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Object Identification with Color, Texture, and Object-Correlation in CBIR System

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***Abstract*—**Needs of an efficient information retrieval in recent years in increased more then ever because of the frequent use of digital information in our life. We see a lot of work in the area of textual information but in multimedia information, we cannot find much progress. In text based information, new technology of data mining and data marts are now in working that were started from the basic concept of database some where in 1960.

In image search and especially in image identification, computerized system at very initial stages. Even in the area of image search we cannot see much progress as in the case of text based search techniques. One main reason for this is the wide spread roots of image search where many area like artificial intelligence, statistics, image processing, pattern recognition play their role. Even human psychology and perception and cultural diversity also have their share for the design of a good and efficient image recognition and retrieval system.

A new object based search technique is presented in this paper where object in the image are identified on the basis of their geometrical shapes and other features like color and texture where object-co-relation augments this search process.

To be more focused on objects identification, simple images are selected for the work to reduce the role of segmentation in overall process however same technique can also be applied for other images.

***Keywords*—**Object correlation, Geometrical shape, Color, texture, features, contents.

I. Introduction

SIZE of our digital collection is increasing day by day because of two reasons. First is the rapid advancement in imaging and storage devices. Reduction in the price is the second main reason. Only some efficient retrieval system can use this huge and diverse collection of digital data.

There are two broad categories of image retrieval ystems. In the first type, images are searched on low-level features where level of understanding is not desired rather cannot be achieved. In such system image color is used for search [1, 2] where in some methods other low level features like texture along with color are used [3-5]. Shapes features are also considered. Low-level features are used in all these methods where contents of image are not utilized.

In the second type of methods high level features of image are used for identification. Although high level features are better choice in image retrieval specially in cases where human perception is more concerned but at the same time extraction of these features are difficult than low level features. Extraction is not the only area which needs more attention and execution time but the later steps also demand more domain knowledge and special treatment.

We as human beings never see images in term if low-level features. No doubt color and texture are important for identification but these alone are not sufficient to achieve the level of understandings. Geometrical shape of the object also shares its part in the process and plays its role for the understanding.

To bridge this gap between the low level features and the concept present in the high level features in the real challenge. Computer can extract low-level features in far better way but our perception is based on high level features so the query posted but human will also be based on high-level features. Conversion of this high level query into low level features in the real part to be done in the whole process.

Text search is enjoying great success and we can now see its practical use in many areas and applications. Google, yahoo, and other search engines are few examples of search engine operation online for image search. Real image search is still a question even in these very advanced and sophisticated systems.

Many techniques used for text search can also be applied in image search and is actually doing this way in many application but these are not search of the images but these are actually search of the tags associated with these image.

Keywords act as the main source in such systems. “Google Image Search”, “Picsearch”, “AltaVista - Image Search”, “ImageToss”, “and Live image search” are some examples of these types working online.

Performance of such systems depends on the relevance of these tags and keywords with the image. Insertion of tags is done manually most of the time. Some work is done to add these tags either automatically [6] or in a semi- automatic fashion [7, 8]. All such key-based system lack the ability of understanding and are totally dependent on the keys attached with them. These can easily be cheated where one totally diverse and different tag are attached with an image which has no relation with the attached tags.

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Tags: Red , CAR Red

Tags: CAR, Honda

Tags: car , Green

Tags: Car Music

Fig. 1. key based search

As shown in the figure 1, if "car" tag is attached with the image of bird and a girl's picture, system will not be able to identify the image

Knowledge of the correct word is yet another limitation of such system. Tags added with image manually, semi-atomic or even in automatic tagging depends on the proficiency of the language and know-how of the vocabulary.

To reduce all these dependencies and overcome these limitations an efficient system is needed where content of the image should be used for retrieval not the keywords tagged with images.

In this paper the concept of an efficient system is presented where image is retrieved by the objects which are identified by their geometrical shapes, color, texture, and co-related objects.

