CLASSIFICATION AND ELIMINATION OF ERRORS DURING THE RADIOLOGICAL RECORDING

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Abstract: This paper presents the most common problems that occur when working with CT equipment for the purpose of medical diagnostics. The causes of most common disorders are classified by type and cause of formation. Disturbances that have occurred during the data acquisition can cause errors later in the reconstruction process. During the segmentation process, a result may sometime vary. During the data acquisition in the maxillofacial region, artifacts often occur due to bridges and amalgam fillings. To ensure high quality of digital recording it is necessary to ensure good conditions. However, if the occurrence of artifacts due to objective reasons cannot be prevented, then it is necessary to apply the procedures for their elimination. A brief overview of some artifacts caused by amalgam fillings is given in this paper.
Key words: Medical diagnostics, segmentation, computerized tomography, error classification

1. INTRODUCTION

Parallel with constant technology development, the production of implants and reconstruction in a relatively short time has been improved (Yushkevich et al., 2006). In order to make custom-made implants better, it is necessary to make a CAD/CAM model based on the aquired data. The data is collected on devices for medical diagnostics such as CT or MRI. In this paper the multislice CT KODAK Iluma ultra cone beam device has been used. Using this device it is possible to make high-quality digitalized sections in sagittal region. Disturbances that have occurred during the CT data acquisition can cause errors later in the reconstruction process. Therefore, the process of their elimination is very important especially in CAD/CAM phase.

2. PHASES OF THE IMPLANT CREATING

The process of making custom-made implants is divided into several phases (Figure 1). At the beginning, in the *first phase* it is necessary to make the digitalized data of the area where the implant is placed. This is accomplished by CT or MRI scans. The vast majority of artifacts (Gomi et al., 2009) migt be created in this phase. In presented case after CT scan, export to the DICOM data format follows. In recent years, DICOM 3.0 has been increasingly used format. The most new medical diagnostic devices can work with that format. Then, the *second phase* follows. In this phase the process of segmentation starts. At this stage it is necessary to choose one of the segmentation techniques in order to achieve the best possible result. Selection process for segmentation technique (Imai et al., 2009) directly depends on the person who is responsible for segmentation process. Sometimes it is necessary to combine several segmentation methods to achieve optimal result. In this paper we outline several segmentation techniques such as: threshold, edge based and region segmentation. Each of these techniques has its advantages, but it is important to emphasize that there is no universal technique that generally provides equally good results in all clinical cases. Since there is

no general solution to the image segmentation problem, these techniques often have to be combined with domain knowledge in order to effectively solve an image segmentation problem for a problem domain. After completing the process of segmentation, the data export to one of standard formats follows. In the present case, the data is exported in stereolithography format .stl. After obtaining a computer model, the CAD/CAM processing phase follows. Some of the CAE programs are: SolidWorks, SolidCAM, Blender, CATIA etc.
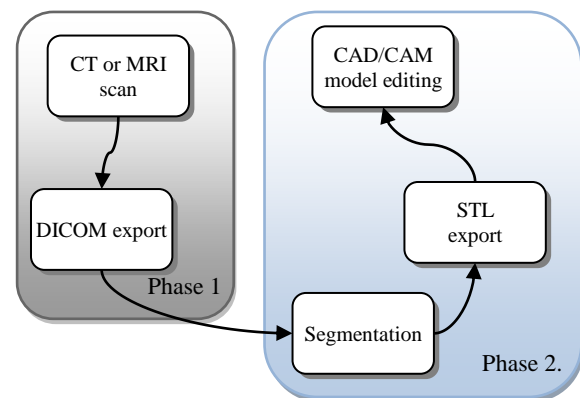

Fig. 1. The implant / reconstruction process

Resulting artifacts can be partially or completely corrected in all phases, but preferably in early stage to avoid furher complications related to them in second phase. Minor defects can be removed by selecting the proper values in the process of segmentation − in case of threshold segmentation, and if the section with artifact covers most of the picture, then sometime it has to be devided into several segments with different segmentation approach.

3. ARETIFACTS DURING CT SCAN

Causes of the artifacts are different and mainly manifest as an extremely bright image areas, as shown in Figure 2.
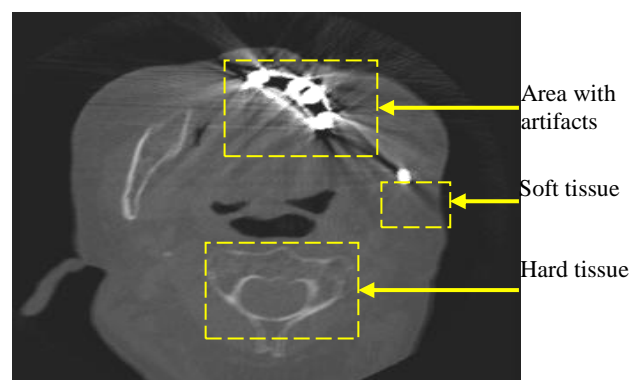

