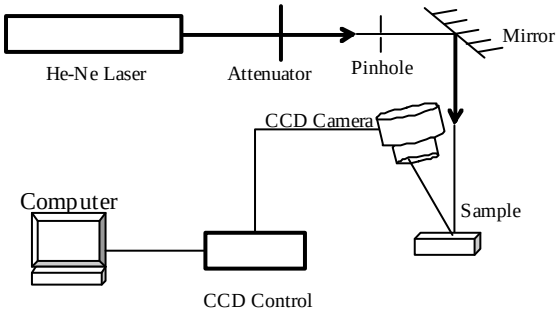


Fig.1 The experimental setup.

To verify the simulation, a diffuse reflectance experiment was done. The experiment set-up for the diffuse reflectance measurements consisted of a He-Ne laser (632.8nm, 11.13mW), a CCD camera (Penguin 150CLM), a CCD control, an attenuator, a pinhole, a mirror, a computer and the processing software (Viewfinder, Studio and Simple PCI 6) [9] . The experimental setup was shown in Fig.1.

A tissue-similarity phantom consisted of Intralipid and ink can be made by using the similar diffuse reflectance equation. In this experiment, the reduced scattering coefficient of the Intralipid-20% was 28.13$mm^{-1}$, the g of it was 0.68. The ink with the absorption coefficient 40.52$mm^{-1}$ was used as a purely absorbing medium in the measurement. Then the similar diffuse reflectance equation was used to design a tissue-similarity phantom. The images of the diffuse reflectance of the phantom were obtained by the Viewfinder and the Studio software, and then the Simple PCI 6 software was applied to acquire the data information of the images. Five replicates were made for every phantom, and the average of the five was obtained for the further study. After preprocessing of the data, the figures of the intensity and relative intensity versus the change of the distance were drawn with MATLAB. The figure showed that the differences of the four kinds of the tissues were significant.

## RESULTS AND DISCUSSION

After preprocessing of the results of Monte Carlo simulation, the figure of the intensity versus the change of the distance were obtained. The curves showed that the diffuse reflectance of the four phantoms were different, from which we can distinguish the four kinds of breast tissues. The plot of the intensity and the relative intensity with the change of the distance was shown in Figure 2 and Figure 3.

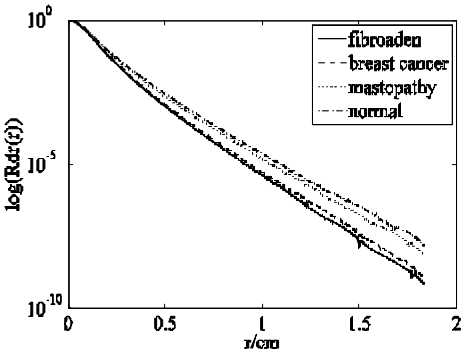


Fig.2 The relative intensity in the Monte Carlo simulation

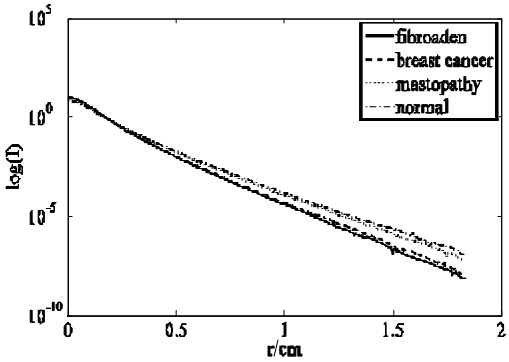


Fig.3 The absolute intensity in the Monte Carlo simulation

The reduced scattering coefficients of the four kinds of breast tissues were different, which determined the diffuse reflection of the tissues. So in the specific wavelength, the diffuse reflection of different tissues was different, and the kind of the tissues can be identified by the plot of the intensity versus the change of the distance.

