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Content Based Image Retrieval Based on Color: A Survey

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----------**ABSTRACT**----------
Information sharing, interpretation and meaningful expression have used digital images in the past couple of decades very usefully and extensively. This extensive use not only evolved the digital communication world with ease and usability but also produced unwanted difficulties around the use of digital images. Because of their extensive usage it sometimes becomes harder to filter images based on their visual contents. To overcome these problems, Content Based Image Retrieval (CBIR) was introduced as one of the recent ways to find specific images in massive databases of digital images for efficiency or in other words for continuing the use of digital images in information sharing. In the past years, many systems of CBIR have been anticipated, developed and brought into usage as an outcome of huge research done in CBIR domain. Based on the contents of images, different approaches of CBIR have different implementations for searching images resulting in different measures of performance and accuracy. Some of them are in fact very effective approaches for fast and efficient content based image retrieval.
This research highlights the hard work done by researchers to develop the image retrieval techniques based on the color of images. These techniques along with their pros and cons as well as their application in relevant fields are discussed in the survey paper. Moreover, the techniques are also categorized on the basis of common approach used.

Key Words- **CBIR, Color Histogram, Digitized Images, Image Indexing, Image Repositories, Vector Quantization**

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I. INTRODUCTION

Many licensed solutions, various freeware software libraries and a large number of research articles by students exist in the CBIR domain giving proof that nowadays retrieving images based on image contents is one of the most recent areas of research in the field of computer science. CBIR has already been applied in a variety of applications being not very old; hence its usage can be seen in the past recent years. In the past and presently the image retrieval has been used for different applications like face recognition / detection[1-24], image enhancement / denoising for feature detection [25-26] and to know the morphology of images[27-28]. CBIR uses the visual content (color, shape, texture) of an image in retrieval process so that the image can be used in different processing methodologies like segmentation[29-32], compression [33-35], feature extraction [36-38], removal / detection of noise for image processing [39-43].

Color is chosen by many researchers as a medium for identifying images relating to its content because color is the most above board property of an image.
Image retrieval techniques based on color are prominent and most adaptable among other image retrieval techniques by the developers due to its distinctive properties which are useful in certain scenarios and are mentioned as under.

- Straightforward Visual Feature
- Robust
- Less complex in nature
- Less effort required for implementation
- Provides reasonable level of accuracy and efficiency
- Independent of image device

A large number of image retrieval techniques based on color can easily be found as a source of information retrieval like vector quantization, indexing techniques and other types of image retrieval techniques which have their own pros and cons and are suitable for particular situations.

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II. METHODOLOGY

In order to have effective and accurate process of searching images, many techniques were used like tagging the image, file name based search etc, but none was efficient enough to meet the needs. In 1992, T. Kato was the first person who introduced the concept of image retrieval on the basis of its contents by taking into consideration the shapes and colors of images for making the image retrieval process automatic and effective. After that researchers have taken much interest in the image searching domain as a result of which a lot of good work in statistics, pattern recognition and computer vision has come into existence to make content based image retrieval more fruitful, efficient and proficient.

Few techniques of retrieving images based on color are highlighted below precisely.

III. IMAGE RETRIEVAL TECHNIQUES USING HISTOGRAM

Color histogram is one of the intelligent methods for separating distinct sections of an image. Because of the requirement of very effective, fast and accurate methods of retrieving images as a result of web servers continuous increasing demands, image retrieval based on color histogram is not anymore considered a unique technique in the field of CBIR. Beside the realistic limitations of using color histogram for image retrieval, the fact is that still some up to the mark CBIR systems exist which have efficiently used color histogram as a tool for retrieving desired images and these systems have proved effective in a number of situations and environments.

In order to make object differentiation simple and easy, a histogram scheme which is more precise on color edges and based on color edge co-occurrence is introduced[44]. This scheme proved nonresistant against geometric attacks and lacks good usability.

