Iris Information Management in Object-Relational Databases

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Abstract. Biometrics is a technology under development that has been enhanced by the increasing security concerns in organizations at all levels. Public agencies that employ this technology need to consult the biometric data efficiently and share them with other agencies. Hence the need for data models and standards that allow interoperability between systems and facilitate data searches. The objective of this work is to develop a generic architecture using object-relational database technology (ORDB), according to international standards, for identifying people by means of iris recognition. In addition, a model expressed in Unified Modeling Language (UML) class diagram where the domain data types defined for use in architecture is proposed. This architecture will allow interoperability between organizations efficiently and safely.

Keywords: Object-relational database, biometrics, iris.

1 Introduction

Currently, biometrics is a technology that is in full development, both in terms of everyday life and research. This rapid evolution is due to the growing concerns about security and the relationship that this technology has to ensure it. Public agencies that employ this technology need to consult the biometric data efficiently and share it with other agencies [1]. Hence the need for data models and standards which allow interoperability between systems and facilitate data searches.

As expressed above, this paper suggests a generic architecture based on an object-relational database adapted to international standards for identifying people by means of iris recognition [2]. For this, a model expressed in UML class diagram is also suggested, in which the data types used in the architecture, with its attributes and behavior are defined.

The article is outlined as follows: section 2 presents the adopted standards. Then, in section 3 the suggested architecture is presented. Next, the motivation and importance for the use of object-relational database is detailed for the implementation of the model. In section 5, the suggested architecture model is laid out. Finally, conclusions and future work are presented.

2 Adopted standards

This section describes the adopted standards for the management architecture of iris information. Firstly, in subsection 2.1 the ANSI / NIST ITL 1-2011 standard, focused to interoperability between systems is presented. This standard also sets the requirements for the representation and iris image compression, which will be discussed in subsection 2.2

1.1 Standards for interoperability between systems

The ANSI / NIST ITL 1-2011 [3] standard is a biometric standard published in November 2011, which defines how to ensure the interoperability of biometric data between different systems. This standard defines the content, format, and units of measurement for the electronic exchange of fingerprint, palmprint, plantar, face recognition, iris, deoxyribonucleic acid (DNA), and other biometric samples and forensic information that may be used in the identification or verification process of a subject. It is the standard mostly used by state entities, largely due to the intervention of the national state that since the Chief of Cabinet of Ministers establishes strict compliance with international standards and the adoption of best practices in this field [4].

This standard defines the composition of the records comprising a transaction that may be transmitted to another organization. The standard currently supports several different biometric modalities, and has reserved record identifiers for the possible future addition of other methods. All records in a transaction shall pertain to a single subject. Biometric data used to identify another individual requires a separate transaction. A transaction is comprised of records. Transactions shall consist of one Type-1 record and one or more of the Type-2 to Type-99 records. The Type-1 record is used to describe the transaction. In this work it is working with iris biometrics, so the transaction must contain at least one record Type-1 and Type-17 records. The Type-17 record specifies interchange formats for biometric authentication systems that use iris recognition.

Among its requirements, the standard ANSI / NIST ITL 1-2011 also has the requirements for representation and iris image compression. They are discussed below in the following subsection.

2.2 Standards for the representation and compression of images

An aspect to bear in mind for the exchange of biometric images is its quality of representation. In many instances, image exchange requires web transactions, so that the size thereof is important. In this sense, the data exchange standards also require compression formats to use methods that meet specific requirements. In many systems the baseline JPEG algorithm (ISO / IEC 10918) is used. However, this algorithm is not currently supported by the ANSI / NIST ITL 1-2011 to iris images. This is because it has been shown that false match rates are increased. As mentioned above, the ANSI / NIST ITL 1-2011 standard only accepts JPEG 2000 (ISO / IEC 15444: 2004) [5] and PNG (ISO / IEC 15948: 2004) [6].

The international standard (JPEG 2000) ISO / IEC 15444: 2004 is an image coding system that allows compression, transmission and efficient storage of still images and sequences of images.

JPEG 2000 represents a family of specifications, developed jointly by the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC) and the International Telecommunication Union (ITU). This international standard defines a set of lossless (bit-preserving) and lossy compression methods for coding bi-level, continuous-tone grey-scale, palletized color, or continuous-tone color digital still images.

The JPEG 2000 standard specifies:

– Decoding processes to turn compressed image data into reconstructed image data.
– A codestream[1] syntax containing information for the interpretation of compressed image data.
– A file format.

In addition, it provides guidance on:

– Encoding processes for converting source image data to compressed image data.
– How to introduce these processes into practice.

