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Application of DICOM Standard in LabVIEW Environment

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Abstract: DICOM is the world standard for picture archiving and communication in medicine. Development system LabVIEW based on graphical programming is primary designed for virtual instrumentation, it offers many tools and operators for image processing and analysis, but it does not directly support the work with DICOM standard. The article deals with possibility of importing native DICOM files to LabVIEW and work with them. *Copyright © 2008 IFSA.*

Keywords: DICOM, Virtual Instrumentation, Image processing

1. Introduction

Intersection of medicine with electronics, informatics and other technical branches underlies modernization of classical diagnostic methods or development of new methods. This progress is visible mainly in radiology. Using modern technologies, new diagnostic methods were developed: nuclear magnetic resonance tomography (NMRT), computed tomography (CT) or angiography. Conventional diagnostic methods (skiagraphy, skiascopy, selected methods of nuclear medicine) were digitized. Outputs of these methods are digital images and signals, which can be archived, processed and presented by methods of digital signal processing (DSP).

World trend of standardization and mutual compatibility in the sphere of digital technologies and communication influenced development of DICOM (Digital Imaging and Communication in Medicine) standard in medicine. This standard can be considered as communication protocol between various imaging modalities (CT, MRI or ultrasonography console) and simultaneously as standard for image archiving.

2. DICOM Standard

The standard (protocol) is arching over various types of imaging modalities originated in 1983. This protocol was developed in cooperation with the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) in the USA. This protocol enabled expansion of PACS (Picture Archiving and Communication System) cooperating with hospital information systems (HIS) [1].

The DICOM file consists of data elements (see Fig. 1). Each data element (e.g. Patient Name, Study Date, Imaging Modality or Image Resolution) has a unique tag containing a group number and element number. List of all data elements with their tags is in original DICOM documentation [2]. Excerpt of this list is in Fig. 2.

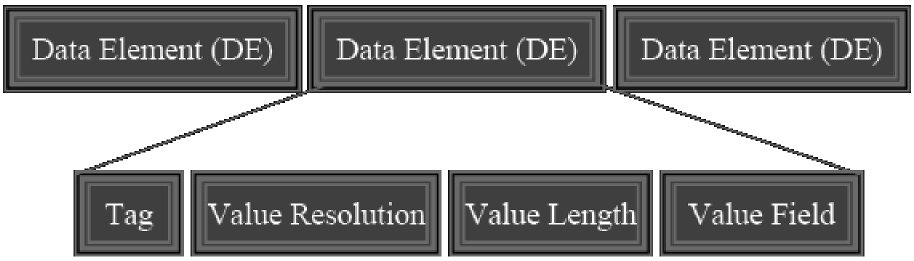

Fig. 1. DICOM Data Element Structure.

The tag is followed by Value Resolution (VR), which is a two-letter acronym of the tag, (PN in case of Patient Name element) and Value Length (VL), which informs about the data element size in bytes. Value Field (VF) is the information contained in the data element.

Tag	Name	VR	VM
(0010,0010)	Patient's Name	PN	1
(0010,0020)	Patient ID	LO	1
(0010,0021)	Issuer of Patient ID	LO	1
(0010,0030)	Patient's Birth Date	DA	1
(0010,0032)	Patient's Birth Time	TM	1
(0010,0040)	Patient's Sex	CS	1
(0010,0050)	Patient's Insurance Plan Code Sequence	SQ	1
(0010,0101)	Patient's Primary Language Code Sequence	SQ	1
(0010,0102)	Patient's Primary Language Code Modifier Sequence	SQ	1
(0010,1000)	Other Patient IDs	LO	1-n
(0010,1001)	Other Patient Names	PN	1-n
(0010,1005)	Patient's Birth Name	PN	1
(0010,1010)	Patient's Age	AS	1
(0010,1020)	Patient's Size	DS	1

Fig. 2. Excerpt from DICOM Data Dictionary.

DICOM files can be divided into metadata and image part. Contrary to standard image files, the size of the metadata part is different in each DICOM file and contains various data elements (except the necessary data element). Software working with DICOM files reads the file element by element and searches tags (data element value fields) needed for image reconstruction. The DICOM file can contain a single image or a set of images (Multislice) and DICOM can be native (contains raw image) or encapsulated (contains JPEG or RLE image).