Logo and trademark retrieval system is proposed making use of color edge gradient co-occurrence histograms [45].This approach uses vector order statistics in order to generate additional correct demonstration of colors on edges of object. Accurate retrieval results have been obtained as well as no control over the algorithm once implemented to tune it accordingly. This scheme showed no resistance against geometric attacks and has lacking in providing good usability. If the usability of this scheme is increased and if it is controllable it would be opted for even more implementations.

On the basis of edge gradient, a logo retrieval technique is discussed which makes effective use of edges[46]. With the usage of edge gradients, the results of experiments proved the robustness of the proposed technique. Although it works best on gradient image logos but it is not appropriate for regular images as well as the algorithm is not controllable dynamically. Geometric attacks are very important when it comes to image manipulation. This scheme is nonresistant against geometric attacks and has limited applications and popularity.

Retrieval system for the detection and retrieval of cloud images is proposed on the basis of histogram descriptor [47]. Results of experiments proved that histogram descriptor is a very precise means for obtaining color features of an image. This algorithm also lacks in providing dynamicity and proved nonresistant against geometric attacks. It has limited applications and not very practical to be used in deployment.

A new scheme based on threshold and makes use of grey level histograms is proposed by N. Otsu [48]. Because of threshold help in the prediction of color changes between objects, this scheme proved to be good for images having unstable colors. This scheme supports threshold value parameter input, allowing control to application to ask the algorithm behave accordingly as required. It is nonresistant against geometric attacks and hence lacks good usability.

Statistical distribution is applied to generate information for fast retrieval of images[49]. Results of experimental showed that the technique is more fast, accurate and resistant against the scaling and rotation attacks. Although the algorithm being robust but it lacks popularity because of the reason that it is not supportive towards dynamicity.

A block histogram image retrieval technique is discussed. It works on the principles of human visual system [50]. Experimental results showed the performance improvement over other techniques but with no support of threshold or dynamic change control. This technique proved nonresistant against geometric attacks and has limited usability.

For color approximation, a method is proposed which is based on rough set theory[51]. For color boundaries and low color areas, this technique turns out to be the best. Being nonresistant against geometric attacks this scheme has limited applications which downgraded its overall ranking.

For image similarity detection, an effective method that makes use of histogram graph is presented by the authors [52]. Weighted undirected graph is used for each color in this method. Because of having low overhead and using color location, the technique proves good but when images are subject to geometric attacks, its efficiency gets affected.

A refinement technique based on histogram is presented for the analysis and retrieval of images[53]. The image is split on the basis of grey scale obtained as a result of detecting the color pixel intensity value in this technique. Then the image searching is performed based on the final outcome. There is no provision of setting or controlling color intensity in this algorithm. Authors could have improved the proposed solution by adding extra features in it to enable it resistant against geometric attacks as well.

Because of the usage of smoothing mechanism that is window based, feature extraction technique proves best for images having a diversity of objects but has lacking in controlling preferred window first approach[54].

A CBIR technique using 5x5 neighboring pixels mean and standard deviation to calculate local mean histogram is presented hence emphasizing on local color histogram

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generation technique[55]. For images having large texture characteristics, this mechanism works better but at the same time lacks control to work differently on small scale texture characteristics. Moreover, it is resistant against geometric attacks and has good usability. If it would have been controllable dynamically, it would be of high excellence. Table1 shows an overview of image retrieval techniques based on histogram.