II. System Architecture

We have a digital collection where images are stored in different format. In our system the core part is the database that contains images along with their features. This database contains both the low level and high level features. In the low level feature database contains color, textures, and their sorted gray level histograms. These are used to cluster images and for indexing.

Geometrical shapes of the objects present in the image are stored in database as high-level features. Both the number of objects in image and their shapes are used for indexing and searching.

The other main part of the system is the knowledge base that works parallel with the database and have knowledge about the relation of the objects with other objects and strength of this relation. More knowledge is added into the system using machine learning methods.

Query is the start of the retrieval process. This query can be text or an image posted to the system. This image is converted in standard format where features are extracted and then used to search in the database. Image can also be retrieved by posting some features directly which are then converted according to stored features. In case of some ambiguities and insufficient evidence about the identification of image, correlation knowledgebase is used to resolve this uncertainty.

Overall flow of the process is illustrated in figure 2.

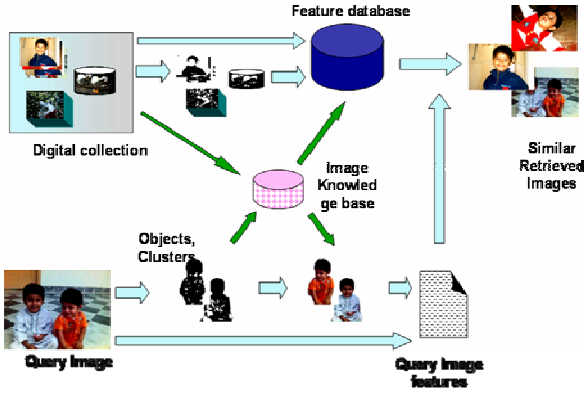


Fig. 2. System Architecture

Objects present in the image are extracted using segmentation and then features are obtained for each object. At the same time features from the image are also extracted that construct feature set of the image. Extracted objects and their correlation information are entered into the knowledge base that is used in the feature extraction process. These features are then acts as query that retrieve image from the image database.

III. Shape Estimation.

"Things" are the main focus in a Contents based image Retrieval (CBIR) system rather than "Stuff" [9]. Finding objects are more important than the features of images in such system [10] where shape is the primary feature of objects used in the system.

Normally an image contains many objects and each object is treated separately. Some time it becomes very difficult to identify objects in image where image is congested and crowded. In such cases entire image is treated as single object and texture with some other low-level features are used for identification. In the images that contain finite identifiable objects, following steps are used to extract them.

Segmentations
Boundary Extraction & Key Point Identification.
Curve fitting and Shape Estimation
Key-Point /Curve Optimization
Shape Estimation.

A. Segmentation

Segments are set of pixels having similar visual attributes. Importance of this grouping is accepted even in psychology [11]. This is a common observation that pixels of similar attributes belong to same object if these attributes are estimated intelligently.

Segmentation is the key step in the image processing and is a bridge between low-level features and high-level image understanding. In last forty years we can see many techniques of different categories [12]. Boundary based and region based techniques are still the two main type of segmentation. In region based methods , segmentation is done by estimating the regions having neighbor pixels with same attributes [13]. In the other method that is boundary based this task is done by identifying the boundary of objects [14].

Deterministic annealing for segmentation is used by J. Puzicha and J.M. Buhman [15]. A.K. Jain used classical clustering [16] while set of objects are used by J. Ponce [17] which have limited no of objects.

We have used our cross-point approach for segmentation which is based on human perception.

B. Boundary Extraction & Key Point Identification.

Once segments are obtained from image the next step is the extraction of boundaries for each segment. Boundaries' obtain by the edges-masks based on first and second order derivation contains fluctuations. These are made smooth to overcome the problem of local variation. After smoothing the boundaries by averaging key points are estimated which are the points having sudden changes in their slope. A square shape is used here as shown in figure 3. Slope and change in slope is shown in figure 4. Figure 4.a shows the slope of a rectangular shape where in the next figure 4.b, change in the slope is illustrated. Next step is shown in figure 4.c where 2nd order datives are plotted for the curve. The point on which this line crosses zero is the point where the change in the slope is the maximum.

