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Chapter 15

Emergent Semantics: An Overview

Viranga Ratnaike, Monash University, Australia

Bala Srinivasan, Monash University, Australia

Surya Nepal, CSIRO ICT Centre, Australia

ABSTRACT

The semantic gap is recognized as one of the major problems in managing multimedia semantics. It is the gap between sensory data and semantic models. Often the sensory data and associated context compose situations which have not been anticipated by system architects. Emergence is a phenomenon that can be employed to deal with such unanticipated situations. In the past, researchers and practitioners paid little attention to applying the concepts of emergence to multimedia information retrieval. Recently, there have been attempts to use emergent semantics as a way of dealing with the semantic gap. This chapter aims to provide an overview of the field as it applies to multimedia. We begin with the concepts behind emergence, cover the requirements of emergent systems, and survey the existing body of research.

INTRODUCTION

Managing media semantics should not necessarily involve semantic descriptions or classifications of media objects for future use. Information needs, for a user, can be task dependent, with the task itself evolving and not known beforehand. In such situations, the semantics and structure will also evolve, as the user interacts with the content, based on an abstract notion of the information required for the task. That is, users can interpret multimedia content, in context, at the time of information need. One way to achieve this is through a field of study known as *emergent semantics*.

Emergence is the phenomenon of complex structures arising from interactions between simple units. Properties or features appear that were not previously observed as functional characteristics of the units. Though constraints on a system can influence the formation of the emergent structure, they do not directly describe it. While emergence is a new concept in multimedia, it has been used in fields such as biology, physics and economics, as well as having a rich philosophical history. To the best of our knowledge, commercial emergent systems do not currently exist. However, there is research into the various technologies that would be required. This chapter aims to outline some characteristics of emergent systems and relevant tools and techniques.

The foundation for computational emergence is found in the Constrained Generating Procedures (CGP) of John Holland (Holland, 2000). Initially there are only simple units and mechanisms. These mechanisms interact to form complex mechanisms, which in turn interact to form very complex mechanisms. This interaction results in self-organization through synthesis. If we relate the concept of CGP to multimedia, the simple units are sensory data, extracted features or even multimedia objects. Participating units can also come from other sources such as knowledge bases. Semantic emergence occurs when meaningful behaviour (phenotype) or complex semantic representation (genotype) arises from the interaction of these units. This includes user interaction, the influence of context, and relationships between media.

Context helps to deal with the problem of subjectivity, which occurs when there are multiple interpretations of a multimedia instance. World knowledge and context help to select one interpretation from the many. Ideally, we want to form semantic structures that can be understood by third parties who do not have access to the multimedia instance. This is not the same as relevance to the user. A system might want to determine what is of interest to one user, and have that understood by another.

We note that a multimedia scene is not reality; it is merely a reference to a referent in reality. Similarly, the output from emergence is a reference, hopefully useful to the user of the information. We use the linguistic terms "reference" and "referent" to indicate existence in the "modeled world" and the "real world," respectively. There is a danger in confusing the two (Minsky, 1988). The referenced meaning is embedded in our experience. This is similar to attribute binding using Dublin Core metadata (Hillmann, 2003), where the standard attribute name is associated with the commonly understood semantic.

The principal benefit of emergence is dealing with unanticipated situations. Units in unanticipated configurations or situations will still interact with each other in simple ways. Emergent systems, ideally, take care of themselves, without needing intervention or anticipation on the part of the system architect (Staab 2002). However, the main advantage of emergent semantics is also its greatest flaw. As well as dealing with unanticipated situations, it can also produce unanticipated results. We cannot control the outcomes. They might be useful, trivial or useless, or — in the worst case — misleading. However, we can constrain the scope of output by constraining the inputs and the ground truths. We can also ask for multiple interpretations. Sometimes, a structure is better understood if one can appreciate the other forms it can take.

In the next section, we state the requirements of emergent semantics. This will be followed by a description of existing research. In the last section, we identify gaps in the research, and suggest future directions.