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A Mathematical Modelling for Quality Based Ultrasound Breast Cancer Image Using Colour Properties

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ABSTRACT

Prediction of cancer in an image is most challenging under computerized process. The image chosen must be noisy free for better prediction. The cancer images are available in the form of ultrasound, Magnetic Resonance Image (MRI), Computed Tomography (CT). Since ultrasound image (theme) is not having quality, color map properties are applied to make an ultrasound image to quality image. This coloring preprocessing makes the pixel to high intensity. It helps to predict small particles in an ultrasound image such as node, speculation, angular margin and the quality is measured as Sensitivity, Specificity, Contract Noisy Ratio, and Accuracy. This article has proposed a new technique called Quality Based Image Model (QBIM), using color properties, to generate quality images for segmentation. The aim of this article is to give a new idea for providing a quality image for image segmentation. The resultant image by this approach is better than the image using filtering techniques, which removes noisy spots, smoothening images, sharpening image, and clear visibility of objects. The new approach has tested on a set of ultrasound 2D converted images and positive predicted values are achieved.

INTRODUCTION

Segmentation is the most potent way for predicting medical disease. Predefined techniques for segmentation of images are available. Medical image with good quality images such from MRI, CT scan would be visually clear for the symptoms of disease. However, in the ultrasound image, such quality is missing. Choosing best quality for feature extraction in ultrasound-screened image is challenging criteria. A new technique without using noise removal technique is proposed.

Converting ultrasound images into color image using color map properties like Jet, HSV, Hot, Cool, Spring, Summer, Autumn, Winter, Gray, Bone, Copper, Pink, Lines. These supported color maps programmatically used in MATLAB for converting an ultrasound image into a color image. A color map is defined as mX3 matrix where its value ranges between 0.0 and 1.0. The image is represented as rows and columns and each row is an RGB vector that defines one color. The mth row of the color map defines the mth color, where the map (m, :) = [r (m) g (m) b (m)]) specifies the intensity of red, green, and blue.

Noise removal is the process of adjusting the image pixel values to get a clear view of an image. To obtain the quality of an image, convert an ultrasound image into an RGB color image and again converting back to its original image.

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Computerized techniques for image feature selection in an ultrasound image are tedious task. Several researches, under color segmentation for an image are performed. The process involves getting the pixel values of RGB components of an image and performing segmentation based on the learning. The quality of an image can be calculated based on the sensitivity, specificity, positive predicted value, negative predicted value. Totaling all measurements gives accuracy. If it is 100%, then the quality of an image is good. The contribution of this article is to provide a better quality image for further computerized processing.

Over the last few decades, quite a lot of techniques were merged for selecting quality images for image segmentation. Color based segmentation on data fusion techniques (Rafika Harrabi and Ezzedine Ben Braiek, 2012) emerged to merge several images of different color spaces. All the images are grouped together to get better segmentation results.

Ultrasound elastography provides a color map for real time gray scale image (Andrew Evans, Pasty Whelehan et.al, 2010). Edge detection of any object in a cancer ultrasound image is a tedious process. Since the image has same pixel values at one position, it is hard to group out the objects within a certain area.

The key idea for color segmentation over an ultrasound image is, to fuse the pixel values of RGB of the original image for increasing the quality (Harrabi R, Ben Braiek E, 2011) and to obtain an optimal segmented image. Color based image selection is done with the help of MATLAB tool which provides User Interface techniques. The feature selection of a processed ultrasound image is calculated with common accuracy values. The values of features range in sonographic speculation (87-90%), Deeper than wide (74-80%), Microlobulation (75%), Hyper echoic (74%), Angular Margins (70%), Branching Pattern (30%), Calcifications (25%). Since the object in an ultrasound image would have minor particles, the quality of an image is to be calculated within certain range. The features for malignant tumor are found accurately if the value resides within the range.

The systematic development of color based quality of images is classified as; RGB, HSV, YIQ, XYZ, LAB, and LUV Color spaces. The result is obtained by merging related images (Andrew Evans, Pasty Whelehan et.al, 2010).The rest of the article is composed as follows: Section II explains the method related to Quality Based Image Modeling. Section III introduces the proposed approach for selection of images. Section IV, deals with resulting part of the work. Final section packs together the discussion with a short conclusion.

