A Semantic Based Retrieval System of Arctic Animal Images

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ABSTRACT

In this paper we propose a semantic based image retrieval system in the domain of arctic animals. The proposed system exploits a semantic engine capable of adapting the processing steps both to the users' need and to the arctic image domain. This flexibility has been achieved by three main steps: 1) arctic domain ontology modeling, 2) identification of features peculiar of the images we are dealing with and, 3) interface composition to support user interaction and search customization. The performance of the proposed system was tested using a set of 200 images depicting wild animals living in the polar environment while users performed different search tasks specifying different constraints through the user interface. The results show both retrieval accuracy of the proposed system and its flexibility with respect to the users' constraints.

General Terms

Content-Based Multimedia Retrieval Systems

Keywords

Image Retrieval, semantic search, ontology, arctic animal

1. INTRODUCTION

The fast growth of the internet and the development of web technologies, turned the Web from a purely research network to a foundamental everyday tool. In particular, the strong demand and availability of multimedia resources combined to the intrinsic semantic gap, have favored the evolution of specific content-based multimedia retrieval systems, designed and developed to satisfy the user requests for a specific domain. Media retrieval is a concern of several different domains and each domain may involve specific tasks that can be performed For example, in the animal domain, some possible tasks are: search animal images in order to identify their behavior (e.g. a lion that attacks a prey), or, identify the different species (e.g. distinction between felines: lion, tiger, leopard, etc.) [10]. Accordingly, domain specific techniques have to be devised to deal with the intrinsic features of the considered domain and media, and at the same time, such approaches have to be flexible in order to accommodate user needs.

In the literature, there exist many approaches for multimedia retrieval [12], which, however, are tailored to specific application domains and, moreover, lack in flexibility and adaptability to the user's needs.

In this work we present a content based retrieval system for arctic animal images which exploits the system proposed by the authors in [4]. In detail, the adopted framework allows one to build easily a retrieval system by three main steps: 1) domain and media ontology modeling, 2)development of media specific features extraction approaches and, 3) interface composition which reflects the ontology constraints identified during the modeling step. A collection of 200 images, depicting wild animals living in the north or the south pole, like penguins, polar bears, sea lions, seals and whales, was used for performance evaluation. The results showed good performance of the system in terms of precision recall and processing time as well as in flexibility to address users' needs.

The remainder of the paper is organized as follows: in Section 2 the framework used for building up our content based image retrieval system is briefly explained. Section 3 discusses the domain ontology modeling, the adopted feature extraction algorithms and the user interface. In Section 4, presents the performance evaluation of the designed multimedia retrieval (MMR) system on a standard dataset whereas, in Section 5 concluding remarks and ideas for future developments are given.

2. SEMANTIC FRAMEWORK FOR MMR COMPOSITION

To build our MMR we have adopted the platform proposed by the authors in [4] whose flowchart shown in Fig.1, guarantees flexibility and adaptability to different scenarios and user needs. In detail, the framework has been devised for two different roles: the User role (the final user who will use the system) and the Developer role (i.e. the domain expert who actually creates the system specifying information about: domain, media type, graphical interface and processing/matching algorithms). For the developer, the steps to build a new MMR are:

1. *Ontology design*: The basic concept behind this frame-

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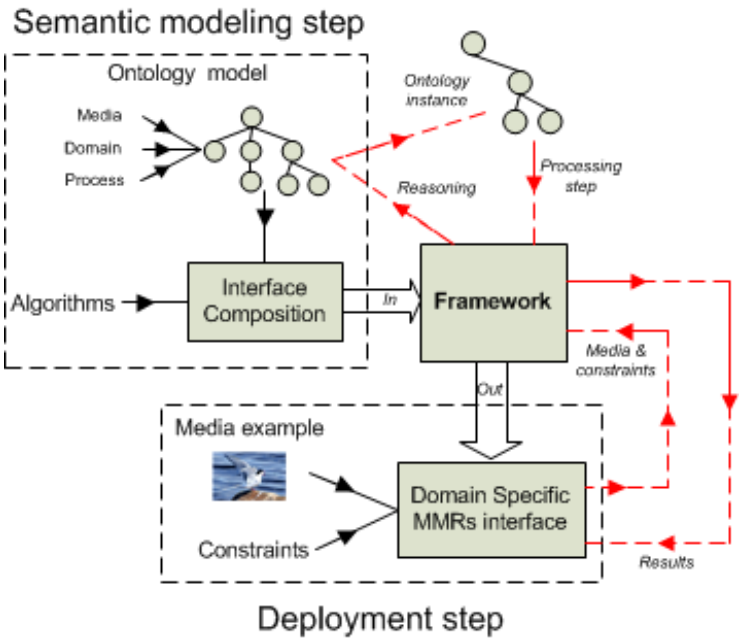

