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Developing a New Algorithm to improve 3D imaging System through Near-Infrared in Cancer Diagnosis

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ABSTRACT

A new algorithm to improve 3D imaging system through near-infrared in breast cancer diagnosis is developed in this paper. A correct diagnosis code for abnormality region has been written in this paper which can guarantee the correct diagnosis of the abnormality region with least errors. 21 percent optimization in diagnosis accuracy of abnormality region was seen as compared to previous researches, this paper managed to study the correctness of two abnormality regions in three dimensional mode in two stages, each with two different coordinates of two different abnormality region which differed in some axis, made us conclude that a correct diagnosis and better image in reconstruction is related to the correct location of sources and the detectors.

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INTRODUCTION

Optical imaging system:

Optical phenomena with their non-aggression features made them appropriate tools in medical investigation including tissue imaging for which significant developments occurred during recent years – as figure 1 shows, the optical imaging is comprised of two parts, including hardware and software [1]. The hardware sections of the system include optical detectors and sources, surrounding the physiological tissues. This part is responsible for providing raw data in order to process the software system. The software system is responsible for shaping images from raw materials for the shortest time [2].

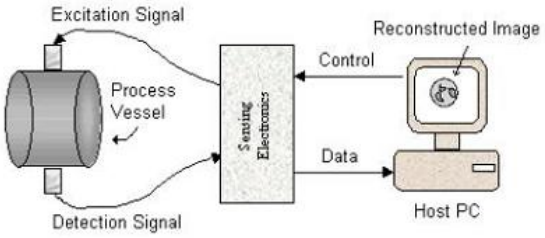

Fig. 1: parts of optical imaging system.

The optical imaging system is designed based on the dispersion of the near infrared waves in the tissues and it is used for oxygen monitoring in this new imaging system, near-infrared waves with a wavelength from 650 to 900 nanometer are shone bye optical fibers surrounding the area under study; Then, the intensity of radiated light is received by other detectors [3]. The reason of using this wavelength for optical imaging is that proteins and water are considered the main observer of light in ultraviolet waves and infrared long wave length, respectively, so the light is rarely able to penetrate in to the tissue. However, the light can penetrate more into the tissues for near-infrared spectrum due to higher light refraction [3].Since the light is more likely to be refracted within the tissue in near-infrared spectrum and considering the fact that the light doesn't move only in a direct path.

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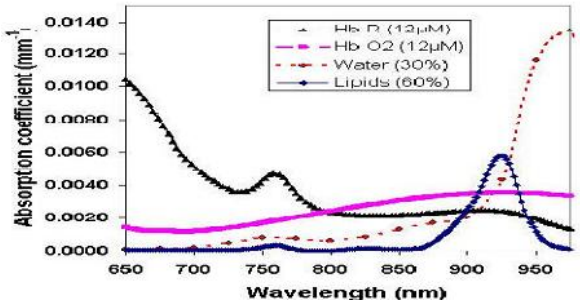

Fig. 2: Combinationes Absorption Coefficient per Wavelength.

Thus, when a source being activated, all of the detectors receive the refracted light which makes it very hard and complex to be analyzed and studied. Impacting on the surface under study, some of the light is absorbed and some is scattered, given the fact that the light depression is based on the tissue's optical features and the elements of the tissue have different wavelengths of near infrared light. Therefore, the intensity of the refracted light can define well the optical feature of the tissue under study [4].

The most important objectives in optical imaging is to estimate and to rebuild tissue's optical features(absorption and scattering coefficients) by the reflected waves, and to measure the reflection of these waves in the area under study.

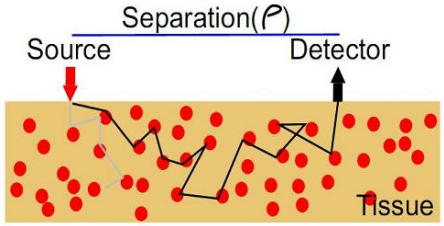

Fig. 3: Light Refraction in Tissue.

Optical imaging system:

Benefits of optical imaging system:

Breast cancer is one of the most common diseases among the women, which if diagnosed and treated quickly could be able to reduce death rate among women. Its most standardized treatment method is to take specimens by operation. However, about %80 of the individuals being operated are not suffering from cancer and would be examined falsely of being diagnosed with cancer. Currently, mammography is being used as the most common imaging system in order to x-raying and diagnosing the tumor. It provides higher resolute images together with diagnosing breast abnormalities. Besides mammography and clinical examination, other imaging methods mainly include: Sonography and MRI. The images from MRI mostly provide the anatomical information from the breast tissues. However, in order to diagnose breast cancer, functional information from it seems to be required per se. In some unique cases, CT is used, but it is not typically applied. Also, PET imaging method could also be used together with these imaging systems. But, in this imaging method, the external radio unclear needs to be injected [5].