Table1: Techniques of retrieving images based on Histogram

Serial no.	Technique	Capabilities	Limits	Outcomes
1	Color edge co-occurrence histogram[44]	Works better on object edges.	Nonresistant against geometric attacks.	Needs improvement on geometric attacks and usability.
2	Logo and trademark retrieval [45]	Works better on logo and small images.	Non generic.	Works better only for logo images i.e., small sized images.
3	Logo retrieval based on edge gradient [46]	Works best on gradient image logos.	Not suitable for general images.	Lacks good usage of general images to become more adaptable.
4	Cloud image retrieval using histograms [47]	Robust and well documented technique for cloud image retrieval.	Nonresistant against geometric attacks.	Improvements needed to make the scheme more usable.
5	Threshold based scheme using grey level histograms [48]	Very fine technique to control the interested domain at run time.	Nonresistant against geometric attacks and lacks good usability.	Good way of managing the interested regions using thresholds.
6	Fast image retrieval [49]	Efficient image retrieval with support against geometric attacks.	Support for dynamically changing the algorithm behavior.	Overall a very good technique.
7	Block histogram based image retrieval [50]	Works on principles of human eye and is generic.	Nonresistant against geometric attacks and complex.	Overall a good approach.
8	Color approximation technique [51]	Works best on low color areas and boundaries.	Non generic.	Needs improvements.
9	Image retrieval using histogram graph [52]	Low overhead and light weight.	Nonresistant against geometric attacks.	Good technique as it uses color locations.
10	Histogram refinement for image retrieval [53]	Works on color pixel intensity and gives promising results.	Color intensity metrics are not under user control.	A new technique with good results.
11	Feature extraction technique [54]	Good for images having various objects.	Not controllable to set the interested region.	A good technique with most usability scenarios.
12	Local color histogram generation [55]	Works on localized histogram for improved accuracy.	Requires increased computations.	Idea is good but not the implementation.

IV. IMAGE RETRIEVAL TECHNIQUES USING VECTOR QUANTIZATION

A color quantization based approach is proposed on top of histogram generation[56]. This works best on images with dark backgrounds. There is no means of providing implementation for images with light background. This scheme can be more beneficial if it is robust against geometric attacks.

Image classification based on image's visual attention of the viewer is discussed[57].This technique has very cleverly used color mean and moment of regions to retrieve images efficiently. It showed no resistance against geometric attacks and has narrow usability which, if improved, can create higher rankings for it.

Clustering and texture analysis based method is also called vector quantization [58]. Vector quantization based image retrieval technique is proposed [59]. The proposed scheme captures the relationship of pixels while indexing images. This relationship is then meaningfully used in efficient retrieval. System robustness and retrieval efficiency is evident through the experimental results. This algorithm cannot resist against general image attacks and fails to be altered without rewriting major part of the algorithm due to unavailability of generalization and dynamicity.

Image retrieval using novel color quantization is proposed [57]. The proposed technique focuses on HSV color

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domain and color quantization technique hence outperforms other techniques of the same domain. This technique really works on images with dark backgrounds but lacks in being persistent against geometric attacks.

Classified vector quantization approach is proposed [60]. The scheme proposes a natural method for image classification based on tree segmentation and color thresholds. It has been shown by the results of experiments that the scheme has good usability as well as it is robust. Table2 gives a brief picture of color quantization based image retrieval techniques.

Table2: Techniques of retrieving images based on Color Quantization

Serial no.	Technique	Capabilities	Limits	Outcomes
1	Color quantization approach [56]	Works best on images with dark backgrounds.	No good results with images having light background.	An average technique which requires improvements.
2	Image classification [57]	Used color mean and region for efficient retrieval.	Non generic.	Support for general images is required.
3	Vector quantization approach [58]	Pixel relationship with colors is used for accurate retrieval.	Nonresistant against geometric attacks.	This algorithm can be really a good one to implement if improved.
4	Novel color quantization technique [57]	HSV domain is targeted and promising results are achieved.	Nonresistant against geometric attacks.	In order to find the desired image, it is a unique technique.
5	Classified vector quantization [60]	Provides color thresholds to look for images within that range.	Nonresistant against geometric attacks.	Overall a good technique.

V. IMAGE RETRIEVAL TECHNIQUES USING IMAGE INDEXING

The need of effective indexing methods for retrieval of images is increasing keeping in view its vital role in the retrieval process[61]. An approach is presented for image retrieval process based on frequency layer color indexing[62]. Image is indexed with the information of color present in the image. This technique focuses on performance with simplicity and lacks dynamicity, geometric attacks resistance and good usage which caused this scheme to be less popular.

A compact color descriptor is being used for indexing the images to make image retrieval efficient[63]. This algorithm focuses on efficient retrieval with high relevance but lacks in providing resistance against geometric attacks and dynamically controllable parameters to tune the algorithm as required. If this add-ins were there, this algorithm could have performed even better.

