

A database management system for digital archiving of paintings and works of art

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Abstract

In museums and conservation centers the need for a database management system arises for the purpose of efficient artwork-related information storage and retrieval. This paper presents a versatile integrated database package, which is designed specifically for painting and other artwork archiving and satisfies conservation needs. Besides alphanumeric information, unlimited digital images of a work of art of various modalities (e.g. visible, infrared, ultraviolet) can also be stored, as well as spectrometry signals and colorimetry measurements. Any station in the network can access this information. It will be shown that this package can accommodate most of the needs of people working in painting conservation, regardless of whether or not Intranet or Internet operation is required.

1. Introduction

The use of a *Database Management System* (DBMS for short) for painting or artwork archiving is a reasonable choice. With the aid of an ordinary DBMS it is

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possible to store, modify, display painting records as well as find records that satisfy certain search criteria.

Although commercial database products do offer this level of functionality, they are not specialized to painting/artwork archiving. Therefore, special software must be developed on top of a DBMS that satisfies the needs of artwork archiving, study and conservation. A non-exhaustive list of these requirements is the following:

- Support of multimodal image storage (x-rays, visible, IR, UV)
- Support of high resolution imaging through image tiling (especially in IR, visible)
- Storage of spectroscopy information
- Storage of colorimetry measurements
- Storage of “classical information” in text and data formats (e.g. theme, artist information, conservation needs, relevant bibliography)
- On-line mass storage (optical)
- Multi-user support
- LAN and Internet access

Most of these needs should be satisfied by a database solution in order for it to qualify as a complete artwork archiving solution. This paper will present such a system which is tailored for digital artwork archiving, the *EIKONA FOR ARTS/DATABASE*. It will be shown that this environment possesses specific advantages for large volume, multi-user storage and retrieval of information related to works of art.

The general structure of this paper is the following. Section 2 establishes the goals that were followed during the design phase. In Section 3 implementation details are discussed. Finally, in Section 4 some important conclusions are presented.

2. Design goals

The *EIKONA FOR ARTS/DATABASE* suite (*EIKONA* for short) was developed to offer a complete multimodal artwork archiving environment. For this

purpose, certain implicit design goals were established during the program design phase. A brief presentation of these goals is given below, which also serves as an introduction to the versatile features of this system.

2.1. Record structure

The problem of selecting a record structure, that could satisfy archiving and conservation needs, stems from the fact that there are different viewpoints as to which fields should be contained in a certain database record. A big effort was made in this direction by the European Union research project *NARCISSE*, which provided a solid framework for the digital representation of art-related information [4].

The wealth of information, that can be associated with a work of art, demands a database implementation that takes into account its different aspects. Thus, characteristics should be grouped together and each resulting group should be coded as a different record structure (e.g. film). In this way, record structures that describe the painting itself or any other related information such as digital images, films or related bibliography are logically organized. Of course, the database should provide for storage of information related to physical and conservation details, available creation data, physical conditions and artistic style.

Since good performance is required from a DBMS, record length should be kept to a minimum. This restriction imposes an upper limit on the number and size of record structures that should be implemented. From our viewpoint, a good compromise is the inclusion of a minimal set of characteristic field types. These fields should be chosen with great care, in order to maximize their overall informational value.

2.2. Storage of digital images

A complete archiving solution should treat visual information in a similar way to alphanumeric (text) information. Digital images of a work of art should be easily stored and retrieved in the database, along with any other alphanumeric data. For

example, tiles of an infrared reflectogram mosaic should be stored in the DBMS and retrieved afterwards for subsequent post-processing. Thus, document-imaging features should be incorporated into the final design. For optimum functionality, multimodal digital images resulting from different acquisition schemes (i.e. infrared, visible, x-ray, ultra-violet and microscopy) should be treated as separate entities. Images should be easily retrieved, according to the type of acquisition. Multimodality support is very important for conservation applications.

No limits should be imposed on the number of digital images that can be stored, since this would represent an undesired constraint. Additionally, every image should be readily accessible from within the database environment.

High resolution imaging through digital image tiling should be supported as well. This is very important for IR imaging (where the spatial resolution of the camera is small), as well as for very high resolution imaging in the visible wavelengths. Naturally, mosaicing software should be used for complete painting assembly from its tiles.

2.3. *Storage of spectrometry signals*

In a related context, data files containing spectroscopy signals (Raman spectroscopy, for example) should also be stored in the database, along with any other alphanumeric information. Suppose that a digital image, acquired from the visible region of the spectrum, and a number of spectroscopy signals are stored in the database. If the coordinates of the sample points that correspond to the regions spectroscopy signals were taken from, are known, a highly desirable feature would be the simultaneous display of both the digital image and the spectroscopy signals on a graphics terminal.

