FAT-WATER SEPARATION

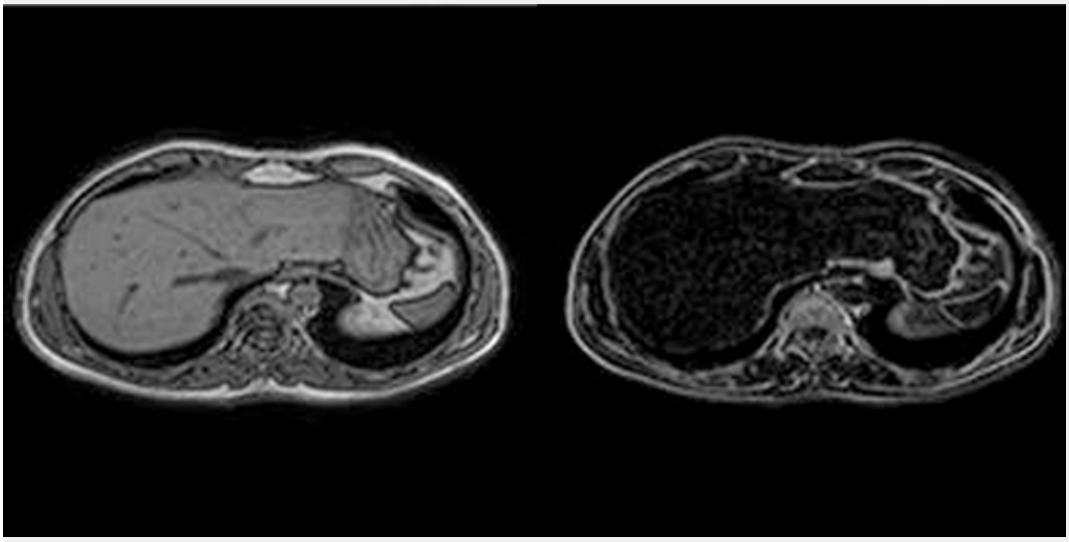

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Table of Contents

Introduction

Fat-water separation is a critical technique in medical imaging, particularly in MRI, to differentiate between water and fat content in tissues. This report focuses on implementing the Dixon method for fat-water separation using T1-Dual sequences from the CHAOS dataset.

In this study, we applied the technique to MRI images of the **liver**, a vital organ commonly affected by conditions such as fatty liver disease.

By separating the fat and water components, this method enhances diagnostic capabilities, enabling radiologists to assess tissue composition with greater accuracy.

The Dixon method utilizes in-phase and out-of-phase MRI images to compute separate fat and water images, providing a more detailed analysis of organ health.

Methodology

2.1. Dataset

The dataset used the **CHAOS** dataset (**train set**), specifically **T1-Dual sequences**. **Three image pairs** (in-phase and out-of-phase) were selected from three folders:

- **Case 1**: Image numbers 70 (in-phase) and 69 (out-of-phase).
- **Case 2**: Image numbers 52 (in-phase) and 51 (out-of-phase).
- **Case 10**: Image numbers 32 (in-phase) and 31 (out-of-phase).

These images were processed using the Dixon method to separate water and fat components.

2.2. Dixon Method

MRI fat-water separation is a technique that leverages the **chemical shift differences** between fat and water. By capturing images at specific echo times where fat and water signals are either in-phase or out-of-phase, it generates distinct "**fat-only**" and "**water-only**" images for clearer tissue visualization.

Image Acquisition:

- In-Phase (IP) Image: The signals from fat and water are aligned and added together.
- Out-of-Phase (OP) Image: The signals from fat and water are out of sync, partially canceling each other out.

$$IP = W + F$$

$$OP = W - F$$

Image Reconstruction:

- Water-Only Image:

$$\frac{1}{2}[IP + OP] = \frac{1}{2}[(W+F) + (W-F)] = \frac{1}{2}[2W] = W$$

- Fat-Only Image:

$$\frac{1}{2}[IP - OP] = \frac{1}{2}[(W+F) - (W-F)] = \frac{1}{2}[2F] = F$$

Implementation

3.1. Desktop Application

A desktop application was developed using **PyQt** to provide an intuitive interface for displaying and analyzing MRI images.

3.2. Image Preprocessing

- **DICOM File Loading**: The selected MRI images were loaded from three folders, focusing on specific image pairs (in-phase and out-of-phase).
- **Normalization**: Each image was normalized to a [0, 1] range to standardize pixel intensity values, ensuring consistent processing.

3.3. Fat-Water Separation Using Dixon Method

- **In-Phase and Out-of-Phase Combination**:
  - The water component was calculated as the **average** of the in-phase and out-of-phase images.
  - The fat component was derived by **subtracting** the out-of-phase image from the in-phase image, followed by normalization.
- **Thresholding**: A threshold was applied to remove low-intensity noise, keeping the background black and enhancing tissue contrast.

