Simulation of Motion Induced SPECT Data with Developed Algorithm

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ABSTRACT

In a Single Photon Emission Computed Tomography (SPECT) study, the data acquisition is performed over a relatively long time, typically in the range of 5-30 minutes. For longer period, patient movement frequently occurs in clinical procedure. This movement causes misalignment of the projection frames,which degrades the image quality. In this work, different SPECT studies by using Hoffman 3D brain phantom without motion were acquired and by using algorithm, the motion induced data were simulated from these real data. Different data without motion were acquired by using a Trionix Triad triple-head SPECT camera with the phantom. Simulated data were evaluated and Mean Square Differences (MSD) was calculated using two differently developed algorithms. These simulated data were produced by adding projection frames partially with the aim to produce a new data set so that it simulates motion induced data. We calculated the MSD from the simulated data by analyzing each projection frame. The result shows the significant MSD values between two different projection frames which were obtained from two different SPECT acquisitions. Motion induced simulated data is useful in quantifying motion estimation and to develop correction methods that will allow derivation of motion free data.

Key words: **SPECT,Simulated data,MSD,MotionCorrection, Algorithmetc.**

INTRODUCTION

Single Photon Emission Computed Tomography (SPECT) is one of the major nuclear medicine equipment used for diagnostic imaging of different organs of human body. SPECT also assesses physiological function of the body. Short half-lived radiopharmaceutical is injected into the patient body and a series of two dimensional (2D) images of radionuclide distribution are acquired using SPECT. These 2D data are then reconstructed for three dimensional (3D) distribution of radionuclide concentration to produce a stack of transverse slices of the patient's organ. The data acquisition is performed over a relatively long time, typically in the range of 5-30 minutes. Due to the long period involved, patient movement frequenly occurs during the procedure and this movement causes the misalignment of the projection frames, which affects the reconstructed image and may produce artifacts. These motion artifacts may significantly affect the diagnostic accuracy and quality of the images. Fundamentally, motion correction is the task of obtaining consistent projection data from the acquisition (1-8).

Motion correction techniques are classified into two categories;internal and external based. The internal based motion correction, which is the main interest of this work, is based upon the database or software based motion correction. In this work we produced motion induced simulated data which has been used for the next step of motion correction. These simulated data are used for internal based technique. These data have been used for the advanced research for data base motion correction. External based is related to the hardware base method which includes some markers on patients or use camera or tracking systemsto detect or estimate patient motion during the SPECTimaging (9-10).

OBJECTIVE

In this work, different SPECT studies with Hoffman 3D brain phantom were acquired without motion and by using the developed algorithm,the motion induced data were simulated from these real data.We calculated the Mean Square Difference (MSD) values from the real data to the simulated data using another developed algorithm.

MATERIALS AND METHODS

Different data without motion were acquired by using a Trionix Triad triple-head SPECT camera with a Hoffman 3D brain phantom. Several motion free data of Hoffman phantom were acquired whereas;the phantom was placed in different position in the camera. We had several data without motion but the phantom positions on the camera were different. All acquisition data were taken for 120 projection frames. Using these data we could simulate and producea motion induced data. An algorithm has been developed in this work for the simulation of the data. These simulated data were generated using this developed algorithm.Different motion induced data were simulated in different position by using algorithm. As an example, we have produced two simulated data from two different data set. The distribution of projection frames from the both data have been showed below

Table 1: Distribution of projection frames for simulated data.