Fig. 2. CT sample with artifacts

Some of the possible causes of artifacts by using a computer tomography are shown in Figure 3.
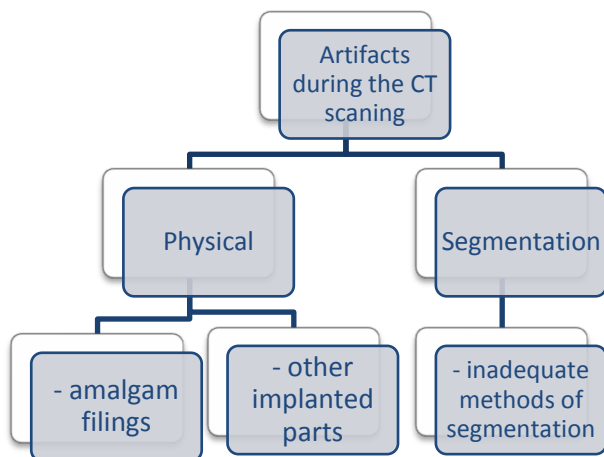

Fig. 3. Some of the causes of artifacts during CT scan

The following CT was used to scan sample data (Table 1)

	Voltage [kV]	Amperage [mA]	Duration [s]	Voxel size [mm]
CT Iluma	120	1 – 3,8	0,75	0,28

Tab. 1. Technical characteristics of the CT scanner Iluma

4. CLASSIFICATION AND ELIMINATION

In the presented case, classification was made according to the size of the area covered by the artifacts. This artifact was caused by amalgam fillings. The classification has been divided according to the several groups. After the CT scan, the DICOM data series have been created with 484 layers. They were grouped according to anatomical regions. Layers of group A (207-303) *mandible*, layers of group B (304-400) *maxilla*, layers of group C (401-497) *sinuses*, layers of group D (498-594) *frontal (forehead) bone*, layers of group E (595-691) *the upper part of the forehead and scalp*. Figure 4 shows the groups of layers A - E in the sagittal plane.
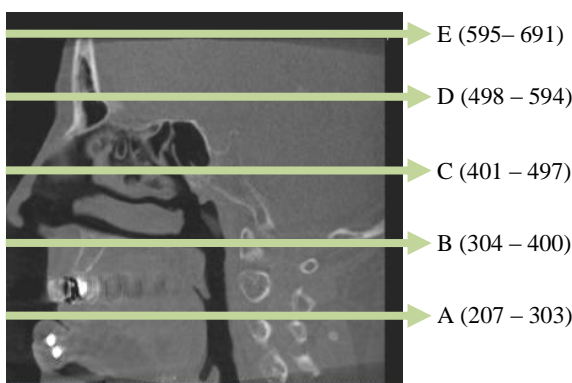

Fig. 4. Sagittal plane

As can be seen from the diagram in Figure 4, artifacts in presented case are manifested mainly in two regions: in the mandible region A because of the mandibular titanium implants, and in the maxilla region B because of the amalgam fillings. These artifacts are classified regarding to the section in which they are manifested, and by the approach of their elimination. There are several methods (Lewis et al., 2010) how to resolve this problem. In this paper we have presented method with three phases: *before the CT scan*, *during the process of segmentation* and *CAD/CAM phase*. Table 2 shows the

estimated data for the observed sections A - E, as previously described. Value 1 – difficult to eliminate, 3 – medium level elimination, 5 – easy level, 0 – no required actions to be taken.

Classification and elimination by layers	Before CT scan	During the segmentation	CAD/CAM phase
A 207– 303	1	3	5
B 304 – 400	1	3	5
C 401 – 497	5	5	0
D 498 – 594	5	5	0
E 595 – 691	5	5	0

Tab. 2. Classification by anatomical regions

According to the phases mentioned before, methods to eliminate artifacts are given as follows:

- Before the CT scan – it is necessary to remove all types of jewlery, prosthesis (if allowed) and check whether there is implants placed and from which material are made from. In case of presence of materials that have been known to cause artifacts, they can be solvable in other two phases,
- Segmentation phase – several different segmentation techniques can be applied to solve problems with the artifacts. In this case manual segmentation is a good option,
- CAD/CAM phase – control of created model, operator can manually edit the model

5. CONCLUSION

This paper gives an overview of some of the causes of artifacts during the CT scan and some of possible solutions in later phases of segmentation. Classifications of artifacts are made by sections divided according to anatomical regions - *mandible*, *maxilla*, *sinus*, *frontal (forehead) bones* and *the upper part of the forehead* and *scalp*. In this paper we have presented one of the possible methods with three phases: *before the CT scan*, *during the process of segmentation* and *CAD/CAM phase*.

Using previously described procedures, influence of artifacts are significantly reduced in most sections (A – C). Future investigations will study the ability of combining previously mentioned segmentation techniques along with the neural networks segmentation.

6. REFERENCES

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