GAMMA CAMERA POSITION ARITHMETIC BASED ON MAXIMUM LIKELYHOOD ESTIMATION AND SUCCESSIVE APPROXIMATION TO IT

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Position calculation can be regarded as a statistical estimation of scintillation flash point from a set of measured numbers of photoelectrons in photomultipliers. If the number of photoelectrons N_i in i-th P.M.T. is normalized to the total number of photoelectrons N, the probability that the numbers of photoelectrons are N ,N ,....,N_k obeys to multinominal distribution. Then maximum likelyhood estimator is given by a solution of the equations,

$$\sum_i N_i(x,y)\frac{\partial \log P_i(X,Y)}{\partial x} = 0$$

$$\sum_i N_i(x,y)\frac{\partial \log P_i(X,Y)}{\partial Y} = 0$$

where P_i is the expected value of a fraction of N_i to total photoelectrons. These equations are linear to N_i therefore $\partial \log P_i/\partial X$ etc. can be regarded as weights to i-th P.M.T. The maximum likelyhood estimator $(\hat{X},\hat{Y})$ thus obtained is unbiased, i.e. linearity of this position arithmetc is ideal.

Variances of this estimator $(\hat{X},\hat{Y})$ are calculated as;

$$\mathrm{Var}\ X=I_{yy}/\det(I), \quad \mathrm{Var}\ Y=I_{xx}/\det(I)$$

where I denotes Fisher's information matrix, i.e. $I_{xy}=I_{yx}=N\sum_i P_i(\partial \log P_i/\partial X)(\partial \log P_i/\partial Y)$ etc. These equations cannot be solved explicitly, but the following successive approximation leads to optimal estimator.

$$\hat{X}_n = \hat{X}_{n-1} + \sum_i \frac{\dot{P}_i}{P_i} N_i \Big/ \left[\sum_i \frac{\dot{P}_i^2}{P_i}\right]_{X=\hat{X}_{n-1},\, Y=\hat{Y}_{n-1}}$$

This process can be realized by means of digital weights stored in digital memories along with multipling DAC. As an initial guess, either the coordinates of the brightest P.M.T. or Anger method based on centroid calculation may be applicable. The former requires additional circuit, but the latter method does not need any extra circuit, since Anger arithmetic can be realized by use of linear weights with respect to coordinates.

The merits of this schema lie in the applicability of optimal weights and the stable operation owing to digital weights.

SELECTION OF SUITABLE COLLIMATOR FOR GAMMA CAMERA IMAGING

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Resolution of gamma camera is influenced by several kinds of factors. Both spatial resoluation and sensitivity of a collimator are important and these are contrary of each other. In the resent gamma camera, several types of collimators for ^{99m}Tc agents, having from high-resolution and low-sensitivity to low-resolution and high-sensitivity, are made. Then, selection of the optimum collimator is essential.

Quality of gamma camera image depend on count density (counts/cm^2). For example, in high count density, image quality is better but in low count density, it is worse.

Line spread function of gamma camera with collimator was approximated by Gaussian function and the relation between scintigram resolution and count density was caluclated in the presence of statistical fluctuation. In high count density, scintigram resolution was approximately the value of FWHM, but in low count density, it was further value of it. In the same count density, scintigram resolution of a higher resolution collimator was better than a lower resolution collimator. But sensitivity of a higher resolution collimator was lower than that of a lower resolution collimator. According to these facts, imaging used a high-resolution collimator was needed long time procedure or administration of high radioactivity.

Using efficiency of collimator, characteristic curves were calculated as relation between product (AD.IT) of radioisotope density by imaging time. Optimum AD.IT region for each collimator was obtained from this characteristic curve.