

Texture Feature Extraction of Video Frames Using GLCM

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II RELATED WORK

Abstract-This paper presents a novel system for texture feature extraction of video frames using Gray Level Co-occurrence Matrix (GLCM).GLCM extraction is done using hardware. Texture is one of the important characteristics used in identifying regions of interest or objects in an image. GLCM is one of the statistical method of examining texture that considers the spatial relationship of pixels is the GLCM, also known as the gray level spatial dependence matrix. The GLCM functions are used to characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship that occurs in an image. This created GLCM is then used for extracting statistical measures.. GLCM is a second order statistical feature which contains information about pixels having similar gray level values in an image.

Keywords- Texture Analysis, GLCM, FPGA, Statistical method

I. INTRODUCTION

Texture is important aspect of an image that has been widely used in medical image classification, visual inspection, remote sensing. Textures are generally complex visual patterns that have characteristics such as brightness, colour, slope, and size. Texture features can be extracted in several methods, namely, statistical, structural, model-based, and transform information. Each method has different techniques. A well-known algorithm to extract texture features is the use of Gray Level Co-occurrence Matrices (GLCMs), which belongs to the statistical methods. The GLCM contains the second-order statistical information of spatial relationship the pixels of an image. Haralick has extracted many statistical features known as Haralick texture features using the GLCMs.

GLCM is created from a gray-scale image. The GLCM contains information about how often a pixel with gray-level (gray scale intensity or Tone) value i occurs either horizontally, vertically, or diagonally to adjacent pixels with the value j . Where i & j are the gray level values (tone) in an image.

Gray Level Co-occurrence is second order statistic measurement that contains information about the positions of pixels having similar gray level values. Haralick has extracted many statistical features known as Haralick texture features [1] using the GLCMs.

Second-order statistics [2] are defined as the likelihood of observing a pair of gray values occurring at the endpoints of a dipole (or needle) of random length placed in the image at a random location and orientation. GLCM directions of analysis:-Horizontal (0° or 180°), Vertical (90° or 270°), Right Diagonal (45° or 225°), Left diagonal (135° or 315°). Denoted as P_0 , P_{45} , P_{90} , & P_{135} respectively.

Fig.1 shows directional analysis [3] of $P(0^\circ)$, $P(45^\circ)$, $P(90^\circ)$, $P(135^\circ)$ in an image. If the adjacent pixel to the pixel of interest is along x axis then it referred to as 0° directional analysis. If the adjacent pixel to the pixel of interest is along 45° then it referred to as 45° directional analysis. If the adjacent pixel to the pixel of interest is along 90° then it referred to as 90° directional analysis. If the adjacent pixel to the pixel of interest is along 135° then it referred to as 135° directional analysis. For each direction GLCM can be calculated. We can obtain four different GLCM for a same image or image sub-region.

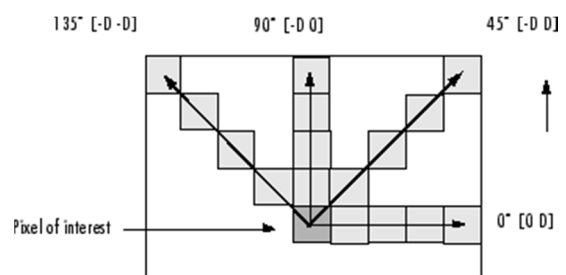


Fig.1: Directional analysis

The following figures explain how to create GLCM for an input image .Consider an input image as shown in fig. 2 and its corresponding intensity matrix.

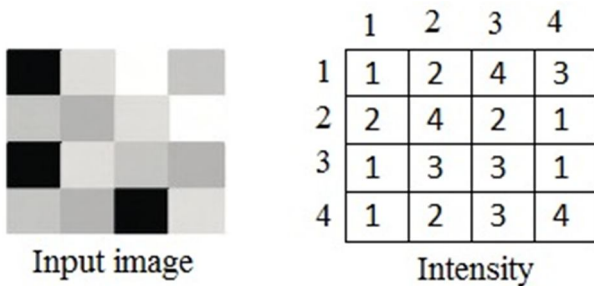


Fig. 2: Input image and its corresponding intensity levels

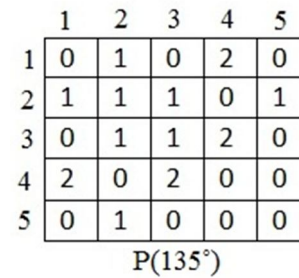


Fig. 6: GLCM for 135°

III TEXTURE FEATURES

GLCM is a $N_g \times N_g$ matrix, where N_g is the number of gray levels in the input image. Number of pixel pair repetitions are counted and updated in the GLCM matrix.

GLCM can be created for four directions namely 0° , 45° , 90° , 135° . Figure 3, figure 4, figure 5, figure 6 shows GLCM for 0° , 45° , 90° , 135° respectively.