2.4. *Storage of colorimetry measurements*

Similarly, provisions should be made for the storage and subsequent display of colorimetry measurements of an object. Any colorimetry measurements that are associated with certain points of the digital image should be easily accessed. An important feature is the display of colorimetry measurements of a certain type (e.g. xyY) in the respective color space diagram. Of course, this level of interactivity requires built-in support for these operations.

Additionally, users should not be limited to the storage of predefined colorimetry types. That is, they should be able to add other measurement (or signal) types, at any time.

2.5. *Mass storage support*

Despite the technological advances in digital image compression, availability of disk space remains a limitation. Thus, in order to store a large number of images, some form of built-in support for mass storage subsystems is required. CD-ROM, write-once read-many (WORM) or magneto-optical drives (MO) towers and jukebox systems can be used efficiently for this purpose.

Utilization of mass storage subsystems solves a problem but introduces another serious one: the image storage details should be “invisible” to the ordinary user. Thus, in a typical database access scenario where a user wants to retrieve a digital image from the database, access should be performed transparently and with no complications.

Furthermore, the procedure of creating CDs containing digital images should be performed easily by the DBMS administrator, with minimal user involvement.

2.6. Network/multi-user operation

The whole environment should support network operation. It is evident that network operation applies not only to alphanumeric data, but to digital images, signals and measurements as well.

As far as the network model is concerned, an important issue is the choice of network protocol. For example, the network stations could be connected via Ethernet or token ring network adapters, with NetBIOS, NetBEUI, IPX/SPX or TCP/IP supplying the necessary connectivity functionality. Of course, each protocol has its own distinct advantages over the other ones. A constraint can be imposed on protocol selection, by taking into account the fact that the solution should be scalable. That is, no changes should be required in order to move from *local area network (LAN)* to *metropolitan or wide area network (MAN and WAN, respectively)* operation.

2.7. Database model

Relational databases provide vast flexibility in viewing and querying data in various ways [1, 2]. However, the final design can only be as flexible as the *database schema* on which it is based. Simply stated, the database schema represents a collection of *entities* (i.e. record structures) and *relationships* [3]. Entities can be thought as structures that hold information, while relationships relate entities between them. Both entities and relationships can have attributes (or characteristics).

In a relational DBMS (RDBMS for short), schema design is perhaps the most influential factor of overall functionality at the implementation level. The domain of all possible queries to the database is related to its schema design. The size of this domain is strongly related to the way entities and relationships were designed in the first place. Thus, a poor design can cripple the potential of the final system.

Adherence to certain rules can ease the path to a more flexible implementation. Let us suppose that an non-optimized schema is given. Then, one can create a new schema with possibly modified entities, relationships and/or characteristics. In essence,

both the initial and the modified schemas contain the same amount of information. However, some queries may be very difficult, if not impossible at all, to perform in the former case. Of course, what really matters to a user is not only the amount of information stored in the database, but the amount of information that can be easily retrieved. In this context, an optimized schema can exhibit higher versatility.

Several commercial RDBMS products exist today (e.g. Oracle, Informix, Ingres, DB2, Sybase) which can form the underlying application layer of the final application. The utilization of a commercial RDBMS presents certain key advantages:

- High reliability
- Multi-user operation in heterogeneous system environments
- Excellent fault recovery features
- Easy upsizing (i.e. upgrading to a more powerful architecture) path

2.8. User interface

During the eighties, a major shift occurred in the way users interacted with a computer system. That is, command line operation lost ground to easy-to-use *graphical user interfaces (GUIs)*. However, *command line interfaces (CLIs)* still present a major advantage over GUIs: they are much more flexible in handling certain tasks with considerable power. For instance, in a database-related context with a *Data Manipulation Language (DML)*, it is possible to perform any desired query. On the other hand, use of a GUI usually limits queries to a predefined set.

The straightforward path, during the development of a database product, is to implement one of the above-mentioned interfaces. That is, the database could be operated either from a command line (utilizing some sort of database language) or from menus with the aid of a pointing device. In any case, some compromises will have to be done.

A more flexible approach is to create a hybrid platform. That is, to create a GUI-based application, with predefined queries and reports, but also give the option of accessing directly the database via a command line interface.

2.9. Adherence to standards

From the previous paragraphs it is evident that the design of our archiving solution presents many implementation alternatives. However, only a small subset of these alternatives should be considered, since some of them depend on proprietary standards. Openness of system architecture is related to the way it adheres to standards (if they apply, of course).

The digital image file format, network protocol and RDBMS language can be chosen in order to maximize the adherence of the archiving solution to international standards. For this purpose, certain standards (e.g. *ISO*, *ANSI*, and *IETF*) can be enforced.

