The DICOM standard for medical thermal imaging

by J. Ruminski*

**Department of Biomedical Engineering, Gdansk University of Technology, Gdansk, Poland*

Abstract

In imaging medicine the DICOM standard has become a widely accepted and implemented format for the exchange, storage and presentation of medical imaging data. Numerous imaging modalities are supported however there is not a dedicated solution for thermal infrared imaging. We designed and implemented a new proposal for DICOM Thermal Infrared Imaging (TII) using existing DICOM data structures and newly defined information objects.

1. Introduction

Medical applications of thermal infrared imaging are becoming more popular (e.g. [1],[2]). There are different thermal imaging based modalities proposed however their success in medical practice depends (besides diagnostic value) on acceptable by healthcare professionals standard tools/formats used by those modalities. In medical imaging world the DICOM (Digital Imaging and Communication in Medical) standard is the leading solution. The DICOM standard is widely accepted (e.g., it is also a European CEN standard: EN 12052). Every imaging modality is described by a data structure named Information Object Definition (e.g., CT Image IOD) and related services (e.g., CT Image Storage). In 2007 standard version there are 32 image IODs (e.g., CT IOD, MR IOD) and 33 non-image IODs, but there is no one dedicated to thermal infrared images. There were previous discussion on the DICOM application in thermal imaging. In 2004 we initiated a discussion about application of the DICOM in thermal infrared imaging during “round table” meeting which took place at IEEE EMBS 2004 Conference in San Francisco. Later, in [3] authors present results of preliminary studies on adopting the DICOM standard for medical infrared images however their proposals are deprecated in the current DICOM version.

2. Method

One of the important aspects in designing of the IOD for thermal infrared images and required software packages is diversity of thermal cameras. They differ in detector types, operational wavelengths, calibration parameters, etc. The discussion is required to establish a consensus about a common set of attributes in the TII IOD. After many analysis we decided to proposed two parallel solutions: first (temporary) using existing data structures in DICOM; second using own proposal of the new TII IOD (which we hope will be a base for normalization discussions). In a case of existing data structures we used the Multi-frame Grayscale Word Secondary Capture Image IOD to represent original, up-to 16 bits/pixel thermal imaging data. Required presentation formats (e.g., colors) can be defined using the DICOM Presentation Context parameters or “DERIVED” Secondary Captured IOD formats.
To fulfill those requirements we used the XML standard to configure destination DICOM attributes. Designing the destination DICOM modules the corresponding XML elements are constructed in the XML configuration file, e.g., PATIENT XML element for the DICOM Patient module, etc. Every element related to the DICOM module has a set of subelements. Those subelements define corresponding attributes. In the listing 1 a part of the XML configuration file is presented.

Listing 1. *A part of the extensible configuration file – all required parameters are defined using XML elements which can added either as a standard DICOM attributes or as a private attributes*

```
<?xml version="1.0" encoding="UTF-8"?>
<!--  CONFIG FILE FOR THE AGEMA THV900SW/TE CAMERA -->
<DICOM>
 <PATIENT>
        <!-- ID -->
        <G GID="0010" EID="0020" M="M">1</G>
         <!-- PN -->
        <G GID="0010" EID="0010" M="M">Ruminski^Jacek</G>
         <!-- Birth date -->
        <G GID="0010" EID="0030" M="M">19701209</G>
        (...)
 </PATIENT>
 <STUDY>
        <!-- UID -->
        <G GID="0020" EID="000D" M="M">1</G>
       <!-- Date -->
        <G GID="0008" EID="0020" M="M">20070223</G>
       <!-- Time -->
        <G GID="0008" EID="0030" M="M">124312.01</G>
```

```
<!-- Description -->
<G GID="0008" EID="1030" M="M">test</G>
</STUDY>(...)<EQUIPMENT>(...)</EQUIPMENT><PROCEDURE>(...)</PROCEDURE> </DICOM>
```

The configuration file contains subelements related to the equipment so for each camera the proper part of the configuration file can be defined. Private attributes should be used to define required camera parameters (e.g., calibration parameters) and procedure parameters. We identify and use more than 40 such attributes but for standardization efforts they should be discussed between interested parties. The private attributes should be additionally identified as the future attributes of new modules in the Thermal Infrared Imaging IOD.

