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THEORETICAL ESTIMATION OF THE RECONSTRUCTED SLICE THICKNESS IN DIGITAL TOMSYNTHESIS

The theoretical estimation of the dependence of the digital tomosynthesis reconstructed slice thickness on the sweep angle is presented. The dependence of the slice thickness on the in-plane object size is shown.
Keywords: *Digital X-ray tomosynthesis, Slice thickness, Biomedical imaging.*

Introduction. Digital tomosynthesis is one of the emerging technologies in medical imaging. It allows the reasonable compromise between image quality, 3D reconstruction and patient dose. Today on market are several models of digital tomosynthesis equipment, mainly general purpose tomosynthesis equipment and mammographic tomosynthesis equipment.

Present study deals with general purpose digital tomosyntesis equipment. Table 1 summarizes some characteristics of equipment.

Table 1

Electromechanical characteristics of general purpose digital tomosynthesis equipment

Model/ Manufacturer	Number of projection images	Angular scan range, degrees	Source-to-detector distance SID, cm	Anode voltage, kV
General Electric Definium 8000/ VolumeRAD	60	±15°	180	120
Shimadzu SonialVision Safire	75	±20°	180	120
Amico FluoroProGraf 7000	30…60	±20°	120	70…90

Characteristics of mammographic tomosynthesis equipment are summarized in [1, 2].

Technically there is possibility to use numerous variants of X-ray tube and digital receptor movement and variety of the reconstruction algorithms. During the design of the digital tomosynthesis system we need some estimations of the relationship between the angular scan range, number of projection images, and the reconstruction quality. The aim of our study is to obtain corresponding theoretical dependencies.

Tomosynthesis slice thickness and angular scan range. There are at least two approaches to calculate slice thickness depending on the angular scan range. Both of them give similar results. First approach is derived from the Radon transform and central slice theorem and is discussed in [1, 2]. Slice thickness is calculated from the Fourier space.

We will use normal space to calculate the slice thickness. The idea of slice thickness calculation is given in Figure 1. We assume, that

1. Incident X-rays are collimated to parallel;
2. There is no divergence of a single X-ray;
3. X-ray source is a point-like source;
4. Reconstruction is done by a simple backprojection algorithm.

Slice thickness is assumed the distance between reconstructed planes, where the intensity of the in-plane object decreases two times.

From the simple geometrical consideration we derive the following relation for the slice thickness h :

$$h = \frac{d}{2\,\mathrm{tg}\gamma} . \qquad (1)$$

The most interesting conclusion from this equation is than slice thickness depends on the size of the in-plane object. So the slice thickness of large objects is bigger than thickness of small ones. This conclusion corresponds to results, obtained in [1, 2].

The physical nature for this result is that the projection angular range is less than π .

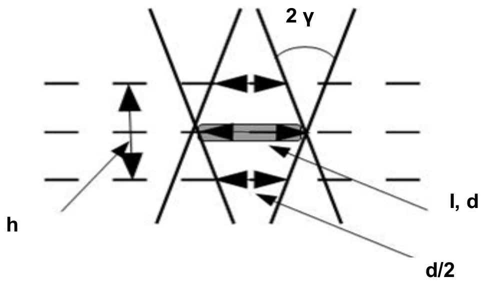

Fig. 1. Calculation of the slice thickness of the tomosynthesis object. Backprojection algorithm is used. Gray rectangle denotes the planar reconstructed object. d is size of the object in tomosynthesis plane, I is the intensity of the reconstructed in-plane object, 2γ is angular scan range, h is the slice thickness

Number of projections and number of voxels. Another problem which appears during the design of the tomosynthesis system is the relation between the number of voxels and the number of projections. The situation is illustrated by Figure 2. A group of voxels is projected vertically (Projection 1) and at a minimal angular interval (Projection 2). The densities of neighbouring black and white voxels, which superpose in Projection 1, in Projection 2 can be distinguished only if corresponding shadows cover different pixels.

