

Chapter XXVI

Semantic Annotation and Retrieval of Images in Digital Libraries

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ABSTRACT

While many digital image libraries allow access to large repositories of images, unfortunately, often the provided free-text search returns unsatisfactory retrieval results. The reason for this is that search techniques typically rely solely on statistical analysis of keyword recurrences in image annotations. In this chapter we show that through the employment of a semantic framework for image annotation, vastly improved retrieval can be accomplished. We present a semantically-enabled annotation and retrieval engine which relies on methodically structured ontologies for image annotation, and demonstrate how it provides more accurate retrieval results as well as a richer set of alternatives matchmaking the original query.

INTRODUCTION

With the ever growing amount of available multimedia information, retrieving relevant information from these repositories is an impossible task

for the user without the aid of effective search tools. Most current public image retrieval engines rely on analysing the text accompanying the image to matchmake it with a user query. Various optimisations have been developed, including

the use of weighting systems to emphasise those keywords that appear in closer proximity to the image location, or advanced text analysis techniques that use term weighting methods, which rely on the proximity between the anchor to an image and each word in a hypertext markup language (HTML) file (Fujii & Ishikawa, 2005). However, despite these efforts, the searches remain limited by the fact that they rely on free-text search that, while cost-effective to perform, can return irrelevant results as it is primarily based on the recurrence of exact words in the text accompanying the image.

Any significant improvement of the accuracy of matchmaking results can only be achieved if the search engine can ‘comprehend’ the meaning of the underlying data that describe the stored images. Semantic annotation techniques have gained wide popularity in associating plain data with ‘structured’ concepts that software programs can reason about (Wang, Liu, & Chia, 2006).

In this chapter we present a comprehensive semantic-based solution to image annotation and retrieval that is suitable for the commercial image provider market and acknowledges their requirements for high quality recall without sacrificing the performance of the retrieval process.

BACKGROUND

The fundamental premise of the Semantic Web is to extend the Web’s current human-oriented interface to a format that is comprehensible to software programmes. For instance, in a Semantic Web scenario, intelligent agents would be able to set up an appointment between a patient and the doctor, looking at both timetables, and finding the best way to the clinic without the patient having to interfere in the process. The user would only have to specify the requirements of a task while semantic agents will complete the task on their own (Berners-Lee & Fishetti, 2000).

The concept of ontologies is fundamental to the Semantic Web. An ontology represents an area of knowledge that is used by people, databases, and applications that need to share domain information. Ontologies include computer-usable definitions of basic concepts in the domain and the relationships between them. The Web ontology language (OWL) (Parsia & Sirin, 2004) has become the de-facto standard for expressing ontologies. It adds extensive vocabulary to describe properties and classes and expresses relationships between classes (e.g., disjointness), cardinality (e.g., ‘exactly one’), equality, richer typing of properties, and characteristics of properties (e.g., symmetry). OWL is designed for use by applications that need to process the content of information rather than just presenting information to humans.

Applied to image retrieval, the semantic annotation of images creates a conceptual understanding of the domains that the images represent, enabling software agents (i.e., search engines) to make more intelligent decisions about the relevance of the image to a particular user query. The use of Semantic Web concepts in image retrieval is likely to improve the computer’s understanding of the image objects and their interactions. To attain such improved results, the data need a better structure, so as to make sense between different semantic concepts. Here, the Semantic Web is likely to bring such a structure that integrates concepts and interentity relations from different domains.

ONTOLOGY DEVELOPMENT

The approach that we describe in this chapter is based on a case study conducted in collaboration with a sports image provider with an image repository in excess of 4 million images (Osman, Thakker, Schaefer, Leroy, & Fournier, 2007). As the company’s search engine relies on free-text search to return a set of images matching the

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