Texture Feature Extraction using GLCM & Wavelets for Image Classification

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Abstract-Classifying images in an ever increasing and large image datasets has become an exigent task for computer vision and pattern recognition applications. In this article, a statistical method that considers the spatial relationship of pixels i.e., the gray-level co-occurrence matrix (GLCM), also known as the gray-level spatial dependence matrix is used to identify texture features. PCA is applied to reduce the dimensionality of data and build train feature matrix. Five different distance measure techniques are used for classification purpose. Proposed method is demonstrated on a very large yet challenging Caltech-101 dataset and observed the impact of GLCM texture features in terms of improved classification accuracy in comparison with some of the popular techniques found in literature.

Keywords – texture feature extraction, GLCM, PCA, image classification

I. INTRODUCTION

"Pictures are not just to be framed off, but a single picture is worth a thousand words" this single quote conveys that still images are not just meaning full but also conveys conceal complex content. The advancement in internet and image acquisition techniques have given away tremendous increase in digital image collections. The application potential of controlling these large image datasets has drawn considerable attention of researchers to improve various proficiencies to browse, store and retrieve images from large image chronicles. Content-based image retrieval (CBIR) technique extracts visual contents of an image such as color, shape, texture, and spatial layout to represent and index the image. Comprehensive surveys on many academic and commercial retrieval systems developed by universities, government organizations, companies, and hospitals can be found. Image retrieval system is a process of matching a query image across a large multiclass image dataset and retrieving similar images. IreS can be divided into three stages, namely, pre-processing, feature extraction and classification. In pre-processing stage, image segmentation is performed to decompose an image into its components and considered as an important step for image content analysis before moving-on to identify them. The main aim is to extract salient features from segmented image data to develop descriptors. A major task after feature extraction is to classify the object into one of several classes. In the following sections, we present an overview of the Texture Feature extraction using GLCM for Image Classification.

II. PROPOSED ALGORITHM

A. Texture Feature Extraction –

GLCM In statistical texture, the surface pattern is not consistently repeated in the same form such as different flower objects in an image that usually contains similar properties but not the same. According to the count of intensity pixels in every union, statistics are grouped into first-order, second order and higher-order statistics. Co-occurrence matrix is a well-known depiction of texture feature of an image. The texture of image is a demonstration of spatial relationship of grey level image. Co-occurrence matrix is established based on the orientation and distance between image pixels. Texture information can be extracted from image using co-occurrence matrix. There are numerous texture features that are extracted from an image using co-occurrence matrix, known as contrast, entropy, homogeneity, and energy. These features represent image as texture features.
• The Gray Level Co-occurrence Matrix (GLCM) is a simple way of bringing up 2nd order statistical texture features.

• This is an analytical method of scrutinizing texture that considers the spatial association of pixels, also known as the grey-level spatial dependence matrix.

• The functions of GLCM distinguishes the texture of an image by designing how often pairs of pixels points with specific values and in a specified spatial dependence occur in an image and then extracting statistical measures from this matrix.

• After the GLCM is created using “graycomatrix”, we can acquire specific statistics from them using “graycoprops”. From these statistics we can obtain information about the texture of an image.

• The resultant GLCM of each element (m, n) is the sum of the frequently occurring pixel with value ‘m’ that take place in described spatial relationship to a pixel with value ‘n’ in the query image. The count of grey levels in the image determines the size of the GLCM.

