

A Module for Visualisation and Analysis of Digital Images in DICOM File Format

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Abstract: *This paper deals with design and realisation of software module for visualisation and analysis of digital images stored in DICOM file format. DICOM standard is oriented to work with digital images resulted from medical equipment. It offers specific possibilities for more efficient use of medical images for diagnostic and therapeutic purposes. Except the visualisation the proposed module realises functions for displaying and analysis of non-image medical information stored in the file.*

Key words: *DICOM Standard, Medical Imaging, Digital Image Processing.*

INTRODUCTION

Improving the technologies in medicine introduces modern diagnostic medical equipment producing images such as X-rays, ultrasound, MRI etc.

Specifying diagnosis on the basis of such kind of information related to the health status of the patient is called Medical imaging. While Medical imaging has traditionally been the domain of the radiologist, other modalities, such as fluoroscopy, endoscopy, EEG signals (not formally an image), dental X-rays, pathology sections (visual light based images) also generate similar sets of data which can be handled using the similar tools as medical images.

There are many standards for storing digital images [1,2], but they do not cover sufficiently the medical science requirements. One solution of the stated problem is development of common standard that presents all the aspects of medical imaging and conventional medical practice.

The DICOM (Digital Imaging and Communications in Medicine) standard is developed to meet above stated needs. It comprises all aspects of medical imaging applications and can be used as a basis of telemedicine.

All kinds of nowadays medical imaging equipment store their data using DICOM standard. A specific software application is necessary to enable medical images management on the wide spread computers and information systems.

A MODULE FOR VISUALIZATION AND ANALYSIS OF DIGITAL IMAGES IN DICOM FILE FORMAT

1. DICOM standard

With the introduction of computed tomography (CT) followed by other digital diagnostic imaging modalities in the 1970's, and the increasing use of computers in clinical applications, the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) recognised the emerging need for a standard method for transferring images and associated information between devices manufactured by various vendors. These devices produce a variety of digital image formats. ACR and NEMA formed a joint committee in 1983 to develop a standard to:

- Promote communication of digital image information, regardless of device manufacturer;
- Facilitate the development and expansion of picture archiving and communication systems (PACS) that can also interface with other systems of hospital information;
- Allow the creation of diagnostic information data bases that can be interrogated by a wide variety of devices distributed geographically.

The DICOM standard is structured as a multi-part document using the guidelines established in the ISO/IEC Directives, 1989 part 3 - Drafting and Presentation of International Standards. DICOM Standard consists of the following parts [5]:

- 1: Introduction and Overview
- 2: Conformance

- 3: Information Object Definitions
- 4: Service Class Specifications
- 5: Data Structures and Encoding
- 6: Data Dictionary
- 7: Message Exchange
- 8: Network Communication Support for Message Exchange
- 9: Point-to-Point Communication Support for Message Exchange
- 10: Media Storage and File Formats for Media Interchange
- 11: Media Storage Application Profiles
- 12: Media Formats and Physical Media for Media Interchange
- 13: Print Management Point-to-Point Communication Support
- 14: Greyscale Display Function Standard
- 15: Security Profiles
- 16: Content Mapping Resource

On fig. 1 is presented the structure of the standard and relations between its parts.