The XML configuration file and the original RAW data file are used for generation of a new DICOM object.

3. Results

The designed solution was implemented using Java programming language. The product enables to convert any kind of source data (original raw data) to the DICOM Multi-frame Grayscale Word Secondary Capture Image IOD using XML configuration file.

Implemented software was tested using files created during experiments with two different thermal cameras (Agema THV 900SW and Flir SC 3000). For each camera 10 different files were chosen (characterized by different number of frames, different frame resolutions, etc.). All tests were performed on the Pentium Dual Core (T2400) computer with 1GB RAM. The two parameters were measured: the conversion time and the DICOM conformance. The conversion time was calculated using the computer system clock in repeatable experiments. The DICOM conformance was tested using different, available DICOM applications (e.g., popular Osiris program).

The results of performance test were proportional (with a value between 1 and 2) to a disk read-write operations. Different files were used from 300kB up to 61MB. Bigger files (sequences with more that 100 images) were processed relatively faster.

In the figure 1 the example of a graphical user interface is presented which is dynamically build using the XML configuration files. All attributes can be modified as required.

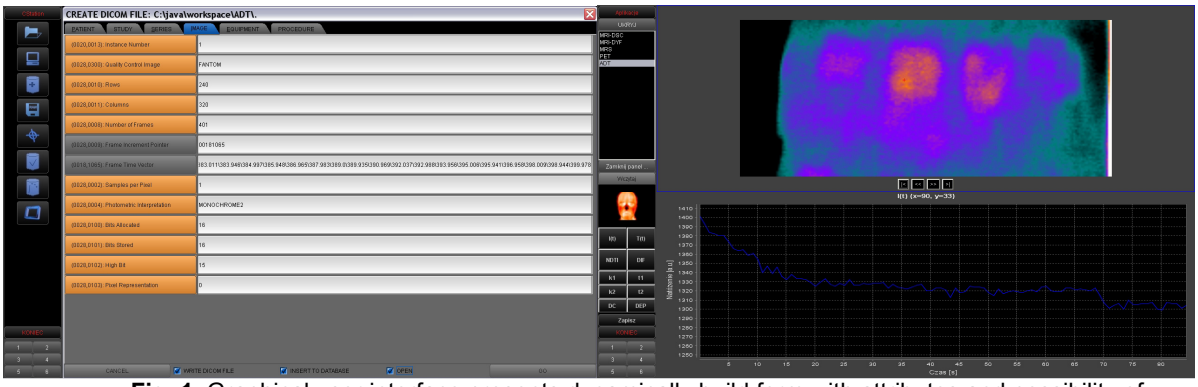

Fig. 1. Graphical user interface presents dynamically build form with attributes and possibility of quantitative analysis using original data stored in generated DICOM file

4. Discussion and conclusions

The created software can be used as a standalone tool or as a part of the computer-aided diagnosis system. The conversion procedure is fast and the final DICOM files are readable by popular DICOM computer programs (which was tested with different DICOM software). However general Secondary Capture formats are limited in the case of modality-related attributes. Private attributes will not be accessible for many DICOM applications. Concluding, we are proposing to create a new Thermal Infrared Image IOD. The whole structure of TII IOD covers 1 page so it is not possible to present it in this abstract. The TII IOD includes many new modules like: TI Image, TI Multi-frame Image, TI Multi-frame Vector, Thermal Camera Equipment, Thermal Camera Calibration and Contrast/Excitation module. Finally we suggest that a new DICOM working group for TTI IOD should be created and the final set of attributes should be specified. We hope the presented work will initiate this process.

REFERENCES

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