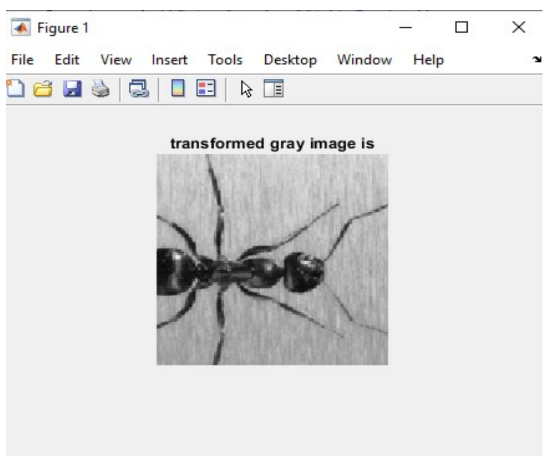
• Sample results of GLCM in MATLAB:

Input image

http://dx.doi.org/10.21172/ijiet.223.03

432	148	22	9	1	0	0	0
137	493	161	74	25	2	0	0
20	172	225	119	72	25	0	0
3	47	116	128	132	90	5	0
0	24	82	120	560	823	13	0
0	0	24	70	803	5976	888	0
0	0	0	1	15	897	3276	12
0	0	0	0	1	0	11	2

Gray co-occurrence Matrix



Transformed Grey Scale Image.

B. Principal Component Analysis

Principal Component Analysis (PCA) is a linear dimensionality reduction technique algorithm that covert a set of unrelated variables into a smaller 'i' number of uncorrelated variables called principal components while keeping as much of the variability. Decreasing the number of components of the data set is obtained at the cost of accuracy. In view of the fact that small scale data sets are easy to traverse and envision and make data analysis faster for machine learning algorithms without irrelevant variables to process.

Standardization:

• Standardization of continuous initial variables in order to get each vale of them contribute equally to the analysis.

• More concretely, the reason why it is critical to perform standardization prior to PCA, is that the latter is quite sensitive regarding the variances of the commencing variables. That is, if there are large dissimilarities between the ranges of primitive variables, those variables with larger ranges of primitive variables, those variables with larger ranges will influence over those with small ranges which will lead to biased results. So, converting the data to comparable scales can prevent this problem.

• Mathematically, this can be represented as:

$$Z = \frac{value - mean}{standard\ deviation}$$

co-variance matrix computation:

• In computation of co-variance matrix, the input variables of data set are from the mean with respect to each other, or in other way, to see if there is any association between them. Because sometimes, variables are highly correlated in such a manner that they have reductant content. So, to identify these correlations, we mathematically compute the covariance matrix.

• The covariance matrix m×m symmetric matrix that has entries the covariances associated with the possible pairs of the initial variables.

$$\begin{bmatrix} Cov(a,a) & Cov(a,b) & Cov(a,c) \\ Cov(b,a) & Cov(b,b) & Cov(b,c) \\ Cov(c,a) & Cov(c,b) & Cov(c,c) \end{bmatrix}$$

• Therefore, Covariance of a variable with its own components is its variance (Cov (a, a) =Var(a)), in the main diagonal the variances of each initial variable. Since the covariance is commutative accordingly, (Cov (a, b) =Cov (b, a)), the inputs of the covariance matrix are symmetric to the main diagonal, i.e., upper and the lower triangular portions are same.

computation of the eigen vectors and eigen values of the covariance matrix to identify the principal components:

• Eigen vectors and Eigen values are linear algebra abstractions that are needed to compute from covariance matrix to identify the "principal components" of the data. But first we need to have knowledge of principle components.

• These variables are new that are put up as linear combinations of the initial variables. These combinations are done in such a way that the upcoming variables are unrelatable and most of the content within the initial variables is suppressed into 1 st components.

• Sorting information in PC (principal components) will let us to reduce the dimensionality without losing more information, and this is by rejecting the contents with lower information and considering the remaining components as new variables.

• An important thing to acquire here is that the principal components are less understandable don't have any real measure since they are constructed as linear combinations of the initial variables

. • Generally, PC illustrate the data directions that describe a "maximal amount of variance" i.e., the lines that capture most information of the data.

C . ***Wavelets:***

Color being the most important low-level features used in image retrivel but sometimes this bears most unsatisfactory results. DWT (Discrete Wavelet Transform) is different from the existing histogram-based methods. The proposed algorithm gives out feature vectors that include both color and edge features. This paper also uses wavelet transform to reduce the size of the feature vector. The validity of the system is also verified against the input image (query) for alterations such as geometric deformations and noise addition.