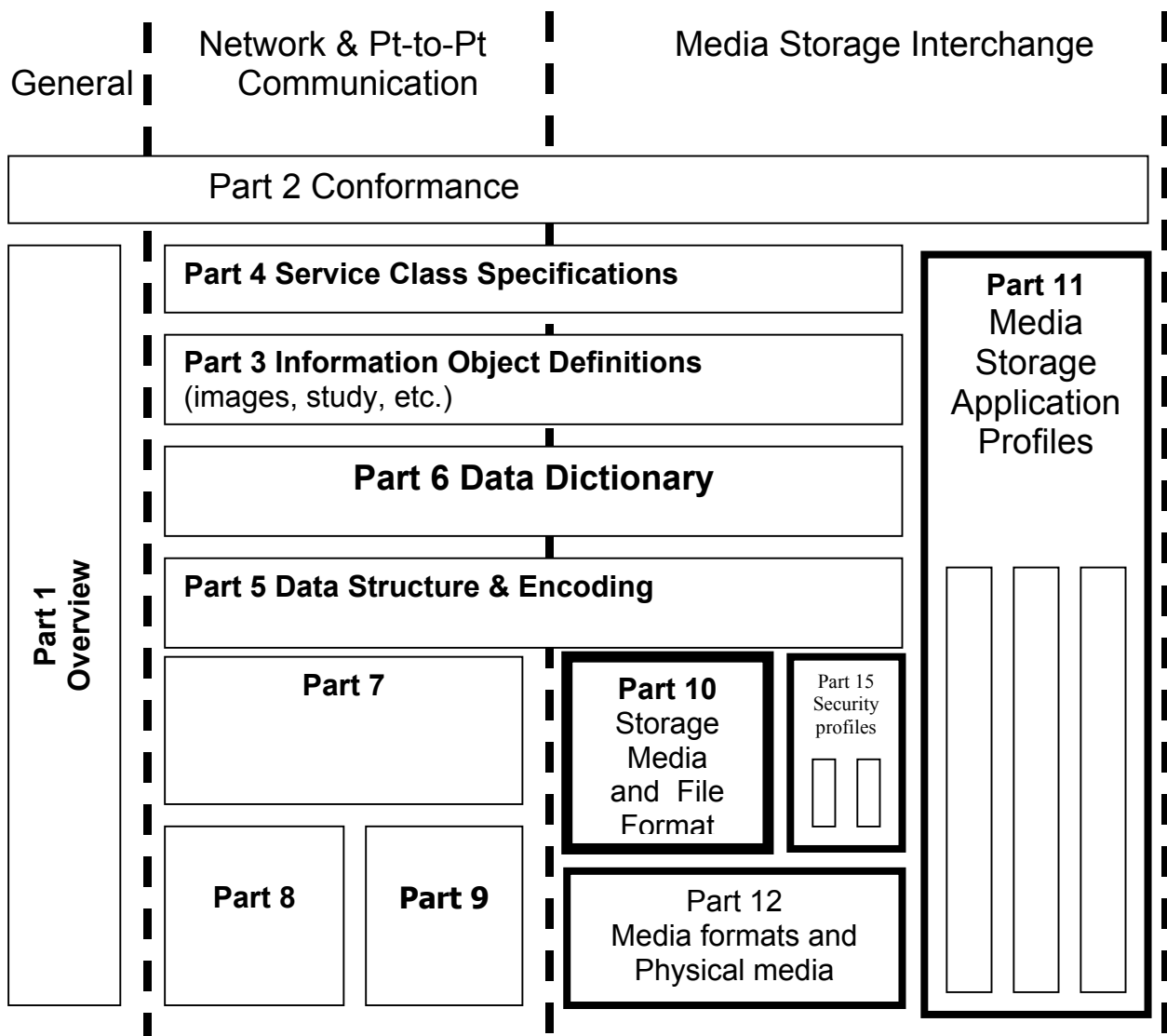


Fig. 1. Structure DICOM standard and relations between its parts.

In the developed module the functions for visualisation of greyscale images stored in DICOM format extracting the additional information from the image file are realised, as well as the possibility for searching images with given criteria.

2. Structure of DICOM file

The DICOM File Format provides a means to encapsulate in a file the Data Set representing a Service-Object Pair (SOP) Instance related to a DICOM Information Object Definition (IOD). The byte stream of the Data Set is placed into the file after the DICOM File Meta Information. Each file contains a single SOP Instance. The File Meta Information includes identified information on the encapsulated Data Set. This header consists of a 128 byte File Preamble, followed by a 4 byte DICOM prefix, followed by the File Meta Elements shown in Table 1. This header presents in each DICOM file. The four byte DICOM Prefix shall contain the character string "DICM" encoded as uppercase characters of the ISO 8859 G0 Character Repertoire. This four byte prefix is not structured as a DICOM Data Element with a Tag and a Length. The Preamble and Prefix are followed by a set of DICOM Meta Elements with Tags and Lengths as defined in Table 1. Some of meta-elements describe the properties of the image and others contain information about medical equipment, patient data, diagnosis etc. The standard defines all meta-elements and Table 1 shows as an example of the required and often used elements in the practice.

