Intelligent Image Retrieval Techniques: A Survey

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ABSTRACT
In the current era of digital communication, the use of digital images has increased for expressing, sharing and interpreting information. While working with digital images, quite often it is necessary to search for a specific image for a particular situation based on the visual contents of the image. This task looks easy if you are dealing with tens of images but it gets more difficult when the number of images goes from tens to hundreds and thousands, and the same content-based searching task becomes extremely complex when the number of images is in the millions. To deal with the situation, some intelligent way of content-based searching is required to fulfill the searching request with right visual contents in a reasonable amount of time. There are some really smart techniques proposed by researchers for efficient and robust content-based image retrieval. In this research, the aim is to highlight the efforts of researchers who conducted some brilliant work and to provide a proof of concept for intelligent content-based image retrieval techniques.

Keywords: Image retrieval, intelligent image indexing, image data store, online image retrieval, search by visual contents.

1. Introduction

When it comes to the usage of digital images over the World Wide Web, it is known to everyone that there could be hundreds of thousands of users working with digital information. This digital information can be in the form of digital images as images are one of the best ways of sharing, understanding and memorizing the information. Image retrieval can be categorized into two types; exact image retrieval and relevant image retrieval. Exact image retrieval can be referred to as image recognition and its real applications can be found in [1] [2]. It requires images to be matched exactly or 100 percent, whereas relevant image retrieval is based on contents and there is flexible scale of relevance depending upon final feature values. A greater number of manipulators of digital information implies a greater number of digital image processing/sharing involved resulting in a greater amount of complexity while managing and manipulating digital contents; therefore, it is quite often required from a digital content management system to provide a graceful interface for efficiently managing the use of digital images in certain applications. The primary goal of an image management system is to search images and to compete with the applications in the current era, image searching should be based on its visual contents. For this purpose, many researchers have devised many techniques based on different parameters to gain more accurate results with high retrieval performance. Figure 1 shows the image retrieval process in general.

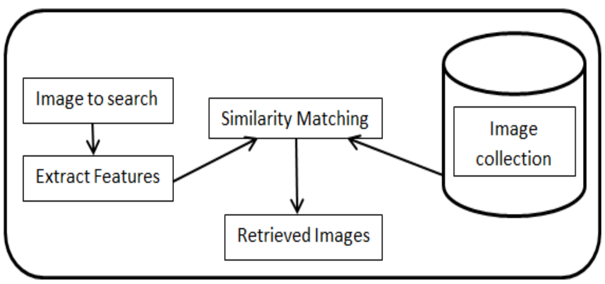

Figure 1. General image retrieval process

The origins of research in the field of content-based image retrieval go back to late 70s. Database technologies for pictorial applications were discussed for the first time in that era and the researchers got attraction for this domain since then. Former image retrieval techniques were not that intelligent and sophisticated and they were not able to search for images based on its visual features instead those techniques were based on text-based metadata of images. All images stored in the database were first tagged with the metadata and then images were searched based on the image metadata. Text-based image retrieval methods were used for conventional database applications. They were used with lot of business applications and purposes but increasing usage and volume of digital images created performance and accuracy issues for text-based image retrieval methods.

Thus, a new direction towards better image retrieval with performance and accuracy was followed by researchers from different application domains to take image retrieval technology to the next level. New methods proposed for image retrieval considered color, texture, and shapes of objects in an image. Let us discuss some of the methods, their suitability, and performance statistics for intelligent image retrieval from different application domains.

2. Content-based image retrieval using neural networks

There are several techniques based on neural networks for content-based image retrieval. Adaptive learning capability of neural networks is the primary fascinating factor behind the usage of neural networks in CBIR. Understanding the contents of image and queries makes the technique different with conventional techniques for CBIR and significant performance gain is achieved. Ideas and researches based upon neural networks in CBIR are presented in [3-21]. The basic concept is to utilize knowledge of application domain for identifying the relationship between images stored in the image databases and queries. Experiments were performed on huge image databases and it has been found out that major performance achievements were obtained after involving neural networks.

