General Image Database Model

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Abstract. In this paper we propose a new General Image DataBase (GIDB) model. The model establishes taxonomy based on the systematisation of existing approaches. The GIDB model is based on the General Image Data model [1] and General Image Retrieval model [2]. The GIDB model uses the powerful features offered by object-oriented modelling, the elegance of the relational databases, the state of art of computer vision and the current methods for knowledge representation and management to achieve effective image retrieval. The developed language for the model is a hybrid between interactive and descriptive query languages. The ideas of the model can be used in the design of image retrieval libraries for an object-oriented database. As an illustration the results of applying the GIDB model to a plant database in the Sofia Image Database Management System are presented.

1 Introduction

The image databases are becoming an important element of the emerging information technologies. They have been used in an a wide variety of applications such as: geographical information systems, computer-aided design and manufacturing systems, multimedia libraries, medical image management systems, automated catalogues in museums, biology, geology, mineralogy, astronomy, botany, house furnishing design, anatomy, criminal identification, etc. As well they are becoming an essential part of most multimedia databases.

The first survey for image databases appeared in the early 1980 by Tamura and Yokoya [3]. They classify the image database systems into three categories: convention databases, conventional databases with extended function for image processing, and specialised systems designed for a particular application domain. On the other hand Grosky and Mehrota [4] classify the image databases into three categories: systems using relational databases, system based on object-oriented model and systems for image interpretation. Grosky elaborated the ideas of image databases to multimedia databases [5].

There are mainly five approaches towards image database system architecture:

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(1) Conventional database system as an image database system. The use of a conventional database system as an image database system is based mainly on relational data models and rarely on hierarchical. The images are indexed as a set of attributes. At the time of the query, instead of retrieving by asking for information straight from the images, the information is extracted from previously calculated image attributes. Languages such as Structured Query Language (SQL) and Query By Example (QBE) with modifications such as Query by Pictorial Example (QPE) are common for such systems. This type of retrieval is referred as ***attribute based image retrieval***. A representative prototype system from this class of systems is the system GRIM_DBMS [6].

(2) Image processing/graphical systems with database functionality. In these systems topological, vector and graphical representations of the images are stored in the database. The query is usually based on a ***command-based language***. A representative of this model is the research system SAND [7].

(3) Extended/extensible conventional database system to an image database system. The systems in this class are extensions over the relational data model to overcome the imposed limitations, by the flat tabular structure of the relational databases. The retrieval strategy is the same ***as in the conventional database system***. One of the research systems in this direction is the system GIS [8].

(4) Adaptive image database system. The framework of such a system is a flexible query specification interface to account for the different interpretations of images. An attempt for defining such kind of systems is made in [9].

(5) Miscellaneous systems/approaches. Various other approaches are used for building image databases such as: grammar based, 2-D string based, entity-attribute-relationship semantic network approach, matching algorithms, etc.

In this paper a new General Image DataBase (GIDB) model is presented. It includes descriptions of: (1) an image database system; (2) generic image database architecture; (3) image definition, storage and manipulation languages.

2 The GIDB Model Description

This section we start with some definitions.

Definition 1. A ***Data Model*** is a type of data abstraction that is used to provide the data conceptual representation. It is a set of concepts that can be used to describe the structure of a database. By the ***structure of a database*** we mean the data types, relationships, and constraints that should hold on the data. It can also include a set of operations for database retrieval and update [10].

Definition 2. An ***Image Database (IDB)*** is a logically coherent collection of images with some inherent meaning. The images usually belong to a specific application domain. An IDB is designed, built, and populated with images for specifics purpose and represents some aspects of the real world.

Definition 3. An ***Image Database Management System (IDBMS)*** is a collection of programs that enable the user to define, construct and manipulate an IDB for various applications. An ***image definition*** involves specifying the characteristics of the application domain, the image indexing mechanism, the image-object recognition mechanism, and the information about the images that will be extracted and stored together with the images. An image database ***constructing*** is the process of storing the images themselves on some storage media, together with the logical image description. An image database ***manipulation*** includes functions such as querying the database for a retrieval of a specific image and updating the image database to reflect changes of the images in the real word. As well the user could create his own set of programs and bind them into an image database system.

Definition 4. An ***Image Database System (IDBS)*** is constituted from IDB and IDBMS. The main differences from a conventional database system environment are: (1) the existence of tools for image databases definition, including tools for image indexing and image-object recognition and (2) existence of image processing procedures.

Definition 5. The way that the users think about data is called ***external view level***, the way that the data are recognised by the database system is called ***internal or physical level***, and the middle layer is called ***conceptual level.***

2.1 The Generic Architecture of an Image Database

The architecture of a generic image database system is given in Fig. 1. Three phases for interactions with the system are provided: domain definition, image entering and image retrieval. In order to introduce new application areas for the system the administrator uses the domain definition phase. At the second phase the images are entered into the system. The third phase is image retrieval. In it the end-users use the system for posing queries and viewing the image features.