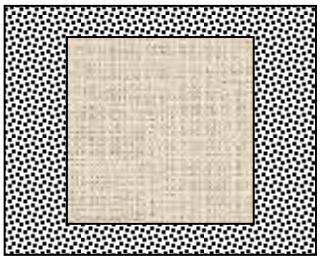


Fig. 3 Square object

During this step some time false points are also obtained which are eliminated by calculating the distance from other points and relative height of its neighbor.

C. Curve fitting and Shape Estimation

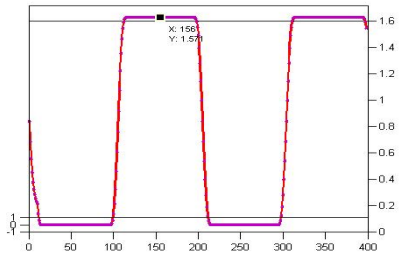
After the key-point estimation and removal of false points, next step is the fitting of the curve between the pairs of key points using least square error.

Initially first order, second order, and third order polynomial curve is fitted for the boundary between two adjacent key points. Equation for m^{th} degree polynomial by least square method is used as

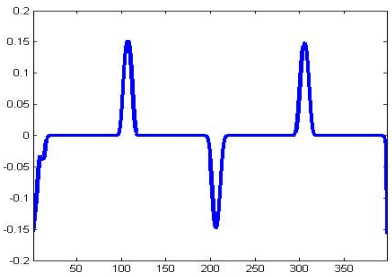
$$y = a_0 + a_1 x + a_2 x^2 + \dots a_m x^m \quad (1)$$

Where $(x_1, y1)$, (x_2, y_2) .. (x_n, y_n) are points between key-points. Curve is estimate such that the error between the curve and the points is minimum.

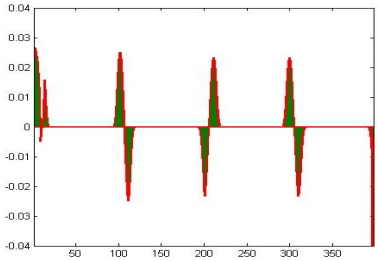
$$\prod = \sum_{i=1}^{n} [y_i - f(x_i)]^2 = \min \quad (2)$$



(a) Slope of boundary



(b) change is slope , first order derivative



(b) First order slope curve, second order slope curve

Fig. 4. 1st and 2nd order slope curves

Where a_0, a_1... a_m are unknown coefficients.

To obtain the least square error, the unknown coefficients a_0, a_1, a_2, … and a_m must yield zero first other derivatives.

(3)

$$\begin{aligned}
\frac{\partial \Pi}{\partial a_0} &= 2\sum_{i=1}^{n} [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \dots + a_m x^m)] = 0 \\
\frac{\partial \Pi}{\partial a_1} &= 2\sum_{i=1}^{n} x_i [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \dots + a_m x^m)] = 0 \\
\frac{\partial \Pi}{\partial a_2} &= 2\sum_{i=1}^{n} x_i^2 [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \dots + a_m x^m)] = 0 \\
&\vdots \\
\frac{\partial \Pi}{\partial a_m} &= 2\sum_{i=1}^{n} x_i^m [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \dots + a_m x^m)] = 0
\end{aligned}$$

