Trial of Computer Simulation of Image Reconstruction from Incomplete Data for New CT with Reduced Exposure

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ABSTRACT

Filtered-Back-Projection technique is used in X-ray CT image reconstruction. This requires X-ray transmission data from all directions. As the transverse cross-section of the body is approximately 50 cm, transmitted X-rays in this direction are strongly attenuated. If X-ray transmission data in this direction is avoided, exposure to the patients seems to be reduced one 20th of usual value. Some alternative method has to be found for clinically sufficient image quality. New methods are under development and tentative results are reported that utilizes the principle of superposition.

Keywords: X-ray CT, dose reduction, imcomplete data, image reconstruction, computer simulation

1. INTRODUCTION

Filtered-Back-Projection technique (FBP) is used for the image reconstruction of X-ray computed tomography. In FBP, X-ray transmission data from all direction is required. This means that strong X-ray must be irradiated to the patient in order to compensate strong absorption of X-rays along long axis of axial transverse cross-section of the body. If the X-ray transmission data are not required in this direction, exposure of the patients (usually 10 to 70mSv per examination) is much reduced. Such CT has been proposed in 1978 by one of the authors (1). Figure 1 illustrates such CT Scanner with X-ray fan beams of right angle, which is to be scanned linearly instead of rotationally. The cross-section of the body is assumed to be elliptic of long axis of 50 cm and short axis of 25 cm. The longest transmission of X-ray beam through body is approximately 32 cm instead of 50 cm in the ordinary case. The X-ray tube voltage is 120kV. Assuming all the X-ray energy to be 120keV (total linear attenuation coefficient for water is 0.16/cm), the X-ray intensity for 38 cm penetration is only one 18th of X-ray intensity for 50 cm penetration. Expected X-ray intensity for 38 cm penetration is fairly less because the energy of X-ray beams is less than 120keV with larger averaged linear attenuation coefficient. The main problem is whether the image thus obtained is of high quality or not. Although analytic prolongation is usually used to extrapolate projection data of missing angular regions, the reconstructed image is usually poor due to the noise enhancement by analytic prolongation in higher spatial frequencies. A new technique is under development which utilizes the linear operation where principle of superposition can be used. That means if a point absorber can be reconstructed exactly, arbitrary absorber distribution can be reconstructed by the principle of superposition. Although the computer simulation is under its way of development progress is to be reported.

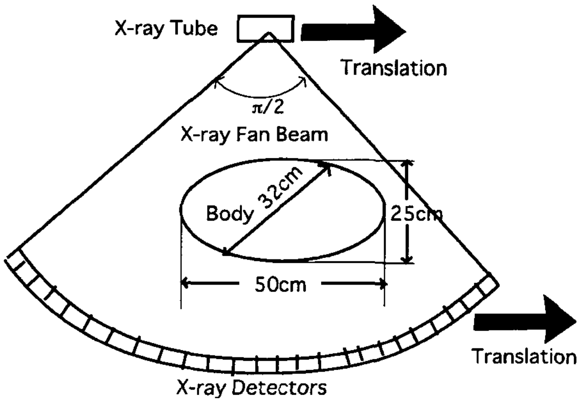

Fig. 1. New CT Scanner for Reducing Radiation Dose.

2. MATERIALS AND METHODS

2.1. Computer and Software for Computer Simulation

Computer simulation was achieved by MAC OS-G4 computer (OS-9.1) using software CodeWarrior Pro 4. The original program of CT image reconstruction using Filtered-Back-Projection technique (employing Shepp Logan Filter) was obtained by the courtesy of Dr. E. Tanaka. Maximum pixel size is 256x256. The program contains birds' eye view for showing reconstructed images. The original program was modified to suit the purposes.

2.2. Results of Computer Simulation

Tentative experimental results are shown in the following. Figure 2 shows the computer simulation of the original Filtered-Back-Projection technique of numerical phantoms with complete data. Figure 3 shows reconstructed images of same phantoms with 90-degree angular data with. Filtered-Back-Projection technique. Figure 4 shows reconstructed images of same phantoms with 90-degree angular data with. Back-Projection technique. Figure 5 shows reconstructed images of same phantoms with 90-degree angular data with Back-Projection technique and 2 dimensional Laplacian.

REFERENCES

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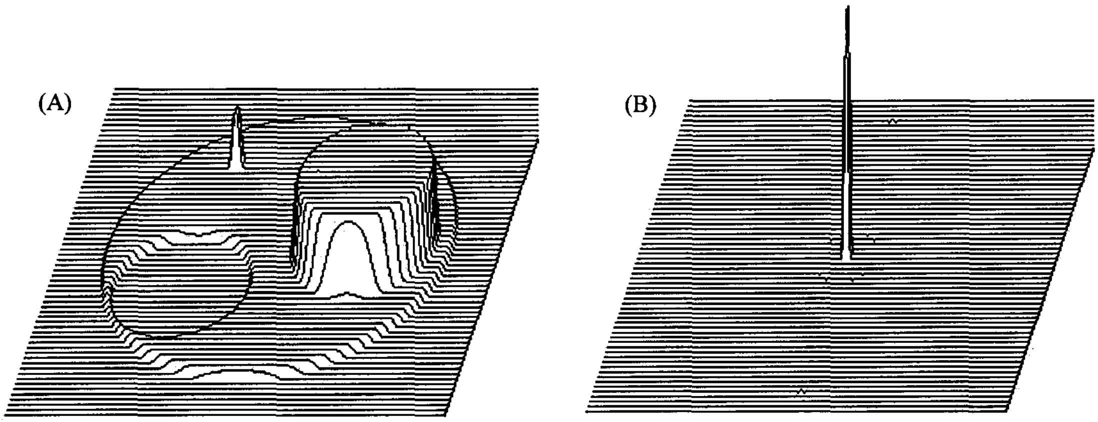

