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CONTRIBUTION TO FASTER ARTIFACT CLASSIFICATION BY CREATING AN EXPERT DATABASE

Sven MARIČIĆ – Mladen PERINIĆ – Daniela KOVAČEVIĆ PAVIČIĆ

Abstract: *This paper proposes a method for faster classification of artifacts that appear during radiological recordings. Section images containing artifacts require significant additional post-processing time compared to other, artifact-free sections. The areas containing artifacts were identified and gradually analyzed in order to optimize the fabrication process. Guidelines for creation of an expert database are given. A suggestion is presented for defining a new expert knowledge database filling method.*

Keywords:

- medical diagnostic devices
- artifacts
- knowledge database
- imaging segmentation techniques
- CAD/CAM modeling

1. INTRODUCTION

The necessity is increasing for faster [1] resolution of problematic artifacts occurring during radiological imaging. Most of the time needed to implement some of the segmentation techniques is spent on removing the defects produced by diverse technological and physical causes. Examples of technological artifact causes in the imaging device include inappropriate parameter settings during imaging and noise caused by computer data processing, while causes of a physical nature generally include implants made of materials unsuitable for this type of treatment or other foreign elements in the organism. Some of the elimination processes suggested in the literature [2] require improvements in order to optimize the total data processing time. The basic hypothesis is that the usage of an XML database could successfully document a variety of artifacts that appear during radiological imaging and could thus serve as the basis for a future expert system.

2. HIGH RESOLUTION CT DATA ACQUISITION

In order to obtain a faithful representation of anatomical geometry, medical diagnostics devices for X-ray computed tomography (CT) or magnetic

resonance imaging devices (MRI) are usually used. CT devices were used over the course of this research. This procedure is referred to as the process of obtaining high-resolution images using sources of ionizing radiation. The images obtained using computed tomography screening represent faster recording of X-ray linear attenuation coefficients when the rays pass through tissue. The 3D model is generated by a computer algorithm from a series of recorded images. Modern computed tomography devices have the ability to record data in the standard DICOM format.

Varying densities can be differentiated with a 0.2% deviation. In comparison with the ordinary tomography, according to the literature [3], we cannot achieve better differentiation of density than 2%. It is the practice for all imaging sessions to use the least possible dose of radiation due to the workings of CT devices that use ionizing radiation, which can cause serious damage if the patient is exposed to large quantities. Effects of reduced radiation doses are described in the literature [4, 5, 6] but on the other hand, reducing the intensity of radiation causes a reduction in image quality of two-dimensional cross-sections as a proportionally smaller dose reaches the detector, compared to the primary beam, because some radiation is absorbed by tissues, and some changes direction (scatters).

2.1. Schematic overview of a multislice CT device

Figure 1 shows a schematic representation of the procedure for obtaining digital section images, and their subsequent treatment.

The schematic representation (Figure 1) shows that the source of radiation is an electron emitter.