3. DICOM Import Possibilities in LabVIEW

NI Vision is LabVIEW module for image processing and image analysis and contains many tools and operators, but does not support reading DICOM files. There are some ways how to import DICOM to LabVIEW:

- Using DLL library file of software working with DICOMs. LabVIEW can find and use functions from these files. Configuration and setting up of these functions is sometimes very difficult.
- Conversion of DICOM file to another standard (JPEG, BMP...) in extern application (e.g. freeware Osiris or ImageJ) and import converted image to LabVIEW.
- Using DICOM ActiveX plugins in LabVIEW. These plugins are not often for free use and their setting up is sometimes difficult. More about this method see [3].

Direct reconstruction of image matrix by searching necessary data elements. The article deals with this method.

4. Direct Reconstruction of DICOM Image Matrix in LabVIEW

In this method, we must find some necessary data elements needed for image reconstruction: resolution (rows and columns), bits allocated for 1 pixel, image depth, pixel data element (offset), image type (native, encapsulated). All these elements must be contained in the file. In addition, it is to our advantage that all data elements are sequenced ascending by their tag, which makes searching easier.

In the beginning, LabVIEW tool Open_Replace_Create File converts the DICOM file to hexadecimal string. After that, we can start searching for data element tags in this string and decompose it into substrings in this order:

0028,0010 – rows (lines) – **r**;
0028,0011 – columns – **c**;
0028,0100 – bits allocated for 1 pixel – $\mathbf{B_A}$;
0028,0101 – image depth;
0028,0102 – MSB (most significant bit) position in each pixel;
7FE0, 0010 – beginning of pixel data (offset).

In Fig. 3 we can see the part of block diagram (graphical LabVIEW source code) dealing with searching of tags in hex string. In the next step, we can build r * c pixel array. B_A value gives the type of constant of this array (e.g. U16, U8). Before the conversion of the array to the image using ArrayToImage tool, the nativity test is carried out:

$$(r.c).(B_A/8) = L, \tag{1}$$

where L is Pixel Data (7FE0, 0010) substring size in bytes. The equation is true in case of native DICOM and false in case of compressed image in DICOM (L is smaller than the left side of the equation). The application works good for native DICOMs; if the nativity test is false, the application returns the error message in text display on the front panel (graphical interface).

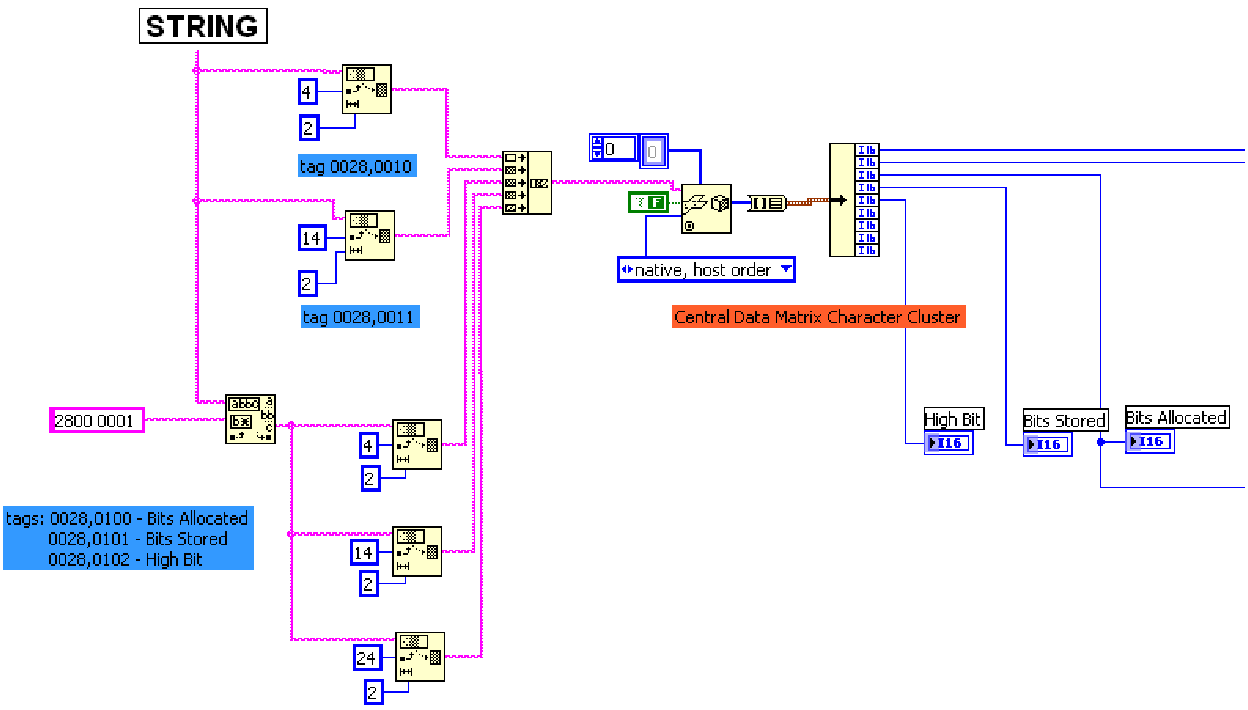

Fig. 3. The part of Block Diagram.

