Bachelor thesis

Determination of geometric and mass parameters of segments of the human body model based on CT scans

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1. Introduction

The objective of this thesis was a determination of geometric parameters (dimensions and volume), and subsequently, setting masses, centres of masses, and moments of inertia for individual segments that make up the model of a human body. The study was conducted on two patients – one adult female and one male child. The fundamental source of data were full-body CT scans (DICOM format) of four structures (Fig. 1).The next step of the analysis is the comparison of the CT results with values set using alternative methods (described in literature, GEBOD program).

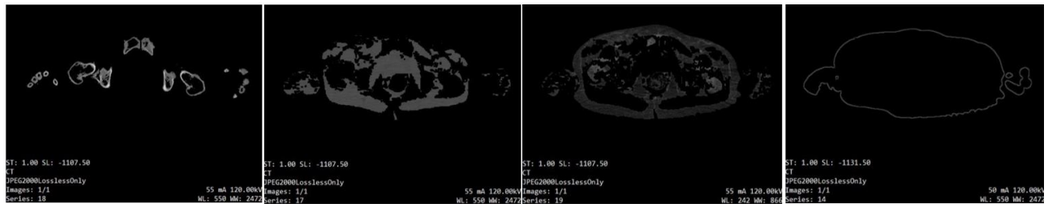


Figure 1: The fundamental source of data – bone tissue, muscles and organs, adipose tissue, and skin.

2. Data preparation

First step of the analysis was determination of correctness of the 3D model and elimination of invalid layers (Fig. 2). Then, the files were split into 17 segments (Fig. 3). Finally, each scan was analysed to separate parts of the images, which belong to different segments (Fig. 4). Thusly prepared scans were exported to a 3D array. Matlab script was used to extract geometric parameters.

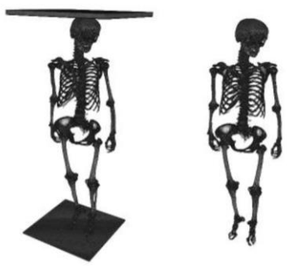


Figure 2: Matlab 3D model.

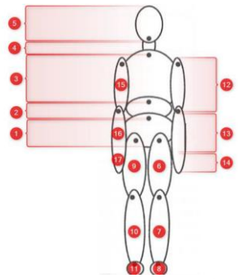


Figure 3: Segmentation of the model.

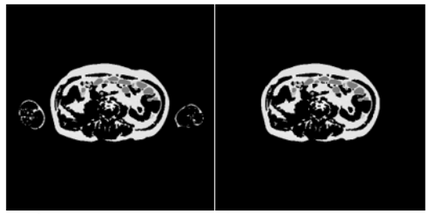


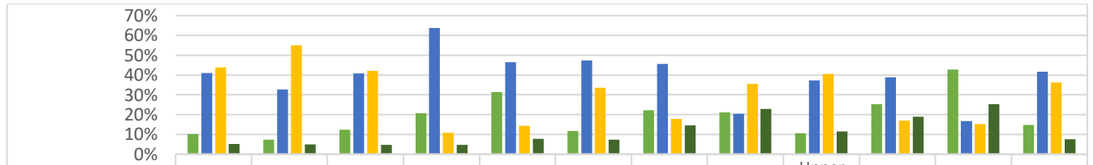
Figure 4: Segment element extraction.

Table *1*: Tissue density assumed in calculations.

Tissue	Density [g/dm³]
Bone	1.80
Muscles and organs	1.06
Fat	0.91
Skin	1.09

3. Results for the adult female

Total mass of the female determined from the CT scans was 42.7 kg, which diverges from the value in medical records (47 kg) by 9.14%. Total segmentation error of the model is 1.51%. Average body density is 1.06 kg/dm³. Results obtained through model segmentation are satisfactory – mass percentage of each of the tissues are similar to standard percentages of an adult woman. It is worth to analyse assumed values of the average density of muscles and organs in any given segment (especially in the thorax). Results obtained through comparative analysis of masses and centres of gravity with examples from literature contain slight errors due to different total masses.



	Pelvis	Abdomen	Thorax	Neck	Head	Thigh	Calf	Foot	Upper Arm	Forearm	Hand	Body
Kości	10%	7%	12%	21%	31%	12%	22%	21%	11%	25%	43%	15%
Mięśnie i organy	41%	33%	41%	64%	46%	47%	46%	21%	37%	39%	17%	42%
Tłuszcz	44%	55%	42%	11%	14%	34%	18%	35%	40%	17%	15%	36%
Skóra	5%	5%	5%	5%	8%	7%	15%	23%	12%	19%	25%	8%

Graph *1*: Mass fraction of particular tissues in segments of human body model.

Obtained values of the moments of inertia have errors of around 200%. Discrepancy between the results is caused by different masses of the segments and the whole body, simplification of usage of the Steiner's theorem and difference between natural shape of segments in CT scans and ellipsoidal shape of segment approximation in examples in literature.

4. Conclusions

In this work all geometric parameters for particular tissues in segments of human body model have been obtained. Total masses diverge by 9 and 10% for in two models. Densities of muscles and organs, as well as sources of errors of moments of inertia must be verified. In the step of data preparation separation of segments should be automatized. Additionally, obtained values could be verified through measurements on live body in standing position. The method of calculating geometric and mass parameters of body model based on CT scans can be concluded to be correct and resulting in acceptable values.