By Expanding the above equations, we have

$$\begin{aligned}
\sum_{i=1}^{n} y_i &= a_0\sum_{i=1}^{n}1 + a1\sum_{i=1}^{n}x_i + a2\sum_{i=1}^{n}x_i^2 + \cdots + a_m\sum_{i=1}^{n}x_i^m \\
\sum_{i=1}^{n} x_i y_i &= a_0\sum_{i=1}^{n}x_i + a1\sum_{i=1}^{n}x_i^2 + a2\sum_{i=1}^{n}x_i^3 + \cdots + a_m\sum_{i=1}^{n}x_i^{m+1} \\
\sum_{i=1}^{n} x_i^2 y_i &= a_0\sum_{i=1}^{n}x_i^2 + a1\sum_{i=1}^{n}x_i^3 + a2\sum_{i=1}^{n}x_i^4 + \cdots + a_m\sum_{i=1}^{n}x_i^{m+2} \\
&\vdots \\
\sum_{i=1}^{n} xi^m y_i &= a_0\sum_{i=1}^{n}x_i^m + a1\sum_{i=1}^{n}x_i^{m+1} + a2\sum_{i=1}^{n}x_i^{m+2} + \cdots + a_m\sum_{i=1}^{n}x_i^{m+m}
\end{aligned} \quad (4)$$

Unknown coefficients a_0, a_1, a_2 … and a_m can be obtained by solving the equations given in (4).

As shown in figure 5, first three order curves are compared with the original boundary and the best one is selected. If higher order polynomial is close to the boundary and lower order curve have larger error, that higher order curve is broken into two lower order curves by introducing another key-point.

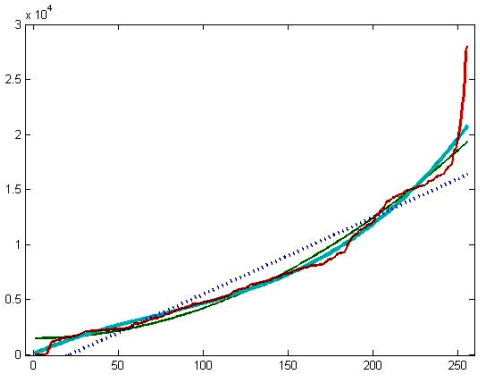


Fig. 5. Curve segment (red) and polynomial curves of first three order

D. Curve optimization and shape estimation.

During this process many false points are added in the list which are because of some noise and do not contribute any role in identification. In this step these points are eliminated by combining two adjacent curves.

All the optimized curve are then combined together to make the complete shape which is composed on line and curves. On the basis of these curves and line segments geometrical shape of the objects is identified.

Once shape of the object is identified, it is matched with one of the basic shapes present in the knowledge base and additional features are then obtained accordingly. These features are used for retrieval of the image.

E. Object Identification.

Object identification is the next step after shape identification. For each geometrical shape we have a set of objects in database which are recognized with the help of features extracted from the geometry with the help of color and texture

IV. Color, Texture and Object Correlation

Color and texture are one of the major visual properties used to identify objects in human and even computer vision Some time we see more then what we view. In simple we perceive more then what we see and this is because of our knowledge not the information in the scene. Object correlation is the feature that fills this gap in this identification and retrieval system.

A. Color:

"Blossom in a sea of wind
Green grass and blue sky"

Color as mentioned above is one of the main visual property through which objects are identified. Some colors are so linked with some objects that when we think about one the other comes in our minds automatically for example "white like snow" "blue like sky", and "green like grass".

Many image retrieval systems based on colors are proposed but most of them work with the dominant color in the image [18]. However in this proposed system set of colors in each object (segment color set) are used for the purpose. Once the objects that are the segments are separated, major colors are identified. These colors are stored as HSL (hue, saturation, and lightness). For each segment at most three colors are selected and stored along the object in database.

B. Texture and Pattern

Texture is the other major feature used for identification of the objects.

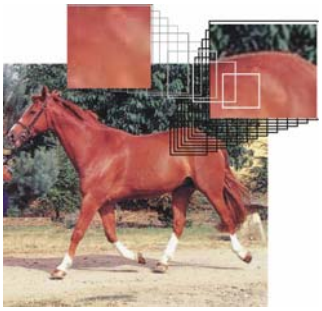


Fig. 6. Extraction of texture.

