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Annotation based Integrated Algorithm for intelligent Retrieval of CAD Images

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ABSTRACT

Computer aided manufacturing environment needs CAD images for production planning and manufacturing of new products. Those images can be retrieved from the database instead of designing every time. To reduce the searching time and to increase the accuracy (99%) this Integrated algorithm is designed for retrieving images with manual and automatic annotation. This study considers all primitive features of an image viz., colour, shape, texture and logical features and abstract attributes. The proposed framework includes annotation and similar image retrieval based on relevance factor of CAD images for production drawings. This improved model can be integrated with any of the design, drawing and development software module.

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INTRODUCTION

. Searching and locating an image with accuracy inside a large image database is considered tedious and time consuming, many a times lacks in accuracy. Many areas of science, technology and business use large number of images for various applications of engineering. Hence accurate retrieval of images is very difficult in larger database. Content-based image retrieval (CBIR) methods are found to be easy and efficient for image retrieval. The CBIR is generally used for image identification, comparison and retrieval based on different techniques of Intensity-based (color and texture) retrieval and Geometry-based (shape) retrieval. The detailed literature study and review of literature done by J. A. Harding et.al, for computer aided engineering (CAE) indicated that there is research potentiality for data mining and knowledge extraction methods to integrate manufacturing with product characteristics, and engineering design processes. The area requires retrieval algorithms for large data bases yet to be explored and addressed. Though image retrieval is desired for all the domains of CAE, the need for establishment of semantic relationship of images and the requirements is needed to be addressed in the field of computer aided engineering. The data on many leading CAE technologies is in textual form for major operations and manipulations; this proposed research uses image data in the form of image or text and combination of both. This paper proposes to improve retrieval method based on the relevance factor with annotation using low level features and abstract attributes of an image. The text data retrieval and processing semantics of the images which can support for a series of complex operations in the field of processing images and videos, such as recognizing shapes and objects. It is also important to have annotation metadata for images for semantic retrieval based on image content.

Ii. Related works:

The work done by Andrew Kusiak, Matthew Smith (2012) gives insight in image based data-mining for product and manufacturing system, one of them is the requirement for development of an efficient algorithm to process image, geometry, audio, and video data. The difficulty in designing geometrical image retrieval system is still unresolved and needs a suitable retrieval algorithm. Danushka Bollegala *et al.* (2003) and Roland Kwitt.*et al* (2007) Edward Kim. *et al* (2011) have demonstrated the applicability of the context of colour texture retrieval on four texture image databases and compared retrieval performance to collection approaches for image retrieval but did not address the issues related to combine the shape based retrieval. Sathyabama. *et al* (16) have developed computer-aided Image Retrieval method based on images of plant leaf shapes has lead to the challenge of combining the color texture and shape, which is discussed with our Integrated model. Jianping Fan. *et al* (2006) Jean Francois aujol, Tony F.Chan (2010) Subramanian Appavu (2012) developed algorithms to classify the image into geometrical information and texture information but the relevance factor was not

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incorporated and addressed in this enhanced algorithm. Cosmin Grigorescu (2003) Alberto J. Alvares.et.al (2008) Balafar (2010). Brian Kulis, (2009) have reported the usage of data mining to design and manufacturing integration as a possibility of usage of STEP based environment which will be the improvement area of this model. Koen Deschacht (2007) Tao Jiang (2008) Yang Mingqiang (20) had given a deep insight of various shape feature extraction techniques using the edge detection algorithms and methods. Mehwish Rehman.et.al., used Texture, color, shape and spatial layout to feature extraction and relevance feedback also tried to bridge extracted low level features and features with high level semantics gap from image are discussed. Aman Chadha.et.al Manimala Singha and K.Hemachandran Mangijao Singh and Hemachandran discussed the ways to improve CBIR by discriminating power of color indexing techniques, the color features by assigning weights to each feature respectively and calculate the similarity with combined features of color and texture using Canberra distance as similarity measure.

Based on the literature findings, the idea is to develop an integrated algorithm which is capable of providing the retrieval of image content based on shape, colour, texture and semantic information with relevance value. The new algorithm is accommodative of geometrical, CAD, CAM and CAE data sources. The complex geometric image and its contents based retrieval methods and its results required in manufacturing environment to be integrated with Computer integrated systems, Machine learning algorithms, Computational intelligence tools, which depend more on the large data bases for their applications. The large data collection, storage and retrieval system for process control and execution purposes is resolved and addressed by inter disciplinary approach of this research work. Customized tools developed so far are in development laboratories, for the above requirement an exclusive and integrated solution is yet to be arrived.

