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Object-Oriented Image Database Model

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Abstract: In this paper we analyze some existing tools and approaches to image data modeling and we propose an Object-Oriented Image Data (OOID) model. It can be applied on a wide variety of image collections. The model employs multiple logical representations of an image. The logical image representation can be viewed as a multiple level abstraction of the physical image view. The OOID model is based on the analysis of different image application domains such as: medical images, house furnishing design plans, electronic schema catalogues and geographical information systems. The proposed model could be used as a frame for designing and building a wide range of image database systems and can be included as a part of the MPEG-7 standard. It can be treated as an extension of the image database models [3, 4]. An example for applying the OOID model to a plant picture database is given, as well as the realization of the model in the Sofia Image Database System.

Key words: Data models, image databases

Images are becoming an essential part of the information systems and multimedia applications. The image data model is one of the main issues in the design and development of any image database management system. The data model should be extensible and have the expressive power to present the structure and contents of the image, their objects and the relationships among them. The design of an appropriate image data model will ensure smooth navigation among the images in an image database system. The complexity of the model arises because images are richer in information than text, and because images can be interpreted differently, according to the human perception of the application domain.

There is a lack of standard model for representing the semantic richness of an image. Most traditional approaches to image data management use multilevel abstraction mechanisms to support content-based retrieval [1]. These levels contain: semantic modeling and knowledge representation, object recognition and feature extraction. The most relevant standards for multimedia data models are: HTML, SMIL, MHEG-5, Hy Time [2]. ISO MHEG-5 defines a hierarchy of classes featuring attributes, actions, and events. These classes constitute a framework for describing multimedia presentation, but not the semantic richness of the images.

THE OOID MODEL DESCRIPTION

An ***Image Data Model*** is a type of image data abstraction that is used to provide a conceptual image representation. It is a set of concepts that can be used to describe the structure of an image. The process of image description consists of extracting the global image characteristics, recognizing the image-objects and assigning a semantic to these objects. Approaches to image data modeling can be categorized based on the views of image data that the specific model supports.

Some valuable proposals for image data models are: VIMSYS image data model, model where images are presented as four plane layers; EMIR^2- an extended model for image representation and retrieval; and AIR - an adaptive image retrieval model.

The proposed OOID model establishes taxonomy based on the systematization on the existing approaches. The main requirement to the proposed model could be summarized as:

- powerfulness. To be applicable to a wide variation of image collections;
- to consider the characteristics of the images and image-objects as different types of data;
- to consider different types of relations among the image-objects;
- to allow different kind of functions over the physical and logical image description.

The data model is object oriented. The image itself together with its semantic descriptions is treated as an object in terms of the object oriented approach. The image is presented in two layouts (classes) - logical and physical. The ***image data*** are defined as a composition of the physical view - the image itself, and the logical view - a description of the image content and additional information about the image. The ***logical view*** of a given image is defined as the description of the global image characteristics and the recognized image-objects and the semantics associated with them. The structured part of

this information can be used in the image indexing and creating an image retrieval mechanism. There are two main approaches to the logical image description: based on the global image characteristics and based on the image content. In the ***global view*** approach the image content is described with the use of a list of attributes. Most of the available image database systems are using this approach for image description. Two kinds of attributes: meta and semantic attributes are used in this approach for global image description. An alternative to the global image description is based on the visual image content. The image ***content-based view*** describes the image-objects properties such as: color, texture patterns, shapes, image-object attributes and relevant location to each other of these image-objects. For the content-based description two approaches: model based and general-purpose based approaches are used. The ***model-based*** approach assumes that there exists some prior knowledge (model) about the types and the structure of the image-objects that can be part of the image. In this approach predefined image-objects are extracted from the image and the relationships between them are studded. The following properties of the image-objects are analyzed: color, texture patterns, shape, logical attributes, and semantic attributes. The following types of ***relations*** between the image-objects are considered in the OOID model: topological, vector, metric, and spatial. The ***general-purpose view*** treats the image as a whole and measures their global attributes such as color and texture. The ***physical view*** contains the pixel matrix of the image and its header.

A semantic schema of the proposed model is shown in Figure 1. Figure 2 shows a possible class description for the proposed model.