This international standard describes an image compression system which allows great flexibility, not only for the compression of images, but also for the access into the codestream. This codestream provides a number of mechanisms to locate and extract portions of compressed image data with the purpose of retransmitting, storing, displaying, or editing. This access enables the storage and retrieval of compressed image data appropriate for any application, without decoding.

The division of both the original image data and the compressed image data in several ways leads to the ability to extract image data from the compressed image data to form a reconstructed image with lower resolution or lower precision, or selecting regions of the original image. This enables the adaptation for a codestream to the transmission channel, storage device, or display device, regardless of the size, number of components, and sample precision of the original image.

Thus, the features of this specification allow a single codestream to be used efficiently by a number of applications. The largest image source devices can provide a codestream that is easily processed for the smallest image display device, for example.

There are four main elements described in this standard:

Encoder. An encoder takes digital source image data and parameter specifications as an input, and by means of a set of procedures generates a codestream as an output.

Decoder. A decoder takes compressed image data and parameter specifications as an input, and by means of a specified set of procedures generates digital reconstructed image data as an output.

Codestream syntax. It consists of a set of rules for the representation of compressed image data that includes all parameter specifications required by the decoding process.

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[1] Sequence of bits representing the compressed image information.

Optional file format. It provides an optional file format for exchange between application environments. The codestream can be used by applications with other file formats.

The ISO/IEC 15948:2004 PNG (Portable Network Graphics) International Standard specifies a datastream and an associated file format for a lossless, portable, compressed image which can be broadcasted on the Internet. Indexed-color, grayscale, and true color (RGB) images are supported, with optional transparency. Besides, it supports a Sample depths range from 1 to 16 bits. PNG is fully streamable with a progressive display option. It is robust, providing both full file integrity checking, and detection of common transmission errors. PNG can store gamma and chromaticity data as well as a full ICC[2] color profile for an accurate color matching on heterogeneous platforms.

This Standard defines the Internet Media type "image/png".

Portability is among the main features of PNG. Encoding, decoding and transmission should be independent from software and hardware platforms. It may display true color, indexed-color, and grayscale images, with or without transparency, in addition to color space information, and auxiliary information such as textual comments.

The format was developed to be used on the Internet, so the encoding and decoding processes can be generated serially as the data stream is received on a serial communication channel. It is also designed to display an approximation of the whole image, which is progressively enhanced as the data stream is received.

By including a CRC it is possible to detect errors during transmission of the data streams.

The format uses filtering and compression processes which are lossless. In any of these processes decoding speed on the coding rate is prioritized, in order to accelerate the image display.

The algorithms involved in the process of encoding and decoding should be freely available.

The format is flexible to accept future additions and extensions without compromising the exchange of PNG data stream.

3 Proposed architecture

For biometric samples captured by any organism can be exchanged with other organisms, the system managing the biometric data must support transaction according to ANSI / NIST ITL 1-2011 standard, that is, it should be able to generate and / or use transactions that are morphological, syntactic and semantic as regards the requirements of the standard.

In Fig. 1, a generic architecture for managing iris images is presented.

In the proposed architecture, the tasks of generating, transmitting and receiving standard records are within the iris image exchange system. This system has the module that handles the generation and transmission of records necessary for an

[2] International Color Consortium: http://www.color.org/.

ANSI / NIST ITL 1-2011 transaction and another module for receiving these records from associated organisms [7]. In this paper, the standard Type-17 record corresponding to iris feature is used.