D. ***Classification - Distance Measure Techniques Euclidean Distance:***

The Euclidean distance is the distance between any two points in Euclidean space. The two points L and M in 2D Euclidean spaces and L with the coordinates (L1, L2), M with the coordinates (M1, M2). The line segment with the endpoints of L and M will form the hypotenuse of a right-angled triangle. The distance between 2 points L and M is defined as the square root of the tally of the squares of the subtractions between the corresponding coordinates of the points.

The 2D Euclidean geometry, the Euclidean distance between 2 points is a = (ax, ay) and b = (bx, by) is defined as:

$$d(a,b) = \oint (bx - ax)^2 + (by - ay)^2$$

II. Experiment and Result

A. ***Datasets:***

Caltech-101 dataset is the overall collection of images that is used in our project containing 101 rows of images with each row containing set of images varying from 40-55 images in each row. Totally containing 9,165 images in whole. Each row contains set of images like Accordion, Anchor, Bonsai, Trees, Fishes, Aeroplan, Barrel, Binocular and much more.

Figure 1. **Sample images of Caltech – 101 Dataset**

Figure Labels: Each image is labeled as shown below:
1i_1v to 1i_55v (Accordion set)
2i_1v to 2i_800v (Aeroplan set)
3i_1v to 3i_42v (Anchor set)
4i_1v to 4i_42v (Ant set)
Similarly continued till 101 set as 101i_1v to 101i_40v (Spanner set).

B. ***Experimental Procedure:***

With the increasing popularity of embedded devices and the increased development of the internet network, a noticeable growth in technological improvement has been witnessed in the last decade. Digital images have made their way in many fields like digital marketing, video gaming, editing world and all other important scenarios. Thus, having a tremendous growth in digital field. Texture Feature extraction using GLCM for Image Classification for Content based image retrieval is a well guided solution to retrieve relevant images from a set of images by considering the query image. Image retrieval is used in many fields for different purpose where particular image is retrieved based on user request. Thus, image retravel is the most upcoming field of research in the present scenario. The main reason why we have used Texture Feature extraction using GLCM is that compared to RGB (the color image extraction) type of extraction GLCM gives higher accuracy and steps of the MATLAB code is reduced as much as possible.

There are two Techniques for image retrieval:

➢ *Text based image retrieval:* Images are annotated with a textual description and their retrieval is based on matching the user's textual description.

➢ *Content based image retrieval (CBIR):* In Content based image retrieval or query-based image retrieval (QBIR) Images are given as query image by the user and the system retrieves the similar images from database to the user.

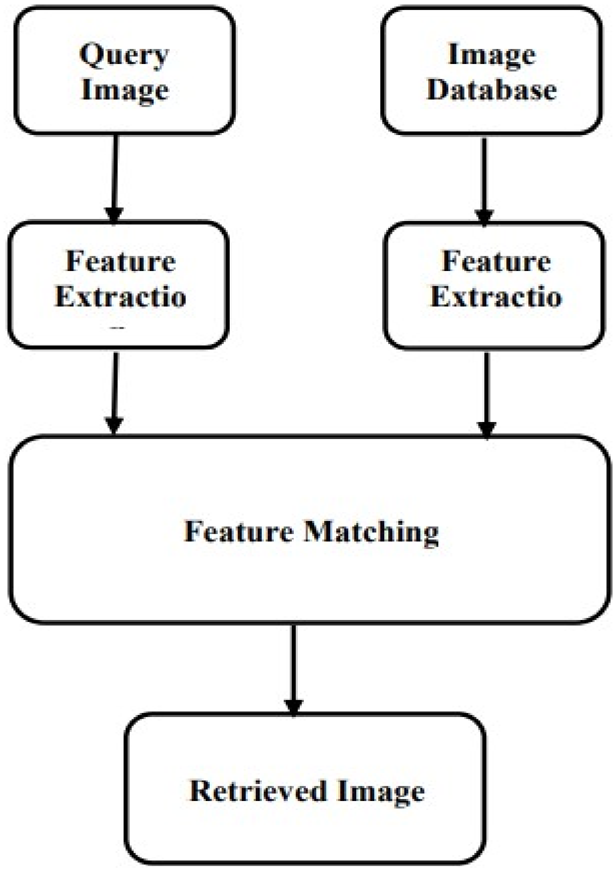
Image retrieval process has two phases namely:
• Training phase: Processing of images in database to similarity matching.
• Training phase: Images – resized -- texture feature extraction using GLCM -- vectorize—PCA -- Feature vector – database. • Testing phase: Processing of query image to similarity matching.
• Testing phase: Query image – resized -- texture feature extraction using GLCM -- vectorize -- distance measure (comparison with feature vector of training phase) -- classification result.

