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Achim Hoffmann
Byeong-ho Kang
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Advances in Knowledge Acquisition and Management

Pacific Rim Knowledge Acquisition Workshop, PKAW 2006
Guilin, China, August 2006
Revised Selected Papers

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Lecture Notes in Artificial Intelligence 4303

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Preface

Since knowledge was recognized as a crucial part of intelligent systems in the 1970s and early 1980s, the problem of the systematic and efficient acquisition of knowledge was an important research problem. In the early days of expert systems, the focus of knowledge acquisition was to design a suitable knowledge base for the problem domain by eliciting the knowledge from available experts before the system was completed and deployed. Over the years, alternative approaches were developed, such as incremental approaches which would build a provisional knowledge base initially and would improve the knowledge base while the system was used in practice. Other approaches sought to build knowledge bases fully automatically by employing machine-learning methods. In recent years, a significant interest developed regarding the problem of constructing ontologies. Of particular interest have been ontologies that could be re-used in a number of ways and could possibly be shared across different users as well as domains.

The Pacific Knowledge Acquisition Workshops (PKAW) have a long tradition in providing a forum for researchers to exchange the latest ideas on the topic. Participants come from all over the world but with a focus on the Pacific Rim region. PKAW is one of three international knowledge acquisition workshop series held in the Pacific-Rim, Canada and Europe over the last two decades. The previous Pacific Knowledge Acquisition Workshop, PKAW 2004, had a strong emphasis on incremental knowledge acquisition, machine learning, neural networks and data mining.

This volume contains the post-proceedings of the Pacific Knowledge Acquisition Workshop 2006 (PKAW 2006) held in Guilin, China. The workshop received 81 submissions from 12 countries. All papers were refereed in full length by the members of the International Program Committee. A very rigorous selection process resulted in the acceptance of only 21 long papers (26%) and 6 short papers (7.5%). Revised versions of these papers which took the discussions at the workshop into account are included in this post-workshop volume. The selected papers show how the latest international research made progress in the above-mentioned aspects of knowledge acquisition. A number of papers also demonstrate practical applications of developed techniques.

The success of a workshop depends on the support of all the people involved. Therefore, the workshop Co-chairs would like to thank all the people who contributed to the success of PKAW 2006. First of all, we would like to take this opportunity to thank authors and participants. We wish to thank the Program Committee members who reviewed the papers and the volunteer student Yangsok Kim at The University of Tasmania for the administration of the workshop.

August 2006

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PART II: Regular Papers (6–8 Pages)

Visual Knowledge Annotation and Management by Using Qualitative Spatial Information

Pedro José Vivancos-Vicente, Jesualdo Tomás Fernández-Breis, Rodrigo Martínez-Béjar, and Rafael Valencia-García

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Abstract. The wide use of the Internet and the increasingly improvement of communication technologies have led users to need to manage multimedia information. In particular, there is an ample consensus about the necessity of new computational systems capable of processing images and "understand" what they contain. Such systems would ideally allow to retrieve multimedia content, to improve the way of storing it or to process the images to get some information interesting for the user. This paper presents a methodology for semi-automatically extracting knowledge from 2D still visual multimedia content, that is, images. The knowledge is acquired through the combination of several approaches: computer vision (to get and to analyse low level features), qualitative spatial analysis (to obtain high level information from low level features), ontologies (to represent knowledge), and MPEG-7 (to describe the information in a standard-way and make the system capable of performing queries and retrieve multimedia content).

1 Introduction

An incommensurable amount of visual information is becoming available in digital form, in digital archives, on the World Wide Web, in broadcast data streams and in personal and professional databases, and this kind of information is increasing.

Nowadays, it is common to have access to powerful computers capable of executing complex processes and despite that, there is no efficient approach to process multimedia content to extract high-level features (as knowledge) from them. Moreover, a lot of processes use multimedia contents as their primary data source in critical domains.

It is clear new computational systems capable of processing and "understanding" multimedia content are needed. So, different processes can be performed more efficiently: multimedia content retrieval, storage and processing. In this way, images can be processed to get interesting information for the user, who is not interested in low-level features of multimedia information but in high-level ones (i.e., the content meaning). This is the so-called semantic gap: how to bridge the low-level features and high-level features. It refers to the cognitive distance between the analysis results delivered by state-of-art image-analysis tools and the concepts human look for in images [4].

