Computer Processing of Gamma Camera Images

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Images obtained by gamma cemera are strongly affected by the statistical properties of gamma-rays. They are also degraded from the original radioisotope distribution in the body by the limited resolving power of the measuring system. We report a new computer method to eliminate these undesirable effects in the clinical diagnosis.

It is almost impossible to expect a true image without any fluctuating component because of the quantum characteristic of the counting rates that distribute around the average according to the probability law.

Fluctuations of counting are decreased by the non-linear filtering method. Mathematically, the components of quantum noise have dependence on the signal, so non-linear transformation to obtain the linear relationship between the signal and noise components is proposed. The filter technique in the frequency domain combined with this non-linear transformation provides a more improved method to eliminate the quantum fluctuations.

Smoothed images thus obtained still contain the effect of resolving power of the whole system. These distributions are described as the convolution functions of the original pattern and the point spread function of the measuring system.

A new technique for the resolution improvement is introduced by utilizing a singular characteristic of Dirac's delta function. By this method, the resolution improved version of image data involves very small spurious ringing oscillations are observed.

A new rapid computer method to carry out the calculation of "deconvolution" is applied to remove the effect of the resolution of the collimator and the electronics system.

Reconstruction of Two-dimension Radioisotope Distribution Profile from Images of Transverse Section

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Images obtained from a transverse section imaging device consist essentially of a number of lines swept from direction of incident γ-rays to the dectector, that is called "line image". Since the "line image" does not represent faithfully radionuclide distribution in the transverse section, there have been developed several methods of reconstructing a two-dimensional radionuclide distribution from image data obtained with transverse section imaging devices.

Here we present theory of two new methods for reconstruction and show some preliminary results of applying the method to brain phantom data obtained by a multi-crystal section imaging device. The first method is called "one-dimension convolution method" in which profile images obtained from various direction are convoluted with a certain one-dimensional filter $\varphi(x)$ and the convoluted images are summed up from their original directions. The filter $\varphi(x)$ is so determined that a point spread function of the processed image becomes a two-dmension Gaussian function, and has been solved analytically as follows:

$$\varphi(x)=\frac{1}{2\pi\sigma^2}\left[1-\frac{x}{\sigma^2}\exp\left(-\frac{x^2}{2\sigma^2}\right)\int_0^x \exp\left(-\frac{s^2}{2\sigma^2}\right)ds\right]$$

The second method is called "two-dimensional convolution method" in which a line image of transverse section is formed by exposing a film to bright lines on a CRT, and then the exposed film is scanned by the "Omni-directional flying-spot scanner". A two-dimensional filter $\psi(r)$ was theoretically derived such that a point spread function of the processed image becomes a two-dimensional Gaussian function, when $\psi(r)$ is convoluted to the line image of the point source. This would be practically accomplished by simulating the frequency characteristics of the amplifier for film density signal to the $\psi(r)$. $\psi(r)$ is ecpressed by the following equation.

$$\Psi(r)=1/(4\,2\,\pi^{\frac{3}{2}}\sigma^3 k)\exp(-r^2/2\sigma^2)\ {}_1F_1\left(-\frac{1}{2};1;\frac{2\sigma^2}{r^2}\right)$$

where ${}_1F_1$ is confluent hypergeometric function.

In order to test the effectiveness the "one-dimensional convolution method," of we processed the image data obtained from the multi-crystal section imaging device which has recently developed by us. A model of brain section was constructed from an array of plastic bottles of haxagonal shape. Bottles which contained ^{57}Co activity were placed in various position of the array and the image data were obtained from 32 directions (11.25 interval). The data were corrected for the detector non-uniformity, then convoluted with the filter $\varphi(x)$ and finally summed up from 32 directions. The resulting image was found to restore the original radionuclide distribution compared to the unprocessed line image.

Reference

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