3. The EIKONA FOR ARTS/DATABASE environment

This environment was designed to address the exact needs of artwork-related information management tasks. Three versions of this system exist, which, although somewhat different in operation, are functionally the same. The first two versions are LAN-oriented, where the latter one is based on a true client-server environment. The third version is oriented towards *World Wide Web (WWW)* operation. Thus, it is ideal for wide area networks or hybrid (simultaneous LAN and WAN) operation.

The rest of this Section is as follows: Section 3.1 examines common features of all three platforms. From a user's point of view, operation of the first two platforms appears the same. Thus, their specific features are examined under Section 3.2. Finally, Section 3.3 presents key features of the WWW environment.

3.1. Common features

3.1.1. Schema and implementation for Byzantine icons

We have considered Byzantine icons a special case. As mentioned in Section 2.1, the choice of the database fields, to be included in the final painting record, plays a critical role. The NARCISSE record structure was the starting point for our implementation [4]. We tried to adapt this structure to the specific conservation needs of Byzantine icons. In Greece, important work has been done in the study of works of art (e.g. mural paintings) from the Byzantine era, which led to a database schema representation.

Such an effort has been made in the Greek research project *ANTHIVOLON*, which deals with the problems of digital processing, representation and archiving of Byzantine icons and mural paintings. The proposed implementation merges the schema representations from NARCISSE with more specific considerations related to Byzantine paintings. Unfortunately, this representation contained a large number of fields. Careful selection of the number of these fields, on the advice of conservators, yielded a much smaller, yet efficient schema representation. The entities and relationships that formed the resulting schema conveyed information about all aspects of a paintingⁱ. However, it should be noted that the schema could be adapted to conform to any other type/style of painting.

As noted in Section 2.7, many possible implementations exist for a given schema design. In order to maximize query flexibility, the schema was implemented in available RDBMS technology in the *third normal form (3NF)* [3]. This design ensures good flexibility in the implemented product, since it provides a large domain of queries that can be performed. In practice, this leads to separation of complex entities into simpler ones. An entity-relationship graph is depicted in Figure 1, where each header

indicates an entity and each field in bold letters indicates a database key. The line segments that connect entities indicate one-to-many relationships.