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Traditionally, textual features such as filenames, captions, and keywords have been used to annotate and retrieve images [7]. Research on intelligent systems for extracting knowledge or meta-information directly from multimedia content has increased in the last years. For example, systems which usually work with sport videos, recognising some kinds of events as a function of audio comments [12,13,14]. But this is not enough to get meta information about the image content. Many content-based image retrieval systems have been proposed in literature [1,2,3]. Most of them try to get more information by analysing the image to work out low-level features such as colours, textures, and shapes of objects, but this is not sufficient to get real information about what an image contents [11].

In this work, an approach to obtain high-level features from images using ontologies and qualitative spatial representation and reasoning is presented. This approach extracts relationships between the regions of the image by using their low-level features obtained in the segmentation step. Then, it creates a content representation where the regions are concepts, the low-level features their attributes and the relationships are inferred knowledge. This information is then used to compare this structure to ontologies stored in libraries so that the system can guess what each region really is and perhaps, what the image represents. An advantage of using semantic approaches is the fact that they do not require to re-design the framework for different domains. It provides a new layer that is completely independent of the methods and techniques used to process the image.

Finally, the structure of this paper is the following. In section 2, the technical background of this methodology is discussed. An overview of the methodology proposed for this work is described in section 3. Section 4 describes the processes for extracting high-level information from images. An example of the methodology is shown in section 5. Finally, some conclusions are put forward in section 6.

2 Technical Background

Along this section the basic methodological components of our approach are briefly explained.

2.1 Image Segmentation

Image segmentation is a challenging and important issue in image processing and computer vision. It tries to extract the objects an observer may find conceptually coherent by themselves, so that the extracted objects (i.e., regions) are distinct from each other. However, segmentation has access only to the descriptions of pixels (i.e., colour), and their spatial relationships, while a human observer always uses a higher level of knowledge (e.g., object recognition) to segment the image objects.

There are many segmentation algorithms, which are usually specialized in extracting specific types of regions (i.e., the background) [16]. Moreover, some can be used together to get different kind of information and then try to merge it.

To us, segmentation will provide a set of regions that will be used to get high-level information. So, after segmentation, an image is decomposed into a set of regions for which the system must try to find out their real meaning. Once segmentation has been performed, a set of low-level features are obtained for each region.

2.2 Qualitative Spatial Reasoning

According to [5], Qualitative Reasoning deals with capturing the knowledge of physical world while creating quantitative models. The ultimate objective of Qualitative Reasoning is to make this knowledge explicit, so that from appropriate reasoning techniques, a computer might predict, diagnose and explain the behaviour of physical systems in a qualitative manner.

Qualitative spatial representations address many different aspects of space including topology, orientation, shape, size and distance, so it has already been used in computer vision for visual object recognition at a higher level, including the interpretation and integration of visual information. It has been used to interpret the results of low-level computations as higher level descriptions of the scene or video input [10]. The use of qualitative predicates helps to ensure that semantically similar scenes have identical or at least very similar descriptions.

2.3 Ontologies

An ontology is viewed in this work as a formal specification of a domain knowledge conceptualization [15]. In this sense, ontologies provide a formal, structured knowledge representation, having the advantage of being reusable and shareable. Furthermore, an ontology can be seen as a semantic model containing concepts, their properties, interconceptual relations, and axioms related to the previous elements. For our purpose, ontologies can represent topological information of different domains, so this knowledge is used to infer the meaning of an image. This usage is discussed in [5], where the authors state that there are strong reasons for taking regions as the ontological primitive.

2.4 MPEG-7

MPEG-7, formally named "Multimedia Content Description Interface", is a ISO/IEC standard developed by MPEG for describing multimedia content data that supports some degree of interpretation of the information meaning, which can be passed onto, or accessed by, a device or a computer code [8].

MPEG-7 offers a comprehensive set of audiovisual Description Tools (the metadata elements and their structure and relationships, that are defined by the standard in the form of Descriptors and Description Schemes) to create descriptions. These descriptions are a set of instantiated Description Schemes and their corresponding Descriptors at the users will form the basis for applications enabling the needed effective and efficient access (search, filtering and browsing) to multimedia content. This is a challenging task given the broad spectrum of requirements and targeted multimedia applications, and the broad number of audiovisual features of importance in such context.