3.4. Visualization

The processed images were displayed for comparison:

- **Normalized In-Phase Image**: Showed the combined fat and water signals.
- **Normalized Out-of-Phase Image**: Highlighted areas where fat and water signals cancel out.
- **Water Image**: Displayed tissues with only water content.
- Fat Image: Visualized fat content within the liver tissues.

Results

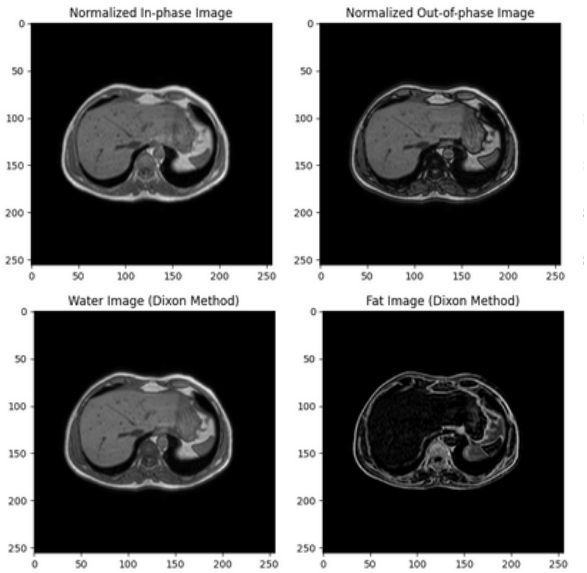

Fig.1 Liver MRI - Dixon Method (Case 1)

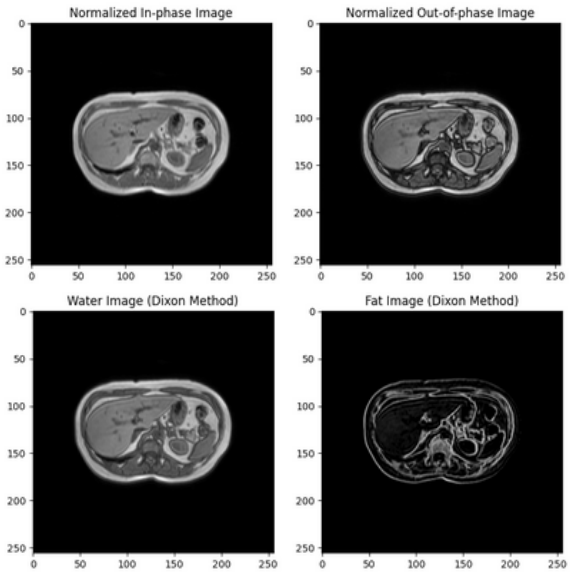

Fig.2 Liver MRI - Dixon Method (Case 2)

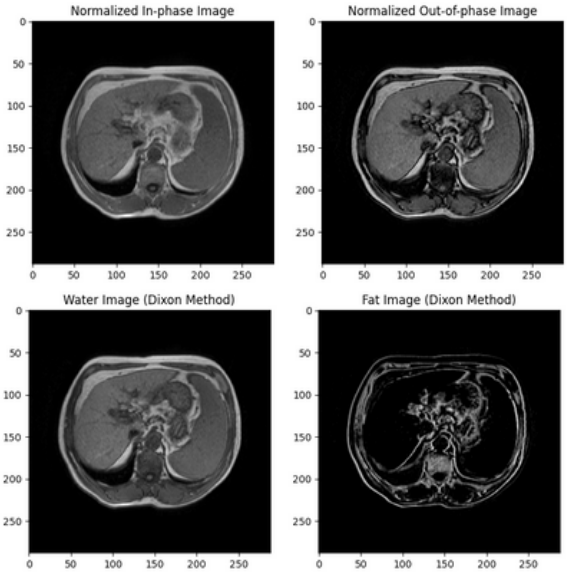

Fig.3 Liver MRI - Dixon Method (Case 3)

The results using the **Dixon method** show clear and distinct images for both fat and water components in the liver MRI.

Our results **closely align** with findings from the paper ***"Deep-Dixon: Deep-Learning Frameworks for Fusion of MR T1 Images for Fat and Water Extraction"***.

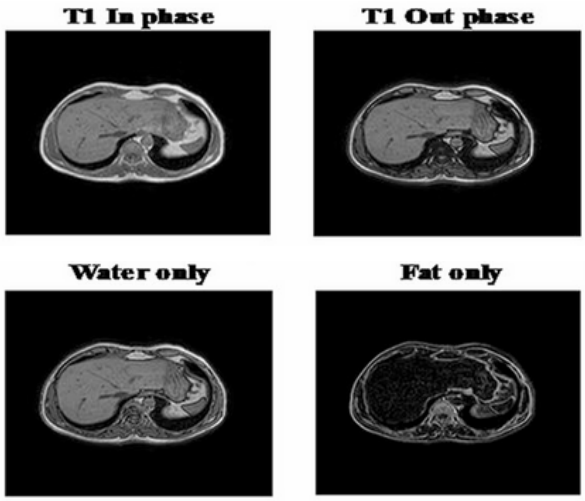

Fig.4 Implementation of the Dixon technique using VGG19 and ResNet18 models