Hierarchical Model for Storage and Retrieval of Images Content-Based Systems

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Abstract - **The need for content-based access to image and video information from media archives has led to the development of methods that provide access to image and video data. Our work tries to provide modelers with a framework and corresponding models for building an image database from a collection of images. We propose a framework and block diagram offering a choice of all possible components in order to build up an image database from a corpus of images and users' requirements**.

Keywords – **content-based image retrieval systems, image databases, image retrieval, data modeling**

I. Introduction

Content-Based Image Retrieval (CBIR) systems are in the focus of attention of all visual information systems investigators. New visual query specification methods, new indexes for data setting, and new ways for similarity determination between the saved in the Image Data Bases (IDB) image description data and describing queries [6] are used for image search and retrieval on the base of their contents. The last investigations examine the content based IDB in the context of the object relation model and the Query-by-example philosophy.

The basic directions for the content based IDB development according to [1] are:

- creation of new methods for image description and image property extraction;
- development of efficient data models that allow content based direct organized access;
- elaboration of the image similarity search and retrieval methods;
- formulation of similarity measures that are necessary in the process of images indexing and retrieval; formulation of queries and complex queries processing.

The key directions for each realization are [5]: efficient description and effective extraction; flexibility and extend ability of the capabilities of the content based access; efficiency and utility.

In this paper we are trying, by using the achievements in the area of the CBIR systems, to create a generalized framework model of the CBIR systems that should be valid for the different types of realizations and applications.

Our work tries to provide modelers with a framework and corresponding models for building an image database from a collection of images.

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We propose a framework and block diagram offering a choice of all possible components in order to build up an image database from a corpus of images and users' requirements. We hope that our work will contribute for the creation of comprehensive environment for modeling and prototyping of CBIR systems and for the development of methodology for image database engineering. Section 2 presents a review of the principle expected features that a framework should include and describes its architecture. An example application is presented in Section 3. The paper finishes with conclusions.

II Content-based Image Databases Modeling

Image databases designers use three main inputs: an image collection, user's requirements, and an application domain. Each input induces constraints on the databases to be built. Modelers must find a compromise between these constraints.

In order to determine the actual needs of IDB designers, we have studied various projects [2], [3], [6]. Our review of IDB can be summarized as follows:

- Volume of data IDB has to manage huge amounts of data. They use two main strategies (indexing and classification) in order to virtually diminish the amount of data to be researched during the image retrieval.
- An image is described by a combination of syntactical (color histograms, textures, shapes) and semantical (also called meta-data) information and a query can be expressed using a combination of syntactical and semantical image features.
- Granularity image descriptions are generally composed of global and local information.
- Most image databases offer a dual search interface (using either classical queries or query-by-content

The existing systems have been designed by a careful choice of basic mechanisms (indexing or classification) and features of images (syntactical or semantical). Such a choice depends on the database application domain, on images themselves (i.e. on their main characteristics), and on users' requirements.

Our conviction is that an efficient framework should:

- be generic enough in order to cover most of modelers requirements, whatever their image corpus and their users' requirements may be.
- provide a convenient support for both syntactical and semantical information
- provide a convenient support for local and global descriptions.

