Classification of Archaeological Monuments for Different Art forms with an Application to CBIR

Padmashree Desai
Dept. of CSE
BVBCET
Hubli, India
padmashri@bvb.edu

Jagadeesh Pujari
Dept. of ISE
SDMCET
Dharwad, India
jaggdp@yahoo.com

N.H.Ayachit
Dept. of Physics
BVBCET
Hubli, India

V. Kamakshi Prasad
Dept. of CSE
JNTU
Hyderabad

***Abstract*—Until now, Content Based Image Retrieval (CBIR) techniques barely contributed to the archaeological domain. The use of these techniques can support archaeologists in their assessment and classification of archaeological finds. Museums and art galleries deal in inherently visual objects. The ability to identify objects sharing some aspect of visual similarity can be useful both to researchers trying to trace historical influences, and to art lovers looking for further examples of paintings or sculptures appealing to their taste. This paper illustrates the use of CBIR techniques for automatic classification of archaeological monuments using visual features shape and texture to study the art form and retrieve the similar images from reference collection. Shape based features are extracted using morphological operators and texture features are extracted using gray level co-occurrence matrix (GLCM). Robust feature set is built to retrieve the similar images. Experiments have been conducted on database consists of 500 images with 5 categories. Results of proposed method are compared with Canny and Sobel methods. Results demonstrate the efficiency of proposed method.**

Keywords—CBIR; shape; texture; GLCM; features.

I. INTRODUCTION

India is blessed with number of world heritage monuments showcasing the breath-taking architecture and intricate work. The monuments of India are living testimony which pull us back to that particular era and helps us in exploring the history of India. Indian monuments have a rare and astonishing unique architecture which tell us the story of bygone era. Monuments of India are considered as the real treasure and are preserved with great importance.

The use of images in human communication is hardly new – our cave-dwelling ancestors painted pictures on the walls of their caves, the use of maps and building plans to convey information almost certainly dates back to pre-Roman times. But the twentieth century has witnessed unparalleled growth in the number, availability and importance of images in all walks of life. Images now play a crucial role in fields as diverse as medicine, journalism, advertising, design, education and entertainment. The creation of the World-Wide Web in the early 1990s, enabling users to access data in a variety of media from anywhere on the planet, has provided a further massive stimulus to the exploitation of digital images. The number of images available on the Web was recently estimated to be between 10 and 30 million - a figure which some observers consider to be a significant underestimate. The large number of images obtained from different sources created a research space for image processing, computer vision, retrieval and analysis of images.

II. RELATED WORK

The term CBIR has since been widely used to describe the process of retrieving desired images from a large collection on the basis of features (such as color, texture and shape) that can be automatically extracted from the images themselves. The features used for retrieval can be either primitive or semantic, but the extraction process must be predominantly automatic. While retrieving the similar images, the type of feature set play an important role as per the comparison study given by authors Thomas deselaers, Daniel keysers and Hermann in [4]. The combination of the color, texture and shape features provide a robust feature set for image retrieval. Shape has become increasingly attractive in multimedia information service system (MISS). Edge detection as preprocessing step for shape extraction, many researchers have proposed different views for edge detection [1]. Comparing with the traditional algorithms of edge detection [1], mathematical morphology has a unique advantage in edge detection of image as it is nonlinear and based on set operation. Chen Hai-yan and Wang Hui-qin discuss advantages of edge detection based on morphological operations [2]. Different shape descriptors [3] can be applied on edge image to extract shape feature. As moment invariants [4] are invariant to rotation, scaling and translation, proposed method uses these for extraction of shape feature.

Hirata and Kato [7] have developed an experimental system for retrieving paintings similar to a given sketch, though few details of its retrieval effectiveness are available. More recently, Holt and Hartwick [8] have developed IBM's QBIC (Query By Image Content) system to manage art library databases and has proved as an extremely useful browsing tool even if its retrieval effectiveness has been limited. Jain [9] has applied CBIR techniques to the management of image and video data relating to a Hindu temple in India. Their article highlights both the opportunities and problems associated with cultural heritage applications of CBIR. IBISA(Image-Based Identification/Search for Archaeology) is a research project supported by the French archaeological research center. The corresponding software tool manages databases of digital images of archaeological objects, and allows the user to perform searches by examples. In IBISA identification is made on ancient coins and tiles. Eigen space approach have been proposed to classify ancient coins[10].

