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GLCM TEXTURE ANALYSIS ON DIFFERENT COLOR SPACE FOR PTERYGIUM GRADING

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ABSTRACT

GLCM texture features have been widely used to characterize biomedical images. Most of the previous studies using GLCM features to characterize biomedical images only consider single or limited color space due to the use of only one color model. To mimic human color perception, conventional RGB color model may need to be supplemented with other color space models for better human vision representation. This study is aimed to find an optimal set of GLCM features extracted from different color space for pterygium grading. Mimicking human color perception has commonly employed RGB color space, which is shown in this paper is inadequate. GLCM features when extracted in various color space show better representation of human perception (correlation coefficient > 0.6) compared to using RGB color space (correlation coefficient < 0.2).

Keywords: GLCM texture, biomedical, pterygium grading.

INTRODUCTION

A measurable system for looking at pixel composition that regards the spatial associations of pixels is known as Gray-Level Co-occurrence Matrix (GLCM) [1]. The matrix representation operates as textural descriptor by ascertaining how frequently a pixel sequence matches with a particular pattern exists in a two-dimensional image, generating a GLCM. Features based on statistical formula can further be applied on GLCM to quantify the texture pattern of the image, for example, correlation and homogeneity analyses.

GLCM texture features have been widely used to characterize biomedical images. Previous researches include classification of benign and malignant liver tumors [2], lung image registration [3], diagnosis in breast MRI images [4], identification of lobar fissure regions [5], and in the classification of epithelial pre-cancer cells [6].

Most of the previous studies using GLCM features to characterize biomedical images only consider single or limited color space due to the use of only one color model. To mimic human color perception, conventional RGB color model may need to be supplemented with other color space models for better human vision representation. Previous studies have shown that different color space is more perceptually relevant depending upon its applications [7]. Prior research works using different color space mostly focus on solving image segmentation problems [8–10].

Tissue redness has been an important indicator in assessing and diagnosing disease [11–13]. The importance of automating the redness grading has been highlighted previously particularly due to low intra-graders repeatability [14]. However, there is a lack of research to employ GLCM features on different color space to mimic human clinical grading. This study is aimed to fill the gap in the literature.

MATERIALS AND METHODS

A total of 68 eye images affected by pterygium are captured with slit lamp bio microscopy using a diffused white light. Figure-1 shows the images with their respective grades labelled by a clinician. The region of interest is from the apex of the pterygium to the limbus as shown in the Figure-1(a). The grading is treated as a continuous variable.

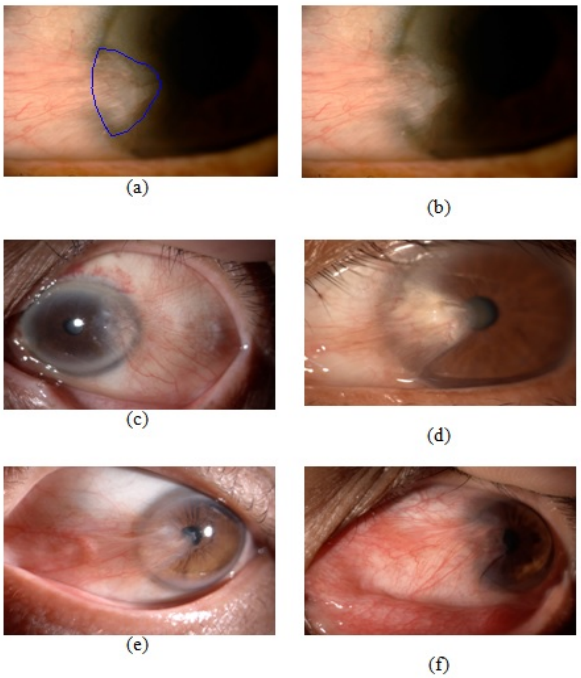

Figure-1. Pterygium grading based on the tissue redness. (a) Grade 1.0, (b) Grade 1.5, (c) Grade 2.0, (d) Grade 2.5, (e) Grade 2.5, (f) Grade 3.0.

The previous research [14] used RGB colour space model as their feature for texture analysis. In this paper, 14 different colour space models are employed as the features for evaluating the quality of pterygium grading. The full list of the colour spaces is available from Table-1.The motivation of using these colour space models is to mimic the real perception of human expert in evaluating these images for grading the pterygium.

Table-1. List of color space used in this work.

HSI
Y'CbCr
sRGB
Y'PbPr
Y'IQ
CIE L*a*b* (CIELAB)
CIE L*u*v* (CIELUV)
Y'DbDr
CIE XYZ
JPEG-Y'CbCr
CIE L*ch
HSV
HSL
Y'UV

The steps undertaken to extract these features using these colour spaces are summarized in Figure-2. For every image and its selected region of interest that are marked for pterygium grading are retrieved in Red, Green and Blue colours. Next, the Matlab Toolbox developed by Pascal [15] is used for converting this image from the RGB colour model to the other 14 colour space models. A matrix is created to split every colour spaces into its 3 components. The total number of textures for the entire colour space models that are produced for each image is 168. Following this, only the selected region of interest are considered for the conversion to GLCM and the remaining pixels residing outside these area are assigned as not a number (NaN).

