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Emergence Index and Content-Based Image Retrieval

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ABSTRACT

Content-based image retrieval is a very extensively researched area of multi-media systems since last decade. We present this topic with emergence index in this paper. Emergence phenomenon talks about the study of the implicit or hidden meanings of an image. This gives a totally different search results than ordinary search where emergence is not considered, as taking into account hidden meanings could effectively change the index of search. We determine our index structures based on explicit as well as implicit meanings of an image. We put forward theoretical aspects of image retrieval with emergence index in this paper.

1 INTRODUCTION

Content-based image retrieval (CBIR) is a very difficult area of multimedia database access system. During the last few years, automated image retrieval techniques have been developed based on color, shape, texture and spatial locations. Although plenty of research works have been done, it has yet to attain maturity. Quite a few models are now commercially available like QBIC, Virage, Excalibur, Attrasoft and others. Non-commercial models developed by universities and research institutions are also available. But they do approximate matches between inputs and objects of image database. Thorough image segmentation, which is essential for accurate image retrieval, is still a problem.

In a paper, an approach depending on clustering of the texture features, with the goal to improve the retrieval performance and to allow users to express their queries easily was studied. The texture features extracted from images are grouped according to their similarities and then one of them is selected as a representative of each group. The users can then use these representatives to express their query. The elaborate descriptions of clustering process and a summary of results obtained from the experiments are presented as well as a comparison about statistical texture extraction methods and effects of clustering to them (Celabi and Alpkocak, 2000).

In another project where a system called CLIMS (Clausthal Image Management System) for content-based image retrieval is developed as a subsystem of a general multimedia database. It allows inquiry by sketch and image example and uses color and wavelet based features for the comparison of images. Each image in the database is expressed by a set of wavelet coefficients and color attributes, which form the basis for the retrieval. For efficient similarity search, two index structures, VP-Trees and Lq metric, are presented. With the extension of the original VP-tree algorithm, a ranking of the n most similar images is possible. Its efficiency has been evaluated on a simple, general image catalogue (Kao and Tendresse, 2000).

In a paper based on fuzzy retrieval of images, the authors claim although some works have been done in the area, none of them rely on a defined model for fuzzy query processing part. In this paper, an approach for fuzzy content-based retrieval using the Fuzzy Object-Oriented Data (FOOD) model is being developed. A novel way of determining the fuzzy values from extracted color features would also be presented (Gokcen et al, 2000).

In a project, to develop content-based image retrieval system, NETRA system has been developed. This uses color, texture, shape and spatial location information in segmented image regions to search and retrieve similar regions from the database. A special aspect of this system is its incorporation of a robust automated image segmentation algorithm that permits object or region based search. Images are segmented into homogeneous regions at the time of entry into the database and image attributes that represent each of these regions are computed. Other components of the system cover a color representation and indexing of color, texture and shape features for fast search and retrieval (Ma et al, 2001).

Although quite a few commercial and non-commercial models are developed, none of them attempted to study the hidden or implicit meanings of the images. We achieve more accurate and different search outcomes when hidden meanings are also taken into account. For example, we can consider a square with one diagonal. This is the explicit or outer meaning of the image. But when we consider implicit or inner meanings, we get two triangles in it. This is what is meant by emergence.

We are presenting content-based image retrieval where we would define our index, based on contents of the image, studying also the emergence phenomenon in the process for a more accurate search.

The paper provides definition and application of emergence index using pictures and application of emergence index in image query processing. Section 2 provides the definition and section 3 the calculation of emergence index and establishing symmetry between input and image. We make our conclusion in section 4.

2 EMERGENCE INDEX

Features of an image, which are hidden and not explicit, are emergent features if these can be made explicit and which could bring out more and different meanings than those of the original.

Examples of emergence. Shape emergence is defined as emergence of single or multiple shapes. Figure 1 contains examples of shape emergence.

