

Content-Based Image Retrieval in Digital Libraries of Art Images Utilizing Colour Semantics

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Abstract. The paper presents the architecture of experimental Content-Based Image Retrieval (CBIR) system APICAS ("Art Painting Image Colour Aesthetics and Semantics"). This system has been developed within a doctoral thesis which aims to provide a suite of specialized tools for CBIR within a digital library of art images. The high-level architecture suggested in this work takes OAIS as a basis and adds a designated layer to it allowing CBIR functions to be used both within ingest and access to the digital library.

Keywords: CBIR, OAIS, colour semantics, digital art.

1 Introduction

The development of specialized digital libraries (DL) for art images has to combine the traditional DL functionality with specialized image processing tools. Such tools can be used at ingest of digitized art objects as a means to enhance their metadata in automated way, or for access if the users would like to benefit from content-based image retrieval (CBIR) or other semantic-oriented tools. In this paper we are presenting architecture for a specialized art image DL which integrates general digital library functionality with designated CBIR tools. The suggested architecture had been implemented and the experience from this implementation informed this work.

2 Functional Requirements

The first step towards defining a suitable architecture for a CBIR system is to analyze the functional requirements it needs to meet. Our state-of the art review demonstrated that CBIR systems are developed most typically as specialized stand-alone applications or modules and are designed as such. This is a typical approach within an emerging domain but with the growing importance of image retrieval in the modern Web environment what becomes of special importance is how to develop modules for CBIR which could easily be integrated in digital repositories and web portals. This would require analyzing functional requirements for CBIR systems in the context of functional requirements within the current trends in digital archives. In order to address them, we will first present the high-level architecture of modern digital archives.

In 2002 the Consultative Committee for Space Data Systems prepared technical recommendations establishing a common framework of terms and concepts which comprise an Open Archival Information System (OAIS) [1] adopted later as the international standard ISO 14721:2003. This model can be successfully implemented as common framework with concretizations in application areas for so called GLAM (Galleries, Libraries, Archives, and Museums). The functional schema of OAIS contains six entities and related interfaces: **Ingest**, **Archival Storage**, **Data Management**, **Administration**, **Preservation Planning**, and **Access**. Within the context of such general digital archive architecture, CBIR-related implementations can be seen as a module which would best fit within the **Data Management** functional entity. However, it would also have influence on **Ingest** and more specifically on the structure of the submission information packages because the successful implementation of CBIR requires some specific data and metadata. CBIR also enriches the possibilities for delivery and will influence the **Access** functional entity which would accommodate more options for digital content discovery. This wider context is reflected in the architecture of a CBIR system called "Art Painting Image Colour Aesthetics and Semantics" (APICAS); this system is fine-tuned to the need of Information Retrieval (IR) in the area of digitized art collections. The specialized core part of the system accommodated the necessary specific instrumentarium in terms of algorithms and methods for IR; these are seen as specialized instances of **Data Management** tools. At the same time the special requirements for **Ingest** of specific data necessary for the IR components and the expanded **Access** possibilities are also highlighted.

3 APICAS Architecture

The software system APICAS was developed in order to supply appropriate environment for testing several kinds of visual and higher level features, connected with the colour presence and interaction between colours within art images [2][3][4][5]. In Figure 2 the architecture of proposed system is shown. The functional schema of APICAS follows OAIS excluding functional entities on administration and preservation planning. The Ingest functions in such experimental system are also very simplified, because the focus is on the extracting of visual metadata and analyzing received features. The main functions in APICAS are:

- data entry – establishing connections with image sources as well as supplying controlling textual metadata;
- feature extraction – producing automated metadata for image labelling;
- query interface – part of user-interface functions, connected with receiving of the tasks from the consumer. The image bank is used in order to select "an example" for searching images with greatest similarity. The metadata bank is used for constructing a "controlled vocabulary" for selecting desired feature(s);
- query processing – analysis of extracted metadata, their potential to meet user query for receiving images with specified colour harmonies or contrast or to be used for building artist practice profile or movement description;
- visualization – the other part of user-interface functions, connected with visualizing of received results. A variety of tools is used, such as image sets (whole images or patches), attribute data sets, distance files, graphics, knowledge analysis results, etc.