Analysis Of Existing Methods:

The present era is a computerized world. Due to the environmental changes, health condition of human also changes. Particularly, the human infected by cancer also showing growth in change. To detect accurately the disease by symptoms, it requires quality image. A few methods, which specify the quality of images, are thrashed out beneath.

Rafika Harrabi and Ezzedine Ben Braiek (2012) proposed new color image segmentation based on the multi-level Thresholding that is processed by combining different data related to same color of the image to increase the quality of the image. The Thresholding is based on the Otsu optimization approach and evidence theory is followed to merge several breast cancer cell images in order to get accurate segmentation results.

Andrew Evans, Patsy Whelehan *et al* (2010) defined a new technique called quantitative shear wave ultrasound elastography which states that the quality of the images are compared foe classification and extraction of features in ultrasound benign and malignant images.

Wen Zhu, Nancy Zeng and Ning Wang (2010) contribute a technique that finds the accuracy based on the attributes sensitivity, specificity using statistical methods. Receiver Operating Characteristic (ROC) curve predicts the relationship between both sensitivity and specificity to get the best threshold for test.

Ismail Avcibas, Bulent sankur, Khalid Sayood (2002), categorized the image quality measures as pixel-difference based; correlation-based, edge-based and Spectral-based. They finalized the quality of space spectrum, which used simple multi resolution technique for good quality image.

Quality Based Image Model (Qbim):

It is noted that the problem over existing methods on ultrasound image provides a visually unclear image. Further, the minute particles in 2D images are not visible. The proposed QBIM approach overcomes the drawbacks of existing methods.

(A) Color Properties with pixel representation:

A color map technique is implemented with the original ultrasound 2D image and a color map technique applied for converting the image into any color image by setting the properties like: Jet, HSV, Hot, Cool, Spring, Summer, Autumn, Winter, Gray, Bone, Copper, Pink, Lines. These are the default color properties, which add RGB color on the intensity values.

This application uses the selection of images into 13 color spaces such as Cs=13 color. The 2G image chosen for processing is an ultrasound breast cancer image, which is used to calculate positive predictive value. If the predicted value is nearby or over 99%, the intensity value is high. In addition, the quality of the image is good, if this image were further processed for segmentation or enhancement purpose, it would provide better results for

predicting any kind of symptoms related to medical terms. In Fig.1, the conversion of an image with color map to each pixel P_{xy} of each row at the location (x, y).

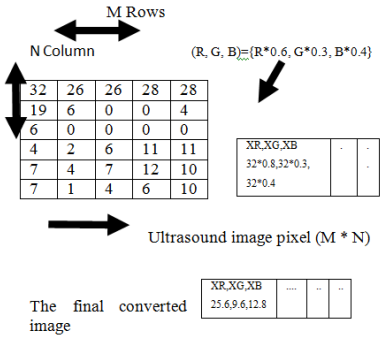

Fig. 1: Color Value calculation of a row in an image.

The images chosen for conversion are taken from an ultrasound image. The format of the image is said to be original, i.e. without using any noise removal techniques. The objects to be detected in an ultrasound breast tumor images are irregular shape, taller than wider, cysts, spreading of tumor cells.

Fig. 2: Original ultrasound breast image.

The original image is processed with color map features. The images with color properties cannot be directly measured and hence it is converted into grayscale images. Histogram for these color inputs can predict the number of colors and its range. The gray converted images are ready for automatic prediction

The complete process for selection of quality image with basis of quality measurements is shown in Fig.3. The color properties such as: Hot, Cool, lines gray, Hsv, copper, jet, winter and more are applied to the original image

Various supporting properties of color map are applied to visualize ultrasound images of Fig.2 and the resultant images are as in Figure 3.

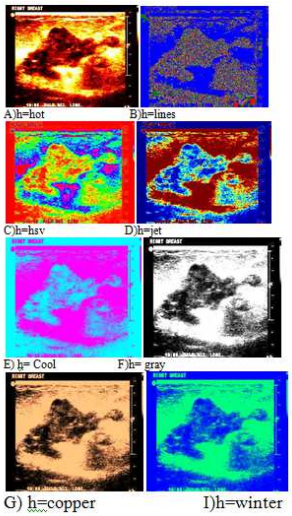

Fig. 3: Ultrasound images using color map properties.