Let us discuss some of the approaches of intelligent image retrieval techniques based on neural networks for intelligence.In [3] authors have proposed neural network-based methodology for high performance image retrieval incorporating usage of wavelets. Symlet transforms are used in combination with Euclidian distance for similarity identification. Experiments were performed on standard image database and fruitful results were shown. The efficiency of image retrieval process is increased up to 92%. Moreover, no additional overhead is observed. A cognitive representation of objects is the primary principal of human visual system. An approach based on similar concept is presented in [4]. The authors have tried to implement the same logic for object recognition as used by human visual system. Neural networks are used to create model for calculating inverse difference. The scheme is highly flexible in order to support dynamic creation of views and scale percentage. In [5-7] the qualities of self-organizing neural networks are used to support image retrieval methods. In [5] self-organizing neural networks supported building of hierarchical quad tree map whereas in [6] multivariate statistics are supported by neural networks. Self-organizing map generation technique in [7] also takes advantage of neural networks. Results of experiments showed the importance and application of self-organizing model in terms of improved image retrieval efficiency.Another image retrieval technique that uses graph based segmentation is discussed in [8]. The scheme proposed works in three common steps of image features extraction, system training and then retrieving images based on extracted features. Experimental results exposed that the tests performed on different datasets of different categories resulted in better performance of image retrieval. An approach for performing content based query on collection of 3D model databases is presented in [9]. The scheme uses 3-level indexing model based on neural networks for efficient retrieval. The results showed that the system performs better on molecular data collection and can be used in any 3-D data retrieval application with efficient retrieval. Multi-instance schemes for learning user interests of image taxonomies are studied in [10][11]. The system proposed in both schemes is trained to classify images in a database as positive and negative to lie in the interested class. The experiments were made and the system was trained by supplying different sets of input images. After a few iterations of learning, the system was able to successfully categorize images that lie in class of user's interested images.

Research in intelligent image retrieval has always tried to device intelligent methods to perceive the high semantic of an image described by low-level image attributes. There is always a huge gap between the two and some of the researchers have tried to minimize this gap. In [12][13] authors have presented a scheme that uses cubic splines models built on neural network principles to minimize the gap between the image semantics and image low-level features. The results showed that the system can retrieve images with high accuracy and better efficiency as compared to other image retrieval techniques.

An online image retrieval system that supports multiple queries is argued in [14]. The good thing about the proposed scheme is that it is implemented over the web and test results are accumulated with lots of different queries and tests. Organ of interest based image retrieval system is proposed in [15]. In this scheme all the images of healthy organs are stored in the database and while performing analysis on any medical image consisting of multiple organs proposed scheme allows the user to identify organs according to the ones stored in the database. Neural networks are used to generate the class identification query and images are extracted based on a distance formula. Another image retrieval idea is hashed out in [16]. The authors presented a scheme for modifying the similarity matching algorithm at run time based on the user's matching preference. This way, the system works like a human and learns the similarity matching attributes on different queries. An agen- based searching architecture is presented in [17]. The scheme has proposed usage of multiple agents to reduce the search space by using an interleaving technique. The neural network plays an important role in the generation of feature- contained vector to be used by the agents for image retrieval in an interleaved fashion.

Another technique of dynamically updating the similarity matching algorithm is proposed in [18]. The usage of radial basis function neural network allows the collection of heterogeneous image attributes for more relevant image retrieval. The system searches more relevant images in comparison to other techniques in the light of experimental results. The dynamic incorporation of a search criterion approach is discussed in [19]. Usage of intelligent agents to incorporate the user selected searching matrix in the next retrieval process makes the overall process to work intelligently. In the light of experimental results, the system has behaved quite well in comparison with other techniques of the same kind.

Art images have very different aesthetic sense and high level of semantics. A technique to interpret the high level aesthetic semantics of art images and use them in efficient image retrieval is presented in [20]. A linguistic variable is used to define the semantics of the high level image attributes of each image. Based on this variable, the neural network generates the feature vector. Experiments showed that the system is good with art image retrieval.

Image classification based on image attributes is presented in [21]. A method for dividing the images in categories for searching from within is discussed and proposed. The idea is to divide the database with certain criteria so that the search space can be reduced. Multi-layer perceptrons are used to train the system and classify images in the database. Experiments showed that the system is capable of retrieving the images efficiently. Table 1 gives a comparison of image retrieval techniques based on the use of neural networks.

