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Preface

Modern complex ICs' design is complicated. As on average up to 2015 in desktop, more than 1 billion of transistors existed. For complete design having more than 500 rules and it's in statistical nature. As per the demand of the market for sophisticated systems, designers/engineers are playing with automated EDA software tools for efficient and bulk design. For these purposes, different automated EDA software have been launched such as cadence and mentor graphics. From these tools, designers are preparing full-custom and semicustom ICs. These tools consider the length of the transistor in manometer range. These range-designed ICs required good support of nanomaterials and its related chemicals. Testing of ICs is also a major issue in sophisticated systems. Without software support, testing is difficult. Nanotechnology allowed the integration of purely electronic devices, chips, circuits and systems. The nanoscale dimensions of nanoelectronic components for systems for giga-scale complexity are measured on a chip or in a package. Nanotechnology improves the capabilities of electronic components by reducing the size of transistors in ICs, increases the density of memory chips, reduces the power consumption and improves the display screen, thickness, etc. In global automation, control and functional environment IoT is playing a major role today. Now, you can imagine a single example—cashless world. The computing systems which are playing behind the cashless world is more reliable, robust, correct and highly accurate. Now, this system is going to adopt smart education system for making a global education hub. This setup already adopted in global factory operation, control and monitoring for perfect and optimized products. This conference provides an excellent forum for young researchers, engineers and professors to work together and share their knowledge. It also gives the ideas on how to work in electronic media safely and securely. Manufacturing companies/industries and education universities have well contribution in the development of any countries. However, they face several challenges such as rapid product development, flexibility, low-to-medium volume, transportation and low cost. Many advanced/unconventional technologies/tools/software are being developed worldwide to face these challenges. Among recent technologies IC design and manufacturing, Internet of Things has become more popular due to the ability of precise work. For the research, development, sharing

knowledge and exchange of ideas in the current trends, the Second International Conference on Microelectronics, Computing & Communication Systems (MCCS-2017) has been organized by Indian Society for VLSI Education (ISVE) Ranchi at Advanced Regional Telecom Training Centre (ARTTC) near Jumar River Hazaribagh Road Ranchi from 13 to 14 May 2017 and 2nd IC-NCCS-2016 organized from 11 to 12 December 2016 at the same venue. These conferences cover advancement in MEMS and nanoelectronics, wireless communications, optical communication, instrumentation, signal processing, image processing, bioengineering, green energy, hybrid vehicles, environmental science, weather forecasting, cloud computing, renewable energy, RFID, CMOS sensors, actuators, transducers, telemetry systems, embedded systems, sensor network applications in mines, etc. Population of the countries are increasing day by day, then the duty of the society to provide all types of facility to the new users for serving their life efficiently. It is possible with the help of research and development only.

In this conference 350 papers and 50 chapters in pedagogy (Washington Accord) was received, in which 67 blindly peer-reviewed, registered and presented papers were accepted for publication in conference proceeding of Springer Scopus book series Lecture Notes in Electrical Engineering (LNEE) and 10 outstanding papers were selected for SCI Journals like *Microsystem Technologies* and *IETE Technical Review & Technical Research*, etc. In parallel conference, excellent reviewer's team guided authors for the extended version of the research articles, i.e. 70–80% improvement/changes with new content and title forward for the publication in listed SCI and Scopus journals. All articles are blindly peer-reviewed by at least three reviewers and details comments have been passed to concern authors with decisions. In presentation session, six expert reviewers' team evaluated their work. They also guided the authors for IPR/patents and new innovative project for funding in their area of research. These series of conferences (NCCS & MCCS) organized by ISVE & IETE Ranchi in support of ARTTC BSNL Ranchi gave a unique platform to young researchers, scientists, engineers and professors for the presentation of their work worldwide. This platform provides outcome-based learning and research strategy. Pedagogy method gives new ideas to the learner to enhance their knowledge in scientific research. This technique is highly beneficial to students, researchers, professors and industrial people to recognize or evaluate the value of their work.

In the conference on dais, Chief Guest Dr. R. K. Pandey, VC, Ranchi University, Ranchi; Guest of Honour Dr. K. K. Thakur, CGMT, BSNL Ranchi; Guest of Honour Dr. A. A. Khan, Former VC, Ranchi University, Ranchi; Dr. R. K. Singh, Former Chairman, IETE Ranchi; Guest of Honour Sh. Sanjay Kumar Jha, Past Chairman, IETE, Ranchi, and Chief Executive Engineer, Government of Jharkhand; Guest of Honour Dr. P. R. Thakura, Professor, BIT Mesra, and Executive Member, ISVE & IETE, Ranchi; Sh. Ajay Kumar, Chairman, IETE, Ranchi & AGM(Admin), ARTTC BSNL, Ranchi; Dr. Anand Kumar Thakur, Faculty, SSMC RU & Organizing Secretary, MCCS-2017; Dr. Raj Kumar Singh, Faculty, RLSYC RU & Convenor MCCS-2017, Ranchi; Dr. Vijay Nath, Faculty, BIT Mesra & General Chair, MCCS-2017; Keynote Speaker Dr. A. Srinivasulu,

Professor, Vignan University, Guntur (AP) were present. The conference began with welcome address by Dr. Vijay Nath, General Chair of the conference, and keynote address by Prof. A. Srinivasulu, Vignan University Guntur, AP, on the topic "VLSI Design and Challenges". All other dignitaries gave their views for the growth of society, quality of publications, research innovations and challenges.