Each phase has 3 major stages:
• Pre-processing
• Feature extraction and
• Similarity matching.

Pre-processing: For enhancement and improvising the image data for further process. In this step it's all about Resizing of image, conversion of image (RGB to grey), reducing the dimensionality using PCA. Thus, making all primitive changes of image needed.

Features extraction: Features of the query and database images are extracted, and data is transformed into numerical value i.e., its vectorized mainly we have implemented the texture feature extraction using GLCM for its advantage in accuracy and also, we obtain the gray co-occurrence matrix at this stage.

Block Diagram Representing the Process



Similarity matching: Feature vectors of the query image and the eigen values of images in database are compared here by implementing the Distance Measure Technique Euclidean Distance. The system goes on comparing each vectorized values of query matrix and eigen matrix thus, preparing for retrieval of image having close similarities.

Retrieval of images: Based on the comparison results the similar images are retrieved.

*C. **Results:***

The result table clearly depicts the accuracy percentage of the algorithms and methodology that we have implemented. The table-1 gives the clear picture on how GLCM has an overall accuracy for varying projection vector in percentage. Coming to table-2 it gives the clarity regarding the best distance measure technique i.e., Euclidian being best in performing distance measures. Finally, a look over of table -3 depicts that our methodology is better than Ridgelets+GRNN and is approximately equal to Serrre et al and Holub et al. but also being competitive to Berg et al.

TABLE I. OVERALL ACCURACY FOR VARYING PROJECTION VECTOR

Method/ projection vector	**Recognition Accuracy in %**				
	10	***20***	***30***	***40***	***50***
GLCM Texture Feature	26.04	21.61	21.04	20.09	17.19

TABLE II. PERFORMANCE MEASURE FOR DIFFERENE DISTANCE MEASURE TECHNIQUES

Method/ Distance	**Recognition Accuracy in %**			
	Manhattan	***MSE***	***Euclidian***	***Angle based***
GLCM Texture Feature	20.95	10.9	25.99	20.1

TABLE III. COMPARATIVE ANALYSIS

Method	Recognition Accuracy in %
Serrre et al. [180]	35
Holub et al. [12]	37
Berg et al. [11]	45
Ridgelets+GRNN [13]	22
Coslets+GRNN []	31
Proposed GLCM	29

IV.CONCLUSION

Image classification in very large datasets has been active research in computer vision and pattern recognition applications. Wavelets extracts features in both time as well as frequency domain and found to be very effective when combined with GLCM technique to discover significant texture features from given image. PCA is helpful to obtain discriminant features in reduced feature vector space to reduce the computational time with increase in recognition accuracy along with different distance measure techniques. Overall, GLCM, wavelets & PCA seems to provide better results, yet lot of research effort is required to exploit the perceptually visual features combining color, shape, and texture to reduce the semantic gap between high level semantics and low-level machine features.