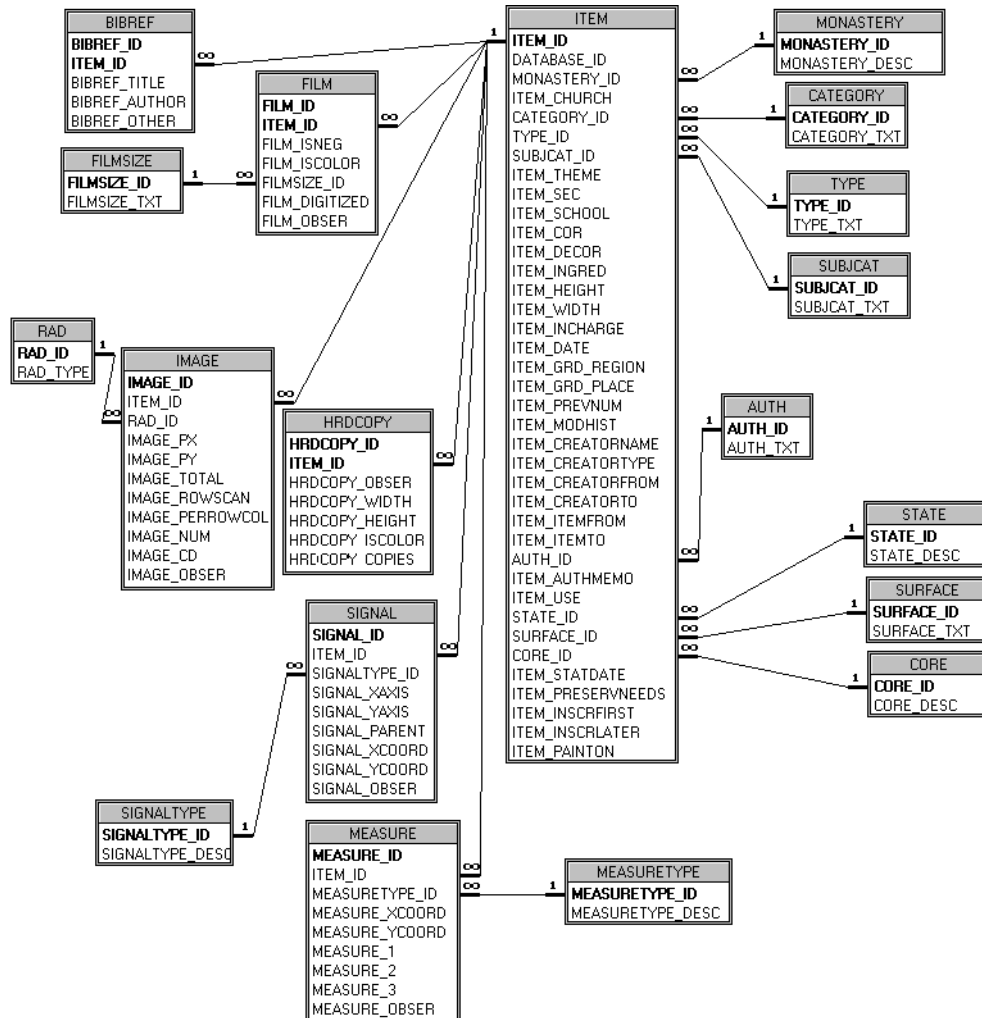


Figure 1 Schema representation of the database. Rectangles denote entities (record structures) and each entity is characterized by the enclosed attributes (fields). Attributes in bold indicate primary keys of the respective entity. For example, the entity **ITEM** represents general painting information, while **ITEM_HEIGHT** holds the height of the specific painting. Finally, line segments that connect entities represent 1-to-many relationships. Thus, many (the ∞ side of the line segment) **IMAGE** entity records can refer to the same (the 1 side of the line segment) **ITEM** entity record.

ⁱ For the rest of this paper, aspects of this system, with regard to paintings, will be discussed. However, our discussion applies to works of art in general.

A painting entity (record structure) was created, that consisted of more than forty attributes (fields). These fields belong to one of the following categories:

- Basic information
- Physical details
- Restoration details
- Available creation data
- Current physical conditions
- Storage information
- Historical data
- Artistic style

The implementation also included entities related to paintings. Some of these entities are the following:

- Hardcopy (HRDCOPY)
- Bibliography (BIBREF)
- Film (FILM)
- Colorimetry measurement (MEASURE)
- Digital image (IMAGE)
- Spectroscopy signal (SIGNAL)

In addition to query flexibility, this separation of the painting entity from any other painting-related entities, offers other important advantages. In the first place, database performance is improved, since a much smaller record is used to hold painting information. Additionally, since painting-related entities (e.g. hardcopy, bibliography, and digital image) are separated from the painting entity itself, there is no limit to the number of records of the former type of entities that can refer to a certain painting record.

3.1.2. Network topology

The network protocol was chosen in order to offer versatile LAN/WAN operation. The TCP/IP protocol was chosen since it provides good scalability and high reliability in operation. Installation can be easily performed in any TCP/IP-based *Intranet* (e.g. in a museum internal network). Since TCP/IP is the network protocol of the *Internet*, no changes will be required for Internet operation.

A simple representation of the network model is shown in Figure 2.

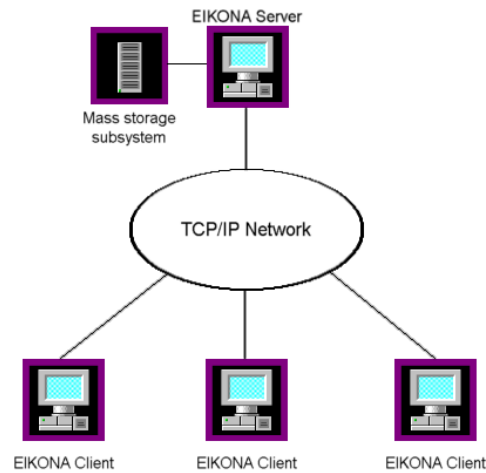


Figure 2 A simplified network operation model.

The *server* holds the actual data, while other systems (*clients*) on the network, can store and retrieve them. Of course, a requirement that should be satisfied is that all systems should have the necessary system software to be connected through TCP/IP.

The server is currently implemented on Microsoft Windows 95 and Windows NT (client-server and WWW versions only) operating systems. However, as it will be discussed in Sections 3.2-3.3, the clients may or may not have to run any specific EIKONA client software.

3.1.3. Digital images and mass storage support

This system is able to store unlimited digital images of a painting. To facilitate easy classification of stored images, the digital image database entity includes fields that describe:

- The acquisition type (visible, infrared, ultraviolet, X-rays, microscopy, other).
- Relative position with respect to the entire painting, in the case of image tiles (subparts) employed in very high resolution IR or visible light imaging.
- Relative position with respect to the entire painting, in the case of microscopy images.
- The removable medium (CD-ROM disk, for example) disk number that will contain this image.

This information can be utilized to query the database in order to extract all the sub-images of a mosaic set. To display an image on a terminal, all that is required is to locate the respective image record and press a button.

