

Diana Wald

Dr. sc. hum.

Automatic Analysis of Adipose and Skeletal Muscle Tissue in Whole-Body Magnetic Resonance Images

Promotionsfach: DKFZ (Deutsches Krebsforschungszentrum)

Doktorvater: Prof. Hans-Peter Meinzer

Heart attack, stroke and cancer are the major causes of death in the western world. Scientific literature provides ample evidence that the incidence rate of these diseases is significantly influenced by lifestyle factors such as smoking, diet, physical activity and the body weight or body fat mass. The relationship between obesity and chronic diseases is the topic of a large epidemiological study carried out in Heidelberg and Potsdam. The aim of the study is to accurately measure the amount of adipose tissue, its distribution and the ratio of skeletal muscle to adipose tissue for the entire body. Since the availability of magnetic resonance imaging (MRI) technology for whole-body scans, measurements of the entire body have become possible. However, manual analysis of whole-body MRI data is a very tedious and time-consuming process, which is particularly unsuitable for large epidemiological settings. In this thesis, an automatic approach for the quantification of adipose and skeletal muscle tissue in whole-body MRI data sets was developed, implemented, and evaluated.

The first step is to generate artifact-free whole-body images of the acquired individual image sections. This procedure includes a novel method for correcting swap-phase artifacts in lower extremities. The second step consists of the segmentation of visceral, epicardial, subcutaneous and total adipose tissue as well as skeletal muscle tissue. For the first time, trained shape models are used for the classification of different adipose tissue types. Further, a new method is presented for the automatic removal of bone marrow for a more precise segmentation result. The final step integrates the developed algorithms into the Medical Imaging Interaction Toolkit. There it supports two different user profiles: a user-guided profile with a graphical user interface and a profile for the sequential automated image analysis of an arbitrary number of data sets.

The developed software approach was applied to 314 whole-body MRI images and results were visually inspected. For quantitative analysis segmentation obtained with the automatic method were compared with 52 ground truth segmentations, which had been created manually by an experienced operator. The result shows a significant agreement between ground truth and automatic segmentation. Further, tests for repeatability and reproducibility reveal that the data acquisition and data analysis provide highly reproducible results. This is particularly important for a software that will be used for analyzing more than 1,000 data sets.

The result of this thesis is a fully automated segmentation system of adipose and skeletal muscle tissue, which can be used to support large epidemiological studies that investigate the relationship between excess body fat and chronic diseases.