V. REFERENCE

[1] Ritendra Datta, Dhiraj Joshi, Jia Li, and fames Wang Image retrieval ideas influences and trends of the new age. ACM Computing Surveys, 40(23-1-60, 2008.

[2] Wavelet-based fingerprint image retrieval Javier A. Montoya Zegarra , Neucimar J. Leite , Ricardo da Silva Torres b a Computer Engineering Department, Faculty of Engineering, San Pablo Catholic University, Av. Salaverry 301, Vallecito, Arequipa, Peru b Institute of Computing, University of Campinas, Av. Albert Einstein, 1251, CEP 13084-851, Campinas, SP, Brazil.

[3] LS-SVM based image segmentation using color and texture information q Hong-Ying Yang a , Xiang-Yang Wang , Qin-Yan Wang a , Xian-Jin Zhang , School of Computer and Information Technology, Liaoning Normal University, Dalian 116029, China b State Key Laboratory of Information Security, Institute of Software, Chinese Academy of Sciences, Beijing 100190, China

[4] A New and Effective Image Retrieval Method Based on Combined Features Pengyu Liu; Kebin Jia; Zhuozheng Wang; Zhuoyi Lv 2016.

[5] A deep one-shot network for query-based logo retrieval Ayan Bhunia , Akan Bhunia b funded by the National Research Foundation of Korea (NRF).

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[7] Y. Dai, M. Yuan, H. Tang and R. Yan, "A temporal encoding method based on expansion representation," 2019 International Joint Conference on Neural Networks (IJCNN), 2019, pp. 1-8, doi: 10.1109/IJCNN.2019.8851973.

[8] F. Cen, X. Zhao, W. Li and F. Zhu, "Classification of Occluded Images for Large-Scale Datasets With Numerous Occlusion Patterns," in IEEE Access, vol. 8, pp. 170883-170897, 2020, doi: 10.1109/ACCESS.2020.3025035.

[9] K. T. Ahmed, S. Aslam, H. Afzal, S. Iqbal, A. Mehmood and G. S. Choi, "Symmetric Image Contents Analysis and Retrieval Using Decimation, Pattern Analysis, Orientation, and Features Fusion," in IEEE Access, vol. 9, pp. 57215-57242, 2021, doi: 10.1109/ACCESS.2021.3071581.

[10] J. Yan, G. Qin, R. Zhao, Y. Liang and Q. Xu, "Mixpred: Video Prediction Beyond Optical Flow," in IEEE Access, vol. 7, pp. 185654-185665, 2019, doi: 10.1109/ACCESS.2019.2961383.

[11] T. L. Berg A. C. Berg and J. Malik. Shape matching and object recognition using low distortion correspondence. In IEEE CVPR, 1:26–33, 2005.

[12] M. Welling A. Holub and P. Perona. Exploiting unlabelled data for hybrid object classification. In NIPS Workshop on Inter-Class Transfer, Whistler, B.C., 2005.

[13] Mahantesh, K., Geetha, G.P. (2015). An Investigation of fSVD and Ridgelet Transform for Illumination and Expression Invariant Face Recognition. In: El-Alfy, ES., Thampi, S., Takagi, H., Piramuthu, S., Hanne, T. (eds) Advances in Intelligent Informatics. Advances in Intelligent Systems and Computing, vol 320. Springer, Cham. https://doi.org/10.1007/978-3-319-11218-3_4.

[14] Mahantesh, K., Aradhya, V.N.M., Niranjan, S.K. (2015). Coslets: A Novel Approach to Explore Object Taxonomy in Compressed DCT Domain for Large Image Datasets. In: El-Alfy, ES., Thampi, S., Takagi, H., Piramuthu, S., Hanne, T. (eds) Advances in Intelligent Informatics. Advances in Intelligent Systems and Computing, vol 320. Springer, Cham. https://doi.org/10.1007/978-3-319-11218-3_5.