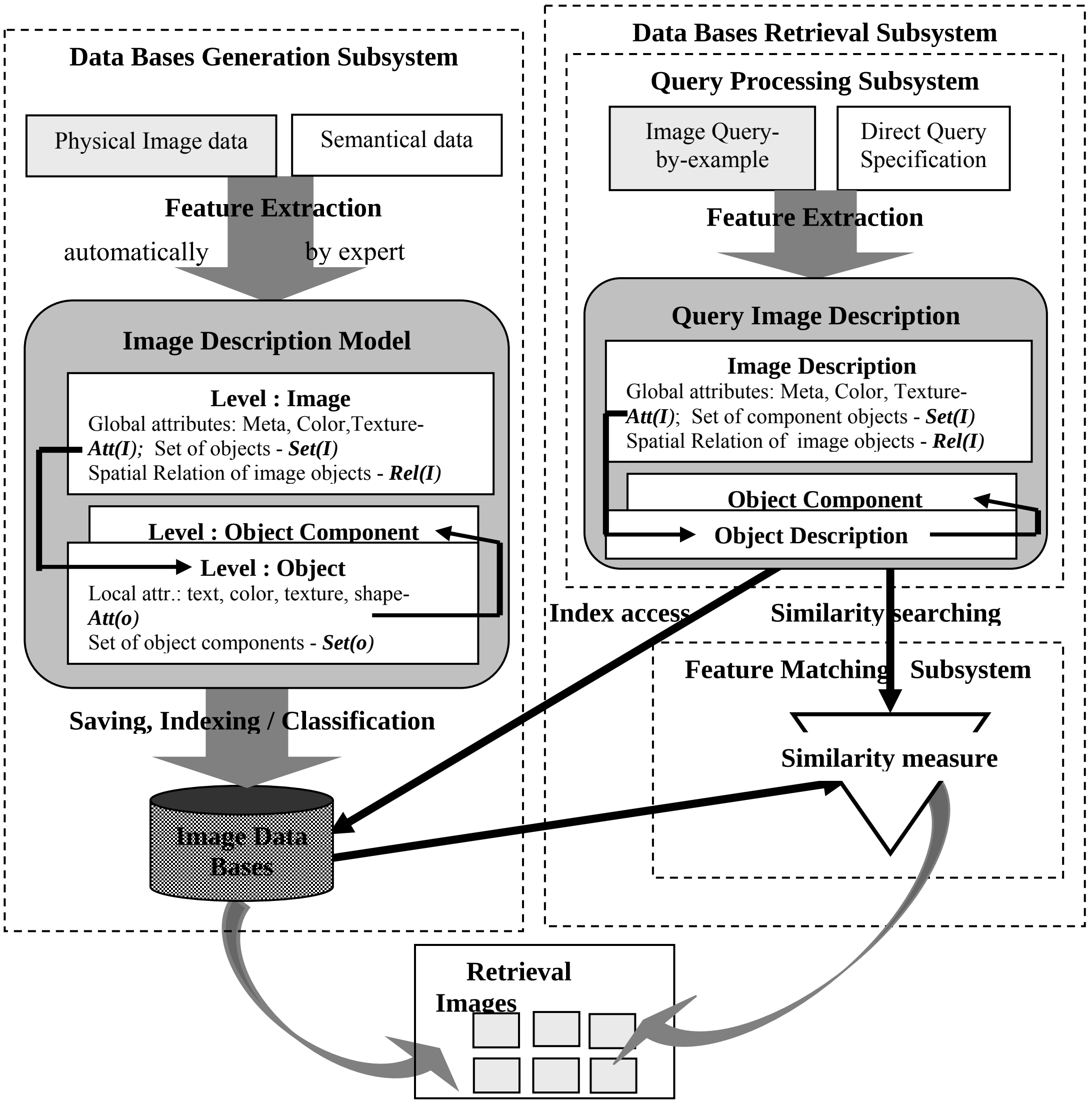

Fig. 1. The framework architecture of CBIR design

The creation of our framework of CBIR system steps on the base of the published in [2], [3], [4] models but it differs from them by structure, components, and data models. It includes: built-by-modules subsystems, processing and algorithms types, data models.
This framework offers a choice of all possible components in order to build up an image database from a corpus of images and users' requirements.

As a result of the analysis of the existing IDB, of their structures, organization and abilities for access that they give, a generalized architecture of the possible image data processing in the basic processes of saving and retrieval of IDB images is presented. This generalized our architecture-based framework for building an Image Databases from a Collection of Images. It is displayed on Fig.1. and may be used for presentation of the key editions and methods that are proposed in the literature.

In our method's architecture, the basic components are the two mutually connected processes: image saving and inserting in IDB and image retrieval by user's query. The two basic subsystems „DB Generation Subsystem" and "DB Retrieval Subsystem" correspond to these main processes. In the first subsystem, the images that are added to IDB are processed by features extraction algorithms or by expert. In this way the images are described by syntactical and semantical attributes, which are presented in our data model. The data model includes connected sub-descriptions on different levels. Each one of them includes attributes, a set of components and spatial relations between components. The types of the extracted image features, their describing characteristics and the levels of their extraction (image, object, components) are determining for the abilities of access to the saved data.

Within our model an image, denoted by *I* is described in terms of simple and of complex objects. Let us denote O_I a set of simple and complex objects. Each object $o \in O_I$ is described by Attributes (semantic and syntactical (colour, texture, shape) denoted by *Att(o)*), Set of object components *Set(o),* and Spatial Relation between Objects *Rel(o)*). We denoted by Descr_I the set of image description:

$$\mathbf{Descr_I = \{< Att(o), Set(o), Rel(o) >\}_{o \in OI}}$$

The images inserted in IDB together with their feature description data form a property presentation that is saved in a data structure of IDB. The features in the form of coded vectors can be used as indexes for direct organization of the access to IDB or for data clustering.