S. No #	Application	Advantages	Limitations	Results
1	Neural network-based image retrieval using Symlet transforms [3]	Performance increase	Lack of algorithm details	Can be a good candidate for modern CBIR systems
2	Cognitive object recognition and retrieval system [4]	Highly flexible	Difficult to implement all properties of human visual system	A good approach for image retrieval
3	Usage of self-organized neural networks for image retrieval [5][6][7]	Improved efficiency	-	Self-organizing neural networks can be efficiently used in image retrieval applications
4	Image retrieval using graph-based segmentatio n [8]	-	Algorithm details are not understand able	Implementatio n is difficult because of lack of algorithm details.
5	Image retrieval technique for 3D model collection [9]	3D model image retrieval.	3D data is very difficult to handle	Good approach for working with 3D model images
6	Multi instance scheme for image classification [10][11]	User's interest-based classification by artificial agent	Training on different datasets can take different time	A good learning scheme to classify images to server user query
7	Cubic splines based image retrieval [12][13]	Accuracy with better performance	-	Scheme can be used as a good candidate for image retrieval

8	Online image retrieval system [14]	Implemented on web and tested in detail	Multiple query manipulation makes the scheme complex	From a user's perspective scheme with tested results is always better on schemes with less testing.
9	Multiple organ of interest-based image retrieval [15]	Multiple organs of interest and retrieval.	Images of all organs of humans can vary in shape in different time; thus, the scheme is very complex to implement	Overall a good scheme but very complex
10	Adaptive learning of similarity matching attributes [16]	System's matching algorithm changes at run time for better relevance	Invalid retrieval criteria can set the system to an invalid matching state	Practical approach with need of performance improvement
11	Agent-based interleaved image retrieval [17]	Reduced search space makes the retrieval even faster	Synchronization of interleaved agents creates a management overhead	With improved synchronization technique performance can be increased
12	Dynamic updation of similarity matching algorithm [18]	Search criteria-based matching technique	No validity check over search attributes	Human involvement slows down the retrieval process and makes it a nonautomated system
13	Dynamic incorporation of user search criterion [19]	Intelligent UI reduces human involvement time	-	System can be automated if human involvement is not required. Makes the approach more workable.
14	Art Image retrieval [20]	High aesthetic semantic-based images are easily retrieved	Input of linguistic variable involves human input	Good approach for retrieving art images
15	Image classification and retrieval system [21]	Reduced search space gives relevance as well as efficiency	Image classification can take long time if database size is huge	Narrowed window for searching an image makes the scheme logically smart

Table1. Comparison of neural network-based image retrieval techniques

3. Relevance feedback system for CBIR

Relevance feedback system [22-122] was introduced to improve image retrieval performance and accuracy. The introduction of human visual perception in process of image retrieval is contributed by relevance feedback technique. There are two types of algorithms that use relevance feedback technique i.e., long term learning algorithms and short term learning algorithms. In long term learning algorithms an index table is maintained with historical data and this table is used for decision analysis. In short term learning algorithms genetic algorithms are adopted. Both kinds of algorithms have their own pros and cons and complexities to implement but experimental results showed that short-term learning algorithms can throw best results and with long-term learning algorithms the system performance was increased by 30% on average. Let us discuss some of the techniques with relevance feedback implementation for image retrieval.

Long term learning using relevance feedback approaches for image retrieval are discussed in [22-27]. The techniques based on long term learning uses an index table for maintaining historical data. This table is used in future decision making for image retrieval. This historical data is not maintained for further referencing in conventional relevance feedback techniques. Empirical results showed that the system gains accuracy as well as performance improvement when historical data is used for image retrieval.

Devising a framework for doing some common tasks is very common approach for generalizing things in problem solving techniques. Same concept is being used in content based image retrieval for years. Many researchers have tried to devise a framework using which some of the common image retrieval tasks can be performed. In [28-33] similar techniques for image retrieval are discussed which opted for designing a framework to do the common task. More or less all schemes discussed have used relevance feedback for learning the semantic searches. Radial basis function neural networks are implemented and systems are tested on image databases of varying sizes. The results of experiments showed that framework based approaches with relevance feedback have standardized number of steps and low complexity to understand and promising results can be achieved.