Some time texture alone is sufficient to identify the object even without any geometrical evidence. For example texture of a zebra, leopard, or tiger is sufficient to identify if the object under consideration is an animal with some correlated jungle objects. Figure 6 show some popular textures. A set of texture for each object is stored in the database as pattern. Pattern matching techniques are applied for search.

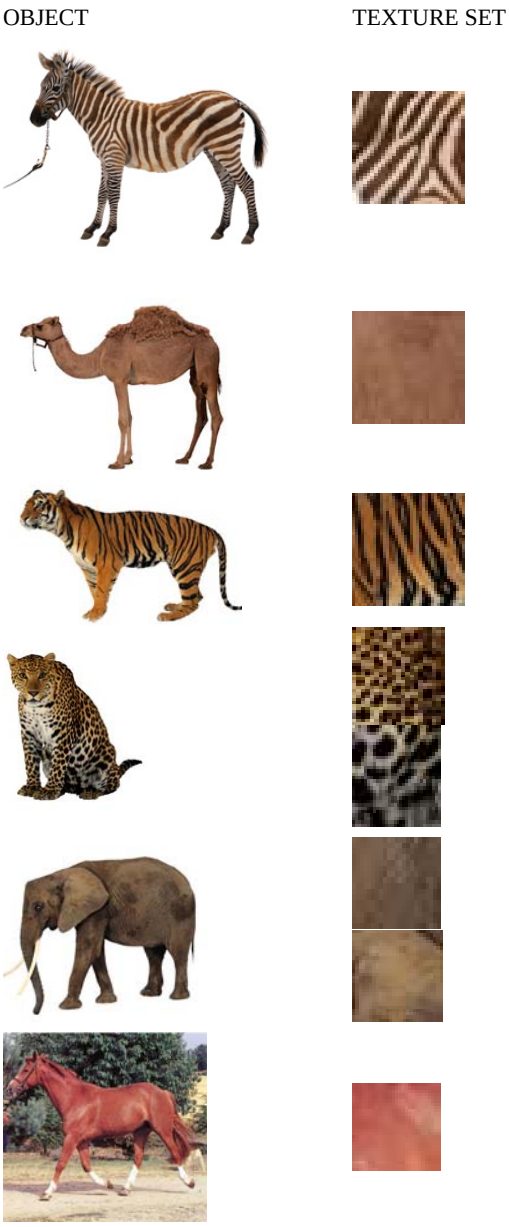


Fig. 7. Object and textures

Some time same object may have different patterns at their different position for example we have different set of pattern for tiger if taken from different part of the body. Same is true for human where we may have different texture of skin at different parts of body. This problem can be solved by taking different texture for each object. This can help in identifying the part of the object or other information about the image like time and season. For example a leaf or a plant may have different textures at different time.

C. Object Correlation.

There are some objects which naturally occur with other objects. For example we know that a fish will be in water, airplanes will be in air or at some airport, and a bus or car will be on road with other similar vehicles. During image identification this is done by identifying the objects in it. Some objet of the image can be easily identified by their geometrical shape, color, and texture as mentioned above. Still there can be some objects in the same image that may fail to identify either because of complex geometrical shape and not enough color and texture knowledge or because of some ambiguity and confusion in the decision. In such situation object correlation is used to resolve the problem.

str(Fish , water) str(cup, saucer) str(bird, tree)

Fig. 8. Correlated objects

Knowledgebase of the system have knowledge about all the objects and their relation and its strength with other objects. For example fish and water have strong relation as car with road or bus.

Fig. 9. Ambiguity due to geometry of shapes

Co-occurrence of different objects in image can be helpful for image identification.Our knowledge base maintains clusters of objects based on their occurrence. This is the major part of the knowledge where learning is used for updating knowledge. For instance the shape of an aero plan is similar to the shape of a shark, and a bread can be similar with a bus. But with the help of other objects in image and their correlation can help in identification of object and solve the problem.

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