In conventional mammography, the breast is pressurized by two plates including a film and a plastic plate which pressurize the breast with 3 to 6 Newton. This method is alleged to be discomforting and in some cases, the breast doesn't reshape to initial mode. This is not a simple and easy method for women.

In conventional mammography, there is other limitation existing in terms of age which is due to the condensation of breast tissues in younger ages. Similarly, due to disruptive damages of X-ray wave on human body, especially for young women whom never have previous cases of breast tumor, together with its high cost, have made optical imaging systems being of much interest [5].

The important features of this imaging system include:

- Simplicity and not being disruptive
- Not making the tissue ionizationized
- Cheapness
- Portability
- Not applying pressure and not having pain on breast tissue
- Omitting unnecessary specimen
- Appropriate for breasts with condensed tissues

- Injection of external radio nuclear not needed

Applications of optical imaging system:

Given the fact that many efforts and progresses have been done on making this system, the images from optical imaging system could be used in diagnosis and clinical applications. Its main applications include:

- Diagnosis of bleeding
- Investigation of nerve activity
- Quick diagnosis of Rheumatic disease in joints
- Diagnosis of breast tumor
- Imaging the heads of new-born babies [3].

Making three dimensional images:

Newton Reconstruction Algorithm:

In 2000, using Newton Reconstruction Algorithm, Dr. Hu Bai J Young and his colleagues from the University of Clemson, U.S.A, managed to diagnose a cylinder with 15 × 10 mm within a larger cylinder with 50 × 50 mm as three dimensional.

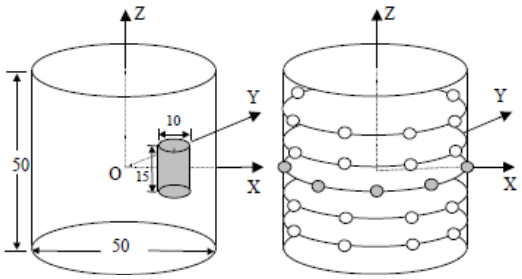

Fig. 4: Location of detectors, sources and location of abnormality.

Using sources aligned with a 16-source row, together with 4 distinctive rows of detectors, each including 16 detectors, they made reconstruction process [9].

2-3- Image reconstruction by near-infrared light:

In 2003, Dr. Dehghani *et al* [10, 11], reconstruct the image by near-infrared light, applying three dimensional system. In their article [10], the operation was solely processed nine times due to the lack of advanced technology and out coming images ware aligned through two dimensional layers.

They concluded that the so-called technique involves lower costs while destructive over tissues less than other similar methods. Also, when passing HBo_2, So_2, HB, it is reported to have a better output obtained for image reconstructing.

Then, in their next article [11], they utilized near-infrared light technology to diagnose small objects. The cylindrical area with a height of 109 mm and a diameter of 84 mm is proposed as the reference area. And the abnormality area is also placed as a small cylinder closed to the reference cylindrical circumference. Placing the small abnormality and a three dimensional reconstructing algorithm, they proved that the near-infrared light can provide a relatively prefect image while also utilize structural benefits which are easily accessed by both MRI and NRI methods.

A new algorithm for improving imaging system:

Proposed Method for diagnosing tumors in reconstructing images:

The current code has been written in order to determine how much the abnormality lump (Tumor) in the reconstructed image overlaps with the abnormality lump in real size. The percentage of this overlap can be utilized as a good criterion for measuring tumor's diagnosis accuracy through three dimensional optical imaging.

In order to better describe, firstly, we express our presuppositions. In this problem, the circumference is defined as a cylinder with a height of 50 and a radius of 25. The optical specifications of the region include: μa = 0.01 and μs = 1. The abnormality region is placed as a sphere with a radius of 8 in the index [13, 0, and 0]. Also, the optical specifications of this abnormality are regarded as μa = 0.02 and μs = 1 (μa is the coefficient for absorption of mesh points for the cylinder and μs is the scattering coefficient for the same points).

For the reconstructing images, μa ranges from 0.009 to 0.02. The abnormality lump in the figure is illustrated with corona edges. The numbers are represented in MATLAB as a, attached File.