This capability is the most valuable asset of Decision Support/ learning Systems, which is supported by the proposed algorithm for digital/CAD images. This algorithm supports in decision making of similar parts identification in computer aided manufacturing environment by reducing manual judgmental decisions on high technology applications. Generally the decision of grouping and processing a part are made based on a combination of judgment and knowledge of the experts from various domains taking in to consideration available resources on the database before making a decision. Hence the manual intervention of the closest part selection out of the large data base is reduced and eliminated if integrated with the Enterprise Resources planning tool platform. The data of the image as knowledge extracted from databases by the proposed work could be integrated with many of the existing execution set up and systems.

III. Proposed Work

The knowledge based decision process for the intelligence of the DSS needs to relate the semantic information of image with the image into Meta data during storage and retrieval, the recent search algorithms Sathyabama does not incorporate the ability to relate the semantic and the image, the main challenges addressed in this study of image retrieval based on annotation and image features. Most of the images understanding tools are based on a collection of low-level processing functions, which have to be combined with third party tools. The mining methods use low level functions of color, texture and shape (e.g., shape recognition and pattern extraction) during the process of image analysis and information extraction, segmentation algorithms are used to partition the image into regions related to the relevant areas according to the application criteria. Hence automatic annotation tool is inevitable and developed in this research for image retrieval, to simplify the process of searching the image database.

In this paper, we introduce a novel approach for feature selection in high dimensional data using an integrated image retrieval algorithm. The dependent attributes of a given image are annotated, identified, compared and enlisted for the CAD images in XML schema. Dependency between attributes are calculated by first grouping them and then by calculating the distance of value of class attribute using Euclidean distance method. The procedure is repeated for all possible combinations of attributes, and the dependencies between the whole attribute set in a dataset are found. The proposed method shows better results in terms of number of selected features, classification accuracy, and running time than most of the existing algorithms. The newly developed image retrieval algorithm uses automatic annotation based on array similarity distance matrix, color layout distance calculation, visual descriptor distance calculation, edge detection and texture segmentation methods, also used as a retrieval tool of keyword or image and both. The idea is to list similar images of the large image database based on the relevance. Proposed system encompasses image annotation and image retrieval with the help of automatic annotation and retrieval tool for CAD digital images.

IV. Frame Work of Integrated Image Retrieval Algorithm:

The images of a dataset are selected based on related application (ie.criteria) and stored in the data base and trained by the manual or automatic annotation frame work incorporated in this Integrated image Retrieval Algorithm (IIRA). Preprocessing phase of IIRA extracts the features of all images and stores in indexed order as Meta data of the object as trained set of data. The search process based on query or by image used to extract the objects and match up with the query data for similar pattern of color, shape and texture and lists based on

relevance factor. The highest relevance factor image is listed first and the next follows in the long list of images under consideration up to the lowest factor of the entire image data base. The relevance may either be color, shape and texture features. The results are then interpreted to generate intelligence to the DSS that can be applied in problem understanding, decision making and other activities. The annotation results can be mapped to a XML schema, once stored using XML (to represent object properties and relationships), the images could be retrieved through descriptions to express selection criteria that should be satisfied. By describing some objects or relationships found in an image of a design, the users could specify search conditions and retrieve similar images from the database, in order to improve design and manufacturing procedures. In this prototype work several methods are incorporated to get complete image retrieval algorithm that suits the requirements of modern day industrial problems.

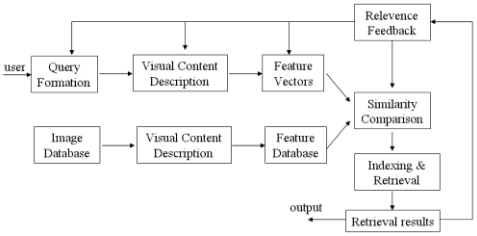

Fig. 1: Frame work of proposed Image retrieval methodology.

Figure 1 explains the proposed work which consists of two modules. Manual Annotation module and Similar Image retrieval module based on the levels of Primitive features such as color, texture, shape of image elements, Derived (sometimes known as logical) features, involving some degree of logical inference about the identity of the objects depicted in the image.