The images generated in Fig.3 are now applying threshold value to increase the intensity of each pixel color. The result is proven that 4-6 values are fixed for good quality. If the threshold value less than 4, the image intensity is slightly changed, but not a clear visual of small particles such as nodes in an ultrasound image are known. If the threshold value greater than 6, shows very high intensity, which results in over brightness and even the object in the ultrasound, gets vanishing.

Then the quality measurements of an image such as sensitivity, specificity, positive predicted value, negative predicted value and accuracy. These measurements should predict the characteristic features of an ultrasound image prescribed by the radiologist.

If the predicted value is greater than the original value, choose the property for auxiliary processing.

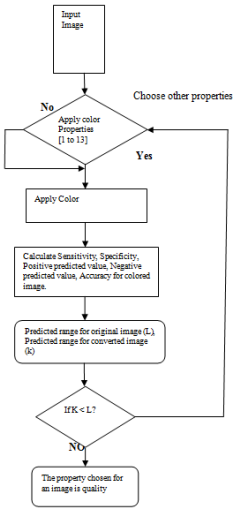

Fig. 4: QBIM Method.

Let M , $L: \Omega \rightarrow G$ be the images described on the image domain Ω, where M stands for the ultrasound breast image (original image) and L stands for the converted image. The difference between the images gives the variation of pixel values. The properties of pixel values are maximized for its original value to improve the visibility of objects in. Finding the correct feature in a medical image is also a challenging task.

Xi stands for a single pixel where i € N, N is the set of all pixels of the image. The conversion of the image is,

$$\sum_{i=1}^{N}(M, L) \rightarrow L(Xi * 2) - M(Xi) \quad (1)$$

In order to illustrate the methods, initially a single medical image is trained for numerical evaluation. After images are converted into RGB format where each of its primeval colors Red, Green and Blue are represented by 8 bits and its intensity values from 0 to 255. The parameters for image selection are various color maps techniques and size of squared window for calculating the difference intensity value among the foreground and background image.

(B) Analysis of Quality Measurement:

As stated before, the quality measurements of an image are reflected by Sensitivity, Specificity, Positive Predicted value, Negative Predicted Value and Accuracy. True Positive Rate and False Positive rate in turn define these factors.

A True Positive Ratio (TPR) is termed as sensitivity, which approach for finding correct diseases based on the case in point. For example, for ultrasound breast image if the images have the possibility of finding the cancer characteristics, then it is measured as sensitivity or counted to true positive ratio.

False Positive Ratio (FPR) is also said to be specificity, which calculates the negative proportion of the measure. For example, the percentage of finding the normal cancer image which does not contain any malignant features.

Sensitivity refers to testing the presence of a particular characteristic in an image with given nature. It is calculated by predicting true positives with summing true positives and false negatives. The equation states,

$$Sensitivity = \frac{True\ positives}{True\ positivies + False\ negatives}$$

Mathematically, referred as,

$$Sen(\%) = \left(\frac{\forall \sum_{i=1}^{n} p\ \epsilon\ M}{\forall \sum_{i=1}^{n} p\ \epsilon\ M + \forall \sum_{j=1}^{m} N\ \epsilon\ M}\right) * 100 \quad (2)$$

Where, n is the number of images, p is the total number of images which is predicted as positive based on the symptoms; m is the number of images with positive symptoms but with negative result, N is the total count images with negative result . M is the total number of images set for testing.

Specificity refers to detecting the absence of specified character and is calculated with true negatives by adding true negatives and false positives.

$$Specificity = \frac{True\ negatives}{True\ negatives + false\ positives}$$

This can be deliberated as,

$$Sensitivity(\%) = \left(\frac{\forall \sum_{i=1}^{n} ne\ \epsilon\ M}{\forall \sum_{i=1}^{n} ne\ \epsilon\ M + \forall \sum_{j=1}^{m} P\ \epsilon\ M}\right) * 100 \quad (3)$$

Since ultrasound images are naturally noisy images, the quality of measurements over noisy image and noisy free images is done. The first calculation for noise ratio is calculated as Contrast to Noisy Ratio (CNR). The noisy ratio is calculated between the background noise and feature of an image. The quantitative result for the dissimilarity images are calculated as,

$$CNR = \frac{Mean(Object) - mean(background\ noise)}{\sqrt{Variance(object)2} + Variance(background\ noise)2}$$

Mathematically represented as,

$$CNR = \frac{\epsilon o - \epsilon b}{\sqrt{\rho o 2} + \rho b 2} \quad (4)$$

Where, Єo is the ratio of mean object.