Figure 1: The flowchart of the adopted semantic framework for developing multimedia retrieval applications.

work is the use of ontologies for modeling the behavior of the retrieval process. The developer designs a new MMR system by modeling three ontologies respectively containing information about: a) the media type (video, audio or image), b) the application domain and c) the processing algorithms, hence information about how to process the media and which algorithms and parameters are to be used for the feature extraction process. These three ontologies are merged in one ontology for further reasoning.

2. *Algorithm binding.* In order to support the automatic selection of algorithms, the developer must have a deep knowledge of the processing algorithms, so that the best ones according to the user's criteria are used. Of course, these algorithms must be connected to the the high level concepts of the full ontology above described.

3. *Interface definition.* Once the full ontology is created, the developer creates the user interface through a specific composition module with which it is possible to bind the ontology features with the interface objects.

For the user, the search step requires the specification of some constraints related to the tackled domain and the desired performance criteria. Such constraints are imposed by interacting with the objects' interface (slider, buttons, etc..) and then mapped to the ontology features. The constraints defined by the user are then given to the Pellet ontology reasoner[1] which identifies the list of processing algorithms to accomplish the required task. Fig. 1 shows how the used framework allows the creation of a new domain specific MMR system.

[1]http://clarkparsia.com/pellet/

3. PROPOSED IMAGE RETRIEVAL MODEL

In this paper we propose MMR for content based search on images depicting wild animals living in the north or south pole. As described in the previous section, developing a MMR for a new domain entails the building a new ontology (composed by the media, domain and processing ontologies), where the developer can associate image processing algorithms to the ontology features, and the building of a new graphical interface. In the following subsections each step to create the semantic content based retrieval system for arctic animal images is described.

3.1 Ontology

The first step for building the proposed system consists in describing the specific domain by ontology modeling. The devised ontology for the considered domain is shown in Fig.2 and consists of the following concept nodes:

- *Environment*, provides information about the type of searched images according to the polar environment domain. In particular, in our case we have distinguished between animals living on ice or on ground.

- *PerformanceCriteria*, describes the type of search that an user can run according to specific performance criteria. In detail, we have identified three main cases: 1) fast but less accurate search, 2) accurate but slower search and 3) balanced search.

- *IPTools* node describes the set of algorithms to extract the features used in the retrieval process. They are classified into color, shape and texture features extraction algorithms and in "edge-based" if they work on object shape, while the algorithms for detecting the texture are classified as region-based.

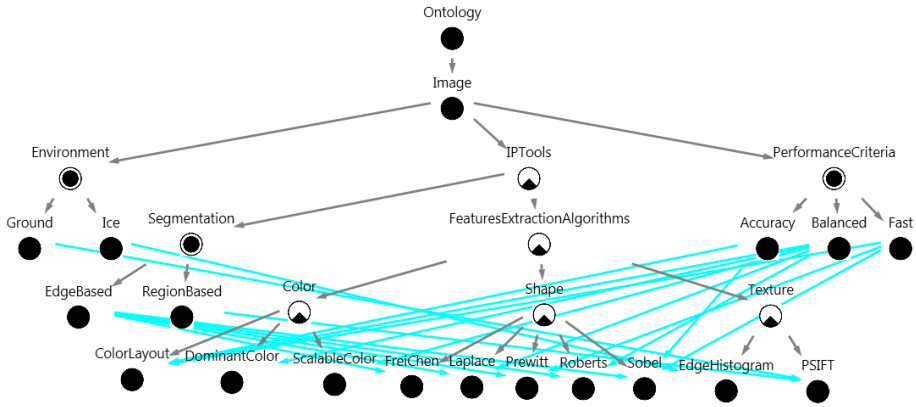

Figure 2: Domain Ontology

The arrow in the ontology model (see Fig. 2) represents an implication between a concept and the related algorithms. According to the user's request, the Pellet reasoner checks the consistency of the selected configuration and then extracts a valid instance, i.e. a list of feature extraction algorithms.