Currently, images in TIFF, TARGA and JPEG formats are accepted. The latter is of great importance, since color images require vast amounts of storage. For example, an uncompressed 4096x4096-pixel color image requires 48 Mbytes of storage. The same image, compressed in JPEG format, may require far less disk space, depending of course on the image content and the compression ratio. JPEG compression is usually lossy, i.e. the compressed image loses some detail with respect to the original. However, with medium compression little detail is lost and compression ratios of at least 10:1 can be used without visual degradations. This compression ratio represents a tenfold increase in the number of images that can be stored in a given storage medium. Additionally, JPEG is an International Organization for Standardization (ISO) standard, which ensures compatibility with a large number of image processing software packages [5, 6].

Since a JPEG compressed image file size is only a fraction of the original (uncompressed) image file size, the JPEG image can be transferred in a network much faster than the original one. This is a crucial advantage in WAN operation, since network lag would otherwise limit response times and, consequently, introduce problems in operation.

In certain cases, a user may want to store an image in the database, with no loss of detail. For this reason, an option to store the image in TIFF, or TARGA formats is given. These image file formats support lossless compression. Thus, the stored image is the same as the original. It should be noted that these options are supported only for the sake of storing an image in uncompressed form, with no loss of quality.

Despite compression, disk storage remains a limited resource. As seen in Section 2.5, mass storage devices can be utilized for the purpose of storing efficiently a large number of images. A mass storage device is connected to the server (Figure 2). These devices can hold a number of rewritable or write-once read-many (WORM) disks. The latter form is preferred, since it is possible that a rewritable disk data can be lost due to user error or system malfunction. Currently, disk tower implementations are supported. For the time being, CD-ROM towers offer a good compromise between available disk storage and cost/compatibility. A single CD-ROM disk can hold about 600 Mbytes of data. This amount can not be compared to the storage capability of other proprietary systems, which is in the order of some GBytes. However, CD-ROM disks can be created in a file system format that is portable, among computer systems of dissimilar architecture. The *ISO 9660* standard describes this "universal" CD-ROM file system, which is widely utilized today in CD-ROM disks [7]. The utilization of CD-ROM mass storage created with the ISO 9660 file system simplifies data interchange among different computer systems, which are equipped with a CD-ROM player. Additionally, CD-ROM drives are widely available and relatively inexpensive.

Suppose that an N -drive CD-ROM tower mass storage system is going to be utilized by a database in order to store a large number of images. Usually, CD-ROM towers with 7, 14 or 21 CD-ROM drives are employed. Sooner or later, all of these drives are going to be occupied by CD-ROM disks, effectively introducing an upper limit to the number of images that can be stored. In order to overcome this limitation a simple, yet effective, solution was implemented. As users start storing images in the server, these images stay temporarily in a specific directory, which is constantly monitored by the system. At some point, the sum of the file sizes of these accumulated images will reach the CD-ROM disk capacity limit. At this point, images are transferred to a CD-ROM disk, freeing the dedicated for images disk space on the server. The CD-ROM disks that are created this way are numbered sequentially from one onwards. As these disks get stored in one of the available CD-ROM tower drives, the server keeps track of a disk number-tower drive mapping. Of course, images that have not yet been transferred to a CD are always available on the hard disk. Let us suppose now that all of the tower drives are occupied. If a user wants to access an image that is not stored in one of disks currently inside the CD-ROM tower, the server will detect this event and inform the user that the disk is not accessible. In turn, the database administrator will have to remove a disk from the tower, insert the wanted one and update the disk number-tower drive lookup table to reflect this change. Although this approach introduces manual intervention in operation, it is a low-cost solution.

3.1.4. Signal and measurement storage

As mentioned in a previous paragraph, storage of spectroscopy signals and colorimetry measurements is supported.

The signal entity includes fields that describe the spectroscopy type (e.g. Raman) and the absolute coordinates of the signal, with respect to either an image of the entire painting or to a microscopy image. For example, let us suppose that a digital image, which is acquired in the visible spectrum, is stored in the database. Let us also

suppose that a spectroscopy signal is acquired from a specific region of the painting. Coordinates of this signal can be stored in the server together with the image data file itself. As it will be shown in Section 3.2.2, the coordinate information can be used to display the visible image simultaneously with its signals on a computer terminal.

Some spectroscopy types are preconfigured. More types can be created and stored in the database, which can subsequently be utilized as though as they were native types.

Measurements can be stored in a similar way. Although there is a large number of built-in colorimetry models, there is still provision for the creation of new types. As in the case of signals, the new colorimetry types can be employed like the built-in ones. They also can be displayed together with the image to which they refer to (Section 3.2.2).