In this conference, the authors are invited for the original papers submission and the quality of papers has been selected for presentation. The authors described their articles in above-mentioned domain very well. Mohan Kashyap et al. explain their research article "Optimal Placement of Distributed Generation Using Genetic Algorithm Approach". Piyush Kumar Ojha et al. demonstrate their work on "Analysis of Voltage Source Boost Inverter". Rahul Sharma et al. explain their research article "Reduction of Redundant Frames in Active Wireless Capsule Endoscopy". Pritha Roy et al. explain their research work on "A Study on Filter Design Aspects of Single Phase Inverter with Various Modulation Schemes". Maninder Kaur et al. demonstrate their work on "Design, Analysis and Testing of Low Voltage CMOS OTA". Sumit Srivastava et al. demonstrate their research article "Speech Based Access to Price of Different Agricultural Commodities Using MFCC, GMM and Naïve Bayes Classifier". Shahid Aziz et al. demonstrate their work as per the current demand of market "Dual Axis Solar Tracker for Solar Panel with Wireless". Naghma Khatoon et al. demonstrate their work on "A Node Stability Based Multi-metric Weighted Clustering Algorithm for Mobile Ad-Hoc Networks". Kumari Mamta et al. explain their work on "Design and Development of Microstrip Patch Antenna for Millimeter-Wave Application". Chitrita Saha et al. introduce their work on "Review on Fault Tolerant Control (FTC) and Fault Detection & Isolation (FDI) Schemes of Wind Turbine". Ankita et al. explain their work on "A Comprehensive survey on Computational Grid Resource Management". Kanchan Bala et al. introduce their research work on "Thunderstorm Prediction Using Soft Computing and Wavelet". Mohammad Javeed et al. define their work on "Design of a Clock Distribution Network Using Low Power Prescaler and Fused P & S Counters". K. Rama Devi et al. demonstrate their research article "Design of RFID Tag Antenna with Impedance Matching Techniques at UHF Band". Chandrashekhar Azad et al. introduce in their research article "Decision Tree and Genetic Algorithm Based Intrusion Detection System". B. Jayalakshmi et al. explain "A Novel Method of Designing Using Non-logical Algorithm". Annu Priya et al. explain in their research article "A Novel Multimedia Encryption and Decryption Technique Using Binary Tree Traversal". Malladi Lakshmi Lavanya et al. demonstrate their research work on "ZC-CDTA Based Integrator Circuit Using Single Passive Component". Saka Harshavardhan et al. explain "Road and Traffic Sign Detection Using Colour Segmentation". Pawan Kumar et al. explain "Switch in Based Trimmed Median Filter for Noise Removal from Medical Image". Surya Gupta et al. introduce their research article "Characterization of Interfering Signal in S Band of IRNSS". Sandip Kumar Singh Modak et al. present their article "Enhancing Multibiometric System Security Using ECC Based on Score Level Fusion". Santhoshi Rupa Gayatri Neralla et al. present their article "Generation of Photographic Mosaic Using Apache Spark and Scalding for Image Processing".

