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Determination of Physical Parameter Model for the Photo Film Mammographic X-Ray Results on the Breast Cancer Histology Classification

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Abstract

The breast cancer is tendentious issues, primarilly on public health problem. To overcome these issues, the scientists have been developed various methods for early detection of breast cancer. The breast cancer have been detected, potentially using the physical parameter of the x-ray mammographic images. To find out the type of breast cancer histology have been developed with a fine needle biobsi method. These studies will have been classifying histological type of breast cancer by using the characteristics of gray-level image structure are referred to as the physical parameter of the mammographic x-ray images. These parameters had been analized using logistic regression methods. The method can be assist radiologist to minimize misinterpretation on these images. The results showed that the physical parameters of the x-ray mammographic images can be classify histological types of breast cancer with a sensitivity of 86.36%.

Keywords: mammographic, breast cancer, histologi, infiltrating ductal carcinoma, infiltrating lobuler carcinoma

1. INTRODUCTION

The intensity of radiation on breast cancer, fractionally there are absorbed and partly transmitted. The intensity of the transmitted radiation related on the density of breast cancer. Solidity of breast cancer density can be increase the amount of radiation absorbed and decrease transmitted intensity on the other. These transmition radiations will be recorded by mammographic films in gray-level values (0-255) are composed as matrix form. Intensity values of each image pixels of the breast cancer featured in varies related on the type cancer which known as gray-level image structure. The more malignant the cancer pixel intensity values are not uniform (entropy). Besides the lack of uniformity there is also the sharpness of the structural variations (contrast), the structural uniformity (angular second moment), the local homogeneity (inverse difference moment), the linear dependence (correlation), the nature of authenticity (mean), the density (deviation). Value of gray-level image structure features or it is called very good physical scale used to classify the types of breast cancer histology.

Breast cancer is a public health majority issues in the world. Mammographic X-ray is the primary imaging method used to detect breast cancer based on its sensitivity and high resolution, that helps early detection [9]. However, mammographic not reveal the network and has a lower sensitivity for dense breast [13] and thus used in the breast are often equipped Computer Aided Diagnosis (CAD).

Computer Aided Diagnosis advantage to detect including macrocalsification or microcalsification in dense breast that are not arisen directly on the x-ray mammographic images, [6], and it decrease time consumption to interpret breast cancer images by radiologist. Many methods have been successfully to detect and microcalsification macrocalsification Hybrid System, among others, [5], foveal, [8], Tsallis entropy and a type II fuzzy index, [7], Wavelet, [11], Fuzzy C-Means [12], Neural Network, [3], morphology of N-ary, [6], Gabor, [14], Orthogonal polynomials, [10], Self-Similar Fractals, [2], Kekre's proportionate error, [4], finally no one has analyzed of all the histological types of breast cancer. For these reasons it is necessary to create a model for classifying types of breast cancer histology using physical quantities of the x-ray mammographic images. The advantage of this model, there are classifying the type of histological analysis of breast cancer fastly, and decreasing the treatment cost. In this research will have been estimating of the significant variables constants using logistic regression methods. The method is performed to minimize the marked suspicious mass error by radiologist.

2. MATERIALS AND METHODS

A. Data Acquitions

This study was approved by the ethics committee of health research at the Dr Soetomo Surabaya Hospital, focused on number 07 / Panke KKE/I/2012 and the patient informed consent are signed alltogether. All the mammographic images are collected from the data base computer at radiodiagnostic Dr. Soetomo Surabaya Hospital, these images of mammographic labelling Kodak brand, type 6900 laser imager dryview data prints of mammographic films and its placed in the direct view 975 CR. The reason importing mammographic image data from a computer data base caused theese images is not deformed by the external scratch influences. Images saved in bmp format and sampled with a matrix size of 5 cm x 5 cm.

B. Radiation Interaction in The Breast Cancer Mater.

If the x-ray enters a material in this case breast cancer, can result in ionization, but ionization is produced mainly through the process of secondary ionization. Thus, the x-rays interact with breast cancer just a few pairs of primary ions are formed. Primary ions were subsequently conducted in order to obtain the secondary ionization ion pair more than which had been formed in the primary ionization process.

When x-rays (electromagnetic waves) into the breast tumor, the radiation intensity will decrease, while the energy remains unchanged. The relationship between the radiation intensity of a material can be written,

$$I = I_0 e^{-\mu L}$$

With I, I_0, μ, and L is the intensity of each of the transmitted radiation, the radiation intensity at first, the linear absorption coefficient of materials, and material thickness.