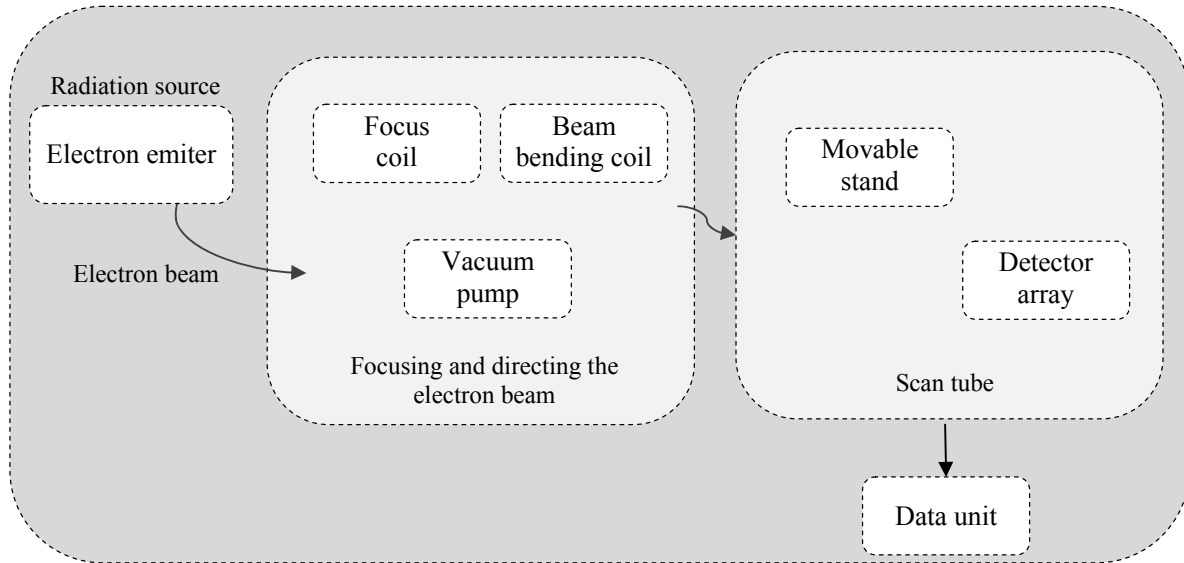


Figure 1: Schematic representation of a CT device

Electron beams pass through a tunnel where they are focused by specially coiled windings and directed by deflection coils towards the data acquisition unit. The data acquisition unit is connected with the computer system where the results are assembled and processed. The total time of this recording, including the reconstruction and 3D visualization,

lasts about ten minutes. This device consists of several sections: the control unit connected to the computer system, the mobile stand where preparations are mounted for scanning, and the ionizing radiation source. After the recording is finished, the data is processed as shown in Figure 2.

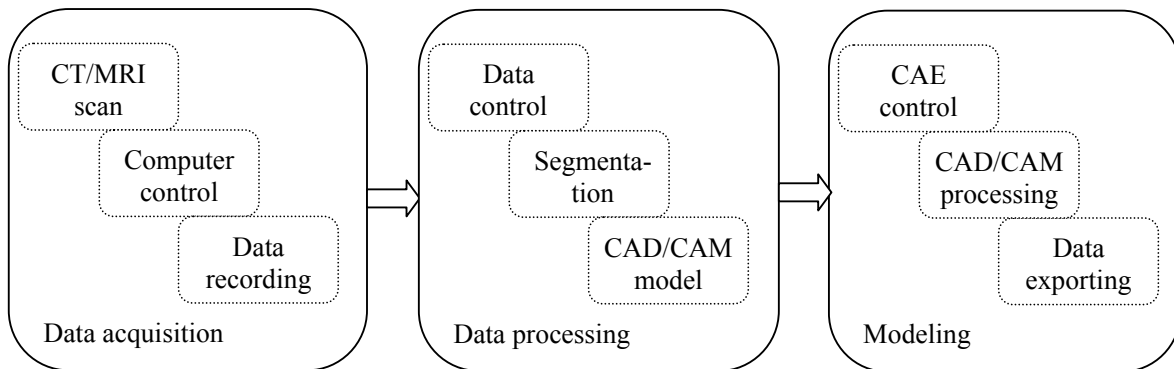


Figure 2: Schematic view of data acquisition, data processing and modeling

Two multi-slice CT multilayer devices were used over the course of this research: the Somatom Sensation 16 by Siemens and the Ultra Cone Beam

by Iluma. Some of the basic features of CT scanners [6, 7, 8] are given in Table 1:

Table 1: Technical characteristics of CT devices

	Device	Product name	Power [mA]	Voltage [kV]	Year of manufacture
1.	Multislice CT	Somatom Sensation 16 [Siemens]	103	120	2005
2.	Multislice CT	Ultra Cone Beam [Iluma]	1 – 3.8	120	2007

3. BUILDING AN EXPERT DATABASE

The work in this paper suggests creating an expert database in order to allow more efficient use of data. Creating an XML database allows [5, 6, 7] better knowledge dissemination in the radiological practice. The classification of artifacts allows them to be filtered later according to the cause of formation, solving techniques, etc. The proposed method directly reduces the time it takes for a radiological technologist to receive information on all cases previously processed and entered into the expert database. Each entry also contains the segmentation technique used and user feedback. This facilitates the decision procedure related to artifact classification.

