Emergence Phenomenon and Fuzzy Logic in Meaningful Image Segmentation and Retrieval

Sagarmay Deb  
Central Queensland University, Australia  
Siddhivinayak Kulkarni  
University of Ballarat, Australia

ABSTRACT

Content-based image retrieval is a difficult area of research in multimedia systems. The research has proven extremely difficult because of the inherent problems in proper automated analysis and feature extraction of the image to facilitate proper classification of various objects. An image may contain more than one object, and to segment the image in line with object features to extract meaningful objects and then classify it in high-level like table, chair, car and so on has become a challenge to the researchers in the field. The latter part of the problem, the gap between low-level features like colour, shape, texture, spatial relationships, and high-level definitions of the images is called the semantic gap. Until this problem is solved in an effective way, the efficient processing and retrieval of information from images will be difficult to achieve. In this chapter, the authors explore the possibilities of how emergence phenomena and fuzzy logic can help solve these problems of image segmentation and semantic gap.

INTRODUCTION

Research on multimedia systems and content-based image retrieval has gained momentum during the last decade. Content-based image retrieval (CBIR) is a very difficult area in the access of multimedia databases simply because there still exist vast differences in the perception capacity between a human and a computer. There are two basic problems that still remain unresolved in the area although some progresses have been made (Zhau, Grosky, 2002). The first one is the problem of efficient and meaningful image segmentation...
where we break-up a particular image into meaningful parts based on low-level features like colour, texture, shape and spatial locations. In computer vision, segmentation refers to the process of partitioning a digital image into multiple segments (sets of pixels, also known as superpixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics (Wikipedia, 2008). Developing a segmentation algorithm which will meaningfully segment all images is yet an open problem in image analysis (Mehta, Diwakar, Jawahar, 2003). The second one is the vast gap existing for an image between low-level features mentioned earlier and high-level or semantic expressions contained in the image like the image of a car, a house, a table and so on (Zhau, Grosky, 2002). To develop efficient indexing techniques for the retrieval of enormous volumes of images being generated these days, we need to achieve reasonable solutions to these above-mentioned two problems. But only in very limited and selected cases, some kinds of solutions have been achieved with apparently promising experimental results. In this chapter we focus our attention on the first problem. The research identifies few issues causing this gap, for example, failure to capture local image details with low level features, unavailability of semantic representation of images, inadequate human involvement in the retrieval, and ambiguity in query formulation (Islam, 2006). We offer future directions of research in solving this difficult problem using emergence phenomena.

The remaining book chapter has been organized as follows. Section Emergence Phenomenon provides a definition of emergence phenomenon, structure, behaviour and function. Section Use of Emergence Phenomenon details about the use of emergence phenomenon in extracting meanings in image segmentation. Next section deals with neural networks for image classification and implementation of fuzzy logic based similarity measure. Finally chapter is concluded in Conclusion Section.

EMERGENCE PHENOMENON

Definition of Emergence

A feature of an image which is not explicit would be emergent feature if it can be made explicit. There are three types of emergence: computational emergence, thermodynamic emergence and emergence relative to a model (Cariani, 1992). In computational emergence, it is assumed computational interactions can generate different features or behaviors (Forrest, 1991), (Langton, 1989). This is one of the approaches in the field of artificial life. Thermodynamic emergence is of the view that new stable features or behaviors can arise from equilibrium through the use of thermodynamic theory. In emergence relative to a model, deviation of the behavior from the original model gives rise to emergence. We will use this latter view in our work.

In computational emergence, new shapes or images develop but within certain limit as programmed by the computer programmers. No new shape can emerge beyond the logic of the program. In thermodynamic emergence, emergence can be defined as emergence of order from noise. Stochastic processes at micro-level form discrete macro-level structures or behaviors. The example of this type of emergence is gas where stochastic movements of atoms or molecules within the gas create the ordered properties of temperature, pressure and volume at a higher level.

Example of emergence relative to a model is where changes in internal structure and consequently in its behavior occur and we as observ-