There are three main processes that can occur when x-rays pass through breast cancer, namely photoelectric effect, Compton scattering and pair production. The third process is the next release electrons that can ionize other atoms in the material. Opportunities for interaction between the x-ray with breast cancer, is determined by the linear absorption coefficient (μ). Because the absorption intensity of the electromagnetic wave through three main processes, the value of μ is also defined by opportunities for all three processes, ie μf for photoelectric, μc for Compton scattering and pair production μpp. Total absorption coefficient (μt) of the three coefficients are

$$\mu_t = \mu_f + \mu_c + \mu_{pp}$$

C. The physical scale film mammographic X-ray photos.

There are ten films that have physical scale on the x-ray mammographic images is [1]:

Entropy is a measure of unequal and defined as

$$Entropy = -\sum_{y_q=y_1}^{y_t}\sum_{y_r=y_1}^{y_t}\left[H\left(y_q, y_r, d\right)\right]\log\left[H\left(y_q, y_r, d\right)\right]$$

$$Contras = \sum_{y_q=y_1}^{y_t}\sum_{y_r=y_1}^{y_t}(y_q - y_r)^2\, H(y_t, y_r, d)$$

$$Anguler\ Second\ Moment = \sum_{y_q=y_1}^{y_t}\sum_{y_r=y_1}^{y_t}[H(y_q, y_r, d)]^2$$

$$Inverse\ Difference\ moment = \sum_{y_q=y_1}^{y_t}\sum_{y_r=y_1}^{y_t}\left[\frac{H(y_q, y_r, d)}{1 + (y_q - y_r)^2}\right]$$

for $y_r \neq y_q$

$$Correlation = \frac{\sum_{y_q=y_1}^{y_t}\sum_{y_r=y_1}^{y_t} y_q y_r H\left(y_q, y_r, d\right) - \mu H_m\left(y_q, d\right)\mu H_m(y_r, d)}{\sigma H_m\left(y_{qq}, d\right)\sigma H_m(y_r, d)}$$

with

$$H_m\left(y_q, d\right) = \sum_{y_r=y_1}^{y_t} H(y_q, y_r, d)$$

$$H_m(y_r, d) = \sum_{y_q=y_1}^{y_t} H(y_q, y_r, d)$$

$$Mean = \sum_{y_q=y_1}^{y_t} y_q H_m(y_q, d)$$

$$Deviation = \sqrt{\sum_{y_q=y_1}^{y_t}[y_q - \sum_{y_p=y_1}^{y_t} y_p H_m\left(y_p, d\right)]^2 H_m(y_q, d)}$$

$$H_{diff}(i, d) = \sum_{y_q=|y_q-y_r|=i}^{y_t}\sum_{y_r=y_1}^{y_t} H(y_q, y_r, d)$$

$$Entropy\ of\ H_{diff} = -\sum_{i=i_1}^{i_t} H_{diff}(i, d)\log H_{diff}(i, d)$$

$$Anguler\ Second\ Moment\ of\ H_{diff}(i,d) = \sum_{i=i_1}^{i_t} [H_{diff}(i,d)]^2$$

$$Mean\ of\ H_{diff} = \sum_{i=i_1}^{i_t} i\ H_{diff}(i,d)$$

With Y_Q, yr, d, are respectively pixel gray-level value of unity, the value of the pixel gray-level and the distance between pixels of unity with the second pixel. H (Y_Q, yr, d) is the second-order histogram illustrating the distribution of likelihood of occurrence of a pair of gray-level.

High uniformity will show a lower structural variation. Conversely if the value is low it can be concluded that the sign of possible events related microcalsification greater. $(Y_Q - yr)^2$ is the unequal size. These measurements provide evidence of how sharp variations in the structure of the image [1].

D. Logistic mapping function

Review the following probability function:

$P_r(Y)$ and $Y = f(X)$ where the dependent variable that is bound to free variables $\{X_i\}$, and X_i linearly independent with X_j that is $X_i \neq \sum_j a_j X_j$ Where Y, is output category, eg: y=0, normal category, y = 1, The category is rather normal, and so on, y=k, particular category.

This form is multinomial, or multiple linear rate.