The proposed method mainly aims at analyzing the archaeological monuments for its visual features to help in automating the process of identifying the monuments and to retrieve the similar images for studying art forms in greater details. Visual feature shape is extracted using morphological operators and moment invariants. Texture is extracted using GLCM. Robust feature set helps to retrieve efficient art forms from the image database.

III. PROPOSED METHODOLOGY

Overview of the archaeological CBIR system is shown in Fig.1. Visual features shape and texture are extracted using morphology operators and GLCM for a given query image. Similarly features are extracted for all images in the database. Similar images are retrieved using Canberra distance. Different art form information is also displayed by extracting metadata associated with the images in the form of text file.

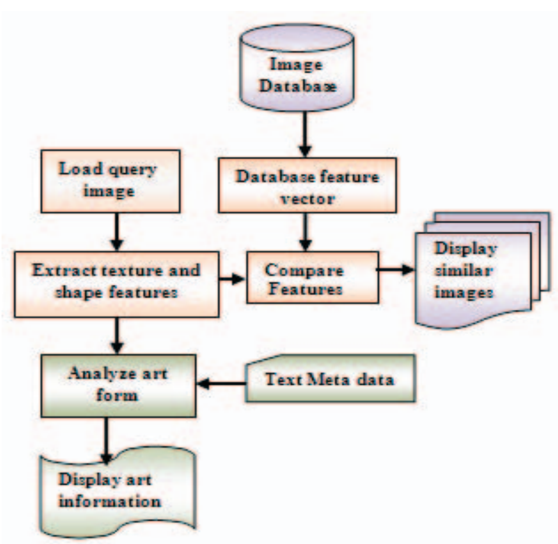


Fig. 1. Overview of the system.

IV. GRAYSCALE MORPHOLOGY

Mathematical morphology has a unique advantage in edge detection of image because it is nonlinear and based on set operation. Different morphological operations like erosion, dilation, open and close can be applied on image with different structuring elements.

A. The Basic Concepts of Mathematical Morphology

The basic concept of mathematical morphology [3] is that using the structure element of the certain form to measure and extract the corresponding shape in image to achieve the purposes of the image analysis and identification. The obtained image structure information has a relationship with the size and shape of structure element. Different structure elements provide different results and helps in image analysis [13]. The group of image processing operations which process the image based on shapes is referred as morphology. In morphology the output image is created with the help of applying structuring element to input image, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors.

A morphological operation that is sensitive to specific shapes in the input image can be constructed by choosing the size and shape of the neighborhood. Dilation and erosion [13] are the most basic morphological operations. Dilation creates the effect of swelling of shapes of the objects by adding pixels to the boundaries of objects in an image, while erosion forms the shrinking effect of the shape of the object by removing pixels on object boundaries. In dilation the value of the output pixel is the maximum value of all the pixels in the input pixel's neighborhood and in erosion the value of the output pixel is the minimum value of all the pixels in the input pixel's neighborhood. The size and shape of structuring element decides the number of pixels added or removed from the objects in an image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels, define the operation as dilation or erosion. Mathematical morphology is mainly divided into two value morphology, gray scale morphology and color morphology.

Morphological gradients are used to extract finer edges which are the combination of dilation, erosion and their differences. The different morphological gradients used here are basic gradient, internal gradient, horizontal gradient and vertical gradient. $f(x,y)$ is representative of the input gray image, $b(i,j)$ is representative of the structure elements, D_f and D_b are respectively representative of the domain of f and b.

Erosion is defined as in (1)

$$(f\theta b)(x,y) = \min\{f(x+i,y+j) - b(i,j) \mid (x+i,y+j)\} \qquad (1)$$

Dilation is defined as in (2).

$$(f \oplus b)(x,y) = \max\{f(x-i,y-j) + b(i,j) \mid (x-i,y-j)\} \qquad (2)$$

Algorithm for edge detection:

1. Input query image from the image database.
2. Convert query image to grayscale.
3. A structuring element 3X3 square matrix is chosen to apply morphological gradients. A structuring element is a matrix consisting of only 0's and 1's that can have any arbitrary shape and size.
4. Use morphological gradients on gray scale image. Morphological gradients used here are basic gradient, internal gradient, horizontal gradient and vertical gradient.
   - Basic_gradient = dilated image - eroded_image
   - Internal_gradient= original_image - eroded_image
5. Horizontal and vertical gradients are the variations of basic gradients with different structuring elements.

Four edge maps are obtained for each input image. Fig. 2 shows the four edge maps obtained for input query image. Shape features are obtained for each of the edge image.