Nonlinear heterogeneous shape texture and intensity features based relevance feedback learning scheme for efficient image retrieval is discussed in [34]. System is made in such a way that it adapts the variance of users and applications using relevance feedback approach. Experiments showed that the system is performing well even on high background images. A hybrid method for image retrieval minimizing semantic gap using query alteration by relevance feedback is proposed in [35]. Hybrid steps of feature extraction, combination and color space transformation are involved in this scheme. Experiments showed improvement over the conventional retrieval methods.

Approaches for reduct-based result generation based on relevance feedback are discussed in [36-39]. The idea is to use the information provided by user at each retrieval pass in the next retrieval pass in an efficient way to reduce the size of search set before applying the next search. Using the relevance feedback technique it is possible to accommodate distilled information in the system for proceeding retrievals. The results of experiments showed that scheme is very fruitful and good to adopt but has fair level of complexity involved. Local general error model scheme for image retrieval is proposed in [40]. It makes use of neural network training capabilities to ensure that only higher similarity images are presented to user for labeling. The scheme is tested and experimented and results revealed that the proposed scheme can retrieve images with performance improvement. Another approach of image retrieval using suitable weighting in performing similarity matching is discussed in [41]. Relevance feedback is integrated with image's texture features when applied to the retrieval process improves the precision. Results of experiments showed that the level of user satisfaction is increased.

An approach for improving image retrieval process with a slightly different way of grasping intended information is demonstrated in [42]. Scheme proposed the usage of semantic tree. This semantic tree is updated after successful retrieval. Moreover, tree is clustered with semantic categories of the results. The experiments showed that the system's retrieval performance increased slowly.

An overview of relevance feedback techniques with re-weighting methodology is presented in [43]. Different relevance feedback schemes are discussed and tested on different datasets with different results.

A technique of image retrieval inspired by another technique for text retrieval is presented in [44]. In this technique a combination of two methodologies is used for achieving better results. These schemes are relevance feedback and query expansion respectively. Results of experiments showed that the inspired scheme works well with image retrieval as well.

Probabilistic scheme for image retrieval based on relevance feedback and selection algorithm is presented in [45]. The algorithm proposed collects the benefits of probabilistic conceptualization and user interaction for memorizing the weight given to an image. The images are then classified into positive and negative examples based on similarity matching algorithm and then the system proceeds with the positive example images for further retrieval process. Experiments showed that the system has a good potential for retrieval of varying images.

A few approaches based on SVM (support vector machines) are discussed in [46-54]. Since SVM based techniques with relevance feedback usually exhibit poor performance with low number of labeled samples, schemes are proposed to overcome the limitation of SVM-based approaches and results of extensive testing showed the betterment made in SVM based algorithms.Making the user interface more interactive has resulted in better image retrieval results is evident through experiments. Few schemes for image retrieval emphasizing on the interactive user interface are discussed in [55-60]. The research study has revealed that more interactive user interface allows the user to tune up the system settings for specifying the attributes for training samples. The results of experiments showed that interactive systems have better accuracy when compared to non-interactive systems.

An approach for log-based image retrieval maintaining retrieval information in user log is proposed in [61]. User preferences over the retrieval results are stored in log files which are used in the next retrieval process to improve the retrieval performance. This scheme focuses on the removal of noise that is stored with the user's preferences while performing image retrieval. This noise can slow down the whole retrieval process. The technique proposed is tested on several kinds of images with different interests of retrieval and experiments showed the importance of the scheme.

An analysis report on relevance feedback image retrieval algorithms is presented in [62]. As we know that the relevance feedback technique is used quite often in image retrieval algorithms, somost techniques have made slight changes to the system and designed components around relevance feedback to gain better image retrieval performance. In this research a system is designed to measure the performance of relevance feedback module in each relevance feedback-based image retrieval process.