Nibha Rani et al. introduce “Mitigation of Congestion in Transmission Line Using Series Smart Wire”. Naghma Khatoon et al. explain their research article “Mobility Aware Distributed Clustering and Routing Algorithm Based on A* Search for Mobile Ad-Hoc Networks”. Meena Singh presents her research article “Floating Admittance Matrix Model Development of Active Devices and Circuits”. Ravi Devesh et al. demonstrate “An Efficient Approach for Monuments Image Retrieval Using Multi-visual Descriptors”. Ruchira et al. present “Comparison of ANN based MPPT Controller and Incremental Conductance for Photovoltaic System”. Sneha Mangalwedhe et al. introduce “Low Power Implementation of 32-Bit RISC Processor with Pipelining”. Bollampally Joy Persis et al. present their research work on “A Novel SINR Based Cooperative Radio Resource Allocation Mechanism (SBC-RRAM) for LTE/Wi-Fi Radio Access System in Smart Home Environment”. Pallavi Choudekar et al. present their work on “Optimal Location of Thyristor Controlled Series Compensator to Assuage Congestion in Transmission Network”. Priyanka Gupta et al. explain “An Efficient Brightness Preserving Contrast Enhancement Technique Using Discrete Wavelet Transform and Singular Value Decomposition”. Ruhi Dubey et al. introduce their research article “Computer Assisted Valuation of Descriptive Answers Using WEKA with Random Forest Classification”. Shaik Qadeer et al. present a chapter on “VLSI Signal Processing”. Debaprasad De et al. present a chapter on “Ramanujan Sums and Signal Processing: An Overview”. Akshaya R. et al. introduce “Analysis and Design of Bandgap Reference (BGR)”. Avireni Srinivasulu et al. introduce the chapter “FinFET Based Negative Rectifiers for Low-Power Analog Applications”. Sonali B. Wankhede et al. introduce “Denial of Service Attacks”. Trilok Kumar Parashar et al. introduce “Analytical Modelling of Room Temperature GaAs/$InAs_{0.3}Sb_{0.7}$ Detector for H_2S Gas Detection”. Om Prakash et al. describe the “Fuzzy Prediction Model for Water Temperature in Scheffler Solar Reflector”. Anil Pinapati et al. introduce “A Reversible Data Hiding Using Difference-Histogram Modification on Multi-directional in Two-Dimensional Histogram”. Chandan Kumar et al. describe “A Novel Single-phase Multilevel Inverter Topology with Reduced Component Count”. K. Srilakshmi et al. demonstrate “Energy Efficient 64-Bit Asynchrobatic Adder”. Gourab Das et al. demonstrate “PV Array’s Resistance & Temperature Sensitivity Analysis with Shading Effects”. Sukesha et al. explain the “Effect of Location of Piezoelectric Sensor Over a Smart Structure”. Dipti Kumari et al. introduce “A Systematic Approach Towards Development of Universal Software Fault Prediction Model Using Object-Oriented Design Measurement”. Varun Bohra et al. introduce “Design and Implementation of a Reaction Timer Using CMOS Logic”. Shubham Goswami et al. describe “A Novel Hybrid Resource Allocation Scheme for Maximum Fairness Among Multiple Services”. Aditya S. Sengupta describes the “Modelling Equivalent Circuit for Supercapacitor Module Voltage Decay”. Rajinder Tiwari et al. demonstrate “An Innovative Design Approach of SoC Based Smart CMOS Sensor for Mixed Signal Processing Based Applications”. Priyanka Parihar et al. describe the “Investigation of MTCMOS 6T SRAM Cell for Ultra Low Power Application”. Neha Gupta et al. describe “Novel Approach for Sleep Transistor Sizing to Suppress Power and Ground Bounding Noise in

MTCMOS Clustering Technique". Mukesh Patidar et al. describe "Efficient Design and Simulation of Novel Exclusive-OR Gate Based on Nano-electronics Using Quantum Dot Cellular Automata". Anup Tiwari et al. demonstrate the "Design Strategy for Smart Toll-Billing Systems". Sanket P. Singhania et al. describe the "Novel Cell Search Method in Long Term Evolution System". Sukesha Sharma et al. describe the "Various Feature Extraction and Classification Techniques". Abhinav Kumar et al. explain the "Path Tracking Method of ALV Based on ADRC Strategy and Differential Flatness Theory". Ravneet Kaur et al. describe the "Performance Analysis of Conventional SRAM with Higher Order SRAM Topologies". Shashank Shekhar et al. demonstrate the "Performance Analysis of Time-Reversal Division Multiple Access Under Multi-path Rician Fading Channels". Amninder Singh et al. introduce the "Analysis of Software Development Life Cycle Models". Sumit Singh et al. explain the "Design of Narrowband 2.69 GHz CMOS Low Noise Amplifier for WiMAX Application". Sarita Kumari et al. describe the "Sensitivity Analysis of Various Magneto-Optic Materials Based on Faraday Rotation Principle". Anil Kumar et al. describe "A Secure Three—Way Handshake Authentication Process in IEEE 802.11i". Gireesh Joshi et al. explain the "BrowserGuard2: A Solution for Drive-By-Download Attacks". Nishat Aafreen et al. demonstrate the "GA Based Energy Optimization in Traffic Grooming WDM Optical Mesh Network". Oshin Garg et al. define the "Piezoelectric Energy Harvesting: A Developing Scope for Low Power Applications". Deepak Prasad et al. explain "An Overview of CMOS Temperature Sensors". Abhishek Pandey et al. demonstrate "A 3.65 mW, Op-Amp Based Up-Conversion Mixer for Zigbee Front-End Transmitter". Vijay Kumar Karan et al. explain "Adaptive Compensation Algorithm for Flux Estimation of PM BLDC Motor Drives". A. Srinivasulu et al. demonstrate the "Performance Analysis of Inter-Satellite Optical Wireless Communication Using 12 and 24 Transponders". These articles are helpful for the product development of smart ICs.

The authors and editors have taken utmost care in presenting the information and acknowledging the original sources whenever necessary. The editors express their gratitude towards the authors, organizers of IC-MCCS and staff of Springer, India, for making the publication of this research book/proceeding possible. Readers are requested to provide their valuable feedback on the quality of presentation and inadvertent error or omission of information if any. We expect that the book will be welcomed by students as well as practicing engineers/researchers/professors.