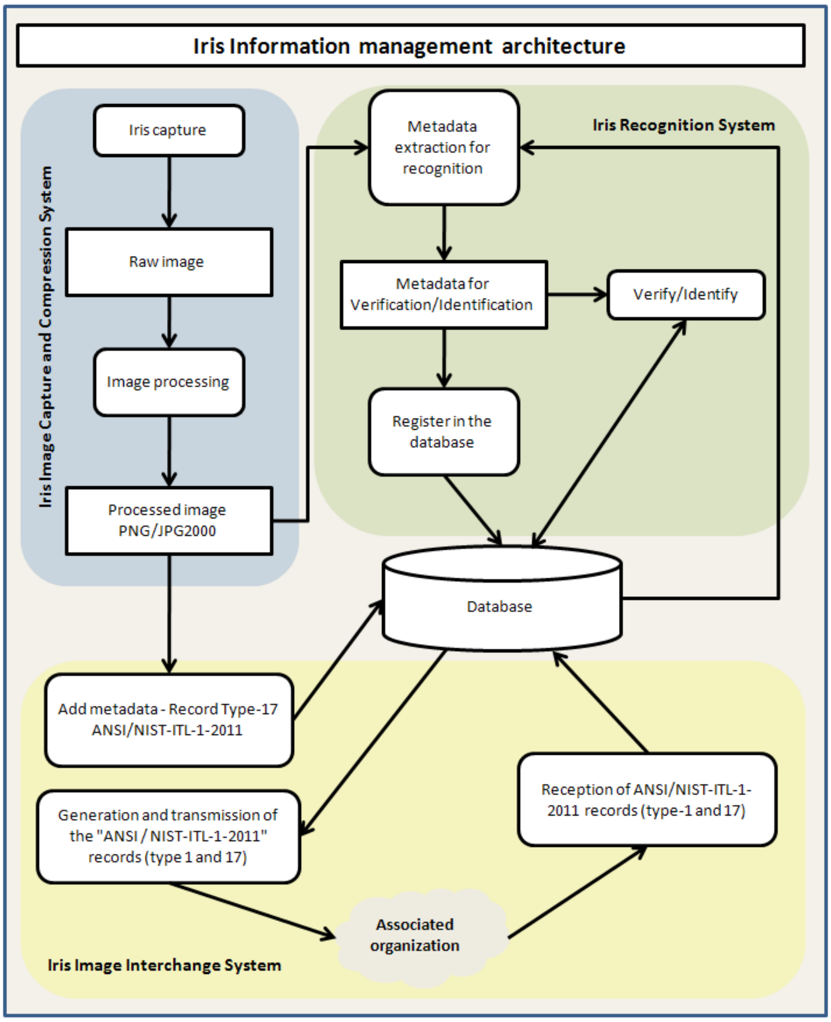

Fig. 1: Iris Information Management Architecture.

The Type-17 record of the aforementioned standard is used only for information exchange. However, you should also consider the generation and storage of metadata required for recognition, i.e. for the processes of identification and / or verification of people by means of the iris (IrisCode) [8] [9] which includes the subsystem for iris recognition.

The images that manage the systems mentioned can be obtained either from transactions with other agencies or from the system captures itself. For this, the capture system and iris image compression is used.

Both the structure Type-17 record and the metadata for iris recognition are complex structures. This can cause some problems when working with relational data model, because of the limitations imposed by it. Therefore, here we have opted for object-relational (OR) technology [10], as detailed in the following section.

4 Object-Relational Databases

The proposed architecture includes the representation of metadata related with iris biometrics data, so that they can be shared, accessed, retrieved and compared in a simple and efficient way. Furthermore, as mentioned above, the rendering quality of the images must be taken into account, particularly those compressed images for exchange. This also follows the specifications of the adopted standards. The representation of these complex data structures can cause some problems when working with relational data model by the following.

1. The structures of the metadata required, for both ANSI / NIST ITL 1-2011 records and the comparison of biometric data (IrisCode), are non-atomic structures, so in relational databases (in order to respect the first normal form) they must be separated into multiple tables. This makes it a less efficient treatment. For example, when comparing two sets of metadata it will be necessary to perform join operations.
2. The data processing must be done from particular languages (C++, Java, etc.), which presents the problem of compatibility and dependence on programming languages, since they must transfer the data generated by methods implemented in different languages to the database for storage. This issue is not trivial, and should be treated for each particular language.
3. In view of the above, so that a language to deal with data such as the method of comparing two biometric features, cursors must be created to be transferred through a network to return a single value. This can result in unnecessary network traffic, since these processes return a single logical value. For example, in a comparison used in the verification process, it returns whether or not it verifies.

Given the above drawbacks of the relational database, here we have chosen to use the OR technology. This technology can provide solutions to the limitations of relational databases since they provide the following abilities [11]:

1. *To define data types*. These types may involve complex structures such as collections, large objects, etc., without the limitation of the first normal form.
2. *To define and implement the data behavior*. Methods can be created to manage the data of defined types, thus facilitating safe access from applications that use, for example, the verification method that compares two IrisCodes.
3. *To define and implement a domain access methods*. It improves the access time in recovering data from a specific domain, as in the case of biometric data.

The mentioned abilities lead to the creation of infrastructures that extend the Database Management System services [12]. These infrastructures let the system deal with data from a specific domain, in this case, with biometric data.

As regards the project, this infrastructure should include:

- The creation of specific types for biometric data: This includes types for raw data (iris images in our case), types for encoding them (IrisCode), and all the metadata required to generate ANSI / NIST ITL1-2011 transaction records.
- Defining and implementing the methods that manage the types previously defined: This includes, among others, the generation of specific encodings, comparison methods (matching) and methods of generation and import of ANSI / NIST ITL1-2011 records.
- The creation of domain indexes to improve the response time in the identification processes: in biometric identification, you need to access multiple records to identify a person. Improving the efficiency in this access is not simple to be achieved with traditional indexes like B-trees, hash, etc. This is because the codes (templates) generated for comparison, are multidimensional data and methods for specific access domain are needed.