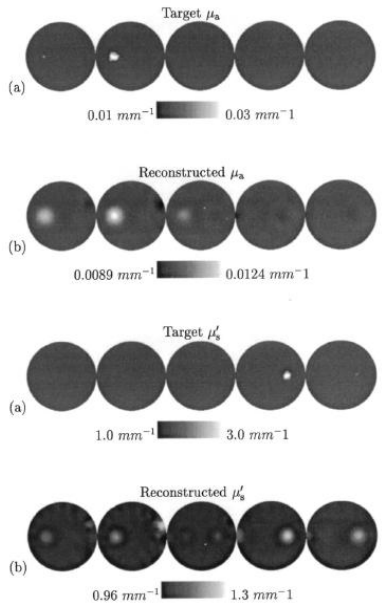

Fig. 5: Illustration of μa and μs before and after image reconstructing in different layers.

For the first stage, the written algorithm calculates the numbers of the points for main lump in the initial unreconstructed from. In this case, the number of nodes with μ a equal to 0.02 are enumerated, then saved in a place in the algorithm. Next, in the reconstructed image, it is intended to measure a range of μ a in which the number of points within the range having less difference with the number of the lump of the main abnormality. To do so, μ a changes from 0.01 to 0.02 with a rank of 0.0001. Then, the number of points higher than the range will be obtained. The difference obtained by the number of the main lump is placed into the Variable A. Finally, this written loop will be saving the least amount of A in A-Min variable and the range linked with the minimum points will be saved into the variable Marz.

Afterward, another loop of the written nodes with μ a more than Marz are stored in the variable B. then, the number points for B are calculated and are saved in the variable noghat- bazsazi. Within this loop, the number of points for B in which their coordinates placed in the abnormality lump before reconstructing, is stored in the variable noghat- dorost.

$$\text{Darsad- dorosti} = \frac{noght-bazsazi}{noght-dorosti} \times 100$$

Simulation:

At First, we seek to test the correct manner of the operations in article [9, 11]. In this case, the cylindrical circumference is 50 × 50 mm with μ a= 0.01 and μ s= 1 and the abnormality region is placed as a lump with a radius of 8 mm in the coordinates [13, 0, 0], the optical specification of the circumference is also μ a= 0.02 and μ s=1.

The location of the sources and the detectors, in this case, matches with the article. The coordinates for location of the sources and the detector is such a manner that a 16-source loop is placed in Z=0 and four 16-detector loops are placed in Z= 7, 14, -7, -14. In this case, the reconstructed image is as follows [9,10,11]:

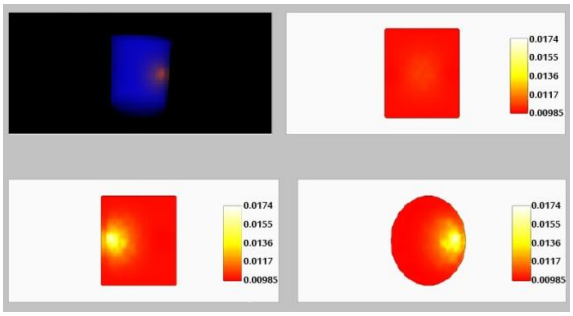

Fig. 6: reconstructed image of three dimensional mesh Developed by Dr. G young.

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Then, with changing the location of the sources and detectors in order to improve imaging system which is our idea to increase image resolution, we will analyze again:

The coordinate of the location of the sources and the detectors includes three 16- source loops in Z=4, 0, and -4, and eight 16-detector loops are placed in Z= 1, 3, 5, 7, -1, -3, -5, and -7.

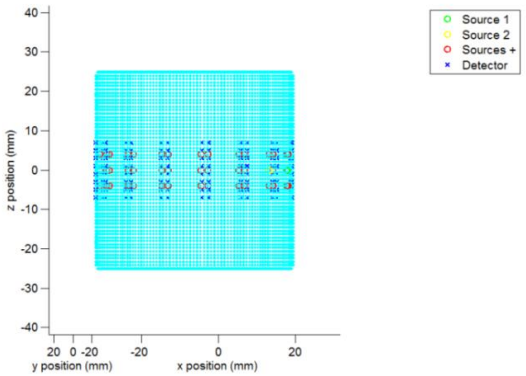

Fig. 7: the place of sources and detectors in the proposed method

The below figure illustrates the reconstructed image:

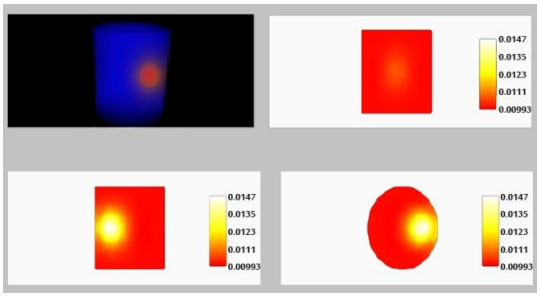

Fig. 8: reconstructed image of three dimensional mesh.

