Extracting, Storing And Viewing The Data From Dicom Files

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This article presents a Java based software tool that implements a series of algorithms in order to extract alphanumeric information and image(s) from the DICOM standard files. The extracted data are stored in a database with a specific structure and can be visualized and subjected to some processing. The structure of the database also facilitates a flexible process of text-based query on any of the tags presented in the Data Dictionary. The created software tool incorporates a Dicom viewer, a database and a search engine. It was created to satisfy the present and future requirements of the Romanian specialists. It represents the first step in building a database for patients at the level of the hospital in the beginning, with the prospect of being extended to the county and even national level.
Introduction

**DICOM** - (From Digital Imaging and COmmunications in Medicine) is a standard developed by ACR (American College of Radiology) and NEMA (National Electrical Manufacturer's Association) for communications between medical imaging devices.

It is conform to the ISO reference model for network communications and incorporates object-oriented design concepts.

The standard specifies: a set of protocols for devices communicating over a network; the syntax and semantics of commands and associated information that can be exchanged using these protocols; a set of media storage services and devices claiming conformance to the standard; a file format and a medical directory structure to facilitate access to the images and related information stored on media that share information.

Such connectivity is important to cost-effectiveness in health care.
DICOM users can provide radiology services within facilities and across geographic regions, gain maximum benefit from existing resources, and keep costs down through compatibility of new equipment and systems. For example, workstations, CT scanners, MR imagers, film digitizers, shared archives, laser printers, host computers and mainframes made by multiple vendors and located at one site or many sites can "talk to one another" by means of DICOM across an "open-system" network. As a result, medical images can be captured and communicated more quickly, physicians can make diagnoses sooner, and treatment decisions can be made sooner.
The Dicom files contain both alphanumeric information (the name of the patient, date of birth, diagnosis, the name of the doctor) and one or more images compressed or in raw format. These files cannot be viewed on a computer. In order to do that, the Dicom files must be processed, the information must be extracted and eventually stored in a database. So, the information can be viewed anytime, subjected to some processing or queries. This processing mainly refer to operations that may lead to the improvement of the image quality and clarity, rotations that allow viewing from several angles, providing help for the medical personnel.
Creating a database by extracting the information and the images from the DICOM files, with the possibility to visualize all the data and to interrogate, brings high benefits to the electronic recording process of the patients.
In this way, it is possible to find all the records relevant to a patient, which means all the investigations that have been made along the years using a medical device, which has DICOM, standard.
Also, a database allows making statistical situations used on national or international level.
The Organization Of The Dicom Files

A DICOM file has the following structure:
• A preamble of 128 bytes
• Prefix (4 bytes) where are stored the letters ‘D’, ‘I’, ‘C’, ‘M’ which represent the signature of the DICOM file
• Data Set, which stores a set of information such as: patient name, type of image, size of the image, etc.
• Pixels that compose the image (s) included into the DICOM file.

Data Set is composed of a number of Data Elements. The Data Set represents a single SOP Instance related to a single SOP Class (and corresponding IOD).
A Data Set represents an instance of a real world information object and the Data Elements contain the encoded values of attributes of that object.
An IOD (Information Object Definition) is a model of abstract and object-oriented data, which allow specifying information about objects from the real world.
Figure 1. DICOM file structure
A Data Element is composed of several fields:

1. **Data Element Tag** – which identifies the information in a unique way. The Tag is also composed by Group Number (2 bytes) and Element Number (2 bytes).
   For example, in (0010,0020) tag the Group Number is 0010 and the Element Number is 0020.
   It is important the group with the number 0002 and the element with the number 0010 from this group which represent the Transfer Syntax Unique Identifier.
   The Transfer Syntax UID defines the byte order for raw data. The integer values can be stored using the big endian or the little endian ordering.
2. **Value Representation** describes the type of data and the size for the value contained in Data Element. It is an array of chars stored in 2 bytes. VR for a data Element tag is defined in Data Dictionary, and the array of chars is encrypted using the default array of chars defined in DICOM standard. Some of the available value representations are: PN (Person name), TM (Time), AS (Age String), DA (Date).