3.2 Algorithms

All the adopted algorithms are classified according to the feature they work on. Some of them work on the object shape (see child nodes of "Shape" in Fig. 2); whereas others exploit image texture (see child nodes of "Texture" in Fig. 2) or colors (see child nodes of "Color" in Fig. 2) to implement the retrieval mechanism. The algorithms ScalableColor, ColorLayout, DominantColor and EdgeHistogram belongs to the feature descriptions of the international standard Mpeg-7 [2, 11]. The features extraction algorithms are associated to the ontology features through the "imply" constraints, in detail, we have:

- The algorithms used for the *fast* search are: Sobel, Prewitt and ColorLayout;
- The algorithms used for the *balanced* search are: ScalableColor, ColorLayout, DominantColor, EdgeHistogram, Roberts and Laplace [3];
- The algorithms used for the *accuracy* search are: ScalableColor, ColorLayout, DominantColor and PSIFT [8].

3.3 Graphical interface model

After creating the ontology, the user interface has been designed in order to reflect the ontology concept nodes and imply constraints. The default components for the content-based search are preview of the query image and two buttons, respectively, for uploading the query image and to start the retrieval process. Moreover, the GUI "sliders" allow the users to navigate through the performance criteria defined in the ontology (e.g. fast, balanced or accuracy) and to select the type of images we are working on: ice or ground. Fig. 3(a) shows the GUI implemented for our system.

4. SYSTEM EVALUATION

The system evaluation aims at measuring the performance of the content-based image retrieval system (see Sect.3). The testing was performed on a set of 200 images consisting of 150 images depicting penguins, polar bears, sea lions, seals and whales were taken from Flickr [2] and the remaining 50 images, taken from the Corel dataset [7], showed different animals. The performance of the system was evaluated by using precision over the first 5, 10 and 20 retrieved images and recall [9]. To test the flexibility of the system we also computed the above metrics while varying performance criteria, (i.e. fast, accuracy and balanced). The evaluation results (see Fig. 4) show that precision increases moving from *fast* to *balanced* and then to *accuracy*. The processing time for each retrieval session varied between three seconds when "fast option" was selected to half a minute when the user selected the "accuracy option". This implies that algorithms under the accuracy search node in the domain ontology performs better and find more relevant images although the required times are sensibly higher. Beside, independently from the selected performance criteria, precision decreases with the number of retrieved images (from *P(5)* to *P*), i.e. the first results are more similar to the query image whereas the other retrieved images belong to different animal classes and can be considered as *false positive*. Fig. 3(b) shows an example of the achieved results when querying the system with a polar bear image.

5. CONCLUDING REMARKS

In this work we have created a content based retrieval system for images in the domain of animal living in north and south poles. The system has been created by using a semantic framework that exploits ontologies for modeling the retrieval process. The test performed on the proposed content based image retrieval system shows the system flexibility and adaptability to the user needs and to the tackled scenario. Future work will regard the extension of this MMR system by defining new and more detailed ontologies about the animal domain and also by taking into account different

[2]http://www.flickr.com/

(a) (b)

Figure 3: (a)Graphical interface designed for searching images about polar animals. Section A represents the users image example. Section B allows to impose the constraints about the Performance Criteria. Section C allows to impose constraints about the animals environment. (b) Example of retrieved images when querying the system with a polar bear image.

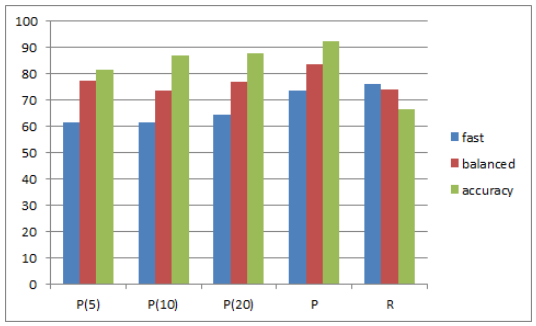

Figure 4: Performance evaluation

media type (e.g. audio, video). Adding the support of other media type might improve the flexibility and the adaptability of the proposed approach, thus allowing the users to have a complete tool for searching any media in a specific ecological domain.

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