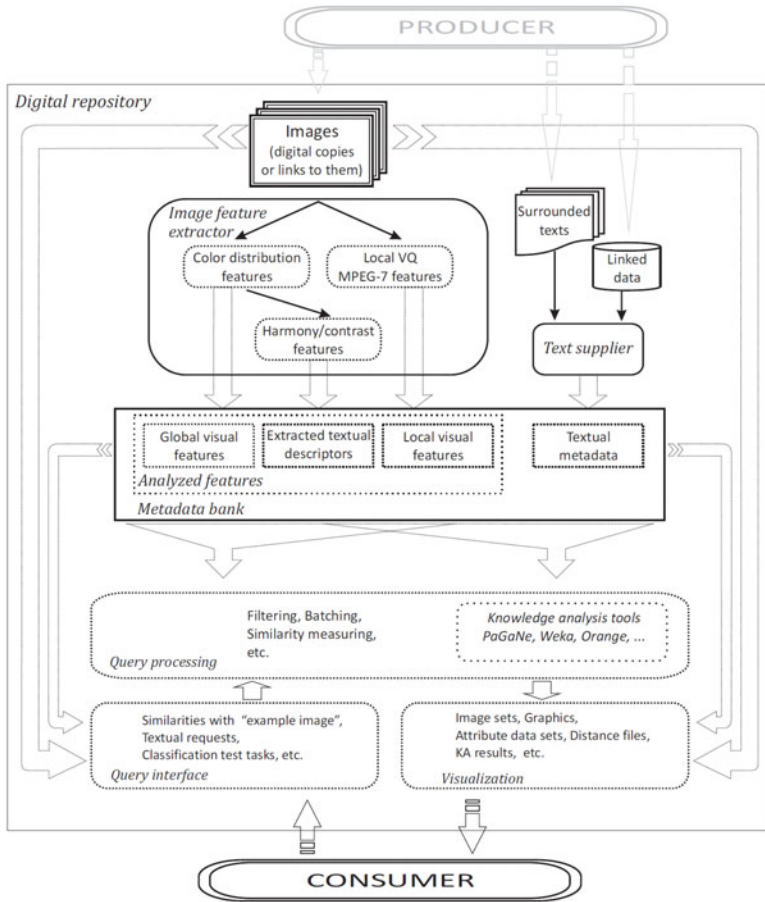


Fig. 1. APICAS architecture

The main goals of APICAS are in two-fold:

- to analyze the possibilities of defined harmonies and contrast features for narrowing the semantic gap;
- to investigate possibilities for finding regularities between these features that can be used as semantic profile of the art paintings.

The system is realized using CodeGear Delphi 2007 for Win32. As metadata storage space Arm 32, property of FOI Creative Ltd., is used. For obtaining the MPEG-7 descriptors APICAS refers to Multimedia Content Management System MILOS [6]. For obtaining the results of multidimensional scaling we used the open component-based data mining and machine learning software suite Orange [7]. As clustering algorithm "vcluster", a part of the CLUTO open source software package [8], is implemented in the system. As knowledge analysis environment we use the data mining environment PaGaNe [9], developed in the Institute of Mathematics and

Informatics, and especially Class-Association Rule classifier PGN, Association Rule Miner ArmSquare and implemented statistical analyzing tools for checking up our results and extracting regularities for artists' and movements' styles based on the extracted attributes. For comparing received results of PGN classifier we used Waikato Environment for Knowledge Analysis (Weka) [10].

4 Conclusion

We have proposed architecture of an experimental CBIR lab-system, aimed at analyzing different types of visual features, which strive to narrow the semantic and abstraction gap between low-level automatic visual extraction and high-level human expression. We have explained the structure and functionality of the software system "Art Painting Image Colour Aesthetics and Semantics" (APICAS). The vividness of proposed features will open the door for indexing and searching in paintings repositories, according to such characteristics of their content. The proposed features can be used as a step in the transition from Web 2.0 to Web 3.0.

Acknowledgements. This work was supported in part by Hasselt University under the Project R-1875 and by the Bulgarian National Science Fund under the Project D002-308.

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