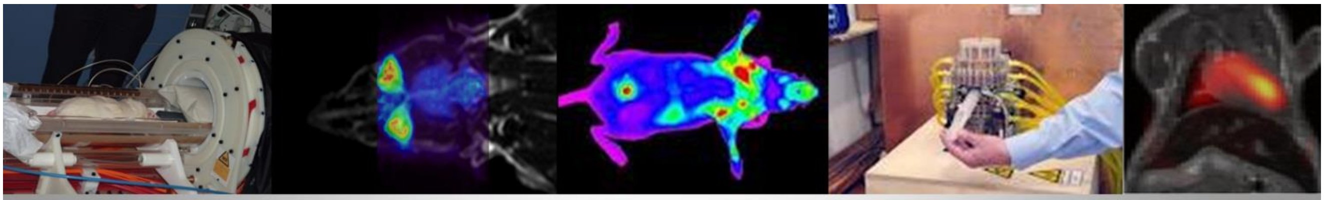


PMI Physics of Molecular Imaging Systems

HELMHOLTZ-INSTITUT FÜR BIOMEDIZINISCHE TECHNIK

RWTH

The department of **"Physics of Molecular Imaging Systems"** (**PMI**) is exploring future molecular imaging technologies. The research areas range from new detector concepts, simulations, hardware prototypes, high speed data processing, image reconstruction algorithms to applications. Our group consists of students and researchers from different disciplines: physics, engineering, computer science, and medicine. PMI (faculties of Physics and Medicine) is part of a large international network with a close link to industry, especially Philips Research.

Master's Thesis: MR Fingerprinting with Water-Fat Separation

MR Fingerprinting

Magnetic resonance fingerprinting is an emerging technique of quantitative MRI [1]. Here, quantitative refers to direct mapping of the relaxation times T1 and T2 of the tissues instead of looking at relative contrasts in an image. During MRF, many images are acquired very fast after each other. The MR signal evolution of the magnetization is precomputed for many different combinations of T1 and T2 and then matched to the measured signals in a postprocessing step. Thereby, parameter maps are obtained. MRF provides a considerable speed-up in comparison to other quantitative methods. As the image quality of a single image does not need to be as high, MRF allows for the use of spiral undersampling techniques that are speeding up the acquisition process.

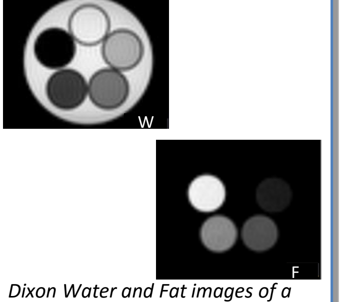
The MRF sequence described in [2] is a spoiled gradient echo sequence, which so far maps the proton density as well as the two tissue relaxation times. However, many tissues of the body, such as breast tissue, contain a high amount of fat. Often, the fat signal needs to be suppressed, as it causes artifacts in the images. E.g. in spiral imaging, the presence of fat leads to a blurring of the images. However, there lies also diagnostic value in knowing the water and fat content of tissue, e.g. to better distinguish tumors from surrounding tissue, to compute attenuation correction coefficients for PET-MR or for the diagnostics of abnormal fat contents in tissues such as liver. Many techniques exist in MRI to separate the water from the fat signal: The Dixon technique using a dual-echo acquisition [3], selective excitation of water and fat, water and fat suppression, the IDEAL technique [4]…

The HYPMED Project

We wish to use MRF for attenuation correction within the HYPMED project. During this project our institute is developing a fully digitized breast PET insert for simulteanous PET-MRI. For PET, accurate knowledge about the water-fat distribution in the body is required. The MRI anatomy provides complementary anatomical information.

Your Master's thesis: Simulateous Water-Fat MRF

The goal of your master thesis is to establish MRF with simultaneous mapping of T1, T2 as well as the water and fat content. In the beginning, you will familiarize yourself with the principles of MRI, fat suppression and quantification methods and the recent literature about MRF. As a start into MRF, you may optimize it for an application within the HYPMED project by tuning the MRF sequence for an optimal distinction of the tissue types that are present in female breast tissue. It is then your task to extend the current simulations to the presence of both aqueous and fatty tissues in a voxel. Optimally, you will understand how fat leads to a blurring in the spiral images and be able to answer if spiral MRF can effectively decompose water and fat, or if it is better to rely on Cartesian techniques. You will then select the most promising water-fat decomposition techniques from the initial literature study and apply them to MRF. After successful validation in a water-fat phantom the technique may be applied to a volunteer.



Dixon Water and Fat images of a phantom with varying W/F content.

We are looking for a highly motivated student with an interest in MRI physics and data treatment methods. Programming skills in QT/C++ are advantageous.

Literature:

[1] Ma et al., *Magnetic resonance fingerprinting*, Nature 495:187-193 (2013)
[2] Jiang et al., *MR Fingerprinting Using Fast Imaging with Steady State Precession (FISP) with Spiral Readout*, JMRM 74:1621–1631 (2015)
[3] Coombs et al., *Two-Point Dixon Technique for Water-Fat Signal Decomposition with B_0 Inhomogeneity Correction*, JMRM 38:084-889 (1997)
[4] Reeder et al., *Water–Fat Separation With IDEAL Gradient-Echo Imaging*, J. MRI 25:644–652 (2007)

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