Relevance feedback with neural networks approach to learn user semantics of particular images is proposed in [63]. Neural network is constructed dynamically in response of images retrieved against the queries. It makes the scheme independent of particular extracted features and matching function. Thus, it can be incorporated in any content-based image retrieval system to improve its performance based on historical queries. Experiments showed performance gain by using the proposed scheme.

Another relevance feedback-based image retrieval system is proposed in [64]. This scheme imposes the learning of weight specification. It helps in automatic weighting of images with approximation of user weighting and best for automated image retrieval systems where user interaction is not necessary.

Increasing the search space for specific features can result in better image retrieval results. A similar kind of approach for increased features search space is introduced in [65]. Authors have taken the advantage of relevance feedback and extended it to work on increased features subspace. System learns the user demeanor for efficient relevance feedback mechanism. Experiments were performed on image database of more than 50 k images and results showed that the newly proposed scheme can retrieval more relevant results as the features search space was increased for matching.

An adaptable image retrieval scheme using relevance feedback is presented in [66]. The authors have proposed the usage of more than once representing sub schemes that can learn and update their similarity detection criteria using relevance feedback at each user input. With the adaptive nature of system, the image retrieval error can be reduced to zero percent. The experiments were performed on database of images taken under water and results showed that the system is capable of learning through the user input and adopts the learned criteria very efficiently for proceeding retrievals.

Efficient schemes for image retrieval with smart logic and understanding are presented in [67-68]. The scheme proposes the limited iteration model for accommodating the user's feedback as this can be trivial on large image databases; hence, as alternative other schemes are used to extract the user's intension instead of iteratively recording the user's response. For example, recoding user navigation patterns from search queries are extracted and the system is trained on these extracted patterns. This reduces the feedback iteration as well as introduces intelligence in the system.

A simultaneous method for updating the query with search criterion extracted in relevance feedback module while updating the query is proposed in [69]. The novel scheme efficiently improves the performance because of the usage of simultaneous processing and this is evident through the results of experiments.

Learning the user intentions from log data and reducing the relevance feedback time is researched in [70]. Log data can be efficiently used to extract the user's intensions and can be used for further image retrieval passes. Authors have utilized the same approach for learning their system from log data instead of the user's feedback. Results of experiments are good with small and trained data sets but are not fruitful for very large and untrained data sets.

Automatic query modification for image retrieval is exploited in schemes discussed in [71-76]. The concept of automatic query modification is based on the idea of updating the query automatically with each retrieval result. This way the user's involvement can be reduced for relevance feedback as well as the user's behaviors will also be known. More or less all automatic query modification schemes have worked around the same concept to achieve automatic query modification. Overall the experiments showed good results but with limited datasets.

Retrieval technique for medical images is presented in [77]. The proposed scheme used a hierarchical learning scheme for classifying images. Relevance feedback for incorporating the user's input is researched but not made part of the proposed scheme and left for future work.

Another scheme for utilizing self-relevance and limiting the user's interaction is proposed in [78]. The proposed scheme limits the user's interaction and tries to provide self-relevance to the search engine. The experimental results showed very slight performance gain and it can be even less on huge data sets. Machine learning has played an important role in recent years of development and image retrieval has also taken advantage of machine learning to make image retrieval techniques more sophisticated and usable. Some image retrieval techniques that make use of learning at relevance feedback, image classification, generation modeling and learning on similarity detection are discussed in [79-94]. The proposed techniques have spotted the usage and advantages of applying learning in image retrieval techniques in the light of research and experimental results. Learning has made image retrieval techniques more sophisticated and this allows limiting user interaction with the system and let the application do most part of the work.Such schemes are very much useful in places where automation is required and supplying user input is difficult.

An approach for extracting the user's interests in image retrieval using multiple rounds is presented in [95]. The use of a support vector machine is proposed in combination with similarity of features detection based on relevance feedback. Results of experiments showed that retrieval accuracy has improved greatly. Usage of combined feature vector with relevance feedback in efficient image retrieval is proposed in [96]. This approach focuses on using multiple features for relevance feedback and then applies searching based on the user's interests. Experimental results showed that the combination of multiple features can extract better results.