The following section suggests a model for Iris Information Management Architecture introduced in Fig. 1. In this model, we suggest the specific data types for representation biometric feature in question and methods necessary for the proper handling of them.

5 Proposed model

This section describes the proposed model for the representation of images and iris metadata adapted to standards. The model not only provides the representation of images with metadata, but also their behavior.

The Type-17 record from the ANSI / NIST ITL 1-2011 standard establishes the metadata required for iris feature. Fig. 2 shows a UML class diagram with the definition of the data types associated with that metadata. Fig. 3 shows a UML class diagram with the types of data needed to capture and process image, as well as the iris recognition system.

The UML class diagram in Fig. 2 shows the IrisImageRecord class with the necessary attributes for the transactional record's generation. This class consists of several other classes which represent different data types. Generally, it is about compound structures or repetitive structures which represent different kind of information about the captured images, devices used for the capture, places and date of capture. Also the diagram shows different enumerations and his literals, which are used by the main class and the other classes.

In the UML class diagram in Fig. 3 classes where images are captured and stored with their respective attributes is observed. The IMGJPG2000 and IMGPNG clasess inherit from the ProcessedImage class and are related with OpenJPG[3] and LIBPNG[4] packages.

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[3] http://www.openjpeg.org/.

[4] http://www.openjpeg.org/.