3.1.5. Server software implementation

Depending on the version, this system may or may not be implemented on top of a native client/server RDBMS environment. A Microsoft Windows NT, Intel processor-based platform is required in the client-server and WWW versions. Both of them are based on the Oracle Workgroup Server 2000 RDBMS. Thus, they can handle a large number of simultaneous transactions to the database, with high reliability. Although the simpler version does not employ any client-server functionality, it provides an inexpensive artwork archiving solution with adequate performance for low- to medium-volume transactions.

3.1.6. Queries and reports

To ease user operation, the system comes with a number of predefined queries and reports. User-designed queries can also be performed, since a subset of the ANSI 1989 standard for the *Structured Query Language (SQL)* is supported. This feature

overcomes the limitations that are usually imposed by applications designed around a GUI environment.

3.1.7. Database upsizing

All three variants can be easily upgraded to the next most powerful one. This is because database entities and relationships have been implemented in a portable manner, which utilizes the *Open Database Connectivity (ODBC)* SQL-based application program interface [2]. For example, even the simpler version of the system can be easily upsized to a client-server-based (or WWW-based) solution, with no data loss.

3.2. **LAN versions specifics**

As it was previously mentioned, the clients of Figure 2 may or may not have to run any specific software, in order to connect with the server. In the LAN-oriented environments, there are certain specifications that the client systems should adhere to. The clients should be PC-compatible systems running Windows 95 or NT. Additionally, special software should be installed on each client system. This client software is optimized for fast database access.

3.2.1. User interface

Implemented as a native Microsoft Windows application, the client offers a versatile as well as a user-friendly environment. In both versions, the same client interface is employed. Thus, no retraining is required in case of upsizing. Data entry, update and search operations are simplified by the use of list boxes, control buttons and VCR-style buttons in forms.

3.2.2. Interactive image display

One of the most powerful features of this system, is its ability to display a painting along with any microscopy images, spectroscopy signals and colorimetry

measurements that refer to it. With a button click, the user can interactively view this information on the same computer screen.

On any client, with a button press, the *VIEWER* client application displays all the microscopy images, signals, measurements that refer to a certain visible spectrum acquired image, which is stored in the program, together with the image itself. In Figure 3, the interactive features of the program are exhibited. A visible image together with a colorimetry measurement, a histogram and a xyY color space chart are displayed on the same computer screen.

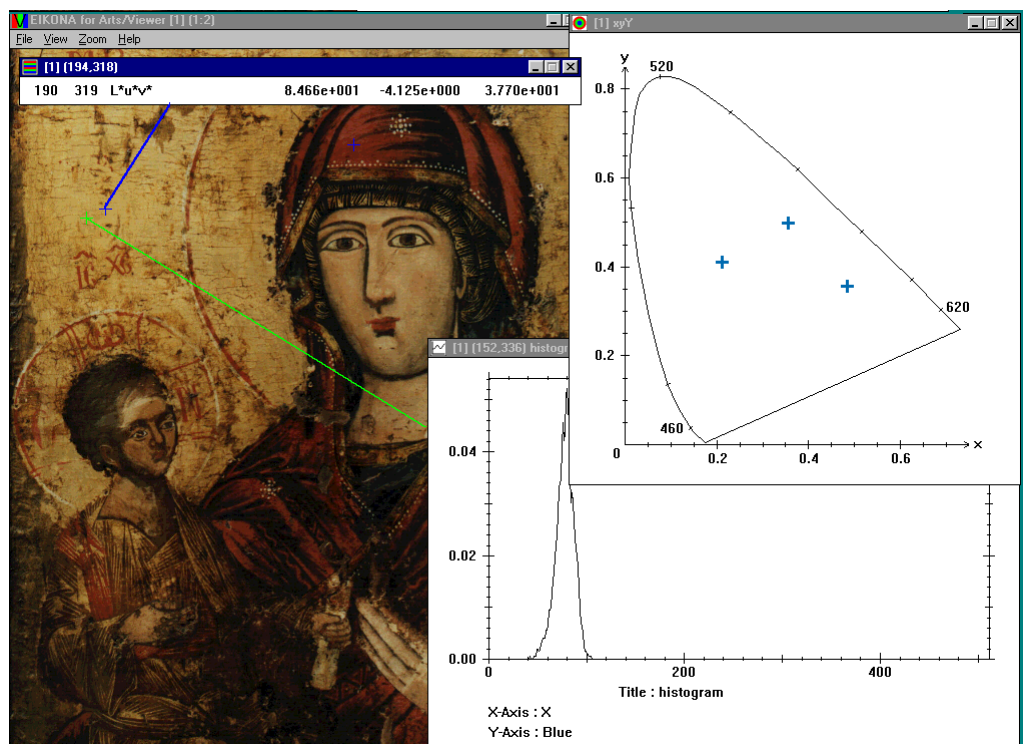


Figure 3 Interactive display of images, signals and colorimetry measurements with the integrated viewer application.