Fig. 2. Image reconstruction of phantom A and phantom B (point absorber) with full data (Filtered-Back-Projection technique)

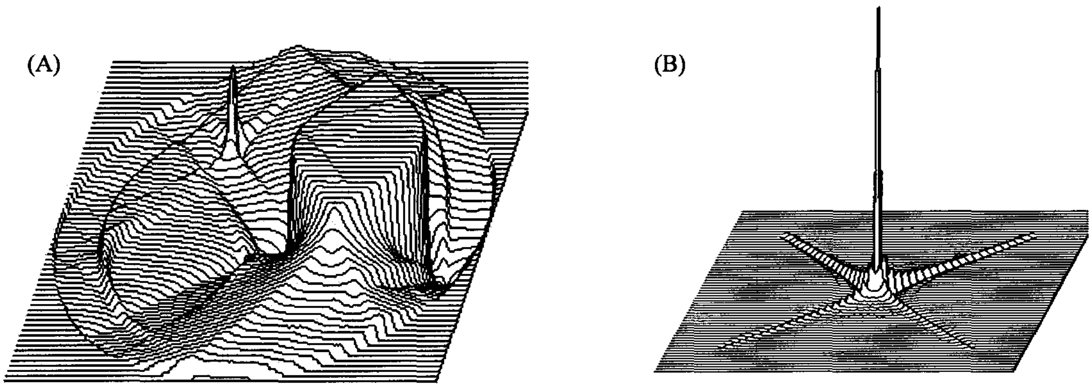

Fig. 3 Image reconstruction of phantom A and phantom B (point absorber) with 90 degree data (Filtered-Back-Projection technique).

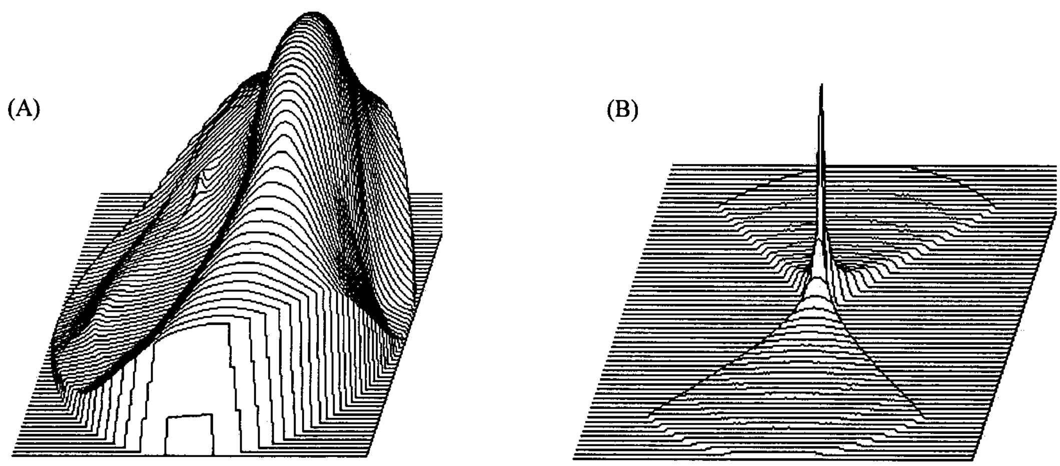

Fig. 4. Image reconstruction of phantom A and phantom B (point absorber) with 90 degree data (Back-Projection technique).

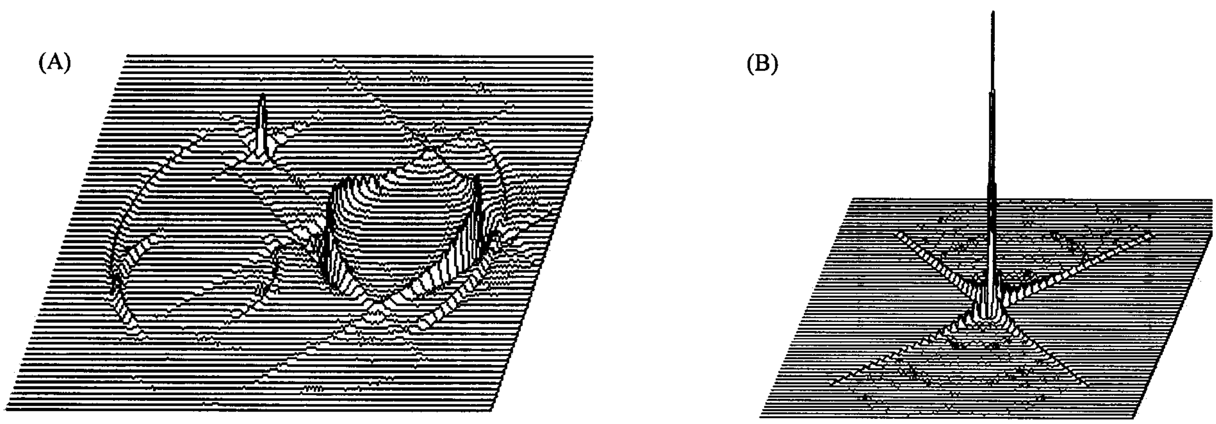

Fig. 5 Image reconstruction of phantom A and phantom B (point absorber) with 90 degree data (Back-Projection technique and 2 dimensional Laplacian).