



UNIVERSITI PUTRA MALAYSIA

***ADAPTIVE ABDOMINAL FAT AND LIVER SEGMENTATION OF CT
SCAN IMAGES FOR ABDOMINAL FAT-FATTY LIVER CORRELATION***

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**ADAPTIVE ABDOMINAL FAT AND LIVER SEGMENTATION OF CT
SCAN IMAGES FOR ABDOMINAL FAT-FATTY LIVER CORRELATION**

By

Ahmed M. Mharib

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia
in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

January 2012

Dedication

To my wife

Reyam

*Who has always helped me and believed that I can do it,
Who has always stood by me and dealt with my long absence
with love, faith and patience*

*It would not have happened without her support and encouragement.
I am forever indebted to her*

To My Parents, Brothers and Sister

*I will always be grateful for your endless love, unlimited
support and deep faith in me*

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in
Fulfilment of the requirements for the degree of Doctor of Philosophy

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January 2012

Chairman : Abd Rahman bin Ramli, PhD

Faculty : Engineering

Overweight and obesity have become a major health concern in the world. Experts believe that fat accumulation in human body (especially at the abdominal zone) has a direct correlation with nonalcoholic fatty liver diseases. Nevertheless, there are no studies that highlight the relationship between a realistic representation of the quantity of abdominal fat and the level of diffused fat in the liver.

This study aims to investigate the strength and the type of correlation between the indexes of abdominal fat and the level of diffused fat in human liver. Adaptive methods for abdominal fat segmentation and human liver segmentation using CT images are proposed. A modified Fuzzy C mean clustering method and Otsu thresholding technique are employed to segment the CT images of each subject into fat and non-fat tissues individually. Then, the segmented fat tissues in each CT slice are further separated into subcutaneous fat and visceral fat. Finally, the segmented fat tissues in the CT dataset for each subject are used to evaluate the quantities of abdominal fat by dividing the number of fat pixels over the number of total

abdominal pixels. The whole liver segmentation procedure is based on processing the CT slices one by one. Gray level, Gaussian gradient, region growing algorithm, distance transformation, canny edge detector and anatomic information are employed together to segment the liver in each CT slice. Then the diffused fat in the segmented liver is evaluated by calculating the mean of liver attenuation (measured in Hounsfield Units) for the segmented liver. The lower the mean value, the lower the tissue density and hence the greater the fat content.

Experimental results show that the performances of the abdominal fat segmentation method and the liver segmentation method are very promising. The abdominal fat segmentation method shows a great capability to handle a wide variety of abdominal wall shapes. The liver segmentation method also shows a good performance as well. Several challenges and difficulties due to the similarity of gray level intensities of the liver and the attached organs have been overcome in the proposed liver segmentation method.

Data sets of 125 subjects were employed to study the relationship between abdominal fat accumulation and diffused fat in the liver. Experimental results show that there is medium negative correlation between the visceral fat to abdomen size ratio and the mean of liver intensity values ($R = -0.3168$, $P < 0.0005$). The same correlation is found between the mean of liver intensity values and the total abdominal fat to abdomen size ratio ($R = -0.3382$, $P < 0.0005$). In conclusion, it could be said that the accumulation of abdominal fat is not the main reason for the increase in the level of diffused fat in the liver. However it does somehow contribute towards the process of increasing that level.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falasfah

**SEGMENTASI LEMAK PENYESUAI DAN HATI DALAM IMEJ
PENGIMBASAN CT UNTUK KORELASI HATI LEMAK -BERLEMAK**

Oleh

AHMED M. MHARIB

Januari 2012

Pengerusi : Abd Rahman bin Ramli, PhD

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Kelebihan berat badan dan obesiti telah menjadi satu kebimbangan kesihatan di seluruh dunia. Pakar kesihatan percaya bahawa pengumpulan lemak dalam badan manusia (terutamanya di bahagian abdomen) mempunyai korelasi terus kepada penyakit hati berlemak bukan alkoholik. Walau bagaimanapun, setakat ini, tidak terdapat kajian yang menekankan hubungkait antara gambaran realistik jumlah lemak abdomen dan tahap lemak yang tersebar dalam hati.

Kajian ini bertujuan menentukan tahap dan jenis korelasi antara indeks lemak abdomen dan jumlah lemak yang tersebar dalam hati manusia. Kaedah-kaedah adaptasi untuk mengsegmentasikan lemak abdomen dan hati menggunakan pengimbasan CT dicadangkan. Kaedah Fuzzy C mean terubahsuai dan teknik Thresholding Otsu telah digunakan untuk mengsegmentasikan imej-imej CT setiap subjek kepada tisu berlemak dan tisu tanpa lemak masing-masing. Seterusnya, tisu lemak dalam setiap kepingan CT diasingkan kepada lemak subkutaneus dan lemak visceral. Akhirnya, tisu lemak yang telah disegmentasikan dalam setiap kelompok data CT untuk setiap subjek digunakan untuk menilai jumlah lemak abdomen dengan