Crosshairs in this Figure indicate points that have associated signals, measurements, or microscopy images. The respective color indicates the type of the associated data. For example, clicking on a crosshair symbol, which is associated with a signal, will display a graph of the respective signal data. Figure 4 displays a sample histogram.

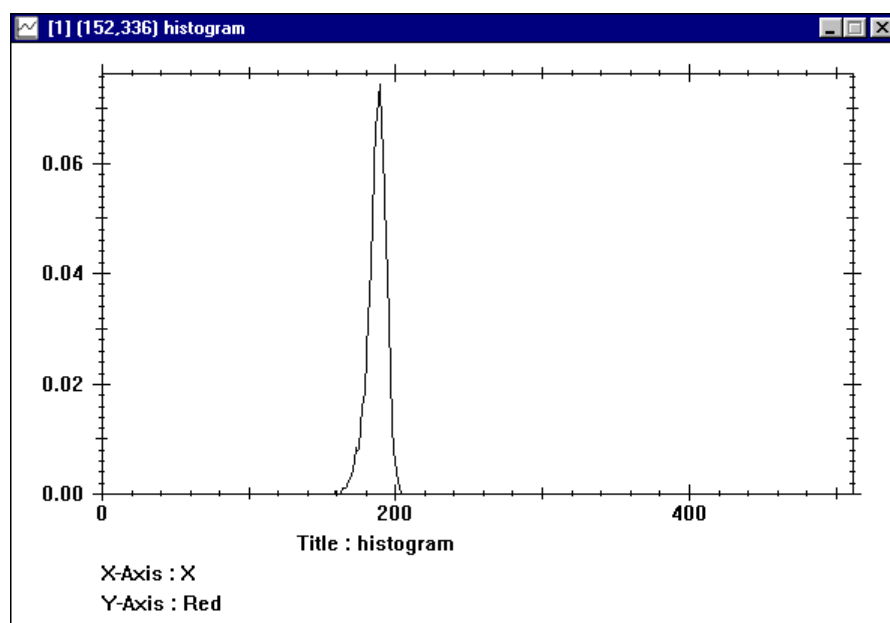


Figure 4 A sample histogram displayed by the VIEWER client application.

Colorimetry measurements can be viewed in a similar way, as it is depicted in Figure 5.

[image id] (172,66)					
170	68	xyY	4.000e-001	4.000e-001	5.000e-001
170	69	HLS	6.000e+001	0.000e+000	5.000e-001

Figure 5 Colorimetry measurement data display.

Similarly, measurements at a certain point of the image can be displayed in a color space graph. Figure 6 shows an example xyY color space set of measurements.