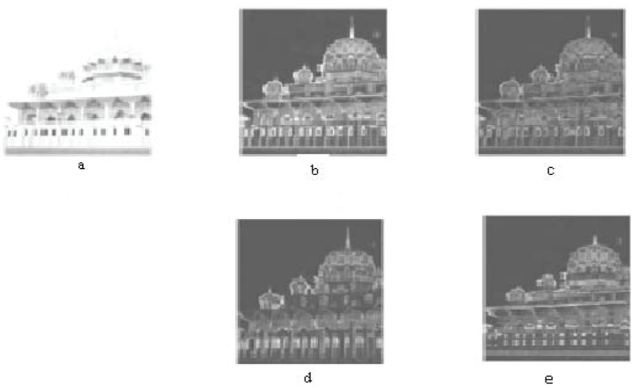


Fig. 2. Edge maps obtained for the query image mosque. (a) Gray image (b) Basic gradient (c)Internal gradient (d) Horizontal gradient (e) Vertical gradient.

B. Shape feature

The seven 2-D moment invariants which are insensitive to translation, rotation, scale change and mirroring are given by following equations (3). Shape feature vector consists of 28 feature values.

$$
\begin{aligned}
I1 &= \eta_{20} + \eta_{02} \\
I2 &= (\eta_{20} - \eta_{02})^2 + 4\eta^2_{11} \\
I3 &= (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \\
I4 &= (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \\
I5 &= (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - \\
&\quad 3(\eta_{21} - \eta_{03})^2] + (3\eta_{21} - \eta_{03}) \\
&\quad (\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \\
I6 &= (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \\
&\quad + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \\
I7 &= (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - \\
&\quad 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12}) \\
&\quad (\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]
\end{aligned}
\tag{3}
$$

C. Texture feature

Grey level co-occurrence matrix (GLCM) is a matrix whose elements measure the relative frequencies of occurrence of grey level combinations among pairs of pixels with specified spatial relationship. Given an image Q(i, j), let p be position operator, and A be a NxN matrix whose element $A(i,j)$ is the number of times that points with grey level (intensity) $g(i)$ occur, in the position specified by the relationship operator p, relative to points with gray level $g(j)$ as shown in Fig. 3.

Let P be the NxN matrix that is produced by dividing A with the total number of point pairs that satisfy p. $P(i,j)$ is a measure of the joint probability that a pair of points satisfying p will have values $g(i)$, $g(j)$. P is called as co-occurrence matrix defined by p. The relationship operator is defined by an angle θ and distance d.

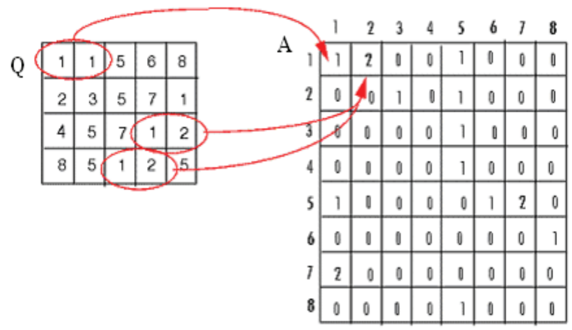


Fig. 3. Demonstration of co-occurrence matrix

From P following texture descriptors can be computed as shown in (4) to (7)

$$Energy = \sum_{i,j} P(i,j)^2 \tag{4}$$

$$Entropy = -\sum_{i,j} P(i,j)\log(P(i,j)) \tag{5}$$

$$Correlation = \sum_{i,j} \frac{(i-\mu_i)(j-\mu_j)P(i,j)}{\sigma_i\sigma_j} \tag{6}$$

$$Contrast = \frac{1}{(G-1)^2}\sum_{i,j}(i-j)^2\,P(i,j) \tag{7}$$

Other texture features are sum of variances, inverse difference moment, and information measure of correlation1, information measure of correlation2, sum average, sum entropy, sum variance, difference variance and difference entropy. Totally thirteen features form texture feature vector.

V. SIMILARITY COMPUTATION

Similarity between two images is obtained by evaluating the Canberra distance between the feature vectors of query image and each image from database. Canberra distance formula is used for calculating the distance between the images and is given by (8).

$$CD_k = \sum_{i=1}^{n} \frac{|x_i - y_{ik}|}{|x_i| + |y_{ik}|} \quad (8)$$

Where CD is the Canberra distance, x and y are the feature vectors of query and database images respectively, n is the length of the feature vector. And k = 1 to m, where m is the number of images in image database. Images are indexed based on the distance between the query image and images in the database. Similar images are displayed in the ranking order.