Єb is the ratio of the mean background noisy image.

ρo refers to the variance of region of interest.

ρb refers to the variance of removal of background noise removal

The similarity between original image and processed image is calculated because the shape and size of the image should not differ in any angle. The mathematical representation for $Correlation\ Quality\ Index\ (CQI)$ [10], is given as,

$$(CQI) = \frac{1}{X} \sum_{x=1}^{X} \frac{C(i,j)2}{\sim C(i,j)2} \quad (5)$$

Accuracy (Acc) is defined by the proportion of true results, whether it is true positive or true negative. It is used for testing the degree of dependability of symptoms in an image. Accuracy also states as the number of correct assessments, to the number of all assessments.

$$Acc = \left(\frac{True\ Negative + True\ positive}{True\ negative + True\ positive + False\ Negative + false\ positive}\right)$$

$$Acc = \frac{\sum TN + TP}{\sum TN + TP + FN + FP} \quad (6)$$

(C) Feature Extraction:

The basic information of an image is obtained from histogram of an image. The probability of density function is the ratio of the values of the intensity level histogram with total number of pixels in an image.

$$Histogram(i) = \frac{h(i)}{H * V} (\ i=0,\ 1 \ldots N) \quad (7)$$

Where:

h- Total number of pixels in an object.

H- Total number of cells in the horizontal spatial domain,

V- Total number of cells in the vertical spatial domain.

N – Total gray level of an image.

The features extracted from ultrasound breast tumor images are Speculation, Taller than Wide, Angular margins, Shadowing, Branching Pattern, Hypoechogenicity, calcification, Duct Extension, Branching pattern, Microlobulation.

(D) Algorithm Specification for selection of quality image:

The following algorithm gives the conversion of pixel values based on the color map properties.

Algorithm QBIM (M, L):

\\ M is the original image,
\\ L is the converting color image
\\ size (M) is the total number of pixels in an image
\\ avg(i) is the testing image values
\\ low (i) is the target image values
\\ FP- False Positive, TP-True Positive
\\ FN-False Negative, TN- True Negative.
\\ TPR- True Positive Rate,

```
\\ FPR- False Positive Rate
\\ L(i) is the pixel value of converted color image
{
u=size (M)
v=size (L)
if (u==v)
{
For i=1 to u
x (i)=L (i)
if x (i) ≠ 0 && x (i) > 50
    avg(i)=x(i)
else
    low (i) =1-x(i)
FP=sum+ (avg(i) * low(i))
TP= sum + (avg (i) * L (i))
FN = sum + (x (i) – TP)
TN= sum + (1 –FP)
TPR = TP / (TP + FN)
FPR = FP / (FP + TN)
End
End
}
End
}
```

RESULTS AND DISCUSSION

The following table1 shows the sensitivity, specificity and accuracy values of an ultrasound breast cancer image. These values are calculated by applying various color map properties and found that the accuracy of color map with gray value is 97.80%.

Table 1: prediction table the cancer tumor.

COLORMAP SUPPORTS	SENSITIVITY (%)	SPECIFICITY (%)	ACCURACY (%)
Jet	99.93	81.13	89.55
HSV	100	81.09	89.56
Hot	100	94.92	97.19
Cool	100	81.09	89.56
Spring	100	81.1	89.6
Summer	100	81.09	89.56
Autumn	100	81.09	89.56
Winter	100	81.09	89.56
Gray	97.82	97.78	97.80
Bone	97.74	97.79	97.77
Copper	98.16	97.15	97.60
Pink	99.65	81.36	89.55
Lines	100	86.99	93.01
Normal gray	94.34	99.19	97.02

The curve illustrates the functionality of the accuracy values among several color map properties. The Y-axis shows the increasing sensitivity value and X-axis shows the False positive rate and the Y-axis shows the True Positive rate. Here the TPR is considered above 90%.

The table below shows the measurement; analysis of ultrasound-converted images by QBIM method and the result is compared with existing techniques Elastography, BI_RADS. The QBIM model shows a better ratio of 97.80%. QBIM method estimates the final accuracy function with respect to high sensitivity (%) i.e. finding of cancer is high and low specificity (%) i.e. less possibility for finding the absence of malignant tumor.

In Fig.5, it explains the outcome of various images with higher accuracy and found that an ultrasound image with gray color map techniques has a greater prediction on cancer images.