1.1 Definition of Emergence Index

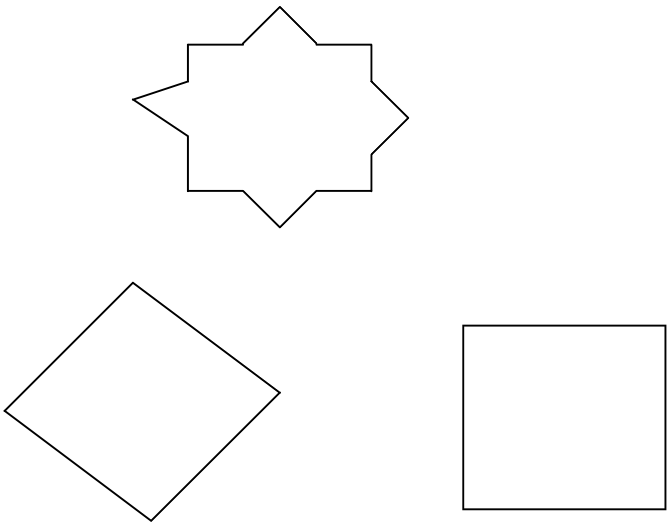
Image retrieval where we study the hidden or implicit meanings of the images and based on those implicit meanings as well as explicit meanings, where there is no implicit meaning at all, an index of search is developed to retrieve images is called emergence index.

2.2 Semantic Representation of images

Symbolic Representation of images. The symbolic representation of shapes could be defined using infinite maximal lines as

$$I = \{N;constraints\} \quad \textbf{(1)}$$

Figure 1: Two Emergent shapes derived from the original one. The first one is the existing shape whereas the other two are emergent shapes from the first image (Gero,Year Unknown)



Where N is the number of infinite maximal lines, which effectively compose image I and constraints are limitations, which define behaviors or properties that come out from the infinite maximal lines (Gero,1992).

2.3 Various mathematical tools that would be used in the definition of the image.

Geometric property. There are four geometric properties related to infinite maximal lines: a. Two lines La and Lb are perpendicular, La ^ Lb. b. Two lines La and Lb are parallel, La // Lb. c. Two lines La and Lb are skewed, La ´ Lb. d. Two lines La and Lb are coincident, La = Lb.

Topological property. Intersection and segment are two properties of a set of infinite maximal lines. If La and Lb are two infinite maximal lines then their intersection Iab would be denoted by a. La ´ Lb => Iab, b. La ^ Lb => Iab where => means ‘implies’. The first case of the above is the skewness whereas the latter is perpendicularity of the geometric property.

The intersection cannot occur if La // Lb or La = Lb. In other words, parallel property of two infinite maximal lines and also coincidence do not generate any intersection.

Properties of intersection a. Iab is same as Iba. b.Iab and Ibc are called collinear intersection in Lb. c. Iabc exists if La, Lb and Lc are concurrent.

The segment generated by two intersections is denoted by (Iab, Ibc) and this segment lies in infinite maximal line Lb.

There are three types of intersection groups: ordinary groups, adjacent groups and enclosed groups. These three groups indicate three kinds of topological structures, which define intersections and line segments in different ways. Ordinary group could be expressed by a pair of ‘(‘ and ‘)’ parentheses. In this case a line segment could be defined by two intersections. If La,Lb and Lc are three lines, then segment of line would be (Iab, Icb). The adjacent group is defined by a pair of angle ‘<’ and ‘>’ brackets. Here only two adjacent intersections can represent line segment of the order <Iab,Iac>. An enclosed group, defined by a pair of square ‘[‘ and ‘]’ brackets represents a circuit of line segments. For a triangle it would be [Iab,Iac,Ibc].

Dimensional property. The length of the segment of two intersections is called the dimensional property and is denoted by d(Iab, Ibc).

3 CALCULATION OF EMERGENCE INDEX

3.1 Structure of Emergence Index

In order to calculate the emergence index, we use the following equation.

$$EI = f(D,F,V,C,E) \quad \textbf{(2)}$$

where EI stands for emergence index, D for domain where the image belongs, F for features, V for variables which can define the features’ constraints under which the features are defined, C for constraints and E for emergence characteristics of images.

We believe any image, static or in motion, could be expressed semantically in terms of the above-mentioned five parameters (Deb and Zhang,2001a).