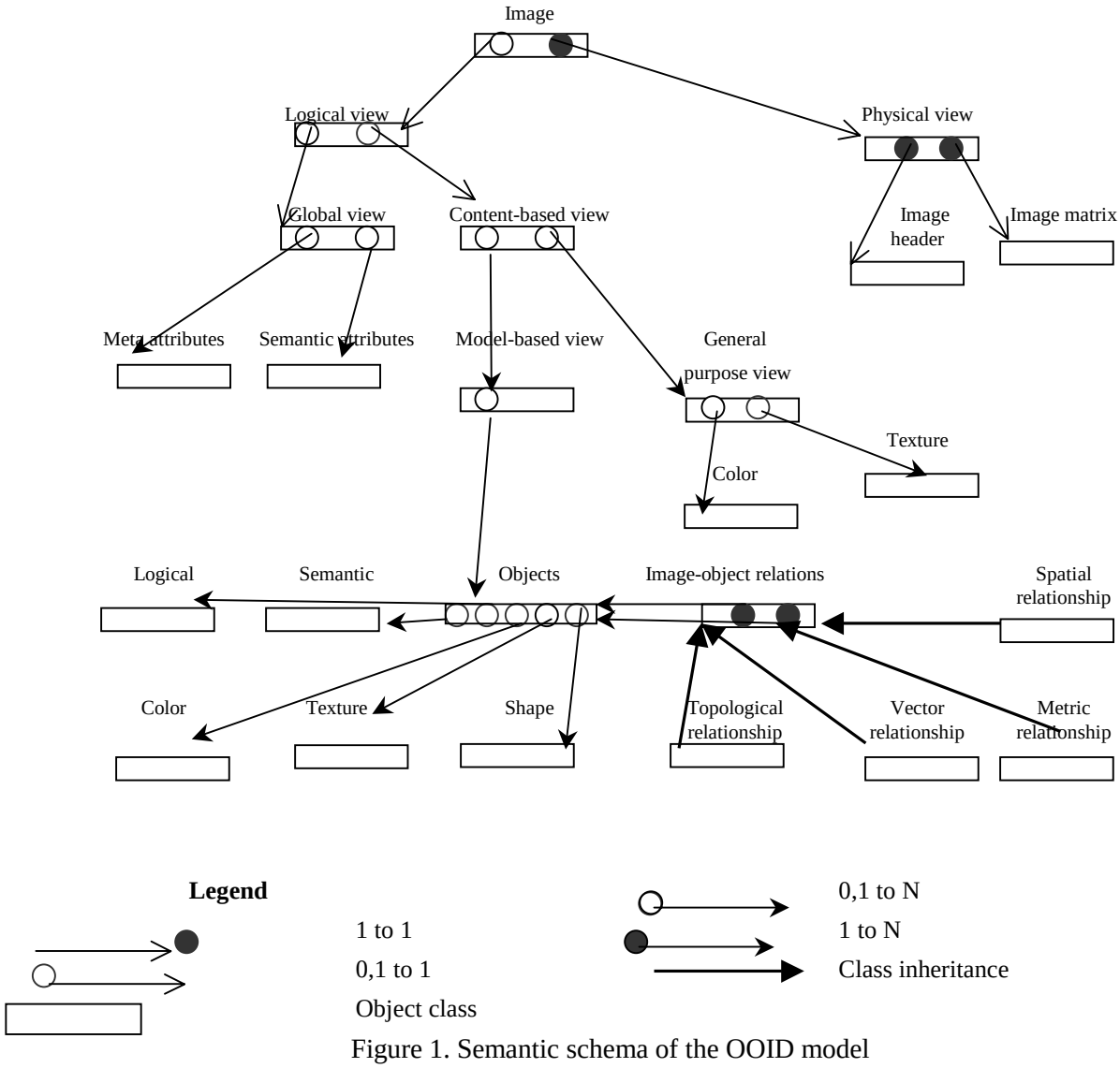

Figure 1. Semantic schema of the OOID model

CLASS NAME	PROPERTY NAME	DOMAIN
Image Header	Image name	Name
	# pixels in X direction	Integer; values {0 to 255}; format 999
	# pixels in Y direction	Integer; values {0 to 255}; format 999
	FOV in X direction in cm	Float
	FOV in Y direction in cm	Float
	# bytes per pixel	Integer; values {1,2}; format 9
	Pixel organization	Specification table
	Compression schema	Specification table
	Image type	Specification table
Image Matrix	Image name	Name
	Image values	Integer Vector; values {0 to 255}; format 999
Meta attributes	Name	Name
	Author	Person Name
	…	
Semantic attributes	Name	Name
	Quality	Specification table
	…	
Logical	Logical $Method_1$ Name	Logical $Method_1$ Domain
	…	
Color	Color $Method_1$ Name	Color $Method_1$ Domain
	…	
Texture	Texture $Method_1$ Name	Texture $Method_1$ Domain
	…	
Shape	Shape $Method_1$ Name	Shape $Method_1$ Domain
	…	
Topological relationship	Topological $Method_1$ Name	Topological $Method_1$ Domain
	…	
Vector relationship	Vector $Method_1$ Name	Vector $Method_1$ Domain
	…	
Metric relationship	Metric $Method_1$ Name	Metric $Method_1$ Domain
	…	
Spatial relationship	Spatial $Method_1$ Name	Spatial $Method_1$ Domain
	…	