Table 1. Description of the required and often used meta-elements

Attribute Name	Tag	Attribute Description
File Preamble	No Tag or Length Fields	A fixed 128 byte field available for Application Profile or implementation specified use. If not used by an Application Profile or a specific implementation all bytes shall be set to 00H.
DICOM Prefix	No Tag or Length Fields	Four bytes containing the character string "DICM". This Prefix is intended to be used to recognise that this File is or not a DICOM File.
Group Length	(0002,0000)	Number of bytes following this File Meta Element (end of the Value field) up to and including the last File Meta Element of the Group 2 File Meta Information.
File Meta Information Version	(0002,0001)	This is a two byte field where each bit identifies a version of this File Meta Information header.
Image Date	(0008,23)	Image creation date
Modality	(0008,60)	Imaging modality (Computed Tomography, Ultrasound, Magnetic Resonance Imaging etc.)
Manufacturer	(0008,70)	Manufacturer of the medical equipment
Manufacturer's model name	(0008,1090)	Medical equipment's model name
Patient name	(0010,10)	Patient name
Patient ID	(0010,20)	Patient ID
Patient date of birth	(0010,30)	Patient birthdate
Patient sex	(0010,40)	Patient sex
Patient age	(0010,1010)	Patient age
Patient weight	(0010,1030)	Patient weight
Photometric interpretation	(0028,04)	Type of the image (black and white, greyscale, colour)
Number of Frames	(0028,08)	Number of frames if the image is multi-frame
Rows	(0028,10)	Height of the image in pixels
Columns	(0028,11)	Width of the image in pixels
Bits allocated	(0028,0100)	The number of bits of each Pixel Cell

Pixel data conveyed in the Pixel Data Element (7FE0,0010) may be sent either in a Native (uncompressed) Format or in an Encapsulated Format (e.g. compressed) defined outside the DICOM standard. Native format Pixel Cells are encoded as a direct concatenation of the bits of each Pixel Cell, where the most significant bit of a Pixel Cell is immediately followed by the least significant bit of the next Pixel Cell.

DICOM provides a mechanism for supporting the use of Run Length Encoding (RLE) Compression, which is a byte oriented lossless compression scheme through the encapsulated Format.

The standard also gives a mechanism for supporting the use of JPEG, JPEG-LS and JPEG 2000 Image Compression through the Encapsulated Format [2, 4]. As a result the images can be saved using a number of lossless (bit preserving) near-lossless and lossy compression schemes.

3. Basic functions realised in the software module

The presented module is a set of functions realised in Borland Delphi 5.0 visual environment. They perform the main operations with images saved according to DICOM standard rules. This module can be used for development of medical information systems and other applications operating with DICOM digital images. The main functions are as follow:

3.1) Determining the file format

This function receives as an input the name of the file and checks if this file is in DICOM format. The output of the function is a pointer to a data structure describing the main parameters of the image or *Nil* value if file format is different.

3.2) DICOM image visualisation;

This function uses the standard Delphi component *TImage*. The image information is extracted from the file and it is scaled to be fitted and displayed in the *TImage* canvas. If the image is multi-framed then the first frame is visualised and the user operates with a *track bar* to go through all frames. The module displays only 256 greyscale levels. Therefore if the pixel values of the original image are presented with more than 8 bits/pixel they are scaled to range 0-255. Fig. 2 shows visualisation of single-frame and multi-frame image using realised function.



a) single-frame



b) multi-frame

Fig. 2. Visualisation of DICOM image.

3.3) Grey level to color transformation (pseudo-color image processing).

This function produces color image from the greyscale one. If the scheme of colonisation is well defined the resulted color image can be more suitable for medical diagnosis by emphasising on areas with given density. The conversion from greyscale to color is realised by replacing of each grey level value with exact color, described in RGB model [1,2,3]. The module can use a number of schemes for pseudo-color image processing. They are saved in files as lookup tables with dimension $L \times 3$, where L is the number of gray levels. The values from the choosen file are loaded in LUT array. The R,G and B components of the color for each pixel are calculated according to:

$$R_{x,y} = \text{LUT}[L_{x,y}][1]; \quad G_{x,y} = \text{LUT}[L_{x,y}][2]; \quad B_{x,y} = \text{LUT}[L_{x,y}][3], \quad (1)$$

where $L_{x,y}$ is graylevel of the pixel with coordinates (x,y) and $R_{x,y}$, $G_{x,y}$, $B_{x,y}$ are corresponding components in RGB model for the same pixel after pseudo-color image processing. There is no limitation for the number of color schemes. The user can choose one and it will be used in all operations for visualisation of the image. On fig. 3 is demonstrated the result of the grey level to color transformation.