Data 1 (D1)	Data 2 (D2)	Simulated data 1 (SD1)	Simulated data 2 (SD2)
Total projection frame 120	Total projection frame 120	Frame 1-20 from D1	Frame 1-78 (D1)
		Frame 21-40 from D2	
		Frame 41-60 from D1	Frame 79-80 (D2)
		Frame 61-80 from D2	
		Frame 81-100 from D1	Frame 81-120 (D1)
		Frame 101-120 from D2	

Figure1: Hoffman 3D brain phantom

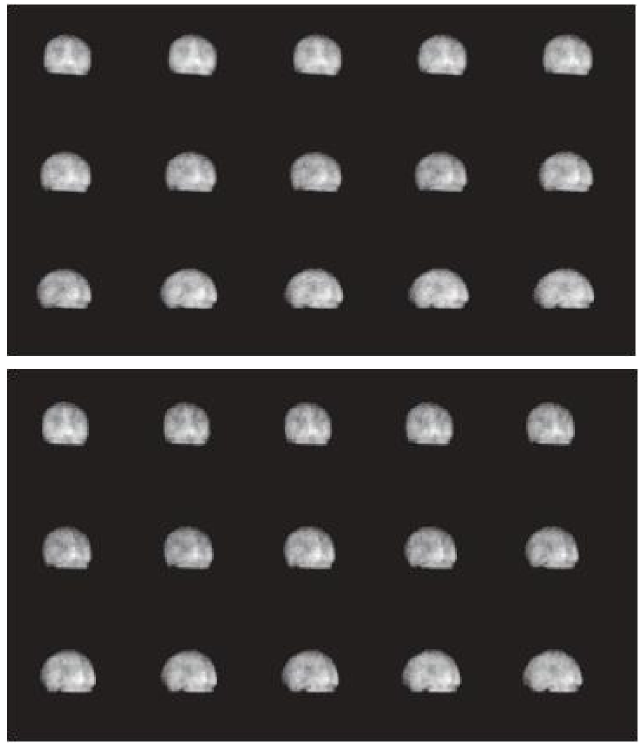

Figure 2a: SPECT data with Hoffman 3D brain phantom (D1) Figure 2b: SPECT data with Hoffman 3D brain phantom (D2)

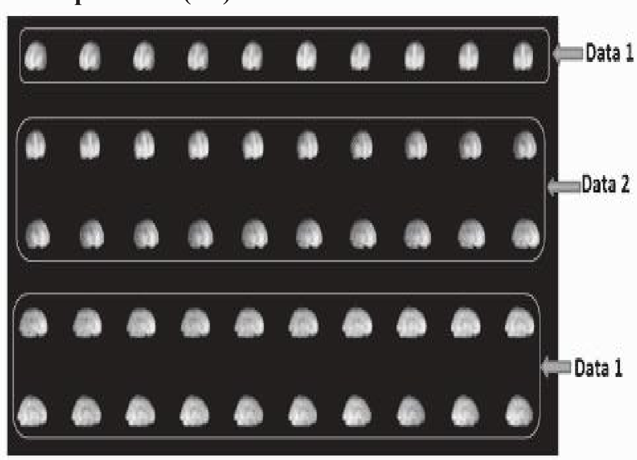

Figure 3: Simulated data 1 (SD1)

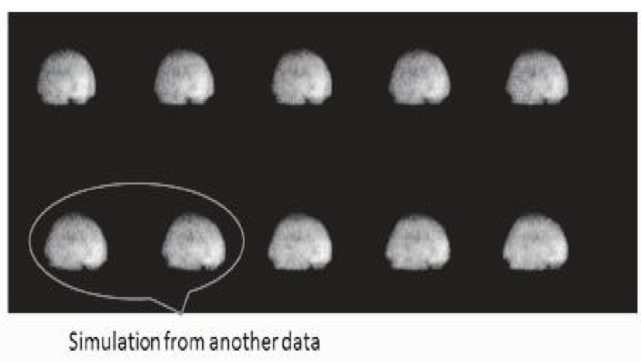

Figure 4: Simulated data 2 (SD2)

Figure 1shows the Hoffman 3D brain phantom which was used for the data acquisition. From the SPECT data, figure 2a and 2b show two different data (D1 & D 2) of phantom intwo different camera positionsin camera.

Figure 3 shows one of the simulated data (SD1), which was produced, from both D1 and D2. A simulated SD2 was produced from the same (D1 & D2) which isshownin Figure 4. The distributions of projection frames for both simulated data (SD1 & SD2) from the real data (D1 & D2) are shown in Table 1.