A. Integrated Image Retrieval Algorithm (IIRA):

1. Collection of Image database, containing 50, 100, 200, 500… 10000 etc CAD /Digital images.
2. Manual, Automatic Annotation and storage of XML schema of the image.

Content-based image annotation starts from a set of candidate annotations obtained by an existing image annotation algorithm. Then, the query-biased transition probability matrix is constructed for the query image using both the content feature of the query image and the corpus information. Feature Extraction is carried out by using color, texture or by using shapes. Color feature extraction is done by Color Layout Descriptor (CLD), Texture extraction using co-occurrence matrices. The CAD images are stored as metadata with their corresponding features such as color, texture, shape.

3. Similarity Searching

3.1 Query based:

Done by image indexing technique,

3.2 Image based (Color, Shape, and Texture):

Done by using color histogram for color. The texture based similarity retrieval is done using Wavelet transform procedure with segmentation methods. The process of Shape feature retrieval is done with moment similar image retrieval can be done using the similarity measure procedures.

B. Manual Annotation:

Step 1: Input the Image.
Step 2: Extract the feature based on color, shape, Texture.
Step 3: Annotate the image based on the pattern.
Step 4: Storage of semantic information as XML schema.

The additional information like Who, Where, What.etc may be given if needed and stores semantic information as XML schema. The input image is taken for clustering using Euclidean distance method by taking ordinary distance between two points that one would measure with a ruler and is given by the Pythagorean formula. By using this formula as distance Euclidean space becomes metric space for comparison between object slicing of the images. The Euclidean distance between points p and q is the length of the line segment connecting them (pq)

In general for an n-dimensional space, the distance is

$$d(p,q) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + ... + (p_i - q_i)^2 + ... + (p_n - q_n)^2} \quad (1)$$

Here we are using 2 dimensional geometrical objects for classification and clustering. The two dimensional Euclidean plane,

if p= (p_1, p_2) and q= (q_1, q_2) then the distance is given by

$$d(p,q) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2} \quad (2)$$

The clustered objects are stored as binary values inside the database, and based on the values of the input image the fast mapping operation done by visual descriptor distance and color layout distance for annotation. This calculator uses the distance between two objects for fast mapping using the following formulae for distance function for symmetric and must obey the triangle inequality Distance in k is:

$$d[k+1](O_1, O_2)^2 = d[k](O_1, O_2)^2 - (x_1[k] - x_2[k])^2 \quad (3)$$

Color Layout Descriptor (CLD) is designed to capture the spatial distribution of color in an image. This descriptor effectively represents the spatial distribution of color of visual signals in a very compact form. This compactness allows visual signal matching functionality with high retrieval efficiency at very small computational costs. It provides image-to-image matching as well as ultra high-speed sequence-to-sequence matching, which requires so many repetitions of similarity calculations.

The distance between the two descriptors can be computed as:

$$D = \sqrt{\sum_i w_{yi}(DY_i - DY_i')^2} + \sqrt{\sum_i wbi(DCbi - DCbi')^2} + \sqrt{\sum_i wri(DCri - DCri')^2} \quad (4)$$

A suffix tree for a string *S* of length *n* can be built in Θ(*n*) time, if the letters come from an alphabet of integers in a polynomial range (in particular, this is true for constant-sized alphabets). For larger alphabets, the running time is dominated by first sorting the letters to bring them into a range of size *O*(*n*); in general, this takes *O*(*n*log*n*) time. Assume that a suffix tree has been built for the string *S* of length *n*, or that a generalized suffix tree has been built for the set of strings

$$D = \{S_1, S_2, ... S_k\} \text{ of total length } n = |n_1| + |n_2| + ... + |n_k| \quad (5)$$

The fast mapped output is stored as XML schema along with the properties of the image, which is used for searching during the similarity search.

At end of the automatic/ manual annotation process a detailed description of the image that is MPEG-7 Meta data of the image is stored in XML schema. For our extraction, we adopt MPEG. MPEG-7 has been developed after many rounds of careful discussion. It is expected that this standard would be used in searching and retrieving for all types of media objects. If we have images stored with MPEG-7 metadata, it would be easier to do semantic retrieval. MPEG-7 files contain a reference to the location of the corresponding image file different schemas. We propose to combine XML schema integration techniques and image retrieval techniques using low-level features with automatic annotations. MPEG-7 uses also XML as the language of choice for the textual representation of content description, as XML Schema has been the base for the DDL (Description Definition Language) used for the syntactic definition of MPEG-7 Description Tools and for allowing extensibility of Description Tools (either new MPEG-7 ones or application specific)..