3.1. Input and relevant data scanning

During regular clinical recording, the radiologic technologist can perform dozens of imaging sessions per day. For this reason it is important to extract all the typical ways of resolving artifacts. Based on the expert database, the operator, in this case a radiological technologist, is presented with

several different solutions based on which he can recommend a method for eliminating artifacts, choose the optimal segmentation method or appraise the approximate time required for data processing. An object-oriented Java programming language was selected during the development because of its availability in several platforms such as Windows, Linux, MacOS and Unix.

To ensure compatibility, the software solution implements support for the DICOM file format, the leading format in the digital processing of medical images. After loading the section image, basic information on the patient is imported. Along with the information contained in the .dcm file, the following is also entered into the database:

- the cause of the artifacts' manifestation
- range of sections containing artifacts,
- resolving techniques
- segmentation methods,
- CAD/CAM model evaluation,
- additional comments.

Some of the segmentation techniques and artifact causes involved in the process are presented in Table 2:

Table 2: Some of the causes of artifacts and appropriate segmentation techniques

The cause of the artifacts manifestation	Prostheses	Segmentation methods	Threshold segmentation
	Implants		Adaptive threshold
	Amalgam filling		Region based
	Moving of the patient		Neural networks

Table 2 shows some of the causes behind artifact formation during recording. If the cause of artifact manifestations is not defined, the field is left blank and the data is not included among the search results. The field will remain blank during the

reviewing of results. In some cases, the user can demand the listing of all the data containing artifacts whose cause of formation is not defined. After the recording is completed, data is entered through the interactive data input interface shown in Figure 3.

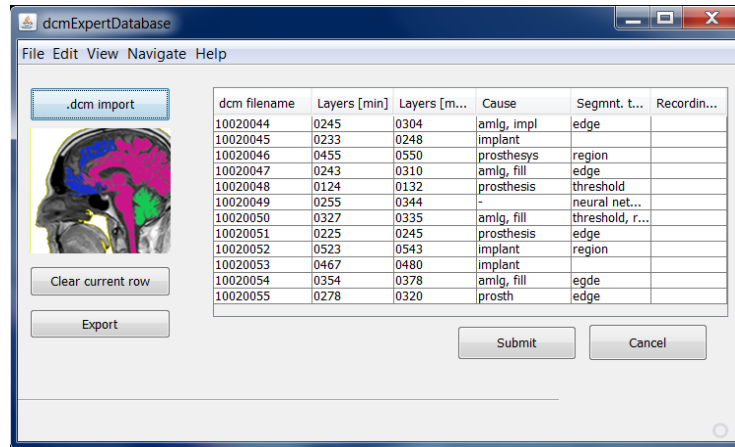


Figure 3: *dcmExpertDatabase* main view

The *.dcm* Expert Database window, as shown in Figure 3, contains the following functions: *.dcm import* – import of DICOM data, *clear current row* – deletes the current row, and *export* – intended for export of created data. The same window contains a table with the parameters: *.dcm filename* – the name given the digital data record, *layers min* – initial section layer, *layers max* – final section layer, *cause* – the estimated cause of artifact formation, *segmentation technique* – segmentation techniques used in solving, and *recording details* – containing a subset of detailed scanning parameters.

The database stores the following information on scanning parameters:

- layer thickness – expressed in mm,

- effective layer thickness – based on beam divergence,
- partial volume effect – which is minimal when the direction of the x-ray beam is perpendicular towards the anatomical structure, and significantly increases in objects parallel to the direction of the x-ray radiation,
- beam radiation collimation – chosen depending on the type of anatomical object tested,
- table feed – a stepwise displacement of the table, determined when working with conventional CT scanners, and unnecessary when working with a spiral CT.