Figure 2. Class description for the OOID Model

AN EXAMPLE FOR APPLYING THE OOID MODEL

Let's consider an image of a plant picture. After the segmentation procedure the image is partitioned in the following image-objects: blossom, stalk, leaf, root. A possible view as a result of applying the OOID model to the example image is given in Figure 3. At present a software realization of the model for Windows 2000 is considered in the Sofia Image Database Management System. An example for applying the OOID model through the Logical Image Definition Language in the

system is shown in Figure 4. It provides an idea about the schema constructors in terms of grammar definition, and their associated set of operations.

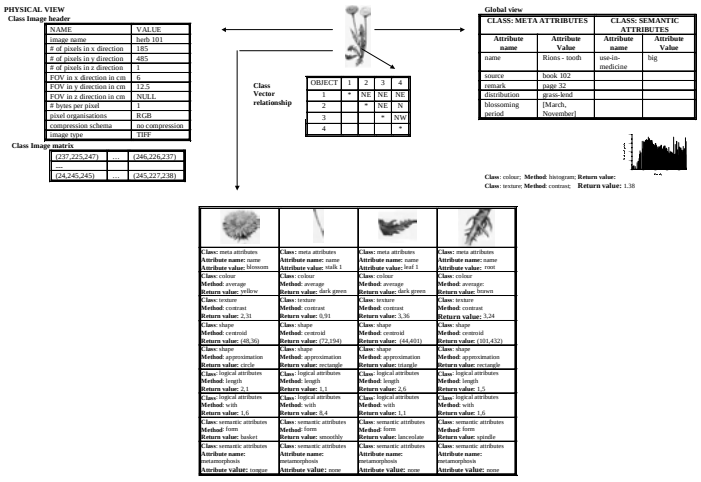

Figure 3. Example database instance of the plant image

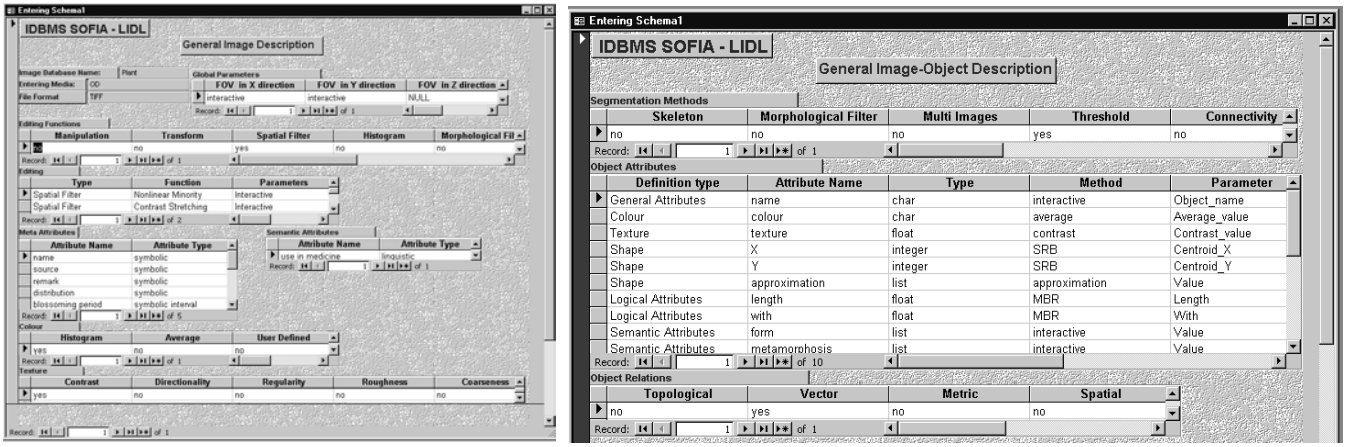

Figure 4. An example for applying the OOID model through the Logical Image Definition Language in the Sofia Image Database Management System

CONCLUSION

The main advantages of the proposed OOID model could be summarized as follows:

- its generality. The model uses the main techniques from the existing image data models and it is applicable to a wide variety of image collections;
- its practical applicability. The model can be used as a part of image retrieval and image database system;
- its flexibility. The model could be customized when used with a specific application.

The proposed model could be extended to include the description of multimedia objects such as voice and video.

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