PHASE	INPUT	PROCESS	RESULT
1. Domain definition			
a. logical description	Logical Image Definition Language (LIDL)	LIDL processor	Procedure for image indexing
b. physical description	Physical Image Definition Language (PIDL)	PIDL processor	Procedure for physical image storage
2. Image entering			
a. input the image and image information	images	Image Storage Language (ISL) processor	Logical and physical IDB
b. image updating	ISL updating tools	ISL processor	Logical and physical IDB
c. image deletion	ISL deletion tools	ISL processor	Logical and physical IDB
3. Image retrieval			
a. image display	Image Manipulation Language-IML	Query processor	Images
b. logical image display	IML	Query processor & Statistical processor	Semantic data Statistical data

Fig. 1. Generic architecture of an IDBS

2.2 Image Data Model Description

The proposed Image Data model establishes taxonomy based on the systematisation of the existing approaches. The proposed approach for the image modelling includes:

• using language approach, where language structures are used for physical and logical image content description;

• using object oriented approach, where the image and the image objects are treated as objects containing appropriate functions calculating its functions.

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. A semantic schema of the proposed model is shown in Fig. 2.

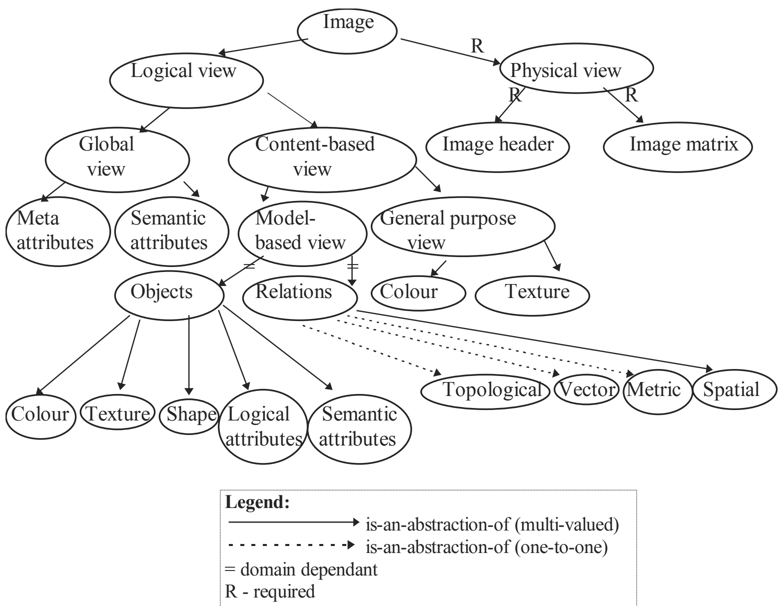

Fig. 2. Semantic schema of the GID model

2.3 Image Retrieval

The retrieval model is unique in the sense of its comprehensive coverage of the image features. The main characteristics of the proposed model could be summarised as follows:

a.) The images are searched by their general image description model representation [1];

b.) The model is based on similarity retrieval. Let a query be converted through the general image data model in an image description $Q(q_1, q_2, ..., q_n)$ and an image in the image database has the description $I(x_1, x_2, ..., x_n)$. Then the retrieval value (RV) between Q and I is defined as: $RV_Q(I) = \Sigma_{i = 1, ...,n} (w_i * sim(q_i, x_i))$, where w_i $(i = 1,2, ..., n)$ is the weight specifying the importance of the i^{th} parameter in the image description and $sim(q_i, x_i)$ is the similarity between the i^{th} parameter of the query image and database image and is calculated in different way according to the q_i, *and* x_i values. They can be: *symbol, numerical* or *linguistic* values, *histograms*, *attribute relational graphs, pictures or spatial representations characters.*

2.4 IDBS Languages

We try to develop the IDBS languages for the GIDB model following an analogy with the conventional database systems languages. Those languages can be divided into three classes: image definition, image storage and image retrieval languages.

2.4.1 Image Definition Language

The image definition language consists of two parts: the Logical Image Definition Language (LIDL) and the Physical Image Definition Language (PIDL).

The Logical Image Definition Language. One physical image has different logical interpretations. The Global Image Data Model is used to create a logical representation of a physical image. The process of the logical representation is described in Fig. 3. Functions for similarity calculations have been included in the chosen methods.

STEP	FORMAT	PROCESS
1.Entering schema	(IDB name, entering media, file format)	reading from outside source into the memory
2. Editing schema	(general parameters, $method_1$, $method_2$, ..., $method_e$)	manipulation, transform, spatial filter, histograms, and morphological filter
3. Global view obtaining	(meta attributes = $name_1$: $type_1$, $name_2$: $type_2$, …, $name_{ma}$: $type_{ma}$; semantic attributes = $name_1$: $type_1$, $name_2$: $type_2$, …, $name_{sa}$: $type_{sa}$)	procedure for meta and semantic attribute definition
4. General purpose view obtaining	(colour = $method_1$, $method_2$, ..., $method_{k1}$, texture = $method_1$, $method_2$, ..., $method_{k2}$,)	procedure for colour and texture definition
5. Segmentation & object definition	($method_1$, $method_2$, ..., $method_s$)	procedure for image segmentation and object definition
6. Relation definition schema	($method_1$, $method_2$, ..., $method_r$)	procedure for relation definition

Fig. 3. The steps in the Logical Image Definition Language

Physical Image Definition Language. The functions for physical image storage are given in Fig. 4.