C. Similarity Searching:

Several methods for retrieving images on the basis of color, texture and shape by using any one of the features have been described in the literature; most have given same idea of similarity search algorithms and its usages. The color histogram technique is used for similarity search of color feature. At search time, the user can either specify the desired proportion of each color (75% olive green and 25% red, for example), or submit an example image from which a color histogram is calculated. Either way, the matching process then retrieves those images whose color histograms match those of the query most closely.

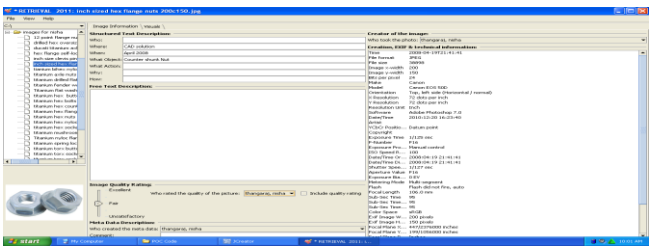

Fig. 2: Manual Annotation of image.

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Texture segmentation is used in this paradigm for retrieving similar image based on texture feature of the image. To know the texture details a set of metrics are calculated in image processing to quantify the perceived texture of the image. It gives the information about spatial arrangement of color or intensities in an image or selected region of an image. It is used to help in segmentation or classification of images.

Shape matching of three-dimensional objects is a more challenging task – particularly where only a single 2-D view of the object in question is available. One approach is to generate a series of alternative 2-D views of each database object, each of which is matched with the query image. Related research issues in this area include defining 3-D shape similarity measures, and providing a means for users to formulate 3-D shape queries.

Query Based search:

A query is given to retrieve the similar CAD image from the image dataset based on the description that is already stored as XML schema during the annotation. This is done by creating an index for the data set that is to be stored. Based on the index the tool retrieves the similar images for the given query.

Image Based Search:

A CAD image is given as a query to retrieve the similar image from the image dataset based on the description that is already stored as XML schema during the annotation. The Color feature of the image, the color histogram serves as an effective representation of the color content of an image if the color pattern is unique compared with the rest of the data set. The color histogram is easy to compute and effective in characterizing both the global and local distribution of colors in an image. The color histogram, i.e., the distribution of the number of pixels for each quantized bin, can be defined for each component. Clustering methods used to determine the K best colors in a given space for a given set of images, option is to use the bins that have the largest pixel numbers since a small number of histogram bins capture the majority of pixels of an image To take the spatial information of pixels into consideration, thus very different images can have similar color distributions. To increase discrimination power, a simple approach is to divide an image into sub-areas and calculate a histogram for each of those sub-areas and the division can be as simple as a rectangular partition, or as complex as a region or even object segmentation.

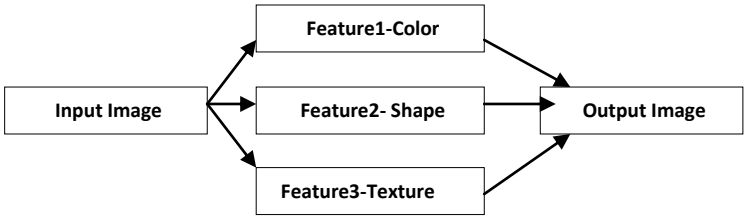

Fig. 3: Feature selection for similarity comparison.

The texture based similarity retrieval is done using Edge detection procedure with co-occurrence matrices and segmentation methods. Segmentation based on image texture, region based and boundary based. Region based attempts to group or cluster pixels based on texture properties together. Boundary based attempts to group or cluster pixels based on edges between pixels that come from different texture properties. Segmenting the objects is based on edge detection algorithm and in order to avoid an extreme segmentation, the description is mapped to a XML. Edge detection is used to determine the number of edge pixels in a specified region helps determine a characteristic of texture complexity. The direction of edges can also be applied as a characteristic of texture and can be useful in determining patterns in the texture. These directions can be represented as an average or in histogram.