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Contents

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An Efficient Approach for Monuments Image Retrieval Using Multi-visual Descriptors

Ravi Devesh and Jaimala Jha

1 Introduction

Nowadays, numerous amount of images are being captured by different image acquisition techniques; these images database are used in many day-to-day applications, for example, military, remote sensing, engineering, medical field, crime prevention, environmental, astronomy, multimedia, and many other applications [1].

For handling the gigantic amount of stored and exchanged image information, some automatic image retrieval techniques are required. In case of database having less number of images, it is practicable to discover a required image simply by browsing while in case a database containing thousands of images it is not practicable to browse the desired image thus some more effective techniques are needed. Image retrieval is the procedure of finding the images having similar kind of content as query image given by the user based upon some similarity functions [2, 3].

Image retrieval can be implemented based on the following two methods:

(a) Text-Based Image Retrieval
(b) Content-Based Image Retrieval

2 Related Work

The word CBIR is used for explaining the retrieval of images based on visual descriptors that are extracted from image automatically in CBIR system [4]. The descriptor used for retrieval system can be either local descriptor or global

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descriptor. But the process used for extraction of descriptors must be automatic. The set of descriptors used has an important role during retrieval of similar images. A robust descriptor set is made by combining shape, texture, and color features. Shape feature is broadly used in multimedia information service system (MISS).

Padmashree Desai et al. in 2013 proposed a CBIR system which classifies the archaeological monuments based on local features [5]. In this paper, morphological gradients with invariant moments for shape feature and gray level co-occurrence matrix (GLCM) for texture feature extraction are used. For comparing the results of proposed system, Sobel and Canny operators are used.

Shilpa Yaligar et al. in 2013 proposed a system for recognition and fetching of archaeological monuments utilizing visual descriptors [6]. Database used consists of 500 images with five categories. For shape, feature morphological gradients were calculated, and then invariant moments were applied on the gradients; GLCM is used for the extraction of texture feature.

Fuxiang Lu et al. in 2016 proposed improved local binary pattern (ILBP) that describes texture feature of an image more efficiently [7]. A significant group of basic primitives is discovered like lines, cross-intersections, and T-junctions; these are generally unnoticed by uniform LBP method.

Malay S. Bhatt et al. in 2015 proposed a system which extracts genetic programming evolved spatial descriptors and on the basis of linear support vector machine (SVM), classification of Indian monuments visited by tourists is performed [8].

Not much work is done in this field. So, it is still a dynamic research field. We need sophisticated systems which could correctly identify, classify, and retrieve monuments images using local or global features.

3 Proposed System

In this paper, it is proposed a CBIR system which is used to retrieve the images of monuments based on low-level features. It forms the proficient combination of shape, texture, and color features of an image. Here, the dataset consists of images of monuments of different categories. The images presented in database are loaded.

The subsequent images are given as input to feature extraction techniques to extract desired features and form a set of extracted features. These features are chosen proficiently so that retrieval accuracy and recall rate is improved. In the last step, the similar images from database are retrieved. This method produces noble outcomes for the monument images in comparison to other methods available.

In the proposed methodology, it used morphological operators along with invariant moment in extracting the shape features [5], improved local binary pattern (ILBP) in extracting the texture features and RGB color histogram in extracting the color feature of images [7, 9]. The proposed CBIR system is depicted in Fig. 1. Similarity metrics are used for evaluating the distance among the query image, and N similar images present in the database. Precision and recall values are evaluated for the purpose of performance evaluation of the proposed system.

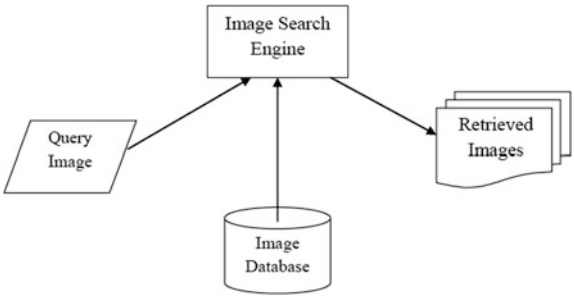

Fig. 1 Image retrieval system

4 Feature Extraction

Mathematical morphology has a sole benefit in detecting boundary of an image, as it is based on set operation and nonlinear in nature. Morphological methods can be applied on image with distinct structuring element. Such operations are Erosion, Dilation, Open, and Close [5, 6].

5 Overview of Mathematical Morphology

The elementary notion of mathematical morphology explains use of structuring element of particular type to determine and elicit the relative shape in image to attain the intents of image analysis and identification [6]. In morphology, structuring element is applied on given image, and output image is obtained. Distinct morphological operations such as Dilation, Erosion, Open, and Close can be enforced on image with distinct structuring element [6].