VI. RESULTS

Experiments are conducted on image database consists of 500 monuments images over five categories mainly Mosques, Churches, Hampi temples, Kerala temples, South Indian temples (trapezoid shape temples). Five query images from each category are used to check the performance efficiency. Matlab Ver. 9.0 is used to implement the system.

The performance of the retrieval system can be measured in terms of its recall (or sensitivity) and precision (or specificity). Recall measures the ability of the system to retrieve all models that are relevant. Precision measures the ability of the system to retrieve only models that are relevant [12]. They are defined as in (9) and (10). These are the standard measures in IR (Information Retrieval), which give a good indication of the system performance.

$$Precision = \frac{\text{Number of relevent images reirieved}}{\text{Total number of images retrieved}} \quad (9)$$

$$Recall = \frac{\text{Number of relevent images retrieved}}{\text{Total number of relevant images in the databse}} \quad (10)$$

Results of five queries have been shown in Table I. Each database image was manually marked as relevant or irrelevant on the basis of our query image. Results show that higher precision can be obtained by retrieving lesser number of images. For higher retrieval of images the recall is less than one. Fig.4 shows the top 10 images retrieved for mosque query images. When user click on any retrieved image, information about that art form will be displayed as shown in Fig.5.

TABLE I. PRECISION-RECALL FOR DIFFERENT CATEGORIES

Query Image	Total retrieved	Precision	Recall
1. Mosques	20	1.00	0.20
2. Churches	40	0.85	0.35
3.Hampi temples	60	0.88	0.55
4.Kerala temples	80	0.78	0.77
5.South temples (trapezoid shape)	100	0.80	0.68

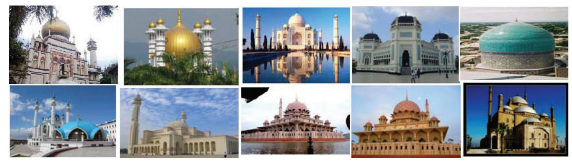
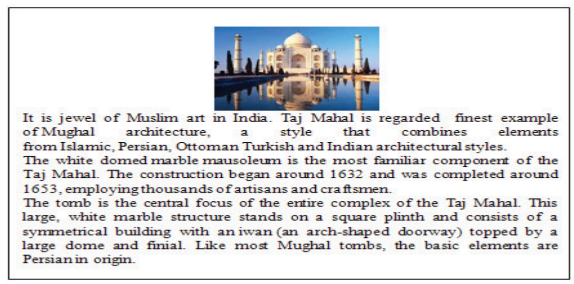


Fig. 4. Top 10 images obtained for query image mosque



It is jewel of Muslim art in India. Taj Mahal is regarded finest example of Mughal architecture, a style that combines elements from Islamic, Persian, Ottoman Turkish and Indian architectural styles.
The white domed marble mausoleum is the most familiar component of the Taj Mahal. The construction began around 1632 and was completed around 1653, employing thousands of artisans and craftsmen.
The tomb is the central focus of the entire complex of the Taj Mahal. This large, white marble structure stands on a square plinth and consists of a symmetrical building with an iwan (an arch-shaped doorway) topped by a large dome and finial. Like most Mughal tombs, the basic elements are Persian in origin.

Fig. 5. Information of an artfirm.

The average retrieval efficiency of proposed method is compared with CBIR systems that use Canny [14] and Sobel [14] edge detectors. Results are shown in Table II and the corresponding graph in Fig.6. Retrieval performance of proposed method is better than the Canny and Sobel.

TABLE II. COMPARATIVE EVALUATION OF WEIGHTED AVERAGE PRECISION

Category	Our method	Canny	Sobel
1. Mosques	0.75	0.68	0.67
2. Churches	0.82	0.80	0.75
3. Hampi temples	0.68	0.55	0.55
4. Kerala temples	0.79	0.66	0.60
5.South temples(trapezoid shape)	0.90	0.89	0.85

Fig. 6. Comparision of proposed method with Canny and Sobel.

VII. CONCLUSION

Proposed method is an effort made to retrieve the archaeological monuments to analyze the different art forms to help archaeologists in their assessment and classification of archaeological finds. Shape is prominent feature helps to identify the monuments and also texture helps to measure the type of monument. Morphological gradients played important role in determining edge information. Robust feature set retrieve the similar art forms from the image data base. Experimental results show that average retrieval accuracy of the proposed method is 78 % and 90% for top 10 images for different categories of the images. Information about different art forms are displayed for 75% of images stored in the image database.

