A Visual Concept Ontology for Automatic Image Recognition

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1 Introduction

Multimedia content understanding is expected to play an important role in the future of the Semantic Web. For instance, many image retrieval engines are currently under development. Many of these systems limit their recognition mechanism to low-level image descriptors which are far from semantic notions. On the other hand, other types of system only rely on human annotations [Von-Wun *et al.*, 2002]. We propose an intermediate approach to image understanding. Our approach stems from the fact that experts (e.g. biological and medical experts) of a specific domain often use and share a generic visual vocabulary to describe objects of interest. This paper introduces a domain-independant visual concept ontology which is used as a guide for describing the objects of a domain of expertise. This ontology driven description is planned to support automatic recognition based on image processing techniques. Section 2 of the paper gives an overview of the proposed approach. Section 3 is dedicated to a presentation of a visual concept ontology. A knowledge acquisition tool is introduced in section 5. We finally conclude and present our future work in section 6.

2 Ontology Driven Knowledge Acquisition

In many application domains, concepts of the domain can be structured as a hierarchy of classes with their associated subparts. For instance, this approach is used for organizing knowledge about medical pathologies or biological organisms. This knowledge is shared by the experts of the domain. When describing images, experts also use usual visual notions. To ease knowledge acquisition, we propose a visual concept ontology based on these shared visual notions. The knowledge acquisition process we propose is described in fig. 1. The resulting knowledge base is to be used by a knowledge-based image understanding system [Maillot *et al.*, 2003].

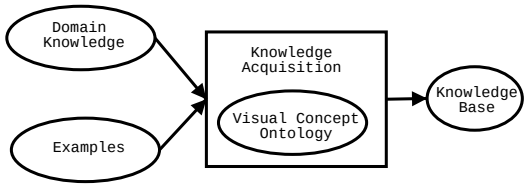

Fig. 1. Knowledge Acquisition Process

3 Visual Concept Ontology

We propose to use a visual concept ontology which is divided in three main parts : (1) spatio-temporal concepts, (2) color concepts, (3) texture concepts.

3.1 Texture Concepts

This branch of the ontology is based on experiments performed by the cognitive science community. The hierarchy presented in fig. 2 is the result of a statistical study on the perception of texture images.

3.2 Color Concepts

The ISCC-NBS[1] color dictionary contains three types of color notions: twenty-eight hue concepts, five lightness concepts (Very Dark, Dark, Medium, Light, Very Ligth) and four saturation concepts (Grayish, Moderate, Strong, Vivid). Note that some color concepts can be combined. For instance, the concept Brillant is defined as the conjunction of the concepts Light and Strong.

3.3 Spatio-temporal Concepts

This part of the ontology provides concepts for describing objects from a spatio-temporal point of view. It is composed of geometric concepts (e.g. Circular Surface, Line) and RCC-8 spatio-temporal relations.

3.4 Context Description

Providing information on the acquisition conditions is necessary to maintain knowledge coherence. For instance, microscopic objects appearance depends on the sensor used for observation. Different context concepts (e.g. sensor, illumination conditions) are used to contextualize visual description.

[1] Inter-Society Council-National Bureau of Standards

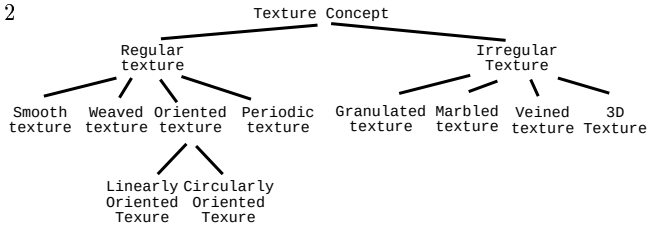

Fig. 2. Texture Concepts

4 Knowledge Representation

Knowledge representation is based on the formalism of a Description Logic. DAML+OIL is used for implementation. A domain object is described through four relations respectively for *hasForSpatioTemporalDescription*, *hasForTextureDecription*, *hasForColorimetricDescription* and *hasForDescriptionContext*: (1)*hasForSpatioTemporalDesc*, (2)*hasForTextureDesc*, (3)*hasForColorimetricDesc*, (4)*hasForDescContext*. A description logic is used to structure the concepts provided by the visual concept ontology:

$$C_i \equiv C_j \sqcap (\exists \text{"}isASubpartOf\text{"}.C_k)$$
$$\sqcap (\exists \text{"}hasForSpatioTemporalDesc\text{"}.C_{SpatioTemporal_a})$$
$$\sqcap (\exists \text{"}hasForTextureDesc\text{"}.C_{Texture_b})$$
$$\sqcap (\exists \text{"}hasForColorimetricDesc\text{"}.C_{Color_c})$$
$$\sqcap (\exists \text{"}hasForDescContext\text{"}.C_{Context_d})$$

This means that C_i is a subclass of C_j and a subpart of C_k. The relations *hasForSpatioTemporalDescription*, *hasForTextureDescription*, *hasForColorimetricDescription*, *hasForDescriptionContext* are respectively restricted to concepts $C_{SpatioTemporal_a}$, $C_{Texture_b}$, C_{Color_c}, $C_{Context_d}$. The powerful expressiveness of description logics allows to define $C_{SpatioTemporal_a}$, $C_{Texture_b}$, C_{Color_c}, $C_{Context_d}$ as unions or intersections of different concepts provided by the visual concept ontology.

5 A Knowledge Acquisition Tool

We have implemented a knowledge acquisition tool called OntoVis [2] composed by three main modules. (1) Domain knowledge acquisition, (2) Ontology-driven visual acquisition, (3) Image example management. We have used the JAVA language to build this tool. The Jena toolkit [3] is used for knowledge acquistion and ontology management.

5.1 Domain Knowledge Acquisition

Our tool allows the expert to define domain objects hierarchy (taxonomy). It is also possible to define a subpart hierarchy (partonomy).

[2] http://www.inria.fr/orion/personnel/Nicolas.Maillot/OntoVis
[3] http://www.hpl.hp.com/semweb/jena2.htm

5.2 Visual Description

This module allows the ontology-driven description of domain objects Currently, a list of visual concepts are displayed to the screen in a symbolic manner. The user is then able to select useful concepts for description.

5.3 Example Database Management

Whenever a domain object or a subpart is described with visual concepts, it is useful to give examples of the visual concepts used for description. For instance, the visual concept Circular Surface can used to describe the shape of a specific object. The user can provide images which examplify the visual concepts. For subpart description, it is also possible to select specific regions of interest in the provided images. Once examples have been provided, the symbolic description guided by the ontology is attached to them.

6 Conclusion and Future Work

We propose an approach to knowledge acquisition for the visual description of the objects from a domain of expertise. Our approach is based on a visual concept ontology. This ontology is used as a guide for describing taxonomies and partonomies of objects and their subparts. A graphical tool is also proposed and allows knowledge acquisition based on the visual concept ontology. Visual concepts used during knowledge acquisition can be examplified. The advantage of using a visual concept ontology is to partially fill the semantic gap between the image signal and domain concepts. Indeed, visual concepts are close to image features which can be computed thanks image processing techniques.

As explained in the previous section, visual concepts are displayed in a symbolic form. We are planning to display them in a graphical way: In particular, spatio-temporal visual concepts should be manipulated with a drawing tool. The important point is that every visual primitive drawn should remain semantically anchored. Texture and color concepts should also be represented in a graphical and user-friendly way.

Our goal is to fill the gap between image features and visual concepts used during knowledge acquisition. We are currently experimenting machine learning techniques to achieve this goal.

References

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