Erosion is given in Eq. (1)

$$(f\theta b)(x,y) = \min\{f(x+i,y+j) - b(i,j) | (x+i,y+j)\}. \tag{1}$$

Dilation is given in Eq. (2)

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

$$\text{Basic gradient} = \text{Image Dilated} - \text{Image Eroded}$$
$$\text{Internal gradient} = \text{Image Original} - \text{Image Eroded}$$
$$\text{External gradient} = \text{Image Dilated} - \text{Image Original}.$$

Five edge maps will be acquired for given image. Shape descriptors are acquired for each of the boundary images. Out of five edge maps obtained, only internal gradient, external gradient, horizontal gradient, and vertical gradients edge maps are used.

Figure 3 depicts edge maps acquired after applying morphological gradients on input image (Fig. 2).

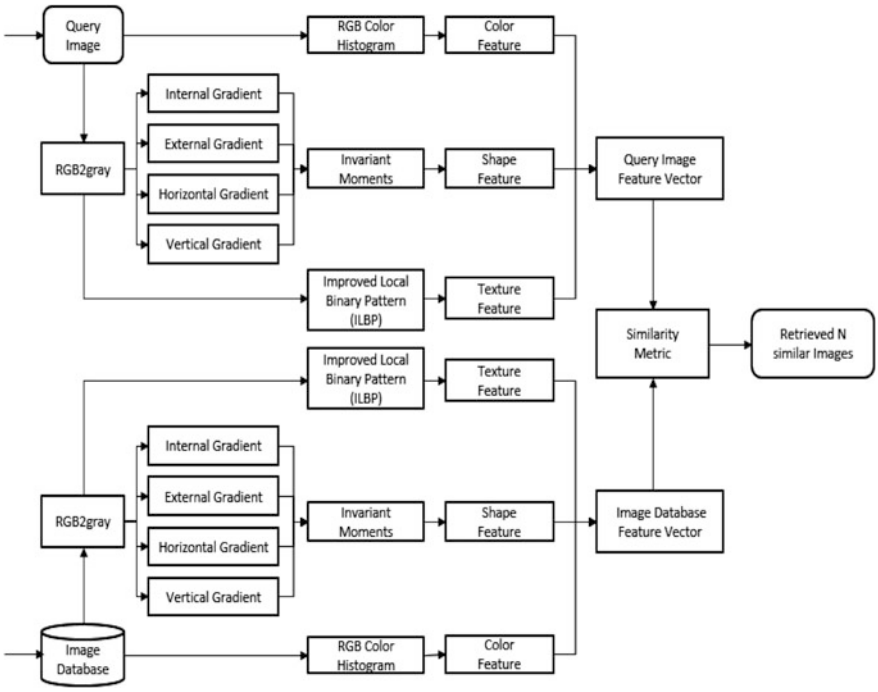

Fig. 2 Architecture of proposed CBIR system

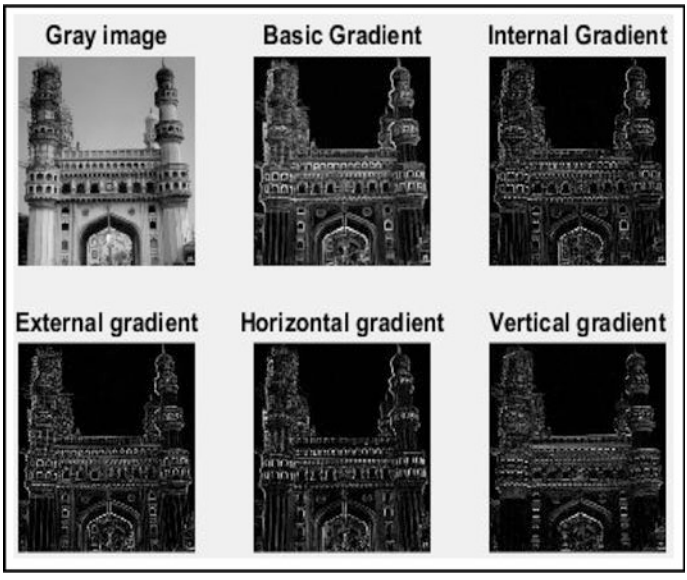

Fig. 3 Boundary maps acquired for the given image

6 Shape Feature

Seven (2-D) moment invariants that are unaffected by rotation, mirroring, translation, and change in scaling are known by Eq. (3). Shape descriptor vector comprises seven descriptor values [5, 10].

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

7 Texture Feature

Local binary pattern (LBP) feature for extraction of texture information was introduced by Ojala et al. [11]. This operator is stout against change in illumination and is characterized by a computational simplicity and capability to encode texture details. Every pixel in LBP feature is described by a binary code. Each pixel's (central) gray level is tested with its eight neighborhood of size (size 3 × 3) [12]. If neighborhood pixels' value is greater than the central pixel, then the result is fixed to one else to zero. For producing binary code, multiply the results with weights given by 2's powers. For the central pixel (x, y) LBP code is given as follows [7]:

$$\mathrm{LBP}_{P,R} = \sum_{p=0}^{p-1} s(g_p - g_c)2^p, \tag{4}$$

$$s(z) = \begin{cases} 1, & \text{if } z \geq 0, \\ 0, & \text{otherwise,} \end{cases} \tag{5}$$

where g_c is the value of intensity for the pixel in center (x, y), and pth neighbor value is g_p. When a neighbor does not fall at integer coordinates, bilinear interpolation is used to determine its intensity value.