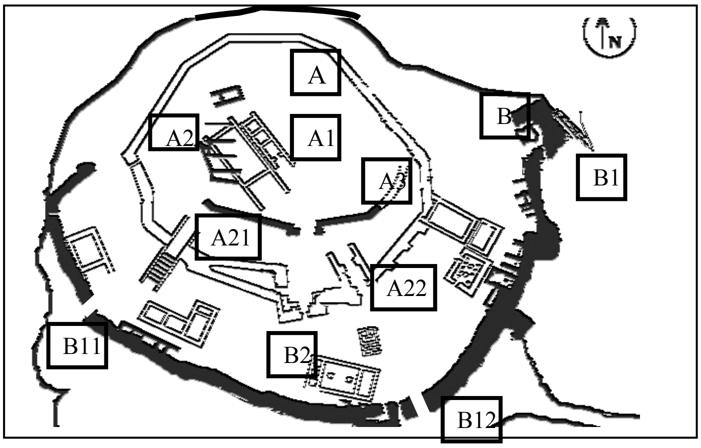

Fig. 2. Image I_{plan} - Plan of ancient town Troy

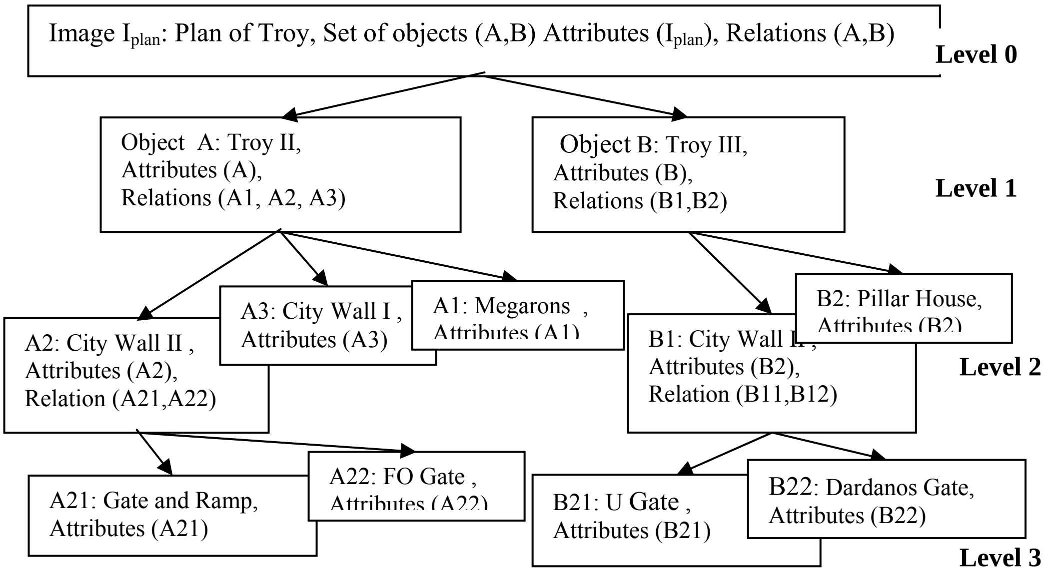

Fig3. Hierarchical composition of the image I_{plan}

According to the level of the used presentation of image contents two approaches for indexing techniques may be determined: indexing on the base of global distribution of the image characteristics and indexing on the base of the typical peculiarities of local image areas or regions.

The small computing complexity and the precision and exactness of the retrieval process are achieved by integration of text annotation with the images as in [6], [5]. The „DB Retrieval Subsystem" has to search and discover an answer of user's query. This subsystem is divided in two subsystems: „Query Processing Subsystem" and "Feature Matching Subsystem". This process is determining the system rapidity. The first subsystem processes the query primarily. The query specification may be done by example image, drawn by the user's draft, or exact and clear information from the user about the primary features of his interest. The cognitively based presentation has an important role in query processing on different levels. The query presentation is a result of the same processing for the same properties extraction so as inserting image in IDB. The same algorithms for properties extraction are used also for the query image named "Example" and the result is a presentation that is used for the query index forming. The search of a similar index to those in the IDB is implemented by the "Feature Matching Subsystem". The similarity matching of the sample index with the IDB indexes aims parts of the images to be found that are similar to a given sample or to a defined variant of a given sample. The type and depth of the properties extraction from the inserted in IDB images are determining for the functionality and flexibility of every visual information system. As in most cases the extracted characteristics-indexes are multi-dimensional; the approach of similarity search is perceived. The similarity search uses a similarity measure as a similarity criterion. The measure evaluates the similarity degree between two images and is determining in the process indexing and similarity integration of multi-dimensional index vectors of the image and the query.