membahagikan bilangan piksel lemak dengan jumlah piksel sel sel abdomen. Keseluruhan kaedah segmentasi adalah berdasarkan pemprosesan Kepingan CT satu persatu. Paras kelabu, kecerunan Gaussian, algoritma rantau yang semakin meningkat, transformasi jarak, pengesanan kelebihan cerdas dan maklumat anatomi digunakan bersama-sama dalam mengsegmentasikan hati dalam setiap imbasan CT. Seterusnya, lemak yang tersebar dalam hati ditentukan dengan mengira purata ukuran kepingan hati (diukur menggunakan unit Hounsfield). Semakin rendah nilai purata, semakin rendah kemampuan tisu dan seterusnya semakin tinggi kandungan lemak.

Keputusan kajian menunjukkan bahawa prestasi kaedah segmentasi lemak abdomen dan kaedah segmentasi hati sangat memberangsangkan. Kaedah segmentasi lemak abdomen menunjukkan keupayaan yang tinggi untuk menangani pelbagai bentuk dinding abdomen. Segmentasi hati juga menunjukkan prestasi yang baik. Beberapa cabaran dan masalah yang timbul disebabkan persamaan dalam tahap keamatan kelabu dalam hati dan organ yang bersampingan telah berjaya diselesaikan dalam kaedah segmentasi hati yang dicadangkan ini.

Set data sebanyak 125 subjek telah digunakan dalam kajian ini untuk menentukan hubungkait antara pengumpulan lemak dalam abdomen dan lemak yang tersebar dalam hati. Keputusan kajian menunjukkan bahawa terdapat korelasi negatif sederhana antara nisbah lemak hati visceral dan saiz abdomen dengan purata nilai intensiti hati ($R = -0.3168$, $P < 0.0005$). Korelasi yang sama didapati antara purata nilai intensiti hati dengan nisbah jumlah lemak abdomen dan saiz abdomen ($R = -0.3382$, $P < 0.0005$). Kesimpulannya, boleh dikatakan bahawa pengumpulan lemak abdomen bukanlah sebab utama peningkatan tahap lemak yang tersebar dalam hati.

Walau bagaimanapun, ia sedikit sebanyak menyumbang terhadap peningkatan tahap lemak tersebut.



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I certify that an Examination Committee has met on 30 January 2012 to conduct the final examination of Ahmed M. Mharib on his Doctor of Philosophy thesis entitled " Adaptive Abdomen Fat and Liver Segmentation of CT Scan Image for Obesity/Fatty Liver Correlation" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

AHMED M. MHARIB

Date: 30 January 2012

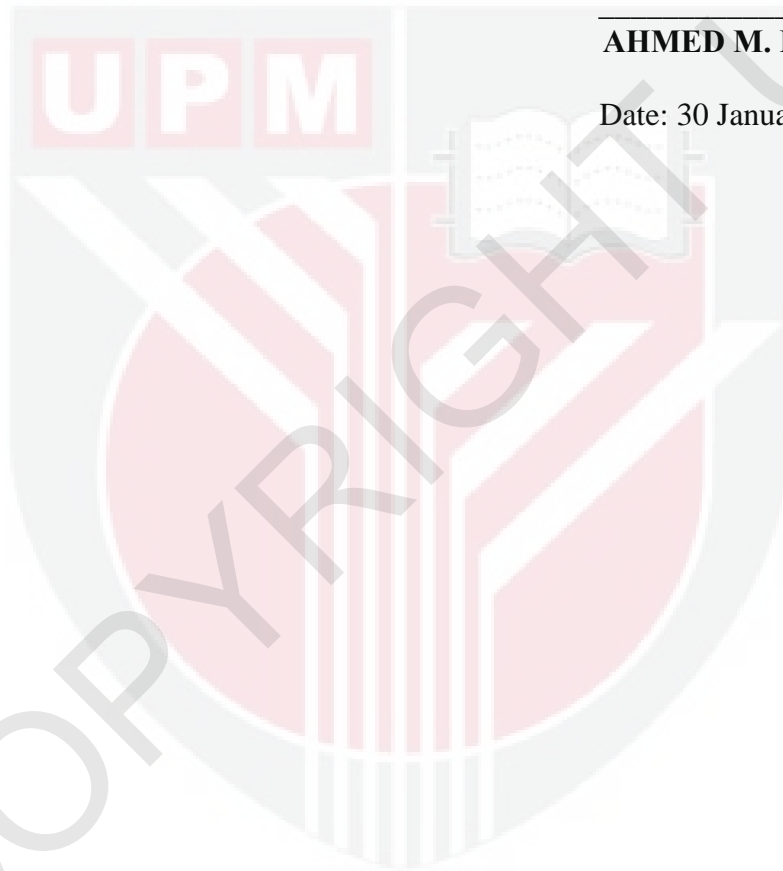


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