As an example, we take the image of a square with a diagonal. The four sides are a,b,c,d and the diagonal is e.

The images in the database have to be kept based on some classifications. A particular class of images would be in the same table. This is because enormous volume of images are being generated and they cannot be kept in the same table as it would be extremely time consuming to access them if placed in one table. The first parameter of equation (2) which is domain would be the table which contains the image of the square, say Table 1.

The feature is defined by the number of maximum sides which is 5 in this case. The variables are a,b,c,d,e. Some of the constraints are a=b=c=d and angles a,b,c,d are same and equals 90 degrees. The emergence is composed of two triangles with sides a,b,e and c,d,e.

These five factors define the Emeregence Index EI (Deb and Zhang,2001).

To establish symmetry between an input image which comes in the form of the front-side of a house and the image of a locality where there is a lake and more than one house, we try to find correspondence between input and one of the houses of the image of the image database. We do that by considering following factors;

Group intersections in each image
Number of infinite maximal lines
Corresponding equivalence
Number of intersections
Geometric constraints of infinite maximal lines
Dimensional constraints of segments
Corresponding intersections
(Deb and Zhang,2001b).

An application of emergence index in practical problems is in geographic location. We consider the image of a map of a township where there is a park, a lake, roads and residential area. The roads surrounding the park and the lake form the shape of a bowl. This is the example of an embedded shape emergence where emergence is a set of the whole image. As we know images are generated in huge numbers. So if we want to locate this particular image from a table containing large volume of data, then we can have an input of a bowl. Then this input of the bowl will find a match with the emergent shape of the bowl in this

Figure 2: Image of a Square with a Diagonal

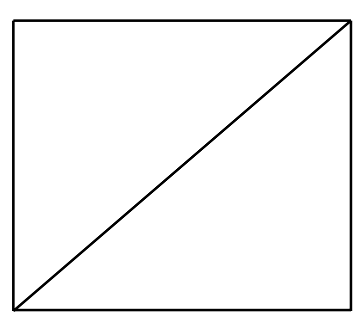


image of the map and select it for display. This is the advantage of using emergence index (Deb and Zhang,2002).

Also calculation of symmetry of input in the form of a lake and a house and image in the form of a lake and two houses is shown. If our input comes in the form of a lake and a single house, then we could compute Dist(I,O) using Lp metric where I1,I2, …., Ik be the vector of feature values derived from input I by considering feature values of I of all objects, namely lake and house and their distance etc. Similarly let O1,O2, ….,Ok be the vector of feature values derived from image O by considering feature values of O of all objects, namely lake and two houses and their distances etc.

Then distance between I and O is

$$\mathbf{Dist_p(I,O)} = \left[\sum_{i=1}^{k} |I_i - O_i|^p \right]^{1/p}$$

where p is the order of the metric.

Suppose the perimeter of the input lake is, say, 190 units and house is 12 and distance between their center points is 57. Also let us assume the perimeter of the image of the lake is 200, one of the house has perimeter of 15 and distance between them is 52.

For p=1, we obtain Manhattan distance between I and O as

$$\mathbf{Dist\ (I,O)} = (200 - 190) + (15 - 12) + (57 - 52) = 18$$

If we set a limit that all images within distance t has to be retrieved then

Dist (I,O) £ t is to be satisfied for retrieval.

If we have t = 20, then obviously the image containing a lake and two houses would be selected for this input. We could use Euclidean distance for p=2. This method can be applied for any Lp metric.

Calculation of symmetry involving an object in motion and three dimensional shape is also shown (Deb and Zhang,2003).

4 CONCLUSION

We have discussed accessing multimedia databases using emergence index and without using it. We have shown how emergence can give rise to altogether different meaning and could be used in accessing large databases in more efficient way. This could help us explain and interpret images in a more accurate way. More research works need to be done to apply this concept in various practical problems. That way we should be able to find more meanings and hidden patterns of those images which not only would enable us to define them more accurately but also should establish more appropriate symmetry with other images when needed. At the moment we are working on the implementation of these concepts.

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