Another color based image indexing scheme is proposed using spatial multi-resolution color correlogram[64]. Color correlograms are used for extracting distribution of color in pixels and spatial information. This scheme has only focused on performance of retrieval while ignoring the accuracy, relevance, resistance against geometric attacks and options to run the same algorithm in different modes as required.

An approach is presented for dynamic indexing and guided search[65]. Multiple features are extracted from the image and indexed for efficient image retrieval. Experimental outcomes proved the ability of proposed scheme to provide good multi-level indexing for making image retrieval efficient. On the other hand, it could have performed better if it supports dynamic handling.

Another algorithm is proposed with a new indexing technique for efficient image retrieval[66]. Wavelet coefficients are used to extract the data to index. Although this algorithm is good but lacks in providing safety against scaling and rotation attacks and has no provision of multiple work flows which are pointed out to be main problems with this algorithm.

Semantic indexing is proposed based on the modeling of semantic aspects[67]. It uses images features and text captions to index them in databases. This scheme is different, provides certain level of accuracy but not a good performer and does not provide multi flow control and robustness which were found to be its main limitations.

Gaussian mixture model color histogram technique is proposed for indexing images[68]. This distortion exists as a result of lossy compression techniques. It is capable to avoid distortion and noise attacks.

Color semantic indexing is discussed in the field of medical image retrieval[69]. Each scheme has slight difference of implementing and finding the semantic of colors of the image. Semantic based algorithms are generally written for retrieving more accurate results. But there is room of improvement in these algorithms to make them persistent against geometric attacks and multi flow control.

Efficient indexing techniques are discussed making use of color descriptors and browsing in image databases[70].

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Efforts are being made to improve the indexing scheme for enhancing the image retrieval performance. This scheme focuses on using image's extracted features for indexing and retrieval. The proposed techniques proved to be a good choice for the applications requiring high speed retrieval and good accuracy.

Image segmentation and region based indexing scheme is proposed for on-line image querying[71]. This scheme is tested in the real environment with more than 10,000 test images. The results of experiments showed the achieved performance improvement and highlight the fact that the algorithm could have been more usable if the dynamic parameters to control flow of the system were provided.

Wavelet based feature extraction for indexing the images is presented which proves to be efficient[72]. Author proposed the idea of modeling image by wavelet architecture for extraction of color related details. These details are then used for indexing the images and later for retrieval of the images. Accuracy, geometric attacks and algorithm control according to requirement are its main lacking as many other algorithms.

Color based technique for indexing images in the database is proposed using 3D model for image retrieval[73]. This solution is proposed with consideration on computational complexity and relationship of objects in the image. A 3D model represents the color code book. This technique is resistant against distortion and can be tuned based upon three input parameters. But this tuning has to be done before actual run and cannot be changed while running.

Enhanced image indexing technique is discussed making use of wavelet quantization[74]. Algorithm works on indexing the images using their grey level information. Algorithm is tested against image database of around 1000 images and shows performance improvement but lacks in resisting against geometric attacks and dynamic algorithm control which are definitely the areas to improve.

A method is proposed specifically for efficient retrieval of lossy compressed images[75]. Discrete cosine transforms are used for extracting color vectors from the image. This technique not resistant towards distortion and basic image attacks which if handled properly can rank the algorithm high.

Another approach is presented for searching medical images[76]. Specifically cancer tissues are targeted based on their color while indexing the images. Results showed that the algorithm fails when images are attacked before searching and can only work well on medical images due to no support of dynamic algorithm control. This technique can be categorized as a result oriented technique.

Fast image retrieval technique is introduced that uses local features for indexing the images in database[77]. This approach focuses on providing vectors for feature indexing. Vectors are useful in avoiding linear search thus increasing performance. Algorithm covers wide range of image viewing conditions but still lacks to resist against distortion and geometric attacks and cannot handle images with different domains due to unavailability of dynamic control over the algorithm.