An extension of original LBP is called uniform LBP, denoted as $\text{LBP}^{u2}_{P,R}$.

$$U\left(\text{LBP}_{P,R}\right) = \sum_{p=0}^{p-1} \left| s\left(g_{p+1} - g_c\right) - s\left(g_p - g_c\right) \right|, \tag{6}$$

where g_p is equal to g_0. If $U(\text{LBP}_{P,R}) \leq 2$, then LBP will be called as uniform (Fig. 4).

ILBP can be defined as

$$\text{ILBP}^{ri}_{P,R} = \begin{cases} \sum_{P=0}^{P-1} s\left(g_p - g_c\right), & \text{if } U\left(\text{LBP}_{P,R}\right) \leq 2, \\ P - 1 + \frac{U}{2}, & \text{otherwise,} \end{cases} \tag{7}$$

where U is defined in (6). By doing so, the $\text{ILBP}^{ri}_{P,R}$ operator has $3/2P$ different output labels.

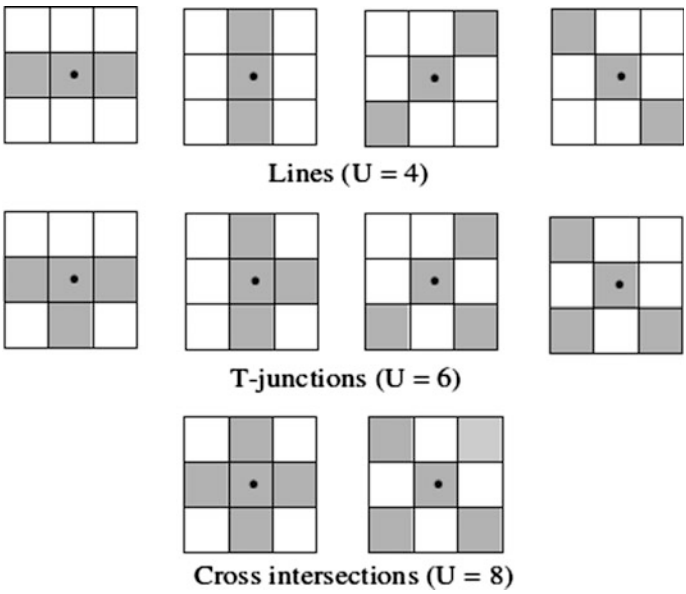

Fig. 4 Basic primitives detected by gray and white rectangles relate to bit values 1 and 0 in binary forms [7]

8 Color Feature

The distribution of colors in an image can be represented with color histogram. Color descriptor is a subtle and comprehensible descriptor of an image, and generally, histogram-based techniques are preferred to show it [9, 13]. The basic benefit of color histogram is its high speed, require less memory and not subject to change in size of the image, and other factors.

Let there are M rows and N columns in an image. Each element of color space is separated into three bins such as B_{red}, B_{green}, and B_{blue}. Also let $R(i, j)$, $G(i, j)$, $B(i, j)$ be the intensity values in each portion of color space, and Ir, Ig, Ib be the bin index values of the color image's histogram using three factors. By dividing H(Ir,I g, Ib) by the size of image, normalized histogram is obtained. The pseudocode for RGB color histogram is given as shown below:

```
1. Initialization:
for Ir = 0 to Bred − 1
  for Ig = 0 to Bgreen − 1
    for Ib = 0 to Bblue − 1
      H(Ir, Ig, Ib) = 0
    end for
  end for
end for
```

```
2. Updating Histogram:
for I = 0 to M − 1
  for j = 0 to N − 1
    Ir = ⌊R(i,j) × Bred/256⌋
    Ig = ⌊G(i,j) × Bgreen/256⌋
    Ib = ⌊B(i,j) × Bblue/256⌋
    H(Ir, Ig, Ib) = H(Ir, Ig, Ib + 1)
  end for
end for.
```

Here, $\lfloor x \rfloor$ is a floor function which returns largest integer smaller than x.

9 Analysis and Outcomes of Proposed System

Database of 360 images of six different classes is used to verify the performance of the proposed system. For the purpose of measuring the retrieval effectiveness of the system, precision and recall values are used.

10 Image Database

The most vital task is the collection of data, no database is directly available of monument images for experimental purpose. The database presented in this paper consists of six different categories. Each image used here is rotated left, rotated right, rotated 180º, flipped horizontal, and flipped vertical. Database is collected by visiting the archaeological monuments individually and images are captured, each image is of 72 dpi. Camera used for taking the images is of 13 megapixels, a feasible distance from the monument while capturing the monument is maintained so that image captured is of good quality and consists of more details. Preprocessing is done to make the database suitable for experimental purpose.