The image data base in the proposed work represents the images in good state. The main challenge here is to compare archeological ruins with good condition monuments. This is addressed in future work as it is very important for the archeology department.

ACKNOWLEDGMENT

Authors thank Nagaratna Yeligar, Supriya, Soumya and Veeresh for their help in implementation of the system.

REFERENCES

[1] Mohsen Sharifi, Mahmoud Fathy, Maryam Tayefeh Mahmoudi,“A Classified and comparative study of edge detection algorithms”, Proceedings of the International Conference on Information Technology: Coding and Computing (ITCC.02)0-7695-1506-1/02 $17.00 © 2002 IEEE

[2] Chen Hai-yan, Wang Hui-qin, Cao Ming-hua, Hu Jia-qi,Hu Wen-tao, “The research and implementation on edge detection algorithms of ochotona curzoniae’s Image based on grayscale morphology” International Conference on Computational and Information Sciences

[3] H.B.Kekre, Priyadarashine, Shobhit Wadhwa, “Image retrieval techniques with shape features extracted using morphological operators with BTC” international journal of computer applications volume 12-no.3 nov-2010.

[4] Thomas deselaers,Daniel keysers and Hermann ney “Features of image retrieval : An experimental comprision”,german research center for artificial intelligence,Germany November-2007

[5] P. S. Hiremath , JagadeeshPujari, “Content based image retrieval using color,texture and shape features”,15th International Conference on Advanced Computing and Communications.0-7695-3059-1/07©2007IEEE ADCOM.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Trans. vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] Hirata, K and Kato, T, “Query by visual example – content-based image retrieval” in *EDBT’92,* Third International Conference on Extending Database Technology, 56-71

[8] Holt, B and Hartwick, L “Retrieving art images by image content: the UC Davis QBIC project”, Proc First International Conference on Electronic Library and Visual Information System Research, de Montfort University, Milton Keynes, 93-100

[9] Jain, A K “Multimedia systems for art and culture: a case study of Brihadisvara Temple” in Storage and Retrieval for Image and Video Databases V (Sethi, I K and Jain, R C, eds), Proc SPIE 3022, 249-261

[10] Huber, R., Ramoser, H., Mayer, K., Penz, H., and Rubik, M. “Classification of coins using an eigenspace approach”, Pattern Recognition Letters,2005.

[11] Davidsson, P. “Coin classification using a novel technique for learning characteristic decision trees by controlling the degree of generalization”. In Ninth International Conference on Industrial & Engineering Applications of Artificial Intelligence & Expert Systems, pages 403–412. Gordon and Breach Science Publishers. 1996

[12] Padmashree D. Desai, Jagadeesh Pujari, Goudar R.H. “ Image retrieval using wavelet based shape features”, Journal of Information Systems and Communication (JISC) ISSN: 0976-8742 & E-ISSN: 0976-8750, Volume 3, Issue 1, 2012, pp.-162-166

[13] Padmashree Desai, Jagadeesh Pujari ,Nagaratna Yeligar, “Shape based features extracted using wavelet decomposition and morphological operators” International journal of Advance Research in Computer Science (IJARCS) ISSN No. 0976-5697, Volume 3, No. 3, May-June 2012

[14] Padmashree D. Desai, Jagadeesh Pujari, Shweta Parwatikar. “ Image retrieval using shape feature : A study”, International Conferece on Computaional Intelligence and Information Technology (CIIT 2011), ACEEE, CCIS 250 pp 610-614 © Springer-Verlag Berlin Heidelberg 2011

[15] Padmashree D. Desai, Jagadeesh Pujari, “Shape based image retrieval using gradient operators and block truncation coding” Third International Conference on Recent Trends in Information, Telecommunication and Computing, ACEEE, ITC 2012, LNEE, pp. 343-346, 2012. © Springer-Verlag Berlin Heidelberg 2012

[16] Jagadeesh Pujari , Padmashree D.Desai, , Pushpalatha S.N, “Content-based image retrieval using color and shape descriptors”,ICSIP 3rd IEEE International Conference on Signal & Image Processing 2010 pp 239-242 978-1-4244-8594-9/10

[17] Padmashree Desai,Ashwini.S.Menasinakai,Jagadeesh Pujari , Pushpalata S.N, “Image retrieval using contour based approach“, 4th IEEE International Conference on Advanced Computing & Communication Technologies (ICACCT–2010), pp 416-419 ,October 30th 2010, Panipat, Delhi