Review the logistic function (logit) the following:

$$logit\{P_r(Y=1|X\} = log\left\{\frac{P_r(Y=1|X)}{1-P_r(Y=1|X)}\right\} \cong ln\left\{\frac{P_r(Y=1|X)}{1-P_r(Y=1|X)}\right\} = Y$$

Further $Y: \{Z_1, Z_2, Z_3, Z_4\}$ with X : {all of Entropy}

For example the category Y = Z_k

$$ln\left\{\frac{P_r(Y=1|X)}{1-P_r(Y=1|X)}\right\} = Z_k,$$

Note: Use of functional ln (natural logarithm related to qualitative mapping (Entropy) to qualitative (histological types of breast cancer), which is not satisfy the normal Gaussian, statistically

$\frac{P_r(Y=1|X)}{1-P_r(Y=1|X)} = e^{Z_k}$ or $\frac{1-P_r(Y=1|X)}{P_r(Y=1|X)} = e^{-Z_k}$ to obtain:

$$1 - P_r(Y=1|X) = P_r(Y=1|X)e^{-Z_k},$$

$$P_r(Y=1|X)\{1+e^{-Z_k}\} = 1,$$

$$P_r(Y = 1|X) = \frac{1}{\{1+e^{-Z_k}\}},$$

And $P_r(Y = 1|X)$ as a multinomial logistic regression of statistical model.

eg for $\{Y = Z_k\}_{k=1,2,}$, it will be found in all categories $\sum_{k=1}^{2} P_r\,(Z_k = 1|X) = 1$,

to

$$\{Z_k = 1\}\begin{Bmatrix} Z_1 = 1, IDC, detected \\ Z_2 = 1, ILC, detected \end{Bmatrix}$$

$$P_r(Z_2 = 1|X) = \frac{1}{\{1+e^{-Z_2}\}},$$

And because the fulfillment of all categories / infiltrating into force,

$$\sum_{k=1}^{4} P_r\,(Z_k = 1|X) = 1$$

$P_r(Z_1 = 1|X) + P_r(Z_2 = 1|X) = 1$, so that

$$P_r(Z_1 = 1|X) = 1 - P_r(Z_2 = 1|X)$$

$$P_r(Z_1 = 1|X) = 1 - \left[\frac{1}{\{1 + e^{-Z_2}\}}\right]$$

E. Linear Regression Multinomial Function as Outcome of The Histological Type

Review the following linear regression:

$$Z_k = Z_{k0} + \left\{\sum_{k,j=1}^{n} B_{kj}\,Entr_j\right\} + \text{Bkn.MeanHd10}$$

Z_k is the outcome / impact of a number of $\{Entr_j\}$

Z_{k0} is the intersection / intersection of the axis, or the initial value of outcome, $Z_k = Z_{k0}$

For the tribe $\{\sum_{k,j=1}^{n} B_{kj}\,Entr_j\} + \text{Bkn.MeanHd10} = 0$

$\sum_{k,j=1}^{n} B_{kj}\,Entr_j$ is a nuisance parameter / variable-free number $\{Entr_j\}$ the rank of 1 (one) or linear.

Bkn.MeanHd10 is the correction factor by the number of outcome $\{Entr_j\}$

For example:

$$Z_2 = Z_{20} + \left\{\sum_{2,j=1}^{n} B_{2j}\, Entr_j\right\} + \mathrm{B2n.\,MeanHd10}$$
$$Z_3 = Z_{30} + \left\{\sum_{3,j=1}^{n} B_{3j}\, Entr_j\right\} + \mathrm{B3n.\,MeanHd10}$$
$$Z_4 = Z_{40} + \left\{\sum_{4,j=1}^{n} B_{4j}\, Entr_j\right\} + \mathrm{B4n.\,MeanHd10}$$

There are illustrated as bellows:

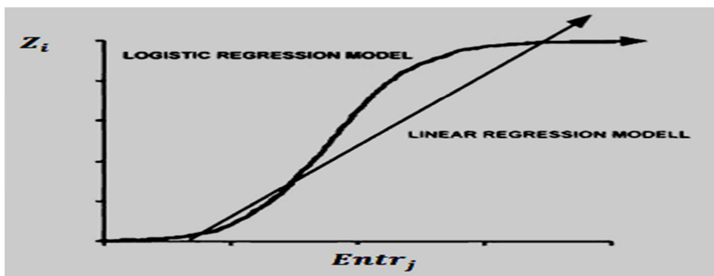
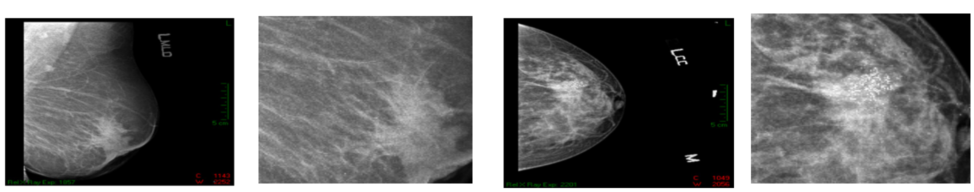