Multi resolution color decomposition and correlation based image indexing and retrieval system is proposed for the effective retrieval of images[78]. Wavelet coefficients are extracted and passed for quantization step and result set is used for indexing. Test results are calculated over 1000 images and found the algorithm as a good candidate.

Wavelet based image indexing is discussed for the analysis and retrieval of images[79-81].Search efficient feature space is extracted and color keys are generated. These color keys are used for image searching in the image database. This algorithm works pretty well in finding images with similar color schemes and objects. Table3 shows an overview of techniques of retrieving images on the basis of indexing.

Table3: Image Retrieval Techniques Using Indexing

Serial no.	Technique	Capabilities	Limits	Outcomes
1	Frequency layer indexing [62]	Performance and simplicity.	Not very practical with complex images.	An average technique which requires improvements.
2	Compact color descriptor [63]	Binary descriptor and efficient results.	Nonresistant against geometric attacks.	Improvement needed for geometric attacks.
3	Color correlograms for extracting index [64]	Retrieval efficiency.	Computational complexity.	Achieving the results with less complexity would work.
4	Dynamic indexing [65]	Index based on multiple features, improved searching changes.	Dynamics are not handled for informing about the index to be used.	In order to find the desired images, it is a unique technique.
5	New indexing technique [66]	Provides improved accuracy and efficiency.	Scaling and rotational attacks are not handled.	Overall a good technique.
6	Semantic indexing [67]	Caption based indexing with certain accuracy.	Not good for all images.	Not a very practical approach.
7	Gaussian mixture indexing [68]	Works best on lossy images.	Dynamically controlling the algorithm according to	Fine approach.

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			needs is lacking.	
8	Color semantic indexing [80]	Accurate results.	Nonresistant against geometric attacks.	Room for improvement.
9	Efficient indexing techniques [81]	Improved efficiency.	Lacks support of attacks.	Room for improvement.
10	Region based indexing [71]	Under use and deployed.	Dynamic interaction is not possible.	A good example of running implementation in production.
11	Wavelet based feature extraction for indexing [72]	Improved accuracy.	No support of scaling attacks.	Improvements needed for deployment.
12	Color based indexing [73]	Takes input and works accordingly.	Increasing number of parameters will be required.	Very efficient approach.
13	Enhanced image indexing [74]	Performance improvements.	No user input incorporation.	Requires extensive testing before deployment.
14	Color vector for indexing [75]	Efficient retrieval.	Distortion and lossy attacks are not resistant.	Needs improvements.
15	Medical image indexing [76]	Works best on cancer images.	Non generic algorithm.	Not the best even for medical image searching.
16	Local feature for indexing [77]	Vector based indexing increases efficiency.	Non generic domain algorithm.	Efficiency is really good.
17	Multi resolution color indexing [78]	Improved accuracy.	Extra overhead at server to manage multiple indexing for the same image.	Can be good in corporate environment.
18	Wavelet based feature extraction for indexing [79]	Efficient and accurate.	Nonresistant against geometric attacks.	Needs improvements for being a deployment candidate.

VI. MISCELLANEOUS COLOR BASED IMAGE RETRIEVAL TECHNIQUES

Image classification plays a vital role in the analysis of digital images[82]. An approach is discussed and proposed for image classification based on image's visual attention of the viewer[83]. Low level visual features are challenge for any system but this scheme has very cleverly used color mean and moment of regions to efficiently retrieve images. Images are retrieved though; there is no support of working with every kind of image to be retrieved. This scheme showed no resistance against geometric attacks hence having limited usability which if improved can create higher rankings for it.

A block histogram image retrieval technique is discussed based on color perception[84]. It works on human visual system principles and thus searches the image based on visual weights assigned to the blocks of image. Experimental results showed the performance improvement over other techniques but with no support of threshold or dynamic change control. With little more effort a future version of this technique can improve its limitations and make it more trustworthy.

Color indexing is suggested based on semantics of intra-region color properties[85]. Every scheme has a new way of implementing the things and finding the semantics of colors in an image. Semantic based algorithms are usually supposed to provide even more accuracy. Providing resistance against geometric attacks will cause the algorithm to be more reliable.