Six randomly selected images from all categories are used as query images, some images used as query image are shown in Fig. 5.

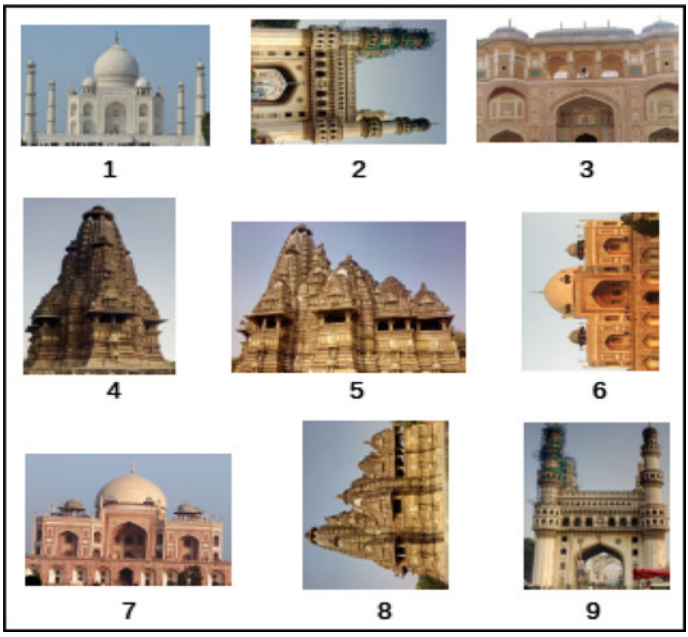

Fig. 5 Sample images used as query

11 Similarity Metrics and Performance Evaluation

For calculating similarity between two images, six similarity metrics are used, namely: Euclidean (L2), Cityblock, Chebyshev, Minkowski, Cosine, and Normalized Euclidean. All these six similarity metrics are used one by one to calculate distance between the query image feature vector and feature vector of each image from database. Comparison table is also built on the basis of retrieval accuracy for different metrics.

Performance evaluation is done by using precision and recall. Average precision as well as recall is computed based on the number of retrieved relevant images. Basic methods of evaluating precision and recall are given by Eqs. (8) and (9)

$$\text{Precision} = \frac{|\{\text{Relevant images}\} \cap \{\text{Retrieved images}\}|}{|\{\text{Retrieved images}\}|} \tag{8}$$

$$\text{Recall} = \frac{|\{\text{Relevant images}\} \cap \{\text{Retrieved images}\}|}{|\{\text{Relevent images}\}|}. \tag{9}$$

Table 1 gives the average precision (%) of six different similarity metrics for six different categories of images. Six images of each category are selected randomly from the database. These selected images are then provided as queries and precision (%) for, respectively, selected image is calculated, and then average of the resulted precision is taken.

Figure 6 illustrates the plot of precision (%) of six different similarity metrics for six different classes. Six random images are chosen from the image database. Chosen images are then given as queries and result is attained.

Table 2 gives the average recall (%) of six different similarity metrics for six different categories of images. Six images of each category are selected randomly from the database. These chosen images are then provided as queries and recall (%) for each selected image is calculated, and then average of the resulted precision is taken.

Table 1 Average precision (%) using six similarity metrics

	Similarity metrics (Nr = 50)					
Image category	Euclidean	City block	Minkowski	Chebyshev	Cosine	Normalized Euclidean
Category 1	94.66	96.00	94.66	93.00	95.66	94.66
Category 2	87.00	84.00	86.66	83.66	81.00	85.00
Category 3	90.66	89.33	90.66	87.00	83.66	90.33
Category 4	76.66	87.00	76.66	68.00	74.66	76.66
Category 5	98.66	94.66	98.66	92.66	95.66	98.66
Category 6	75.66	72.66	75.66	74.66	69.33	77.00

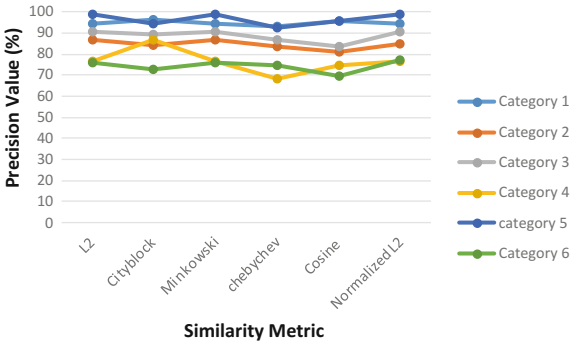

Fig. 6 Plot of average precision (%) of different similarity metrics for six different categories

Table 2 Average recall (%) using six similarity metrics

	Similarity metrics (Nr = 50)					
Image category	Euclidean	City block	Minkowski	Chebyshev	Cosine	Normalized Euclidean
Category 1	78.56	79.68	78.56	77.19	79.39	78.56
Category 2	72.21	69.72	71.92	69.43	67.23	70.55
Category 3	75.19	74.11	75.19	72.21	69.38	74.94
Category 4	63.62	72.21	63.62	56.44	61.96	93.91
Category 5	81.34	78.56	81.88	76.90	79.39	81.88
Category 6	62.79	60.30	62.79	61.96	57.54	63.91

Figure 7 shows the plot of recall (%) of six different similarity metrics for six different classes. Six random images are chosen from the image database. These images are then given as queries and result is obtained.