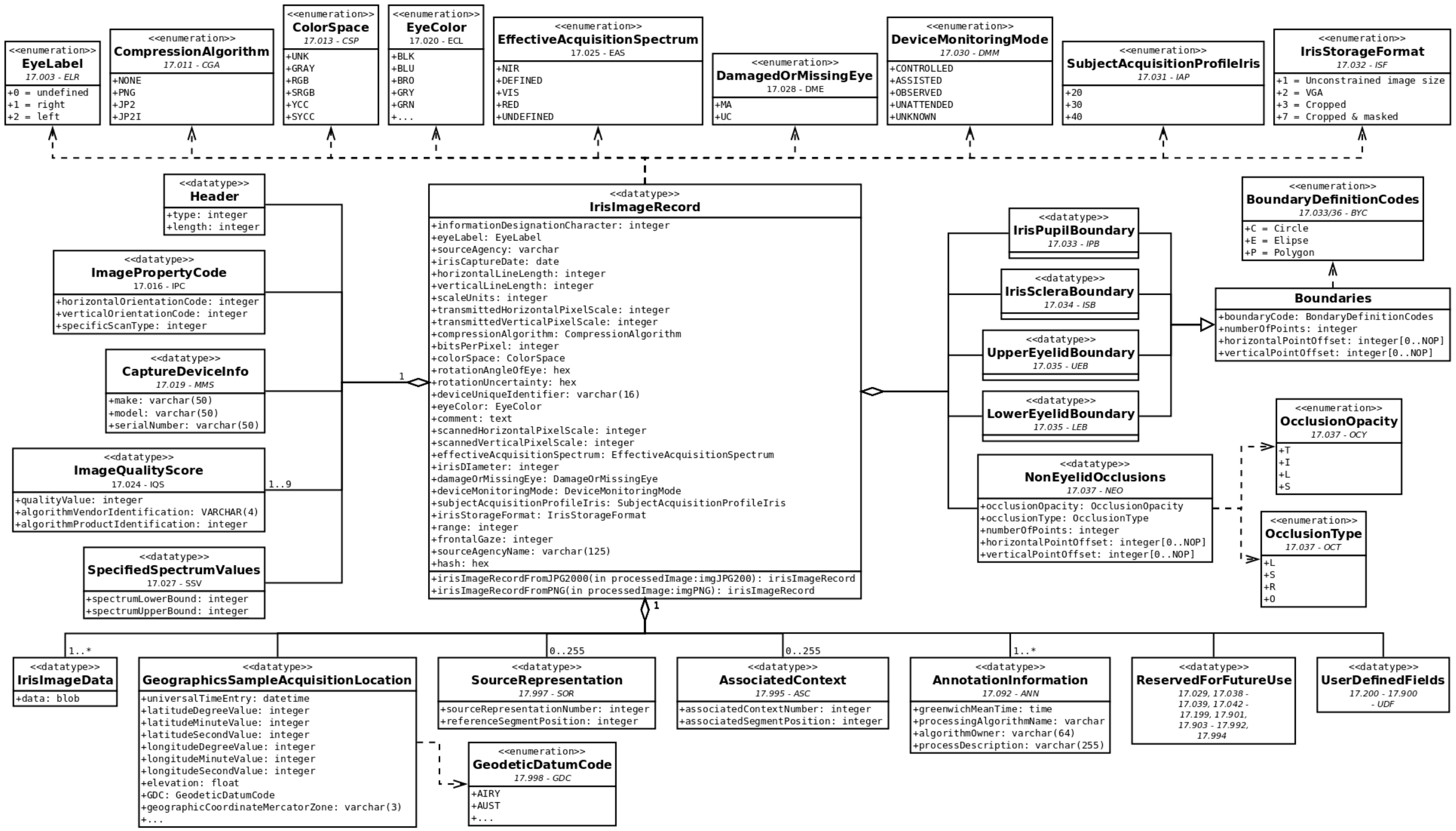

Fig. 2. Class diagram necessary for metadata required by Type-17 record from ANSI / NIST ITL 1-2011 standard.

OpenJPEG is an open-source JPEG 2000 codec written in C language. It has been developed in order to promote the use of JPEG 2000, a still-image compression standard from the Joint Photographic Experts Group (JPEG). The OpenJPEG code is released under the 2-clauses BSD license. Since May 2015, it is officially recognized by ISO/IEC and ITU-T as a JPEG 2000 Reference Software.

The PNG reference library (known as LIBPNG) is the official PNG reference library. LIBPNG is available as ANSI C (C89) source code. LIBPNG was written as a companion to the PNG specification, as a way of reducing the amount of time and effort it takes to support the PNG file format in application programs. The LIBPNG code is released under Open Source license.

The ProcessedImage class generates two subclasses by inheritance according to its implementation, which are associated with their respective libraries packages. This class, in turn, generates an IrisCode class with its respective methods of verification and identification.

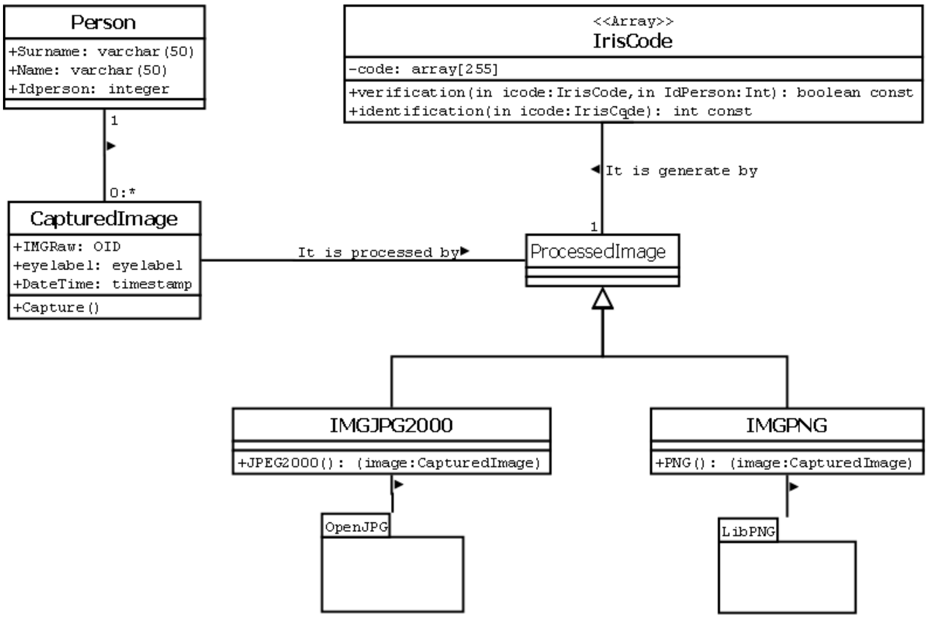

Fig. 3. Class diagram with data types required for capture and image processing and iris recognition system.

6 Conclusions and Future Work

This paper introduces a generic architecture for managing information in the iris biometric feature. This architecture uses object-relational technology. In addition, it suggests a model expressed in UML class diagram defining the domain data types to be used in the architecture. The suggested solution aims to obtain greater reliability, performance and interoperability, using standards-based systems. It also provides a model in compliance with standards to capture, process and store data, ensuring the exchange of information between different agencies and / or applications.

In later stages, work will be focused on the implementation of methods to manage specific types for raw biometric data, data types for encoding them, and all the necessary metadata to generate records of ANSI / NIST ITL 1-2011 transactions. In addition, alternatives for creating domain indexes to improve response times in recognition processes will be studied.

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