In accordance with our data model we can define in a generous aspect the similarity measure that evaluates similarity between query image (Q) description and a saved in IDB image (I) description. The measure sim(Q,I)∈ [0,1] and is given by Eq. (1).

$$\mathrm{Sim}(Q,I)=\frac{\|O_I \cap O_Q\| - \sum_{k}^{\|O_I \cap O_Q\|}\sqrt{w_1 \sum_{i=1}^{attnumber}\left[Att_i(O_{kI})-Att_i(O_{kQ})\right]^2 + w_2 \sum_{j}^{relnumber}\left[\mathrm{Rel}_j(O_{kI})-\mathrm{Rel}_j(O_{kQ})\right]^2}}{\|O_I \cup O_Q\|} \quad (1)$$

where w_1, w_2 are weigh coefficients and $w_1 + w_2 = 1$; $\|O_I \cap O_Q\|$ is the number of common objects and $\|O_I \cup O_Q\|$ is the number of all objects in compared images. In a case of absolute identity Sim(Q,I)=1 and is 0 in absence of common objects. Those images from IDB whose presentation is evaluated by the similarity measure as maximal similar are returned as a query result.

As an example for illustration of our frame work architecture and data model we present an image (Fig. 2) denoted by I_{plan} which is a plan of ancient town Troy presented in the archeological literature. The principal of image decomposition is depicted in Fig. 3.

In the first level there is image description with global attributes. Set of objects includes two complex objects A (Troy II) and B (Troy III). Their descriptions compose the next level 1. By their sides these objects consist also of separate components. In the level 2 are presented components of object A - A1(Megarons), A2 (City Wall II) and A3(City Wall I). The next level 3 contains descriptions of components (A21: Gate and Ramp), A22: FO Gate). Analogically the object B is decomposed to two objects B1(City Wall II) and B2(Pillar House) and B1 contains B11 (U Gate), B12(Dardanos Gate). For the example image I_{plan} we obtain the set of simple objects:

Level 2(I_{plan})={ A1,A21, A22, A3,B11, B12, B2}

Under the control of an expert, a set of all objects can be defined:

OI_{plan} *={I, A, A1,A2,A21, A22, A3,B,B1,B11, B12, B2}*

Each object is presented by its description.

$Descr_o$ = < Att(o), Set(o), Rel(o)>

For example the object A description can be presented by records:

$Descr_A$ =<Attributes “Troy II”, area geometry, Sub-objects A1, A2. A3, Spatial relation matrix 3×3)>

III. Conclusion

In this paper, we proposed a framework and a block diagram offering a choice of all possible components for building an image database from a collection of images together with our data model. Image descriptions in our model are based on set of simple and complex objects. Objects can be either syntactical or semantical described in different levels commonly with their spatial relations. With our framework architecture based our and another’s experience we try to make the CBIR systems design more understandable. Despite their specificity, we are trying to bring their design to closer to this of the ordinary object-relation systems.

The future development of this work we see in the development of the methodology for image database engineering by using of new methods, approaches and strategies. We already began the creation of a program tool that will poses different feature extraction algorithms, indexing and classification algorithms and combination strategies that are organized in a library.

References

[1] W.Al-Khatib, , Y.Day, A.Ghafoor, P.Berta, Semantic Modeling and Knowledge Representation in Multimedia Databases, IEEE Trans. on Knowledge and Data Ingenering, 11, 1, 64-80, 1998

[2] S.Antani, R.Kasturi, R.Jain, A surveyon the use of pattern recognition methods for abstraction, indexing and retrieval of images and video, Pergamon, Pattern Recognition, 35, 945–965, 2002

[3] L. Besson, A.da Costa, E.Lecrcq, M.Terrasse, A CBIR-Framework: Using both Syntactical and Semantical Information for Image Description, Proceedings of the 7th International Database Engineering and Applications Symposium (IDEAS 2003), short paper, IEEE Computer Society, 385-390, Hong Kong, 2003

[4] L. Besson, A.da Costa, E.Lecrcq, M.Terrasse, Ikosem's Genric Model for Syntactical and Semantical Image description: the core component of a framework for image database engineering", Proceedings of the Tenth International Workshop on Multimedia Information Systems, University of Maryland, USA, 2004

[5] J.Smith, Integrated Spatial and Feature Image Systems: Retrieval, Analisis and Compression. http: //disney.ctr.columbia.edu /jrsthesis /thesissmall. html

[6] P. Stanchev, Content-Based Image Retrieval Systems, ComSysTech’2001- Bulgarian Computer Science Conference Sofia, Bulgaria, P11-P15, 2001