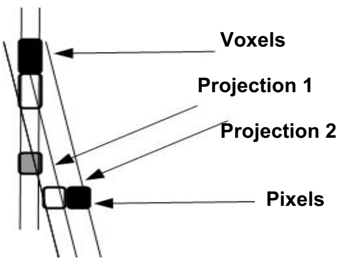

Fig. 2. Calculation of the minimal angular scanning interval

This means that if v is the voxel height or slice thickness, b is the projection pixel dimension and $\Delta\gamma$ is the minimal angular scanning interval, than

$$v = \frac{b}{\operatorname{tg}\Delta\gamma}. \qquad (2)$$

If H is the total height of the reconstructed volume, then the number of voxels should be

$$N_{vox} = \frac{H}{h} N_{pix} = \frac{H}{b} tg\, \Delta\gamma\, N_{pix}, \qquad (3)$$

where N_{pix} is a number of pixels in projection.

On the other hand, in algebraic reconstruction technique to calculate the X-ray densities of N_{vox} different voxels, we need at least the equivalent number of equations. When the total angular scanning range is 2γ , the corresponding number of equations is

$$N_{eq} = N_{pix} \frac{2\gamma}{\Delta\gamma} = N_{pix} N_{proj} , \qquad (4)$$

where N_{proj} is the total number of projections. From equations **Ошибка! Источник ссылки не найден.**, **Ошибка! Источник ссылки не найден.** and **Ошибка! Источник ссылки не найден.**, we obtain

$$N_{proj} \geq \frac{H}{v} \qquad (5)$$

For instance, if we take angular scanning range $2\gamma = 90^o$, $b = 0.25\,mm$ which corresponds $2\ lp/mm$, and $\Delta\gamma = 1^o$, then $h \approx 14\,mm$ and for $H = 200\,mm$ minimum number of projections, needed for reconstruction, is about 14. Making more projections decreases the relative noise and increases patient dose.

Conclusions. The relationship between the angular scan range and the tomosynthesis slice thickness obtained. Slice thickness appears to be proportional to the in-plane object dimension. The number of projections necessary for the reconstruction of the given number of voxels was calculated. Number of projections is inverse proportional to the projection pixel size.

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ТЕОРЕТИЧНА ОЦІНКА ТОВЩИНИ РЕКОНСТРУЙОВАНОГО ЗРІЗУ ПРИ ЦИФРОВОМУ ТОМОСИНТЕЗІ

Представлено теоретичну оцінку залежності товщини реконструйованого зрізу при цифровому томосинтезі від куту розвороту. Показано залежність товщини зрізу від розміру об`єкту в площині зрізу.

Ключові слова: *Цифровий рентгенівський томосинтез, товщина зрізу, медичні зображення.*

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ТЕОРЕТИЧЕСКАЯ ОЦЕНКА ТОЛЩИНЫ РЕКОНСТРУИРОВАННОГО СРЕЗА ПРИ ЦИФРОВОМ ТОМОСИНТЕЗЕ

Представлено теоретическую оценку толщины реконструированного среза при цифровом томосинтезе в зависимости от угла разворота. Показано зависимость толщины среза от размера объекта в плоскосте среза.

Ключевые слова: *Цифровой рентгеновский томосинтез, толщина среза, медицинские изображения.*

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SPECIAL JOINTS OF GRAIN BOUNDARIES IN NANOSILICON FILMS WITH EQUIAXED AND FIBROUS STRUCTURES

Atomic force microscope was used for investigation of grain boundaries joints in undoped nanoysilicon films. It was shown that in films with equiaxed and fibrous structure joints differ in the number and mutual arrangement of special boundaries $\Sigma = 3^n$ and of the general type boundaries.

Key Words: *nanosilicon films; structure; joints of grain boundaries*

Introduction. Nanosilicon films are one of the leading electronic materials for large-area application as solar cells or switching electronics used for flat-panel displays. As is known [3, 8], the characteristics of the electronic devices that use nanosilicon films are directly connected with the structural properties of the films, in particular, their grain boundary and grain boundary joints. Grain boundary joints in a polycrystalline microstructure correspond to the one-dimensional regions of space where three or more grain boundaries meet. In total volume of nanocrystalline material part of the grain boundaries and joints of grain boundaries is ≥ 50%. It is evident that the joints influence the film structure formation and properties of the films. This effect is different for various joints and is structure-dependent.