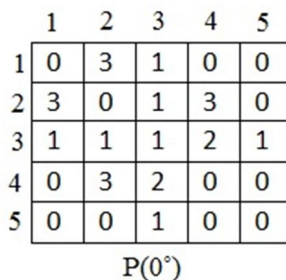


Fig. 3: GLCM for 0°

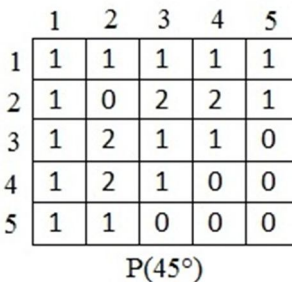


Fig. 4: GLCM for 45°

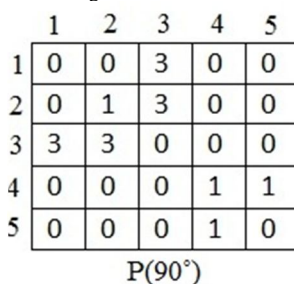


Fig. 5: GLCM for 90°

Haralick has extracted many properties or features from GLCM. To extract Haralick features GLCM should be a symmetric and normalized matrix. To make a matrix symmetric, we should take transpose of GLCM and add it with the original GLCM. To get a normalized matrix, calculate sum of all elements in a GLCM and divide each element of the matrix with the obtained sum. From the normalized symmetrical GLCM texture features are extracted.

The properties or features [1] extracted from normalized symmetrical GLCM are

1. Energy or Angular second moment
2. Correlation.
3. Homogeneity.
4. Contrast.

Energy parameter is also called as Uniformity. Energy measures textural uniformity, i.e., pixel pairs repetitions; when the image patch under consideration is homogeneous (only similar gray level pixels are present) or when it is texturally uniform. Energy is a feature that measures the smoothness of the image. Less smooth the region is, the more uniformly distributed P_{ij} and the lower will be the value of ASM.

$$\text{Energy} = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} P_{ij}^2 \tag{1}$$

where P_{ij} is the ij th entry of the normalized co-occurrence matrix, N_g is the number of gray levels of the video frame.

Correlation is a measure of gray tone linear-dependencies in the image, in particular, the direction under investigation is the same as vector displacement. High correlation values (close to 1) imply a linear relationship between the gray levels of pixel pairs. Thus, GLCM correlation is uncorrelated with GLCM energy and entropy, i.e., to pixel pairs repetitions. Correlation reaches its maximum regardless of pixel pair occurrence, as high correlation can be measured either in low or in high energy situations

$$\text{Correlation} = \frac{\sum_{i=1}^{N_g} \sum_{j=1}^{N_g} i \cdot j \cdot P_{ij} - \mu_x \cdot \mu_y}{\sigma_x \cdot \sigma_y} \tag{2}$$

where $\mu_x, \mu_y, \sigma_x,$ and σ_y are the means and standard deviations of the marginal probabilities $P_x(i)$ and $P_y(j)$ obtained by summing up the rows or the columns of matrix P_{ij} respectively.

Homogeneity parameter also known as inverse difference moment measures image homogeneity as it assumes larger values for smaller gray tone differences in pair elements. Homogeneity is a measure that takes high values for low-contrast images.

$$\text{Homogeneity} = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} \frac{1}{1 + (i - j)^2} \cdot P_{ij} \quad (3)$$

Contrast parameter measures the spatial frequency of an image and is difference moment of GLCM. It is the difference between the highest and the lowest values of a contiguous set of pixels. It measures the amount of local variations present in the image. A low contrast image presents GLCM concentration term around the principal diagonal and features low spatial frequencies.

$$\text{Contrast} = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i - j)^2 \cdot P_{ij} \quad (4)$$

IV DESIGN FLOW

Steps involved in the proposed design are shown in fig.7.

Steps involved are as explained below:

- A. First step in the project is to extract frames from video
- B. Create Gray Level Co-occurrence Matrix(GLCM), It will be a square matrix $N \times N$ in size where N is the Number of gray levels .The matrix is created as follows:
 1. Let s be the pixel of interest for the calculation
 2. Let W be the set of samples surrounding pixel s which fall within a window centered upon pixel s of the size specified for the video frame.
 3. Considering only the samples in the set W , define each element i,j of the GLCM as the number of times two samples of intensities i and j occur in specified Spatial relationship (where i and j are intensities between 0 and Number of gray levels)

The sum of all the elements i, j of the GLCM will be the total number of times the specified spatial relationship occurs in W

- C. Make the GLCM symmetric:
 1. Make a transposed copy of the GLCM
 2. Add this copy to the GLCM itself