3 Overview of the Methodology

The methodology proposed here can be visualised through a framework comprised of three main modules, namely, image processing and low level features extraction, qualitative spatial information extraction and ontology library sub-system.

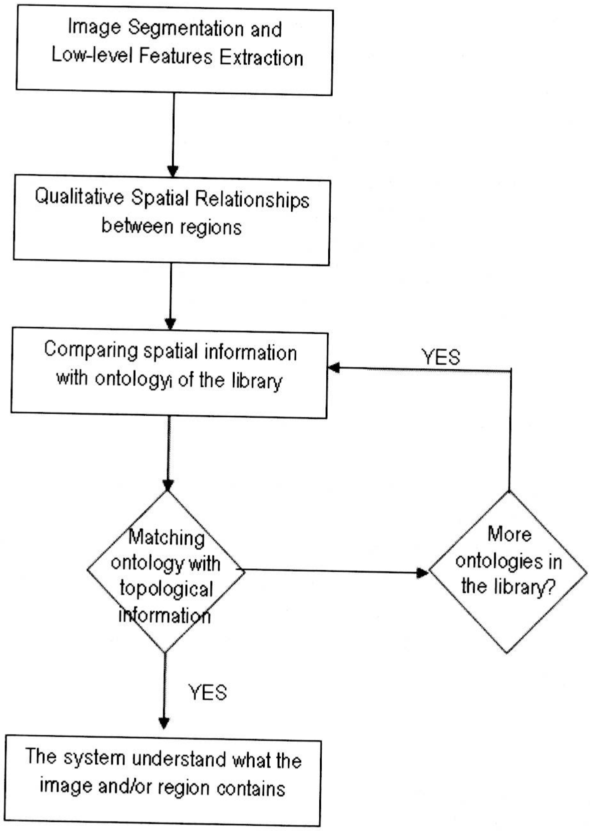

Fig. 1. Methodology schema

The goal of the framework is to get high level information from an input image. This process may be supported by an expert during the image processing task to extract the image segments.

At the beginning, some filters and techniques are applied to the input image to determine the segments. This step may be done by an expert if the content of the image is not previously known. This may be done (semi) automatically if the system has analysed similar images (the same domain) before, so it knows which algorithms and techniques to apply. After that, the system knows every segment that composes the whole image; so, it is possible to extract low level features for each segment and for the whole image in general (e.g. the background dominant colour). Once segmentation has been performed, a set of low-level features are obtained for each segment. This process will be explained in the next section.

Another sub-system will be able to get qualitative spatial information between segments so a structure of topological relationships between concepts will be obtained (e.g. “A is left of B”, “C is similar size to D”...)

Once the structure is obtained, it can be compared with all the ontologies with topological information stored in our library subsystem to match the structure with an ontology. In this case, the system is able to interpret the image in the context of a particular domain.

4 High-Level Information Extraction Process

After describing the framework, the focus of this section is the knowledge extraction processes carried out. For each image, the system performs three sequential phases: image segmentation and low level features extraction, qualitative spatial relationships extraction and inference.

4.1 Image Processing and Low Level Features Extraction

As it has been abovementioned, the input is an image. The system processes each image to obtain the elements that appear in the image, using several techniques based on segmentation, which is the process that partitions the spatial domain of an image or other raster datasets like digital elevation models into mutually exclusive parts, called regions. After that, the system gets several quantitative features [6] for each element found. Theses features are enumerated in the following list:

Table 1. Features description

Features Description	
Position	It is defined as the portion of space that is occupied by the object.
Orientation	Where the object is pointing to.
Location	refers to the location of the object in the image (e.g. far north)
Size	The area of the segment.
Compactness	Represents the density of an object.
Dimension	It is composed by two properties: width and height.
Perimeter	It represents the distance around a figure.
Shape	It represents the visual appearance of a region.
Colour	The visual attribute of the region that results from the light they emit or transmit or reflect.
Texture	The tactile quality of a surface or the representation or invention of the appearance of such a surface quality.

Once all this information has been obtained, it may be represented in MPEG-7 because it has descriptors to represent general information about the image and for each region. Some of them are to define basic structures like colour, texture, shape, localization and others for another kind of multimedia contents such us video or sounds.