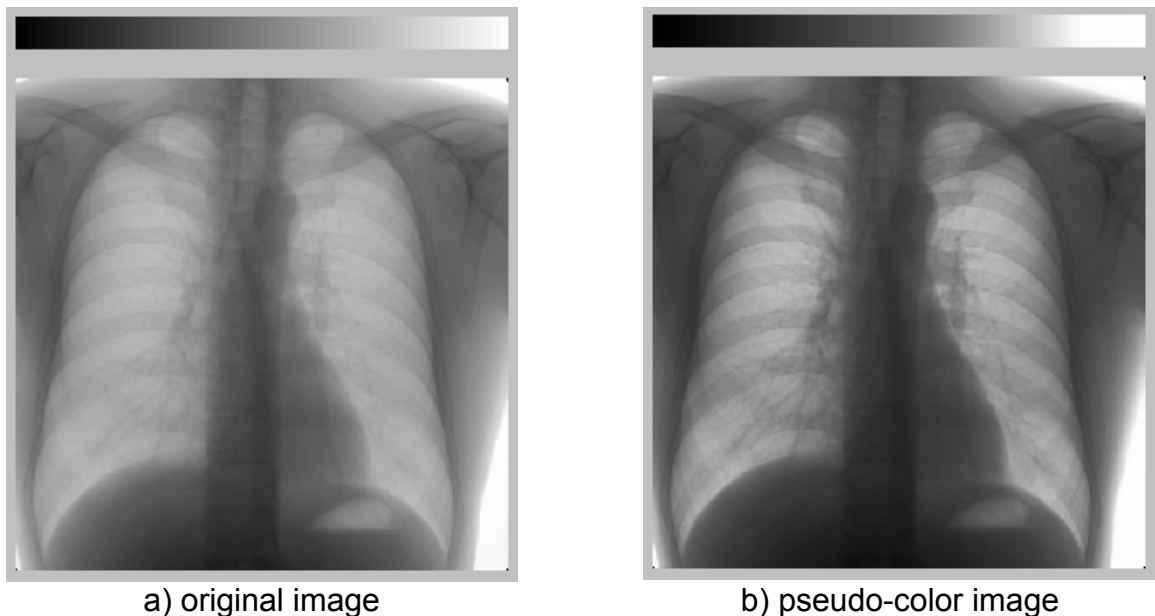


Fig. 3. Pseudo-color image processing

3.4) Extracting of the additional non-image information stored with the image.

This function returns a collection of ASCIIZ strings with data from all meta-elements stored in the file. The result has the following format:

```
0000: (0008,0000) identifying group: 4 176
000C: (0008,0008) image type: 46
          ORIGINAL.SECONDARY.OTHER.ARC.DICOM.VALIDATION
0042: (0008,0016) SOP Class UID: 26 1.2.840.10008.5.1.4.1.1.7.
0064: (0008,0018) SOP Instance UID: 26 1.3.46.670589.17.1.7.0.23.
0086: (0008,0060) modality: 2 OT
0090: (0008,0064) unknown: 4 WSD
009C: (0008,0070) manufacturer: 24 Philips Medical Systems
00BC: (0010,0000) patient group: 4 ....
00C8: (0010,0010) patient name: 10 Anonymized
00DA: (0020,0000) relationship group: 4 ....
00E6: (0020,000D) Study Instance UID: 28 1.3.46.670589.17.1.7.1.1.23.
010A: (0020,000E) Series Instance UID: 28 1.3.46.670589.17.1.7.2.1.23.
012E: (0020,0012) acquisition number: 2 1
0138: (0020,0013) image number: 2 1
0142: (0028,0000) image presentation group: 4 Z...
014E: (0028,0002) samples per pixel: 2 ..
0158: (0028,0004) Photometric Interpretation: 0
016C: (0028,0010) rows: 2 512
```

```
0176: (0028,0011) columns: 2 512
0180: (0028,0100) bits allocated: 2 8
018A: (0028,0101) bits stored: 2 8
0194: (0028,0102) high bit: 2 7
019E: (0028,0103) pixel representation: 2 ..
01A8: (7FE0,0000) pixel data: 4 ....
01B4: (7FE0,0010) pixel data: 262144
```

3.5) Checking if given meta-element has given value.

This function determines if particular DICOM file meets given criteria. It also checks for full or partial equivalence between searched and stored in the file values. In this way the user can extract all the images for one patient, to form list of image files corresponding to a specific disease etc.

CONCLUSIONS AND FUTURE WORK

The described above module realises the basic functions for visualisation and analysis of greyscale digital images in DICOM format received from a medical equipment. During the visualisation images can be colored using grey level to color transformation. The result image is more suitable for diagnostic purposes. Additional medical information about the patient, diagnosis, equipment etc. is also analysed.

This software module can be applied in the development of medical information systems the realisation of DICOM viewers and can take place in telemedicine projects.

In future the module will be expanded with color DICOM images support and functions for conversion from standard formats (BMP, TIFF, JPEG etc.) in DICOM.

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