This produces a symmetric matrix in which the relationship i to j is indistinguishable for the relationship j to i (for any two intensities i and j). As a consequence the sum of all the elements i, j of the GLCM will now be twice the total number of times the specified spatial relationship occurs in W (once where the sample with intensity i is the reference sample and once where the sample with intensity j is the reference sample), and for any given i , the sum of all the elements i, j with the given i will be the total number of times a sample of intensity i appears in the specified spatial relationship with another sample

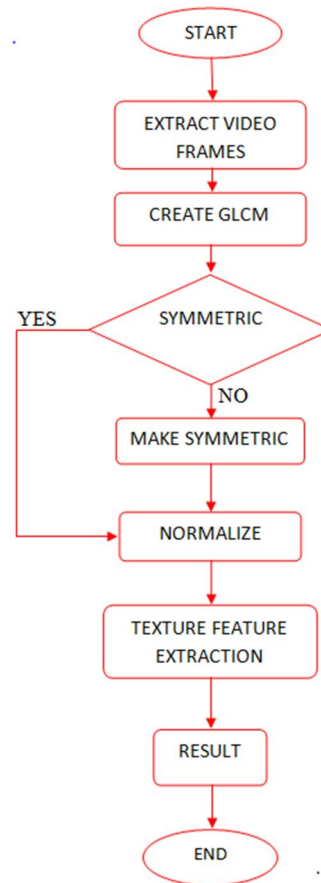


Fig. 7: Flow chart of the system

- D. Normalize the GLCM: Means expressing the elements of GLCM in probability. After making GLCM symmetrical there is still one more step to take before texture features can be calculated. The measure requires that each GLCM cell contain not a count ,but rather a probability .Probability here means total number of times an outcome occurs, divided by sum of all possible outcomes

Divide each element by the sum of all elements. The elements of the GLCM may now be considered probabilities of finding the relationship i, j (or j, i) in W

- E. Texture feature extraction
Texture features namely Contrast, Correlation, Energy, Homogeneity are extracted and results are tabulated

V RESULTS

Video frames are extracted from a video. The obtained frames will be resized to 8x 8 image[4], then this image will be scaled down to 8 tone image (image having pixel values from 1 to 8). For this image GLCM is created and texture features are extracted from each frame. Fig.8 shows the extracted image from a video. This frame will be converted to gray scale image. Then this gray scale image is resized to 8x8 matrix and scaled down to 8 tone image. This scaled down matrix is as shown in fig. 9.



Fig. 8: video frame 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | 4 | 5 | 6 | 8 | 7 | 4 | 6 |
| 2 | 3 | 5 | 7 | 8 | 5 | 5 | 5 |
| 2 | 3 | 5 | 6 | 6 | 6 | 6 | 5 |
| 2 | 3 | 3 | 3 | 4 | 6 | 6 | 3 |
| 1 | 2 | 2 | 2 | 3 | 3 | 2 | 1 |
| 1 | 1 | 2 | 3 | 3 | 3 | 2 | 1 |
| 2 | 2 | 1 | 3 | 4 | 4 | 3 | 3 |
| 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

Fig. 9: Scaled down image

Simulation result obtained from Xilinx Isim for GLCM is as shown in figure 10. update_matrix shows the output (GLCM) values. a and b represents the position and c, d represents the inputs. Figure 11 represents the GLCM obtained from simulation.

Features extracted from video frame 1:

- Contrast : 1.8202
- Correlation : 0.7358
- Energy : 0.0542
- Homogeneity : 0.5824

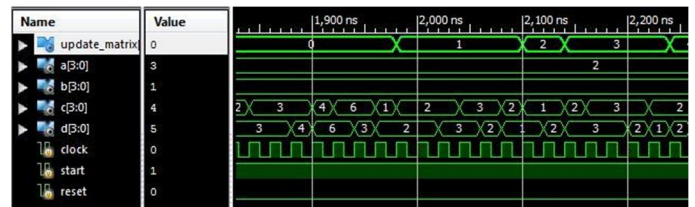


Fig. 10: Simulation result of GLCM

| | | | | | | | |
|---|---|----|---|---|---|---|---|
| 1 | 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| 5 | 3 | 8 | 1 | 0 | 0 | 0 | 0 |
| 1 | 8 | 12 | 3 | 2 | 1 | 0 | 0 |
| 0 | 1 | 3 | 1 | 1 | 2 | 1 | 0 |
| 0 | 0 | 2 | 1 | 2 | 3 | 1 | 1 |
| 0 | 0 | 1 | 2 | 3 | 4 | 0 | 1 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 |
| 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 |

Fig. 11: GLCM for video frame 1

V.CONCLUSION

In this paper, a novel system for texture feature extraction of video frames using GLCM method is proposed. The design was focused on GLCM hardware realization and texture feature extraction from software. The results were cross checked with simulation results.

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