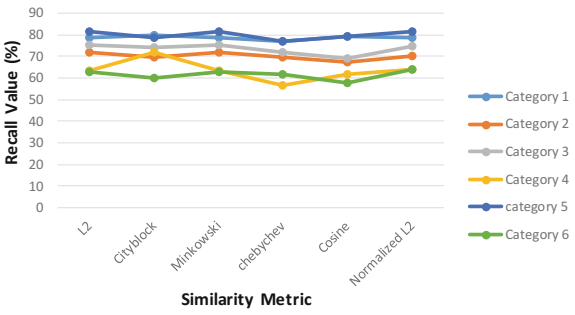

Fig. 7 Plot of average recall (%) of different similarity metrics for six different categories

12 Results

The results generated by proposed system are good; it can be perceived in the graphs of precision and recall, where average precision and average recall of six categories of images are shown in Figs. 5 and 6. 50 images are retrieved for the input query image. A snapshot of retrieved similar images is depicted in Fig. 8.

Results for the implemented system show that the system is efficient enough to retrieve similar kind of images for monument images database. The database used for experimental purpose is synthetic database and may vary from the database used in other papers. The system presented in this paper includes all the three descriptors so it is able to differentiate and retrieve images more accurately and can be applied on any database of monument images.

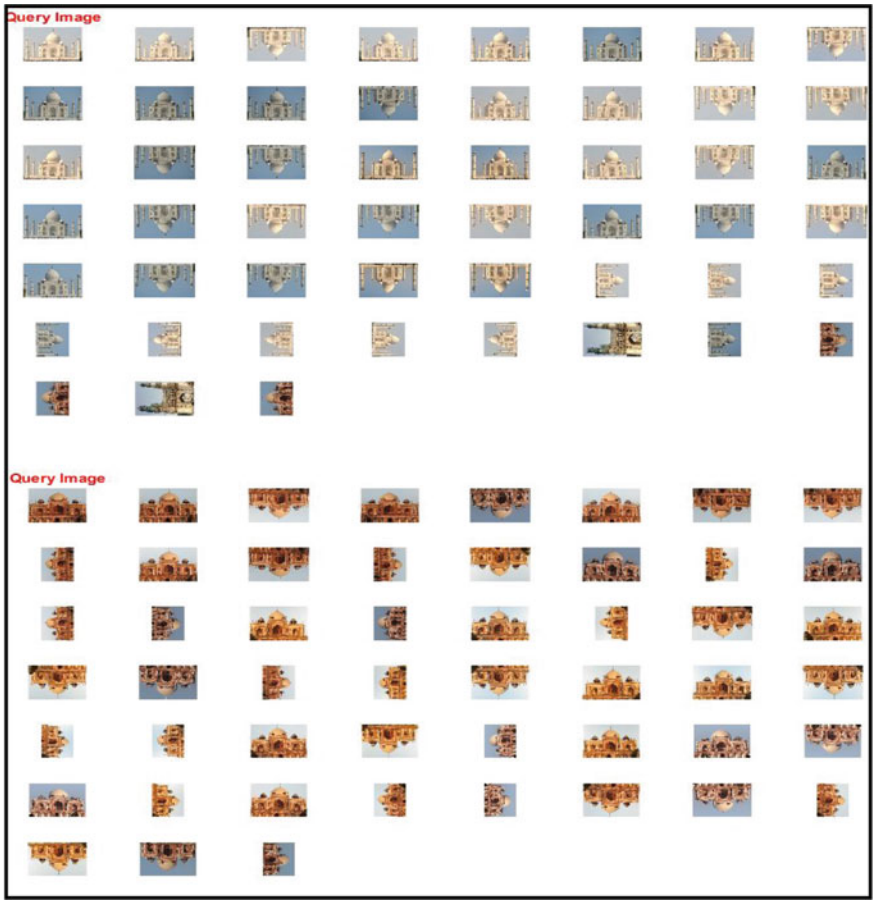

Fig. 8 Retrieved *N* similar images

13 Conclusion

The CBIR system proposed in this paper is an efficient approach to retrieve monument images. Shape feature of an image is extracted by using mathematical morphology, texture feature is extracted using ILBP, and color feature is extracted using RGB color histogram. The retrieval technique present in this paper for monument image retrieval is better than other retrieval techniques, because color feature is also considered in this proposed system which produces more precise results.

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