Another scheme of image retrieval focusing similarity judgment based on relevance feedback is described in [97]. The authors have claimed that using their proposed scheme of relevance feedback and similarity detection incorporating fuzzy rules is recommended for image retrieval.An incremental approach of relevance feedback for efficient image retrieval is proposed in [98-99]. A long term consistent performance of image retrieval is focused on these schemes. Instead of incorporating every user's feedback in image retrieval, correlations are identified in feedback and, based on graph models, these similarities are accommodated for proceeding retrievals.

The association-based relevance feedback technique for image retrieval is presented in [100]. The authors followed a similar approach for storing and retrieving images as that of human brain. The images are associated and then saved and the same association is used while retrieving the images.

The introduction of fuzzy systems with relevance feedback for high performance and improved accuracy image retrieval techniques is discussed in [101-106]. Radial basis networks play an important role in the learning capabilities of the systems discussed. The level of user involvement varies in each methodology depending upon the need of information and context of perception. Fuzzy systems have outperformed this domain as well and experimental results show that, while utilizing fuzzy systems, the accuracy and performance of image retrieval is improved. A relevance feedback-based scheme incorporating hierarchical distance is presented in [107]. The main focus is on the inequality-based algorithm which gives up to twenty percent retrieval performance according to the results of the experiments.

Usage of irrelevant information while updating the user's feedback in relevance feedback scheme is proposed in [108]. Similarity measures are updated recursively to exclude the unwanted information. The experimental results showed that the scheme is effective and reliable.

A Bayesian classifier-based approach utilizing relevance feedback is proposed in [109]. The classifier is used for classifying thesamples in positive and negative classes. The information retrieved in the relevance feedback is used for system training and the results show the effectiveness of the system.

Geospatial data is always difficult to handle and, when it comes to image retrieval of geospatial images, it becomes even harder. An approach for geospatial image retrieval using relevance feedback is discussed in [110]. The scheme is based on the idea of small number of iterations of relevance feedback with the introduction of intelligence for generating dynamic weighting for upcoming queries. Experiments demonstrated that retrieval accuracy is increased up to ten percent with the proposed solution.

Another relevance feedback scheme focusing on continuous feedback is presented in [111]. The authors argue about the amount of feedback and system performance and their point of view is to have sufficient feedback in an image retrieval system. Graph-cut based schemes using relevance feedback for image retrieval are described in [112-113]. The proposed schemes focused on implicit labeling of data. The main idea of these approaches is to minimize the effort required to label the data according to the user's feedback. These kinds of approaches can be implemented on generic as well as on specific kinds of image repositories. Test results show the importance of the scheme. Most relevance feedback schemes are introduced to cater the gap between low level features of image and their high level meanings. A couple of techniques for reducing the semantic gap for mammographic and CAD images are described in [114-115]. Experiments show that the relevance feedback can improve accuracy in mammographic images up to forty percent.Using the relevance feedback for feature selection can improve the retrieval data correctness. This debate is brought in research in the research articles presented in [116-120]. The user's response in context of features is recorded and incorporated for further queries.With several experiments, it is evident that the context in terms of selected features is very important and it can play an important role in increasing the level of correctness.

An error propagation-based relevance feedback research is conducted in [121]. The ease of feedback is the main emphasis of the research. The user is required to answer only "yes" and "no" for the relevance of images retrieval. This input generates an error propagation report which is then used to refine the query for next search. The application is tested over a huge image collection and robust and claimed results are achieved.

A dual layer conformation kernel-based approach for image retrieval aiming at increasing retrieval correctness is researched in [122]. The idea presented in this research revolves around the theory of identifying the dominant feature that categorizes the image group. As in conventional relevance feedback schemes, the user's response is recorded as a huge vector and there are chances of misinterpretation of the feedback vector. This can result in wrong image categorization and can lead to accurate retrieval.

An image retrieval technique involving relevance feedback and a color and shape based descriptor is proposed in [123]. The authors have applied a new technique and the experimental results show the effectiveness of the proposed scheme.
At the end survey of image retrieval techniques is proposed in [124]. The authors have highlighted the importance of relevance feedback in the whole image retrieval process while discussing other parts of content-based image retrieval algorithms.
A comparison of relevance feedback-based image retrieval techniques is given in Table 2.

