Concepts of Emergence Index in Image Databases

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INTRODUCTION

Images are generated everywhere from various sources. It could be satellite pictures, biomedical, scientific, entertainment, sports and many more, generated through video camera, ordinary camera, x-ray machine and so on. These images are stored in image databases. Content-based image retrieval (CBIR) technique is being applied to access these vast volumes of images from databases efficiently. Some of the areas where CBIR is applied are weather forecasting, scientific database management, art galleries, law enforcement and fashion design.

Initially image representation was based on various attributes of the image like height, length, angle and was accessed using those attributes extracted manually and managed within the framework of conventional database management systems. Queries are specified using these attributes. This entails a high level of image abstraction (Chang, 1988; Gudivada & Raghavan, 1995). Also there was feature-based object-recognition approach where the process was automated to extract images based on color, shape, texture and spatial relations among various objects of the image.

Recently, combinations of these two approaches, efficient image representation and query-processing algorithms, have been developed to access image databases. Recent CBIR research tries to combine both of these approaches and has given rise to efficient image representations and data models, query-processing algorithms, intelligent query interfaces and domain-independent system architecture.

As we mentioned, image retrieval can be based on low-level visual features such as color (Pass et al., 1996; Smith & Chang, 1996; Srisuk & Kurutach, 2002; Sural et al., 2002; Swain & Ballard, 1991; Traina et al., 2003), texture (Manjunath, 1996; Sheikholeslami, 1997; Smith & Chang, 1994; Zhou et al., 2001), shape (Safar, 2000; Shahabi & Safar, 1999; Tao & Grosky, 1999), high-level semantics (Forsyth et al., 1996; Torratha & Oliva, 1999) or both (Zhao & Grosky, 2001).

But most of the works done so far are based on the analysis of explicit meanings of images. But image has implicit meanings as well, which give more and different meanings than only explicit analysis provides. In this article we provide the concepts of emergence index and analysis of the implicit meanings of the image, which we believe should be taken into account in analysis of images of image or multimedia databases.

BACKGROUND

Concepts of Emergence

A feature of an image that is not explicit would be an emergent feature if it could be made explicit. There are three types of emergence: computational emergence, thermodynamic emergence and emergence relative to a model (Cariani, 1992). We use the latter one in our article.

Whenever we shift our focus on an existing shape, in other words an image, a new shape emerges. The representation of the new shape is based upon our view of the original shape. The new shape emerges as we change our view of the original shape. This is the most important idea of emergence.

Two classes of shape emergence have been identified: embedded shape emergence and illusory shape emergence (Gero, n.d.; Gero & Maher, 1994). These procedures could be based on geometrical, topological or dimensional studies of the original shape.

Model of Emergence

To extract emergent shape from an image, first we have to destroy the original shape of the image. This would give us an unstructured image. Now we take the unstructured image and find out the extra or implicit meaning out of it in addition to the original meaning, and this process gives rise to emergent image with implicit meaning, making explicit and emergent images generated. This can be defined in a model in Figure 1 (Gero & Yan, 1994):

Definition of Emergence Index

For image retrieval where the hidden or emergence meanings of the images are studied and based on those hidden meanings as well as explicit meanings, where there is no hidden meaning at all, an index of search is defined to retrieve images is called emergence index.

Figure 1. Model of emergence
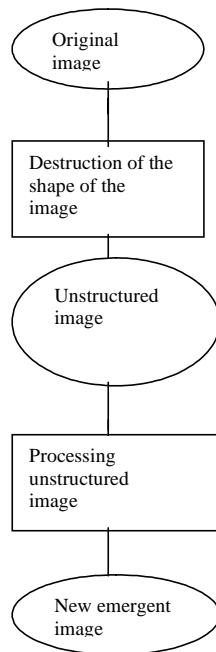
When images are retrieved based on textual information, then various parameters and descriptions might define the input and the images of the database. Whenever there would be symmetry of parameters and descriptions, the image could be retrieved. As mentioned earlier, in CBIR, color, texture and shape are widely used as index to retrieve images. But in our studies, we can find the hidden meanings of the images and whenever those hidden meanings match with the input given, although the original image may not match at all with the input, we can retrieve that image.

When an input would come in the form of an image, the image could be studied based on features, constraints, variables and domains and converted into parametric form. Then the image database would be accessed and each image would be interpreted considering the items mentioned previously and also emergence and converted into parametric form like the input image. Whenever there would be a match between parameters of the input and the images of the database, these records would be selected. In other words, indexing would be decided by the outcome of emergence, which means more meaningful images could be found hidden in an image which would otherwise not be understood.

Many images of the database may not have any apparent similarities with the input, but emergence could bring out the hidden meaning of the image and could establish similarities with the input image. So emergence outcomes of the images would form the index structure of the search.

Analyses of Works Done

Attempts have been made to give rise to symbolic representation of shape where shape is defined as

$$S = \{N; \text{Constraints}\}$$

where N is the cardinality, that is, the number of infinite maximal lines constituting shape S, and the constraints limit the behaviors or properties resulting from the infinite maximal lines, based upon which particular shape is defined. Lines have been defined as Ik, Ij and so on with their intersection as Ikj. Then topological, geometric and dimensional properties are defined (Gero, 1992). Also symmetry has been found through the corresponding relevant positions of the lines and coordinates of one shape with that of the other, and in the process, emergence of the shapes are studied (Jun, 1994).

There is no direct approach to solve the problem of emergent index other than the ones mentioned previously. There is only an indirect approach where this conception has been applied. In a model named Copycat involving computer programs, the program makes all possible sets of consistent combinations of pairings once all plausible pairings have been made. In other words, it gives rise to something explicit that was implicit earlier, which is the essential feature of emergence phenomenon (Mitchell & Hofstadter, 1994).

MAIN THRUST OF THE ARTICLE

We attempt to study the problem of image query where a query made would be searched through the database to select those records where a similar shape has been found. But in addition to that we pick up records based on the emergence phenomena where the query input may not have an apparent match in a particular image of the database, but emergence phenomena could give rise to a similar structure in the same image and as such this image should be selected as a query result. For example, a square with single diagonal can be observed as two triangles. So whenever search intends to find a triangle, this image, which apparently is much different than triangle, would be selected because of emergence.

We calculate emergence index of images of image databases based on features, constraints, variables, domains and emergence.

Various mathematical tools that could be used in defining the image are:

- Geometric property
- Topological property

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