The VR may or may not be explicitly encoded in the data set. When it is used the Explicit VR function, Data Element is composed by four consecutive fields: Data Element Tag, VR, Value Length and Value. An example of a Data Element with an Explicit VR, such as would be the case for data type OB, OW, SQ, or UN is shown in figure 2.

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Element Number</th>
<th>Value Representation</th>
<th>Reserved</th>
<th>Value Length</th>
<th>Value Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 bytes</td>
<td>2 bytes</td>
<td>2 bytes</td>
<td>2 bytes</td>
<td>4 bytes</td>
<td>&quot;Value Length&quot; bytes</td>
</tr>
</tbody>
</table>

Fig. 2. Data Element with an Explicit VR
3. **Value Length**: Either a 16 or 32-bit (dependent on VR and whether VR is explicit or implicit) unsigned integer containing the Explicit Length of the Value Field as the number of bytes (even) that make up the Value. It does not include the length of the Data Element Tag, Value Representation, and Value Length Fields, or a 32-bit Length Field set to Undefined Length (FFFFFFFFH).

4. **Value Field**: An even number of bytes containing the Value(s) of the Data Element. The data type of Value(s) stored in this field is specified by the Data Element's VR.

5. **The Value Multiplicity** specifies how many values with this VR can be placed in the Value Field.
Extracting The Data From The Dicom File

Taking into account every tag from the DICOM dictionary can make extracting the data from the DICOM file. This will be searched in the file and in case of finding it the corresponding value will be extracted. The steps of extracting information from DICOM files are:

- Establishing the type of VR (ExplicitVR or ImplicitVR). This information is given by the UID (Unique Identifier), information stored in value field corresponding to the Transfer Syntax Tag.
- Establishing the Byte Ordering (BigEndian or LittleEndian). The information is also given by UID, stored in value field of the same Transfer Syntax Tag. The DICOM standard contains all the values that UID can have.
- Searching a tag in DICOM file according to the VR type and ByteOrdering
- Value extraction of the corresponding found tag.
Next it is described the problem of image extracting from the standard DICOM files, taking into account the method of compression that was used: RLE, JPEG.

The images from DICOM files can be classified using several criteria:
• The number of images stored in a file: single frame or multiframe.
• Number of bits per pixel: 8 bits, 12 bits, 16 bits or 24 bits.
• Compression: without compression (raw) or with compression (RLE or JPEG).
• Photometric interpretation: gray scale images, color images, palette color images.
The pseudo code for retrieving the frames is:

Set variable number to 0
Loop until all frames are retrieved
  Set file dimension as Rows*Columns* (SamplePerPixel)
  Read all file dimension pixels from file starting with (Header Length + number* file dimension)
    If MONOCHROME image
      Save as image
      Store image using GIF or JPEG image format
      Return
    End If
    If PALETTE COLOR image
      Get the Palette tables (one for red values, one for green values and one for blue values)
      Get Pixels color from the Palette.
      Save as image
      Store image using GIF or JPEG image format
    End If
    If RGB image (24 bits)
      Get red, green and blue values
      Compute the color using the formula:
        \(((255<<24) | ((0xff&r) << 16) | ((0xff&g)<< 8) | (0xff&b))\)
      Save as image
      Store image using GIF or JPEG image format
    End If
  End Loop
End Loop
Storing The Data From The Dicom Files

It is proposed a structure of the database different from the one existing in the DICOM standard. This structure has the advantage of permitting a flexible text-based query of the database using the table, which memorizes the entries from the data dictionary, specified by the DICOM standard. This table is also used to extract the information from the DICOM files. Entity-relationship model for the proposed database appears in figure 3.