STEP	FORMAT	PROCESS
1. Physical image storage schema	($method_1$, $method_2$, ..., $method_{n1}$)	procedure for physical image storage
2. Logical image storage schema	($method_1$, $method_2$, ..., $method_{n2}$)	procedure for logical image storage
3. Indexing mechanism schema	($method_1$, $method_2$, ..., $method_{n3}$)	procedure for indexing creation
4. „Thumbnail“ image storage schema	($method_1$, $method_2$, ..., $method_{n4}$)	procedure for „thumbnail“ image storage

Fig. 4. The steps in the Physical Image Definition Language

2.4.2 Image Storage Language

The ISL contains three parts: (1) ***image entering language***, (2) ***image updating language*** and (3) ***image deletion language***. Image updating and deletion are seldom used and are not typical for image databases. For all these operations a specific interactive environment has to be created. Image processing and measurement functions are available in this language to assist the user.

2.4.3 Image Manipulation Language

The Image Manipulation Language includes retrieval by attribute value, shape, colour, texture, example image or spatial constrain. The query is translated to a GID model representation and then the GIR model is used to retrieve the desired images. The retrieval method is described in more details in [2].

3 An Example for Applying the GIDB Model

The GIDB model manipulation capabilities are illustrated on drawings and pictures of plan image database realised in the Sofia Image Database Management System.

3.1 Image Definition Language

The first level of interaction is the domain definition. The definition of the image application area is given in Fig. 5.

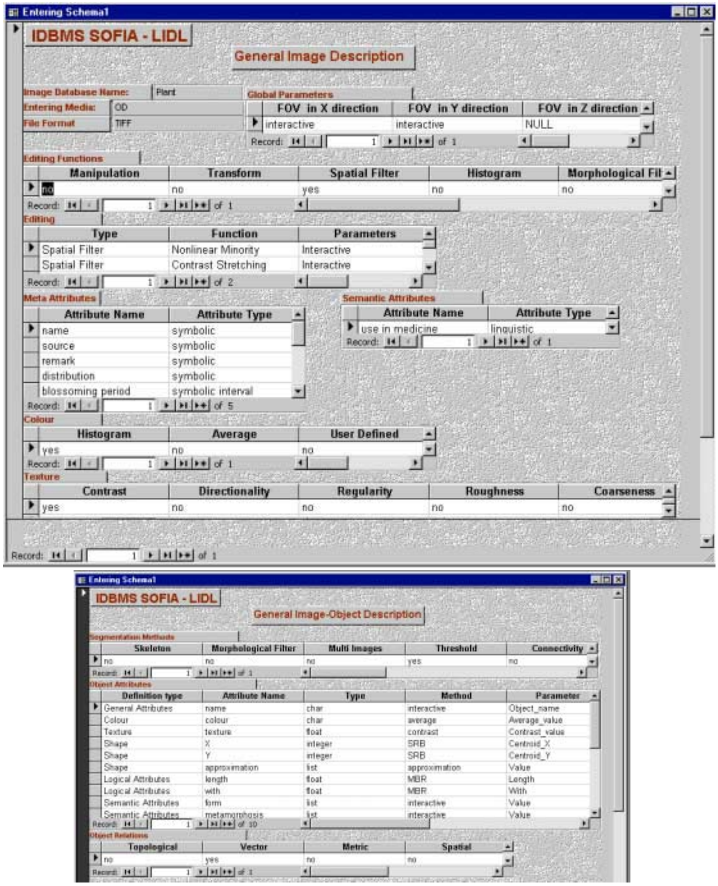

Fig 5. An example of the Logical Image Definition Language

3.2 Image Storage Language and Image Manipulation Language

Let a plant image be entered in the image database. The GID description and the image itself are stored in the image database. The Image Manipulation language is described in [2]. An example for a query result is given in Fig. 6.


Fig 6. An example for a query result

4 Conclusions

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

(1) Its generality. The image representation is done trough the general image data model. The image retrieval is based on the general image retrieval model. Therefore the model is applicable to a wide variety of image collections.

(2) Its practical applicability. There are numerous methods for the decomposition of the image into objects and for image indexing. According to the application domain the appropriate method could be used.

(3) Its flexibility. The model could be customised when used with a specific application.

The presented GIDBS model could be extended for distributed IDBS and multimedia database containing text, video and speech signals. At present software realisation of the model for Windows NT is considered in the Sofia Image Database Management System.

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