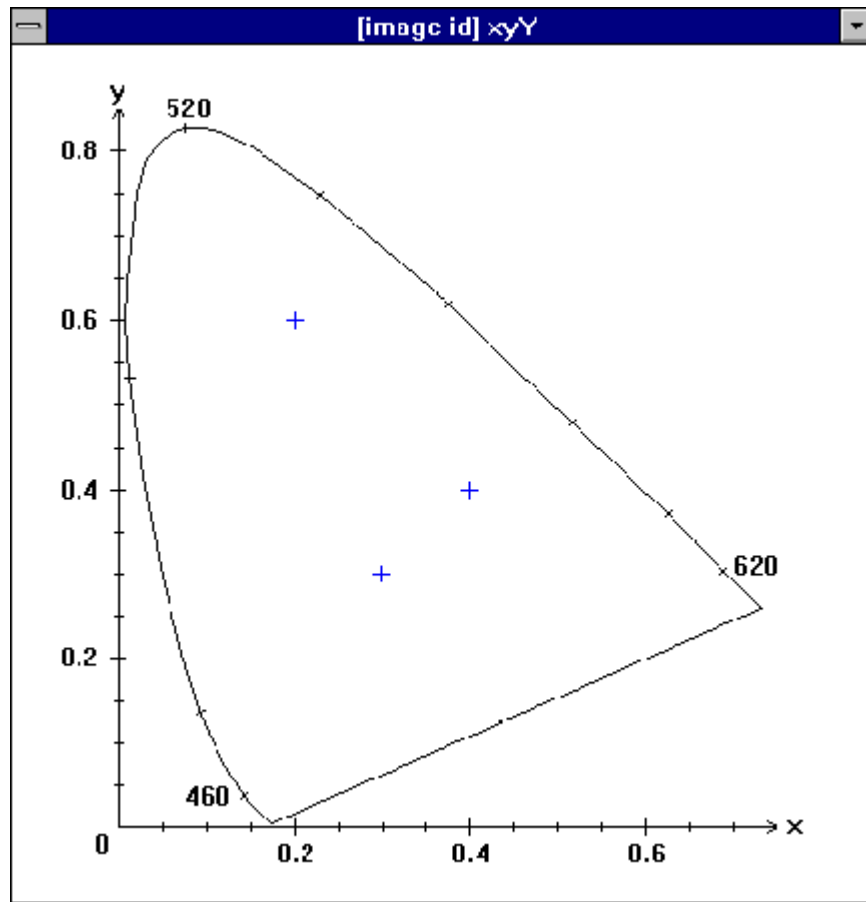


Figure 6 xyY color space measurement display.

3.3. WWW version specifics

The WWW version was developed in order to take advantage of the World Wide Web as a medium that abstracts the underlying client system architecture. The only client software that is required in this case is a WWW browser application that can parse *Hypertext Markup Language (HTML)* version 3.2 documents. This means that any system can qualify as a WWW client, as long as browser software is installed, regardless of the computer architecture and operating system (e.g. Apple Macintosh or Unix-based system). It is also possible for a client to access a server that physically resides on the other side of the world. Thus, WAN operation, without the hassle of client program setup and platform incompatibilities, becomes a feasible alternative to classical LAN-oriented database operation. Unfortunately, the WWW version of the

system does present a certain disadvantage when compared to the other ones: there is a certain overhead, which is associated with the extra network traffic generated due to the transmission of redundant alphanumeric information in the form of HTML page generation data. The other client versions are optimized in this sense, since all form processing logic is embedded in the client software. It is up to the database administrator to decide which version is the most appropriate, depending, of course, on the size of the implemented network.

All the functionality that was built into the client has been moved to the Web server while the web browser acts as a dumb terminal. Changing and upgrading the functionality of the database becomes much easier since all the required changes take place at the server's side and are immediately visible to everyone.

Even though we have tried to maintain the same functionality with the other versions the system, the differences in the nature of the clients have imposed some restrictions. For example, in order to add an image to the database, it must first be sent to the server by uploading it to the incoming directory of the FTP service.

On the other hand, the hypertext capabilities of the Web open new possibilities for searching the database. These capabilities were used to link the results produced by a query with new queries that depend on the previous results. For instance, a query for a painting based on the theme produces information on the creator of the painting. The creator's name can be linked to a new query that produces all the paintings that this creator has painted.

In the WWW platform, concurrent operation of the server by both WWW clients and Client/Server version clients is possible. Thus, a company can utilize the latter clients inside its own Intranet. On the other hand, WWW clients can perform access from the rest of the network. This hybrid operation adapts better to the needs of heterogeneous network environments.

Forms, on this client platform, resemble the ones of the other versions of the system. All of the functions are supported in this platform. In addition, a multilingual interface to the server has been introduced. Figure 7 shows a sample HTML page of a digital image entry form.

EIKONA for Arts/WWW Server

Subforms

Digital Image Addition

[[First](#)] [[Previous](#)] [[Next](#)] [[Last](#)]

Type	IR <input type="button" value="v"/>
Number of images	<input type="text"/>
Scan by rows	<input type="radio"/> Yes <input type="radio"/> No
Digital images per row (column)	<input type="text"/>
Sub-image number	<input type="text"/>
Observations	<input type="text"/>
<input type="button" value="Entry Addition"/>	

[[Main Painting Form](#)] [[Form Selection](#)] [[Main Page](#)]

Figure 7 Web digital image entry page.

On the server, a WWW server should be installed in addition to the Oracle RDBMS. Currently, the Microsoft Internet Information Server is required on the server system. This WWW server provides the Information Server Application Program Interface (ISAPI), an interface that eases data extraction from the database by receiving SQL commands as input and subsequently formatting the resulting records in the form of HTML pages.

A demonstration version of the WWW system can be accessed at the *Uniform Resource Locator (URL)* <http://aias.csd.auth.gr/eikona/>.

4. Conclusions

This paper presented a digital archiving solution for paintings and other works of art. The EIKONA FOR ARTS/DATABASE software is a scalable database management system, which addresses specific problems in this area. Besides alphanumeric data management, it offers a friendly environment for the storage and retrieval of multimodal digital images, spectroscopy signals and colorimetry measurements. Images can be viewed on a client system, together with any related stored signals, measurements and microscopy images.

This software system utilizes standard-based technology to deliver database access in both local and wide area networks. Transfer of data between the available platforms is also supported.

Future directions in the development of this system include plans of inter-server connectivity, in order to provide a transparent distributed database environment. The WWW client will be improved to support multiple queries and provide better error handling.

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