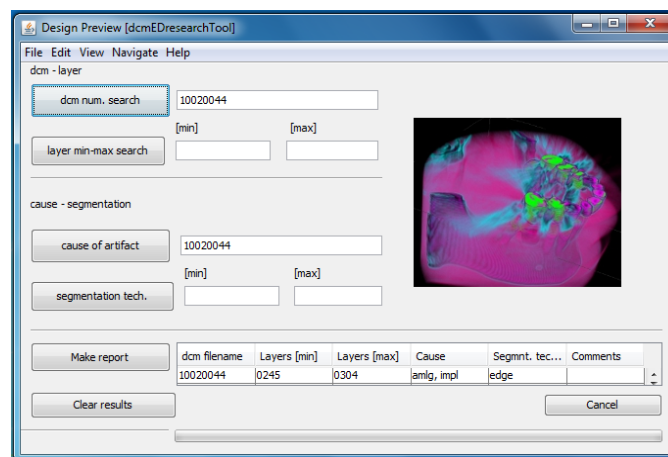
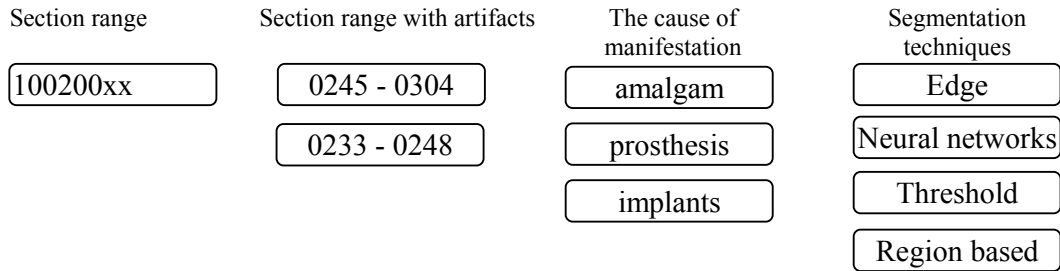


Figure 4: The search results window

Aside from the mentioned data, the database can store information about the generation of the CT device used. When using the newer-generation spiral CT scanners [12], the most important parameters are the *scan reconstruction interval* (RI), the *collimation of the x-ray beam* also named the *nominal thickness of the layer* (SC) and the *table feed* (TF). The search process is performed through an interactive interface

shown in Figure 4: Searches within the expert database are performed using an interactive form, as shown in Figure 4. An XML database was selected in order to enable a search through all information entered and to allow usage of all submitted technical data. A rough schematic organization of the database structure and information within is shown in Figure 5.



XML base

Figure 5: Expert database, schematic view

The advantages of using XML records [9, 10, 11, 13] are numerous considering its ability to generate complex documents which are portable between different computer systems. The XML file format is easily viewable and editable on a

wide range of computer systems. The semantics of active structures in the database conform fully to the XML specifications, as shown in the example of variable naming given in Table 3.

Table 3: Variables

	Variable name	Description
1.	<section range>	defines the total observed range
2.	<cross-sectional range of artifacts >	defines the overall section range where the artifact manifests
3.	< cause of artifacts manifestation >	information on the cause of artifacts manifestation
4.	<segmentation>	selected segmentation techniques
5.	< scan parameters >	selected scan parameters

4. CONCLUSION

Reducing the total time required for processing digital data received by means of medical diagnosis will reduce the time needed to manufacture the CAD / CAM model, which is the basic input for further analyses and budgets. A higher quality of artifact classification makes multi-parametric searches possible. The proposed method of classification allows

searching the database by .dcm file name, section range and type, and manner and cause of artifact formation. Beside the basic patient data from DICOM files, specific technological parameters of the imaging session are listed and can also be included in the research results. Further research will investigate the possibility of implementing neural networks which would enable the software to propose a method for the elimination of artifacts based on available

search results. This expert system could further reduce the time required to create CAD models from CT or MRI scans.

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Author's address

dr. sc. Sven Maričić, mag. ing. mech.
 izv. prof. dr. sc. Mladen Perinić, mag. ing. mech.
 Faculty of Engineering University of Rijeka
 Vukovarska 58, 51000 Rijeka, Croatia
 smaricic@riteh.hr
 doc. dr. sc. Daniela Kovačević Pavičić
 School of Medicine University of Rijeka,
 Br. Branchetta 20A, 51000 Rijeka, Croatia
 daniela.kovacevic@medri.hr