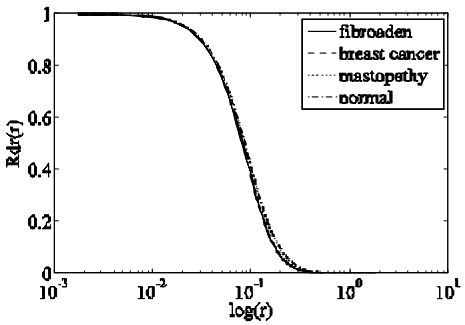


Fig.4 The plot of the relative intensity of the simulation

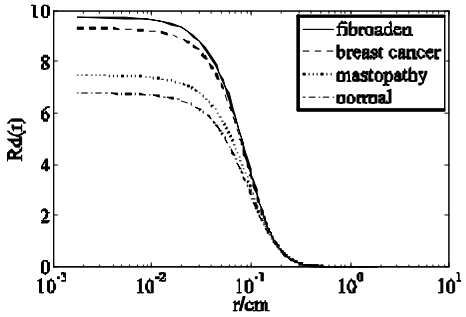


Fig.5 The plot of the absolute intensity of the simulation

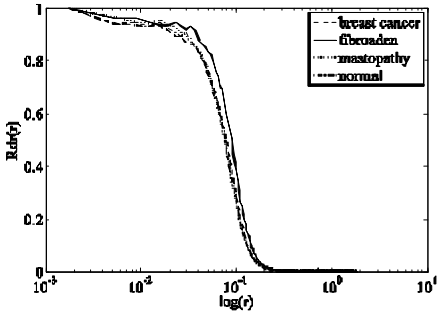


Fig.6 The plot of the relative intensity of the experiment

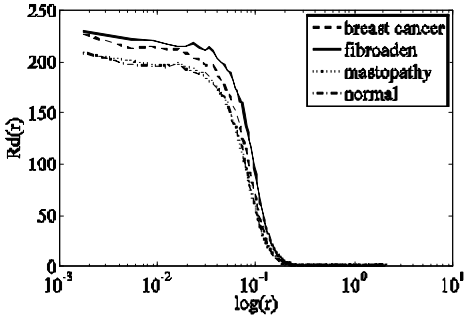


Fig.7 The plot of the absolute intensity of the experiment

To verify the simulation results, a diffuse reflectance experiment was done. The results of the measurement were processed in the simple PCI software and the Excel, and the plots of the experiment data were drawn with MATLAB. Different from the plots of the Monte Carlo simulation, the abscissa was the logarithmic of the distance. The curves of different tissues can be identified easily. The figures of the experiment were shown in Figure 6 and Figure 7. In order to compare the simulation result with the experiment, Figure 4 and Figure 5 were drawn with the simulation data using the a logarithmic abscissa. The figures of the experiment also indicated the difference of the diffuse

reflection of different tissue, and the difference of the absolute intensity was better than that of the relative intensity.

In order to make a direct comparison of the simulation results and the experiment results, the data of the breast cancer in the simulation and the experiment were input into the MATLAB to draw a figure of comparison. The figure indicated that the experiment results were similar to the simulation in the middle distance. The different in other distance maybe caused by the system error in the measurement. The figure of the comparison was shown in Figure 8.

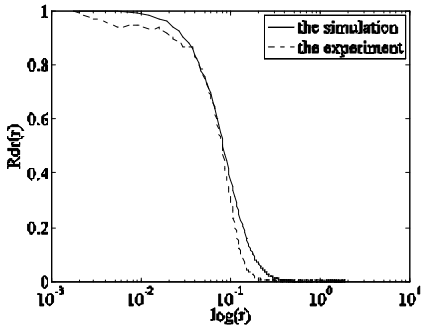


Fig.8 The comparison of the simulation simulation and the experiment

*Summary*
In this paper, four different kinds of breast tissues were simulated and measured in the wavelength of 633nm. An aqueous suspension of intralipid-20% and a bottle of ink were used to make the tissue-similarity phantoms. The results of the simulation and the experiment both indicated that the breast tissues can be distinguished by the diffuse reflection. It means that the diffuse reflection contains information of biological structure of the tissue. In other words, further study about the diffuse reflection maybe used in the clinical diagnosis of the breast diseases.

**Acknowledgements**
This work was supported by the Basic Operational Outlays for the Research Activities of Centric University, Civil Aviation University of China (Grant No. 3122013k002 and ZXH2012K006).

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