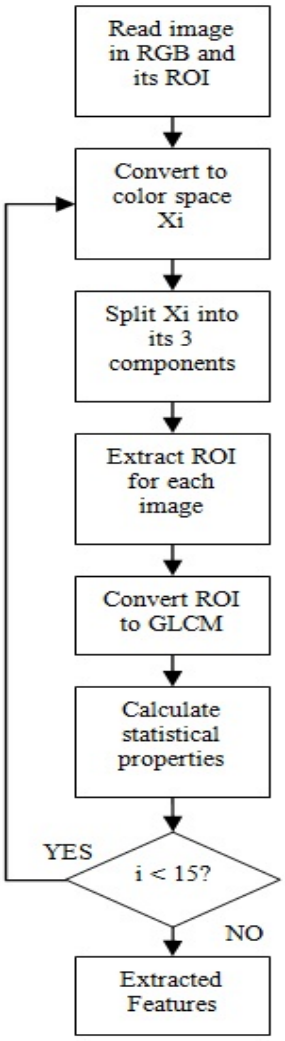

Figure-2. Flow chart on extracting features based on GLCM properties.

Figure-3 demonstrates the conversion to GLCM. The value of each pixel is set between the ranges of 1 to 8, which indicates the level of intensity for each colour component in the image. The spatial relationship between each pixel from the region of interest is determined by calculating the frequency of the intensity of that pixel in i against its adjacent pixel in j.

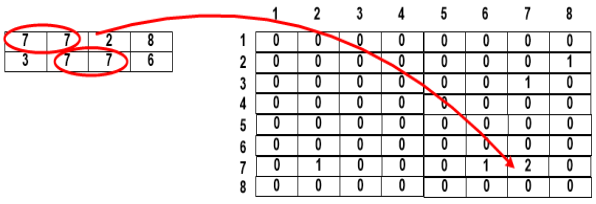

Figure-3. The construction of GLCM (right) from a hypothetical image with varying intensity (left).

For example, in Figure-3, the value 2 in element (7,7) from the GLCM is the total sum of co-occurrence between the adjacent pixels with the same intensity of 7 throughout the image. The algorithm will scan from these pixels from left to right until it reaches the end of the pixel. The remaining elements from the GLCM have the value of 1 and 0 because the sum of co-occurrence between its respective adjacent pixels is 1 or 0.

The GLCM produced is used to statistically examine spatial distribution of the pixels' intensity levels in this image. The statistical analyses employed for the texture analysis are contrast, correlation, energy, homogeneity. The details on these statistical properties are described below.

Contrast measures the differences in intensity between a pixel against the remaining pixels in the image. It is defined as,

$$\text{Contrast} = \sum_{i,j} |i-j|^2 p(i,j),$$

where p(i,j) is the position of the GLCM in that the value represent the sum of co-occurrence between adjacent pixels of i and its neighbour j.

Correlation measure the level of correlations between a pixel against the remaining pixels in the image. It is defined as,

$$\text{Correlation} = \sum_{i,j} \frac{(i-\mu_i)(j-\mu_j)p(i,j)}{\sigma_i \sigma_j}.$$

Energy measure the summation of squared element in the entire GLCM. It is formulated as,

$$\text{Energy} = \sum_{i,j} p(i,j)^2.$$

Homogeneity measure the similarity in the variation of the distribution in the GLCM against the diagonal of the matrix. It is defined as,

$$\text{Homogeneity} = \sum_{i,j} \frac{p(i,j)}{1+|i-j|}.$$

RESULTS

Figure-4 shows the results of correlation analysis between the GLCM features and scores from the human grading. Four features are identified as good features with correlation coefficients more than 0.6. The features are GLCM-Contrast (Pr component of Y'PbPr color space), GLCM-Energy (Pr component of Y'PbPr color space), GLCM-Homogeneity (Pr component of Y'PbPr color space), and GLCM-Energy (V component of Y'UV color space). The features extracted from conventional RGB color space perform poorly with correlation coefficients less than 0.2.

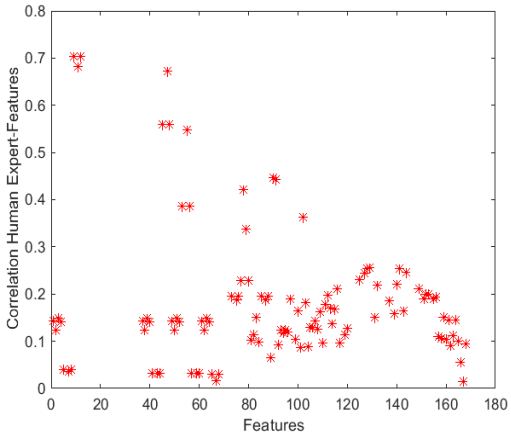

Figure-4. Correlation between human grading and the GLCM features extracted from images with different color space.

CONCLUSIONS

This research work identifies a set of good GLCM features that can be used in the future on modeling human perception of tissue redness. It has been proven that GLCM features extracted from conventional RGB color space are not sufficient and must be supplemented with features in other color space. GLCM features when extracted in various color space show better representation of human perception (correlation coefficient > 0.6) compared to using RGB color space (correlation coefficient < 0.2).

However, with a single feature, the best GLCM feature can only account for 49.63% (from r-squared analysis) variability of the human grading. Fusion of multiple features is warranted to produce a better model of pterygium grading. Experiments with different type of textural features which include fractal dimension [16, 17] may also further be tested in future research.

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