Consider a region with N pixels the gradient –based edge detection is applied to this region by producing two outputs for each pixel p: the gradient magnitude Mag (p) and the gradient direction Dir (p). The edginess per unit area can be defined by

$$Fedgeness=|\{p|Mag(p) > T\}|/N \text{ for some threshold T.} \quad (6)$$

The Co-occurrence Matrices formula is used to capture properties of a texture. Numeric features computed from co-occurrence matrices can be used to represent and compare textures. Standard features from a normalized co-occurrence matrix is

$$Energy= \sum_i \sum_j N2dd[i,j] \quad (7)$$

$$Entropy= - \sum_i \sum_j Ndd(i,j)log2Nd(i,j) \quad (8)$$

$$\text{Contrast} = \sum_i \sum_j (i-j)^2 N_{dd}(i,j) \quad (9)$$

$$\text{Homogeneity} = \sum_i \sum_j \frac{N_d(i,j)}{1+|i-j|} \quad (10)$$

Searching:

Fig. 4: Image retrieval based on the input query.

Fig. 5: Results for Query based search.

Fig. 6: Image retrieval based on the input image.

Fig. 7: Results for image based search.

V. Discussion On The Results:

The above integrated approach is proposed for CAD /digital image databases combining text annotations. This approach combines a conceptual and visual content description together with an improved relevance scheme and performs better than the prevailing data mining techniques for the image data retrieval. Our retrieval framework is primarily intended for databases where the CAD / digital images do not have text annotations captured and stored as Meta data of the image for the retrieval. The different schemes in the prevalent data mining methods and their features used in this System and its performance comparison are as listed in Table 1. The IIRA method is also checked for the effectiveness of the retrieval and proved faster than the methods discussed in the reference texts. The time required to perform the retrieval is computed and plotted in Graph.1 for the different numbers and heterogenic nature of CAD/digital images in the database by steps.

This paper evaluates the results and its effectiveness by using the integrated tool, which could be used to collect annotation data and to retrieve the similar CAD images from the image set. The cycle time of image retrieval is taken as parameter for performance of the algorithm with respective to the amount of data/ number of images. Larger the data longer will be the retrieval time. This algorithm is estimated to perform in a shorter time than that of the algorithms developed so far. Table 1 compares cycle time for algorithms developed by Irina Mocanu for retrieval of the images by the famous methods like Centroid Radii Turning angle (CRTA)

method, Distance Histogram (DH) method, Centroid-Radii model (CR), Fourier Descriptors (FD), Turning Angle (TA) methods and the comparison has yielded the method proposed (IIRA) gave the best even when operated for the most complex (CAD) of the shapes being compared for less than 2000 images in a database.

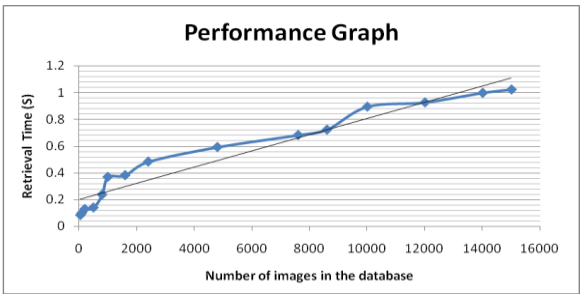

Fig. 8: Performance of the algorithm Retrieval time.

Considering the average precision and recall obtained for the test databases, the IIRA method outperforms the rest of the analyzed methods. The low retrieval performance of turning angle method indicates it as an inaccurate shape representation. There are few situations in which distance histograms method outperforms precision and recall of the centroid radii and turning angle method (these situations appear for shapes with a lot of small edges).

Table 1: Comparision of Performance of Various Methods.

Method	Retrieval Time (Secs)	Comparison Time (Secs)	Total Time (Secs)
CR	0.02	0.6	0.8
FD	0.3	0.01	0.31
TA	0.06	0.05	0.11
DH	0.9	0.8	1.7
CRTA	1	1	2
IIRA	0.02	0.03	0.05

VI. Conclusions:

This work explores the connection between an annotation and retrieval for a given CAD image family by annotating manually and stores the details of image into the database as XML schema of the image, which is used to recall the image. The search criterion for a new image is established and easy to retrieve an image of complex CAD shapes. Our results show that the tool is able to greatly simplify and fastens the process of annotation from large CAD image. This prototype is able to annotate and retrieve CAD data using methods, compare, classify and group datasets, analyze similarity and perform data mining in different levels.

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