CBIR scheme for medical images is proposed for the analysis of dermatological lesions[86]. In this scheme, image classification based on mixed tissue composition is made. This classification is used to index the images related to particular categories. The technique focuses on result accuracy and neglects the efficient retrieval and attacks to the input images. There is no provision of changing algorithm behavior at run time.

Image retrieval is discussed using query by example[87]. This technique is focused on finding images based on interested regions and ignoring the irrelevant objects. This system is tested against large image data sets and the results are promising. Algorithm does not provide any details of resistance against geometric attacks and ability to behave according to application requirement.

Association based image indexing is presented for efficient image retrieval[88]. The proposed algorithm works on finding hidden association of objects in the image and indexes the images with all this information. Results showed better precision and acceptable performance but inefficiency in resisting against popular image attacks and algorithm control and this is an important area in which authors must work.

For the creation of an index which is a combination of shape, relevance feedback and color, a matrix is introduced [89]. A new technique has been developed on

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the basis of three other techniques as a result of which a unique descriptor is made for images storage inside the images database. Experimental outcomes proved the efficient and accurate images retrieval from the images database. An approach based on angle edge and histograms is presented which is resistant against geometric attacks. Experimental results showed its outperformance by attaining 94% precision rate and 79% recall rate[90].

A survey is presented about existing content based image retrieval techniques[91].About eighty plus papers have been discussed in the survey and the authors have concluded that image retrieval algorithms having simple implementation, reasonable accuracy and efficiency are mostly adaptable and acceptable by different implementations. Further the authors have highlighted the different components involved in the image retrieval process like feature description, index generation, image storage and image retrieval based on unique index. Another survey is given focusing on image retrieval techniques using shapes of objects[90]. Techniques discussed in the survey highlight the importance of using shape as a prominent feature in image retrieval process. One more survey is presented highlighting the low level features usage in CBIR[92-95]. It gives detailed information about the different methods and algorithms that used low level features of images for content based image retrieval.Table4 summarizes miscellaneous image retrieval techniques based on color.

Table4: Miscellaneous techniques of retrieving images based on Color

Serial no.	Technique	Capabilities	Limits	Outcomes
1	Image classification [78]	Works on low level features.	No support of user input.	For working in real environment it need improvements.
2	Human visual system type image retrieval [79]	Works like human visual system. Extracts more information than the other systems.	Lots of complexities involved.	Designing a system like human visual system is not an ordinary job. Needs much more improvements.
3	Color semantic indexing [82]	Works best on low level image features.	User input incorporation is a must.	Need improvements.
4	Medical image retrieval [83]	Focuses on result accuracy.	Not very efficient approach.	Incorporation of user input and resistant against geometric attacks.
5	Query By example [84]	Focuses image regions and improves accuracy. Extracted regions are indexed and increased chances of searching.	Overhead of extracting regions.	A very good approach with little overhead. Workable in corporate setup.
6	Association based image retrieval [85]	Better results are achieved.	Computational complexity.	A very advanced approach; if complexity is reduced the algorithm is the most advanced one to use.
7	Combined matrix based image descriptor [78]	Dynamic features based descriptor.	Good results achieved.	A complex technique to define combined matrix based descriptor. Overall good results achieved.
8	Powerful Descriptor for Angle Edge and Histograms [93]	Very useful characteristics are obtained by making use of Pythagorean theory for the procedures of image matching, search and retrieval.	-	Outperformed other techniques by attaining precision rate as 94% and recall rate as 79%.

VII. RESULTS AND DISCUSSION

In this paper four main categories of color based image retrieval techniques are presented. Most of the color based methods in each category have focused on high performance retrieval. Very low attempts are seen which try to cover the image retrieval process as a whole and provide some generic solution of image retrieval. In other words, color based image retrieval techniques are good in some cases but also lack in accurately and efficiently retrieving images in certain circumstances. Of course there is room for improvement in color based techniques

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for image retrieval. We can conclude that image retrieval techniques based on color feature have always inspired the researchers and as a result we can find many deployed techniques that are working on the same principles of image retrieval.

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