Mean Square Differences (MSD) values were calculated to simulated data from real data using the algorithm developed. Algorithm was developed for simulation of new data from the phantom motion free data.The both algorithm were developedby usingIDL program.

RESULTS

The simulated data were produced by adding partial projection datawith the aim to produce a new data setso that itsimulatesmotion induced data.By using simulated data and real data,we calculated the MSD values by analyzing each projection frame.These showed significant MSD values. The average MSD values which were 933.25 between two different data (D2 to SD1) were calculated.

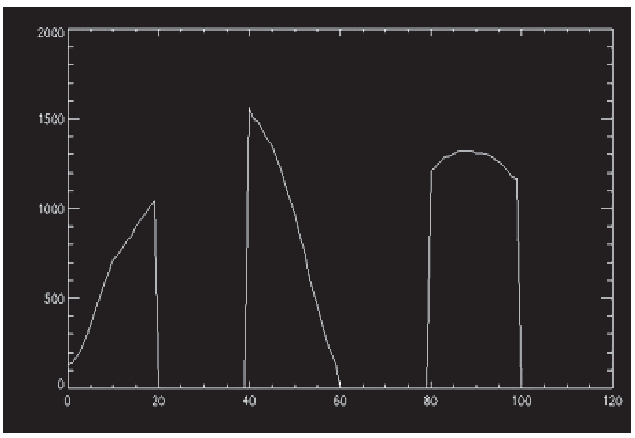

Figure 5: Mean Square Difference (MSD) Calculation (D2 to SD1)

From Figure 5 shows the significant Mean Square Difference (MSD) in the shifted projection frames where data 2(D2) was compared to the simulated data 1(SD1). We found the significant Mean Square Difference (MSD) comparing D1 to SD2. In figure 6, the MSD in the projection frames 79 and 80 which were moved from the different datawere calculated the average MSD which was 1247.5 between two data.

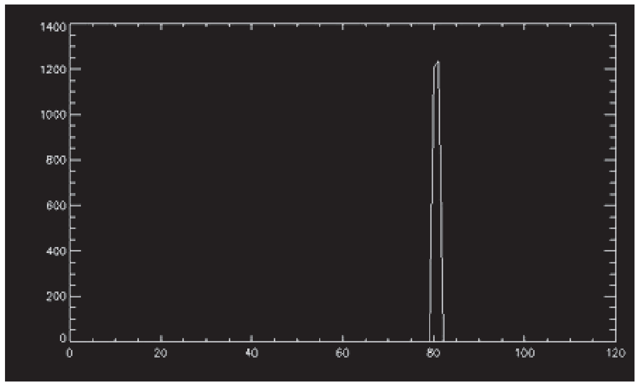

Figure 6: Mean Square Difference (MSD) Calculation (D1 to SD2)

DISCUSSION

The motion induced simulated data is markedlynecessaryfor advance research in data based motion correction. Within this simulated data we actually know where the motion was occurred or produced. We can do the motion correction for the known motion with these simulated data. For confirmation the motion induced or motion produced in simulated data, we calculated mean square difference (MSD) from the simulated data to real data with another algorithm developed for this purpose. And these were showed the significant value. When these simulated data were produced, different techniques of motion estimation could be applied to correct the subject's motion. It is also possible to simulate data from real SPECT data using IDL function. Simulation of new data set could be done by shifting pixels both in X or Y direction and also by rotating the projection views in different angles applying IDL function. Then motion induced data can be produced applying our algorithm. MSD values could be calculated also from the simulated data to real data by applying this algorithm.

CONCLUSION

Motion induced simulated data is useful in quantifying motion estimation and develop correction methods that will allow derivation of motion free data. The field of motion detection and correction in SPECT is very open to future novel ideas especially software basedimprovement of motion estimation, characterization, compensation and optimization. The simulated data is very essential for examining the algorithm based methods.

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