After array conversion to the image, many tools and image operators from NI Vision module can be applied. In clinical practice, LuT (Lookup Table) operators are often used for contrast enhancement and better details (e.g. in radiological images of some types of soft tissues).

The application converts imported native DICOM to another standard, such as BMP, JPEG, JPEG2000, PNG or TIFF. In each conversion type, user can set up the parameters like compression ratio or quality. In classical sequential JPEG, 16-bit grayscale image must be remapped and converted to 8-bit first, because JPEG algorithm (except JPEG2000) can work with 1 or 3 (RGB) 8-bit planes. In this type of conversion (16 to 8-bit) many grayscale levels are downsampled and some details are rejected. Fig. 4 shows the front panel of the final application.

5. Conclusions

The designed application is virtual instrument which converts native DICOM files to other standards and enables to work with them in LabVIEW environment and apply tools and operators from the module for image processing and analysis. In the future, the application could also read encapsulated images, even though native files are more frequent. This application can be the first segment in virtual instrumentation integration in medicine or imaging diagnostic methods.

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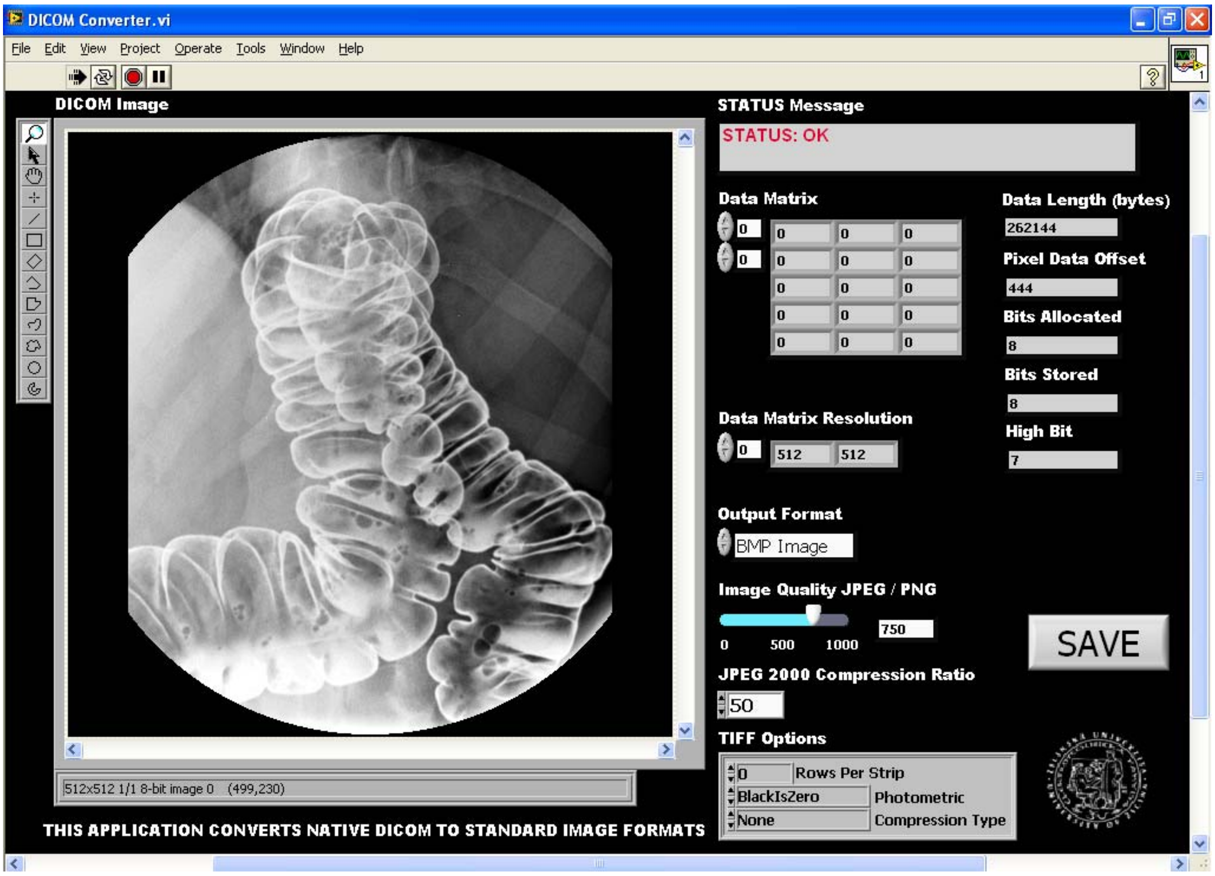

Fig. 4. Front Panel of application.