S.No #	Application	Advantages	Limitations	Results
1	Long-Term learning in relevance feedback [22-27]	Performance increase with improved accuracy.	-	System can perform slowly while learning but once the learning is complete system's performanc e will be boosted
2	Devising framework for image retrieval process [28-32]	Devising framework reduces the number of steps and complexity of retrieval algorithm	Difficult to separate steps of algorithm which are highly dependent	Framework based image retrieval algorithms help in minimizing complexity and giving good retrieval results
3	Multi-feature (Shape, Texture and Intensity) incorporation in image	Image is searched for similarity with respect to 3 factors returning the	Performanc e can slow down when images have complex	Detailed attributes-based image retrieval technique.

	retrieval [34]	most relevant images	details in all three attributes	Good for high accuracy requiremen t applications
4	Hybrid image retrieval [35]	-	-	An average typical hybrid approach for image retrieval
5	Reduct-based set generation for image retrieval [36-39]	Reduced set to search for images will result in efficient retrieval	Complex	Fairly complex to distill user selected properties and incorporate in generation of reduced set
6	Local general error method for image retrieval [40]	Limited labeling can increase performance	-	Fair scheme for image retrieval
7	Suitable weighting with relevance feedback [41]	Increased precision	-	Improved user's satisfaction level with better precision.
8	Semantic tree for image retrieval [42]	Improved performance with logical distribution	Semantic tree generation can take longer time	A good approach. As the number of retrieval tasks is increased, the system prepares itself for efficient retrievals
9	Overview of relevance feedback methods [43]	Overall benefits of relevance feedback techniques are presented.	No detailed algorithm specific details.	A good survey of relevance feedback techniques.
10	Combined relevance feedback with query expansion for image retrieval [44]	An inspired technique from text retrieval domain.Works fine with image retrieval.	-	Good inspiration and good execution resulted in better outcome.
11	Probabilistic conceptualizat ion for image retrieval [45]	Image categorization discards the irrelevant images from result set.	Image classificatio n is quite difficult while incorporatin g user experience.	A new concept which has good potential for improveme nt.
12	SVM based image retrieval techniques [46-54]	Performance is not an issue with improvements to SVM based algorithms.	Modification to algorithms is required.	Now SVM based schemes can also be used with confidence in image retrieval process.
13	Interactive image retrieval techniques [55-60]	Lots of control in hands of user to adjust system settings accordingly.	User interaction makes the process unusable with automation.	Interactivity improves the accuracy.
14	Relevance feedback scheme with noise removal log [61]	Noise filtering from log file.	Log file processing can be slow when the log is too huge in size.	A very observing idea to remove noise for improving image retrieval process.
15	Measuring performance of relevance feedback [62]	Relevance feedback performance is measured to know the overall impact.	The performanc e of other components cannot be measured.	The importance of relevance feedback is made clear in a big scenario.
16	Neural network applied over relevance feedback to improve image retrieval performance [63]	Using neural networks user experience is learned for next retrieval.	Increased complexity.	Very good approach for learning user interest in particular images.
17	Automated image weighting for image retrieval [64]	User interaction is not required.	Learning can take longer time.	Practical approach for dealing with the possible image retrieval scenarios.
18	Increased feature space for image retrieval [65]	More relevance can be retrieved efficiently.	-	Good to search for specific features in increased features space for more appropriate results.
19	Multiple representing schemes for image retrieval [66]	Reduces the retrieval error to zero percent	Redundant mapping can increase time when an update to the database is made	With consistent database state the scheme can outperform other schemes
20	Efficient image retrieval using limited iterative feedback model [67][68]	Automated behavior learning	Query expansion and extraction can take longer if a search criterion is complex	From a user's perspective limited iterations for feedback is always good
21	Simultaneous query	Multi-processing	Dependenci es must be	Overlappin g of tasks