Clearly, abnormality lump is diagnosed better in the second case:

In the next step, two symmetric abnormality regions with different Z axes have come to be used to see whether the written algorithm could diagnose well.

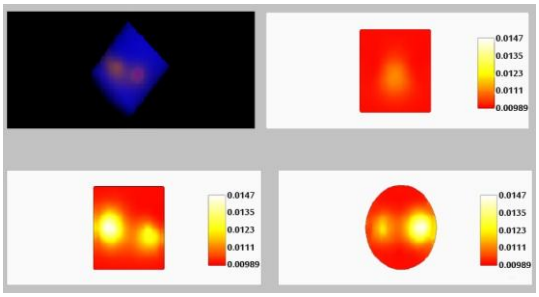

Fig. 9: A three dimensional mesh reconstructed image with two abnormality regions.

To be more sure of the proposed method, the two symmetric abnormality regions with corona overlap were applied to see whether the written algorithm could diagnose well.

Conclusion:

A correct diagnosis code for abnormality region has been written in this article which can guarantee the correct diagnosis of the abnormality region with least errors. We showed that the percentage of diagnosis accuracy of abnormality region by placing the sources and detectors in proposed coordinates provided in this article is more than that of provided by Dr. G. Young and Dr. Dehghani. %21 optimization in diagnosis accuracy of abnormality region was seen as compared to previous articles, we managed to study the correctness

of two abnormality regions in three dimensional mode in two stages, each with two different coordinates of two different abnormality region which differed in some axis, made us conclude that a correct diagnosis and better image in reconstruction is related to the correct location of sources and the detectors. As the operations showed when the location of the sources and the detectors change, better results would be obtained intuitively and quantitatively. Using the design can significantly help a better diagnosis of breast cancer by utilization of NIR Imaging.

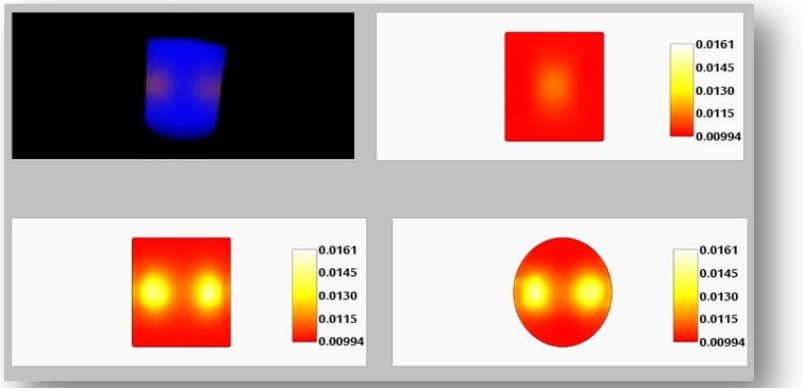

Fig. 10: reconstructed image of three dimensional mesh with two abnormality regions and corona overlapping.

Table 1: results of an abnormality region.

	The spectrum features	The spectrum features of abnormalities	The size of the cylinder	The place of two abnormalities	irritation	irritation of the reconstructed algorithm	Percentage of the accuracy of the reconstruction
Jiang Article	μa = 0.01 μs = 1	μa = 0.02 μs = 1	R=25 H=50	(13,0,0) R=8	9	25	72.63%
Dehghani Article	μa = 0.01 μs = 1	μa = 0.02 μs = 1	R=25 H=50	(13,0,0) R=8	9	28	78.57%
The 1st proposed method	μa = 0.01μs = 1	μa = 0.02 μs = 1	R=25 H=50	(13,0,0)R=8	8	17	99.53%
The 2nd proposed method	μa = 0.01 μs = 1	μa = 0.02 μs = 1	R=25 H=50	(13,0,0) R=8 (-13,0,0)R=8	9	19	A=98.63% B=99.13%
The 3th proposed method	μa = 0.01 μs = 1	μa = 0.02 μs = 1	R=25 H=50	(13,0,0) R=8 (-13,0,-5) R=8	11	18	A=98.43% B=65.13%

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