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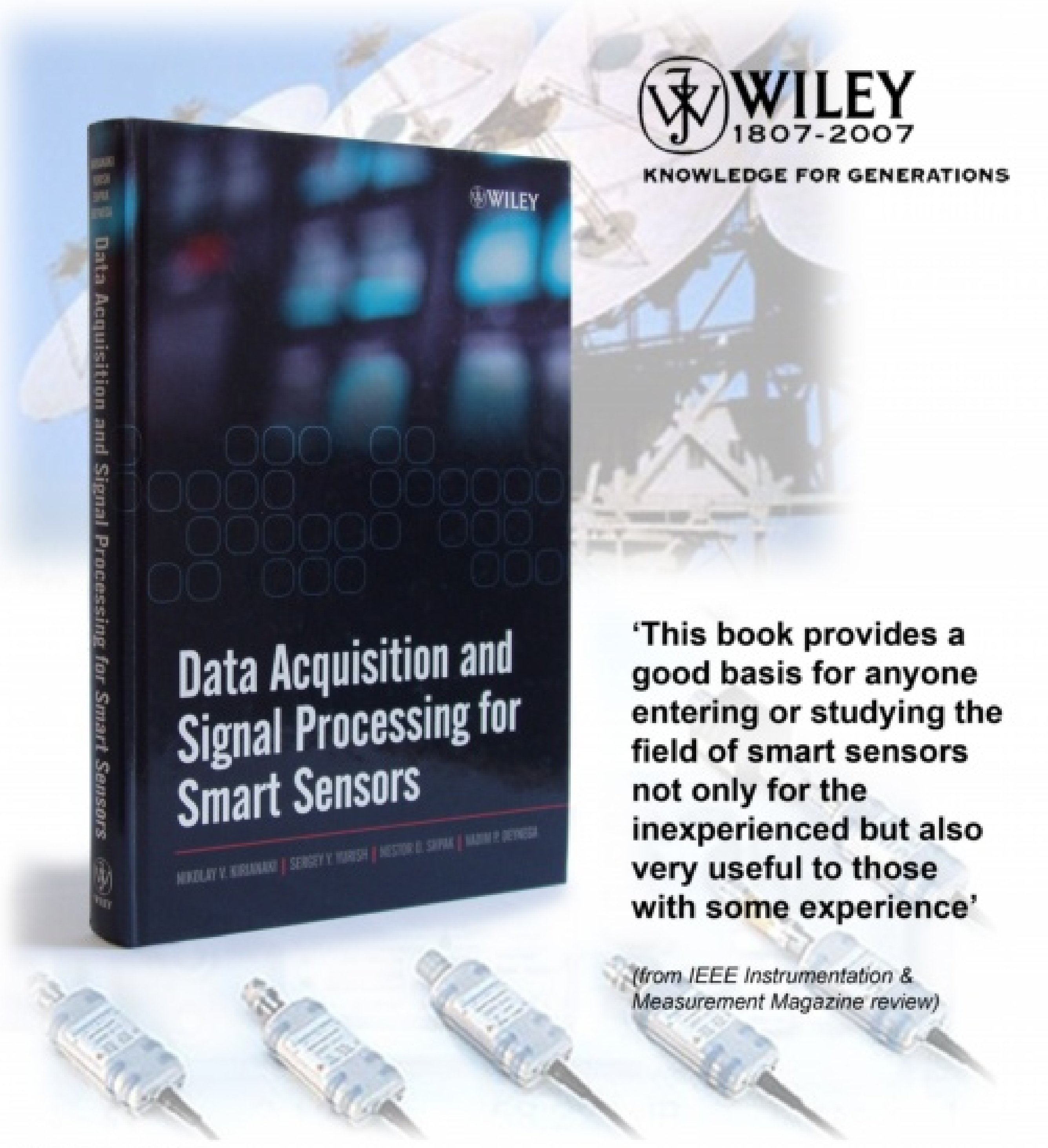

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