	modification for image retrieval [69]	gives efficiency	removed before multi-tasking can be started	always gives performance but also introduces an overhead to manage the multitasking.
22	Using log data for relevance feedback based image retrieval [70]	Limits user's input and increased learning	Untrained and large datasets can be real problematic	Good for small and medium sized databases
23	Automatic query modification for image retrieval [71-76]	Reduces user's involvement on relevance feedback for performance improvement	Large result sets returned for certain query can trouble the scheme of query modification	It depends on the dataset on which it is tested
24	Proposal of relevance feedback on existing medical image retrieval technique [77]	Works well with medical images of 75 different categories.	Performance can be increasing if relevance feedback is implemented.	Incorporating relevance feedback will increase efficiency and accuracy.
25	Self-relevance for image retrieval [78]	Slight performance improvement with no user input.	-	Not practical with large datasets.
26	Learning-based image retrieval techniques [79-94]	Automation possible with no or very limited user involvement.	Management overhead but can be overcome if properly implemented.	Very practical approach for image retrieval algorithms.
27	Support vector machine and relevance feedback for image retrieval [95]	Improved accuracy.	Complex to implement.	Overall complex approach. Can increase retrieval accuracy if implemented accurately
28	Usage of multiple features for relevance feedback [96]	Improved accuracy and efficiency.	Complex and irritating to get multiple feedbacks from user for each feature.	Not a good technique from a user's perspective
29	Similarity detection using relevance feedback for image retrieval [97]	Practically implemented at multinational company.	-	Practically implemented and usable scheme
30	Long term consistent performance of image retrieval	Long term consistent performance	Association detection and management is	Good approach, complexities can be handled

	[98][99]		complex to implement	properly with good implementation.
31	Association-based image retrieval [100]	Fast image retrieval and accuracy improvement	Additional hardware is required	Good system for very large image data repositories
32	Fuzzy relevance feedback for image retrieval [101-106]	Improved accuracy and efficient retrieval.	-	Fuzzy systems have dominated the field of image retrieval with relevance feedback.
33	Hierarchical distance based image retrieval [107]	Up to 20 percent increase in retrieval performance.	Sub features level extraction can be tricky and complex.	According to the results the scheme is capable of increasing image retrieval performance.
34	Unwanted information exclusion using relevance feedback for image retrieval [108]	Improved accuracy and reliability.	Iteration can lead to user dissatisfaction.	Another way of filtering the results by excluding the irrelevant information.
35	Bayesian classifier based scheme for image retrieval [109]	-	Limited experiments were used for conclusion.	Needs more training and testing.
36	Geospatial image retrieval [110]	Spatial image retrieval with noticeable increase in accuracy.	Large data sets are required to be tested.	Good scheme for retrieving geospatial images.
37	Consistent feedback based image retrieval [111]	-	Not evident through practical results	Proposed scheme should have supported experimental data
38	Graph-cut based image retrieval [112][113]	Reduced data labeling time and effort and implemented on generic and specific datasets.	-	Idea that can be very useful in upcoming systems being developed on this scheme
39	Minimizing semantic gap for image retrieval [114][115]	Good techniques for mammographic and cad images	-	CAD and mammographic images can be retrieved with more accuracy and efficiency
40	Feature selection-	Correctness can be	If user is only	Overall a good

	based relevance feedback scheme [116-120]	improved in context of features selection	interested in one feature, rapid feature modification makes no sense	scheme that covers the missing part in other relevance feedback schemes
41	Error propagation for image retrieval [121].	User's feedback time and complexity is noticeably reduced	Hard to map the yes/no in user's interests	Idea needs very fine implementa tion
42	Dual layer dominant feature-based image retrieval [122]	Improved correctness and better chances of relevant retrieval	-	Nice idea and focusing point. Needs good implementa tion and testing for making it a better candidate for implementi ng
43	Combined features based image descriptor [123]	New hybrid technique, retrieval accuracy and efficiency	Complex process to generate hybrid image descriptor	Overall a good technique

Table2. Comparison of Relevance Feedback based image retrieval techniques

4. Conclusion

With the increasing demands of multimedia applications over the Internet, the importance of image retrieval has also increased. In this research study, image retrieval techniques that have used the neural networks and relevance feedback to improve the performance as well as accuracy of the image retrieval process are discussed. All these techniques have their own advantages as well as certain limitations. In other words, there is not a single technique that fits best in all sorts of user's requirements; therefore, the doors are still open to keep inventing new methodologies according to the requirements of image retrieval applications.

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