Abdominal Adipose Tissue Segmentation

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Introduction

Abdominal fat percentage is considered to influence the changes in the age at which children enter puberty. For estimating the body fat percentage it is important to distinguish between the different types of abdominal adipose tissue: visceral fat (VAT), superficial subcutaneous fat (sSAT) and deep subcutaneous fat (dSAT).

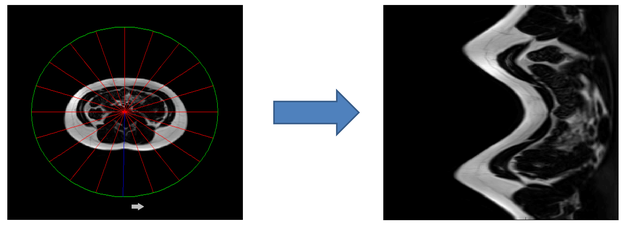
The purpose of this project is estimating the subcutaneous (SAT) and visceral adipose (VAT) tissue from volumetric DIXON type MR images.

Data

Abdominal scans (~56 scans) of 16 girls with ages between 11-12 years old
- Type : MRI DIXON reconstruction images
- Fat separated images
- Resolution : 240 x 320

DIXON imaging:
- Linear combination of images acquired at different echo times
- Separate images for water and fat tissue
- Advantages : Less bias field

Data Preprocessing:
- Transformation of input images to polar images



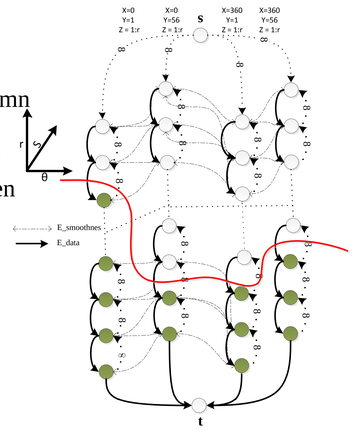
Transformation to polar coordinates

Methods

Subcutaneous fat segmentation

- 2 steps process using the Optimal Net Surface Segmentation method
  - ➢ Detecting the abdomen exterior boundary
  - ➢ Detecting the subcutaneous fat interior boundary
- Sought surface must be terrain like
- Each vertex in the sought surface belongs to exactly one column
- Input data:
  - ➢ Step 1: 3D dataset of polar images $I(\theta, r, slice\_number)$
  - ➢ Step 2: 3D dataset of polar images containing the abdomen
- $G_{st} = (V \cup \{s,t\}, E)$, where $E = E_{data} \cup E_{smoothness}$
- Solved using Min-Cut/Max-Flow algorithm

by Boykov and Kolmogorov on the 3D MRI volume

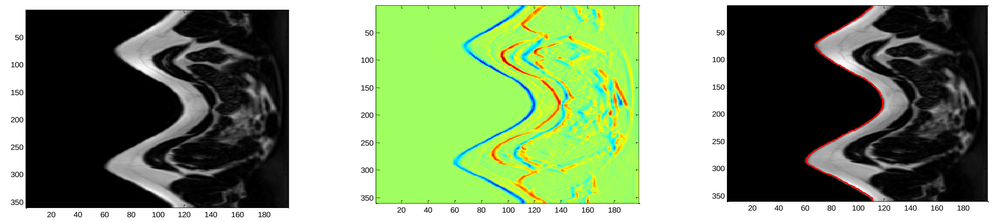


Graph setting

Results

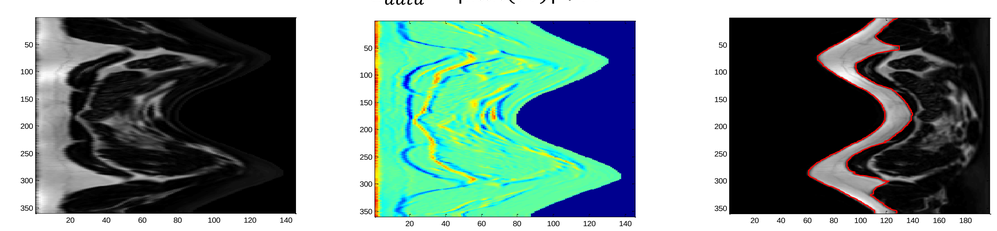
$$E_{data} = max(\nabla I) - \nabla I \,, \nabla I = \left(\frac{\partial I}{\partial \theta}, \frac{\partial I}{\partial r}\right)$$

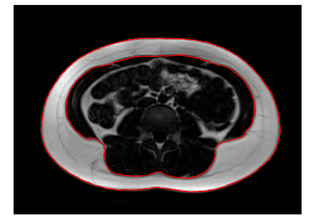
SAT Exterior Boundary Detection (1)



$$E_{data} = |min(\nabla I)| + \nabla I$$

SAT Interior Boundary Detection (2)



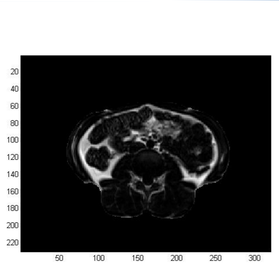


SAT delineation

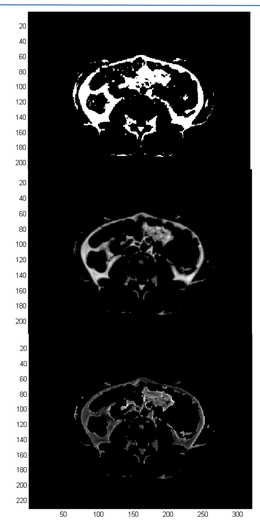
Visceral fat segmentation

- Input data: fat selective and water selective MRI datasets of the abdominal cavity (excluding the subcutaneous fat area)
- Steps:
  - ➢ Fitting a mixture of Gaussians using an EM (Expectation Maximization algorithm)
  - ➢ Clustering based on the Gaussian mixture distribution
  - ➢ Creating a mask based on the cluster having the maximum mean value (pixels classified as fat)
  - ➢ Computing the fat ratio image: $Fat\ Ratio\ Image = \frac{F}{F+W}$
  - ➢ Obtaining the visceral fat mask by thresholding the Fat Ratio Image.

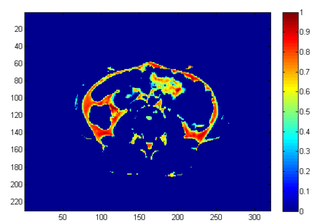
- **Why use both fat selective and water selective MR images?**
  - ➢ It has been observed that in some of the slices of the fat selective MRI's the bone structure response has as higher intensity than the fat tissue response, causing misclassification of bone as fat



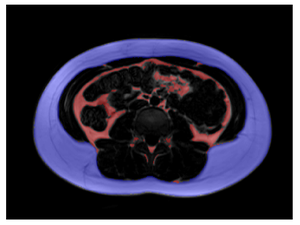
Input data



Clustering



Fat ratio image



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