Fig. 3 The Entity-Relationship Model of the database
Dicom Viewer

The DICOM Viewer in the software system has the following facilities:

1. A tree view of all the DICOM files from the database sorted by their modality (CT, MR, US, etc)
2. An image view panel
3. A tools panel, which contains several image processing functions: (invert, blur, brighten and sharper functions, pseudo colors, edge detection)
4. Slider used to see a particular frame from multi frame images
5. Cine Mode for viewing a multi frame file as a motion picture
6. A DICOM Tag Browser organized in categories for displaying all the tags from each category found in the DICOM file together with all their information and value.
Fig. 4. The DICOM Viewer
The main frame, presented in figure 4 contains the following:

1. A DataBase Panel that has a tree view of all the file path of the DICOM files from the MSSQL database. The files are sorted by their modality (CT, MR, US and so on). When clicking a file path, the frame (or the first frame in case of multi frames) of that file is shown in the ImageView Panel;

2. An ImageView Panel. When double-clicking the file path from the tree view, the first frame (in case of multi frames) or the frame from the Dicom file is shown in the ImageView Panel. The panel is also used to show the frame (or frames) of the file after image processing functions.
3. A Tools Panel, which contains several image processing functions. It is composed of:
3.1 An Image Processing panel which contains a Checkbox Group with image effects functions:
3.2 Some Rotate and Flip buttons used by physicians to determine the area of interest:
3.3 A Text Area and a Slider used for multi frame Dicom files. In the Text Area the number of the current frame is shown. The Slider dynamically changes with the Dicom file displayed. It can also be used to see a particular frame.
3.4 A Cine Mode option. By clicking this option a multi frame file can be viewed as a motion picture. It can be used by physicians when studying the human heart and not only.
3.5 OneFrame and AllFrames buttons used in case of multi frame Dicom files. By pressing AllFrames button all frames will be displayed. By pressing OneFrame, only the first frame of the file will be displayed
3.6 Show Tag Info button that will open a new frame where all Dicom file tags are displayed by category.
4. The Dicom Tag Browser frame contains a list where all the categories are displayed. By double clicking one of them, all tags from that category that were found in the Dicom file are displayed, together with all their information and value. It is possible that for a category no tag can be displayed, because no information was found in the file. The tags and all their information are taken from the database where they were stored after the file had been processed.

5. Adding a Dicom file to the database is done by selecting [File| Add a Dicom File]. The dicom file package will be used to decode the Dicom file, save the images as jpegs or gifs and store the tags and the paths of the images in the database. When decoding is done, the file is added in the Database tree. It can be selected and the frames will be displayed in the ImageView panel.

6. If Dicom Dictionary has to be seen, select [Help| See Dicom Dictionary]. A frame will be displayed with all the tags from the dictionary sorted by category.
Fig. 5. Application of the Pseudo Colors function
Fig. 6. Viewing all the frames from the DICOM file
The Flexible Text-Based Query Of The Database

A flexible query is a query that uses as parameter any of the data types from the DICOM file. The conditions given in the query can be connected with the logical operator “AND”. There is a list type control in the query window, which has as articles the names of the information types from the data dictionary. There is also a text type control, which will be filled with the string that will be searched in the database among the values corresponding to the selected type of information.

For example, if the selected tag is Patient name, and in the text control is typed the value “Popescu Ion”, the query will return all the records from the database which have this value in the same tag. Consequently there will be found the information and the images corresponding to the patient with the name “Popescu Ion” obtained during his consultations that were recorded into DICOM files along the time and recorded in the database afterwards.

The query process may continue in the same manner, the conditions from Where clause of corresponding SQL Select command, being merged through the logical operator “AND”.
Fig. 7. Text based query of the database
Conclusion

The article presents a software tool that allows computer viewing and manipulating of the standard DICOM files generated by the medical devices used in the diagnosis process.

• One of the functions is the extraction of the alphanumeric and imagistic information from the DICOM files and their storage in a Ms SQL Server database.
• The second function is the visualization in a better form of the extracted and stored information.

In order to improve the image quality and to support the diagnosis process, several functions can be applied. Also, the database can be subjected to the simple text-based query. The advantage of this Java based software tool is the fact that all the extracted information is stored in a database, which is advantageous in the process of recording the patient evolution.
Future Work

• The simple text-based query can be completed with the content-based visual query on color and texture characteristics.
• Once the images have been extracted from the Dicom files, stored in the computer and indexed in a database, they can be subjected to a process of extracting color, texture or shape characteristics. These can be further used in the content-based visual query.

Consequently, the software tool can acquire new interesting and modern uses in the diagnosis process, in research or medical studies.
The application is tested now by the Romanian medical personnel taking into consideration aspects like execution speed, retrieval quality and new necessary options.