Figure 1. Linear Regression Model

3. RESULTS AND DISCUSSION

Figure 2 (a) and (c) are characteristic lobuler type of infiltrating carcinoma (ILC) and the type of infiltrating Ductal Carcinoma (IDC), while (b) and (d) is the excerpts of each ILC and IDC with a size of 5 cm x 5 cm which will be analyzed to make mathematical models.



(a) (b) (c) (d)

Figure 2. (a) ILC, (b) Excerpts of ILC with a size of 5 cm x 5 cm. (c) IDC. (d) Excerpts of IDC with size 5 cm x 5 cm.

Formulating mathematical models that can classify infiltrating ca mamma, then do skraning variable physical quantities movies x-ray results of mammography images using the method of logistic regression results as follows.

Optimum variables for classifying types of histology there are Entropy (E), angular secound Moment (MA), Mean (MN), Entropy of Hdiff (EH), angular secound Moment of Hdiff (MAH), Mean of Hdiff (MHD). With the estimated value as the following equation:

Z := -1836.934 + 6888.371* E[1] -14247.818* E[2] + 6611.320* E[3] + -4079.380* E[4] + 5428.171* E[5] + 14.284* E[6] + 1427.621* E[7] -1537.421* E[8] -648.404* E[9] + 6.619* E[10] + 2647.499* MA[1] + 305.296* MA[2] -81529.334*MA[3] -19958.633* MA[4] + 9211.990* MA[5] + 3650.557* MA[6] + 1058157.031* MA[7] - 2563702.464*MA[8] + 2349513.476*MA[9] -747689.772*MA[10] -177.402*MN[1] + 225.654*MN[2] – 0. 253*MN[3] -1.094*MN[4] + 38.244* MN[5] - 0.023*MN[5] + 13.896* MN[7] – 300.025* MN[8] + 90.543* MN[9] + 110.452*MN[10] -1588.560*EH[1] + 8028.265* EH[2] -193.301*EH]3] + 4998.507*EH[4] -7983.892*EH[5] -19.248*EH[6] + 215.800*EH[7] -24539.684*EH[9] + 23227.280* EH[10] + 19212.830*MAH[1] + 1581.604*MAH[2] + 42634.038*MAH[3] -119589.405* MAH[4] -227899.575* MAH[5] + 308931.535* MAH[6] + 137648.993*MAH[7] + 12686.232* MAH[8] -226984.576* MAH[9] + 48797.966* MAH[10] -63.103* MHD[1] -14.829* MHD[2] + 240.890* MAH[3] -606.835* MHD[4] -90.952*MHD[5] + 573.267* MHD[6] + 3.386* MHD[7] + 113.840* MHD[8] + 7.225* MHD[9] -232.076* MHD[10];

Probabilitas_ILC := $\frac{1}{1+e^{-z}}$;

Probabilitas_IDC = 1 – probabilitas_ILC;

IDC and ILC VALUE RANGE

Variabel Fisis Film	IDC	ILC
Entropy	1.05095 – 5.01892	3.69954 – 4.17982
Anguler Secound Moment	0.00008 – 0.74840	0.00008 – 0.00028
Mean	10.20608 – 158.26904	113.7815 – 132.54800
Entropy of H_{diff}	0.68777 – 1.92526	1.47797 – 1.90791
Anguler Secound Moment of H_{diff}	0.01402 – 0.400670	0.01479 – 0.04042
Mean of H_{diff}	1.59896 – 31.20632	11.05230 – 30.51935

4. CONCLUSION

Research has been done by formulating a mathematical equation model for classifying types of breast cancer histology. The results obtained from clinical cases can be made the following conclusions.

1) The optimum physical film to mengkalsifikasi histological types of breast cancer is the entropy, angular secound Moment, Mean, Entropy of Hdiff, angular secound Moment of Hdiff, Mean of Hdiff.
2) Determination of the amount of physical models the movie x-ray mammographic images in the determination of histological type of breast cancer could be increase performance in diagnosing breast cancer with a sensitivity of 86.36%.

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