The original ultrasound image is converted to color gray image. The edge detection technique is applied to detect the edges clearly and accurately using the canny edge detector. Clearly, all particles in the ultrasound images are separated by edges. This is visible to the user, since the image has higher quality intensity range.

The chart depicts accuracy of five images using QBIM Method. Image 1 has accuracy for predicting cancer 97.8%, 96.11% for image 2, 95.68% for image 3, 92.95% for image 4 and 96.23% for image 5.

Each image has accuracy above 90%. It is understood that the proposed model gives the more probability in prediction of cancer classification.

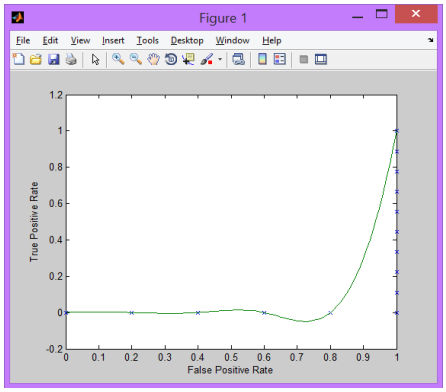

Fig. 5: ROC color based image selection.

Table 2: Comparison of Measurement.

Measurements	Threshold	Elastography	BI-RADS	QBIM Model
Specificity	91.67%	83 %	78%	97.78%
Sensitivity	96.08%	97%	87%	97.82%
Accuracy	94.25%	91%	83%	97.80%

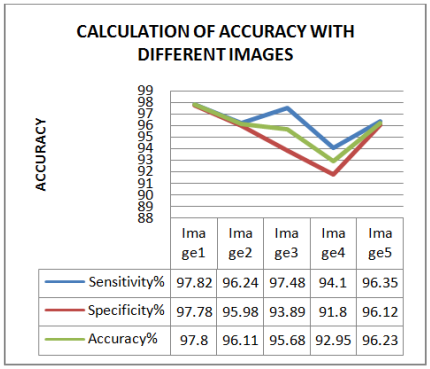

Fig. 6: Graphical representation for 5 images.

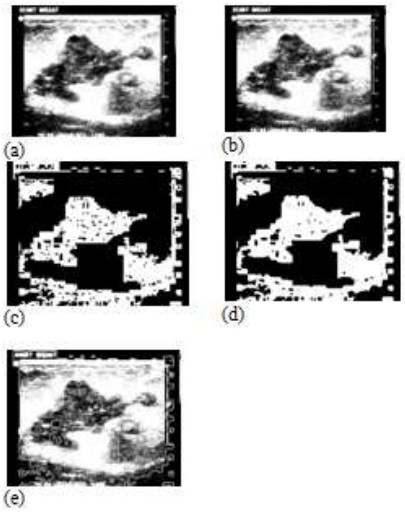

Fig. 7: Segmentation process for detecting edges (a) Original image with gray color map properties,(b) resulting image for computing intensity on first phase,(c)resulting image in second phase, (d) resulting image for high intensity value,(e) resulting image for edge detection.

The Correlation Quality Index (CQI) is calculated for similarity between original image and Quality based image. The result obtained for both the images is measured as 88.6% for image1, 70.5% for image 2, 63.3% for image 3, 80.2% for image 4, 62.1% image 5. The limitation over QBIM method is that the computation of similarity is possible only when the image is converted to gray map properties.

Contract noisy ratio is calculated to find the clear appearance between background and foreground image. The visibility ratio found are line: 172.42, new gray: 88.50, autumn: 90.52, jet: 135.67, cool: 90.95 cooper: 87.59. These values are evaluated with a total number of pixel values in it. The difference between the signal insensitivities in the Region of Interest and Standard Deviation of the pure image noise is calculated.

Conclusion:

This article is presenting a new approach for choosing a high intensity image for computerized operation. The goal is to achieve quality-based image. Using color image and contract function, the image is enhanced and the features: Speculation, Taller than Wide, Angular margins, Shadowing, Branching Pattern, Hypoechogenicity, calcification, Duct Extension, Branching pattern, Microlobulation are extracted well effectively. The accuracy of calculating quality of an image is above 97%.

Instead of using noise removal techniques, color map function converts the image back to grayscale. The image with high intensity is used for predicting features related to prescribe. This technique is more helpful for segmentation and feature extraction of an ultrasound 2D image.

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