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Probabilistic-based Algorithm for Liver Images Segmentation

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By

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Abstract

Medical images processing is the technique or process of creating visual representations of the interior of a body for clinical analysis. Medical images processing is increasingly being used within healthcare for diagnosis, planning treatment, guiding treatment and monitoring disease progression.

Medical imaging seeks to show internal structures hidden by the skin and bones, as well as to diagnose and treat disease. Medical imaging also establishes a database of normal anatomy and physiology to make it possible to identify abnormalities. Although imaging of removed organs and tissues can be performed for medical reasons, such procedures are usually considered part of pathology instead of medical imaging.

Medical images processing could be dividing into some stages as pre-processing, segmentation, analysis and diagnosis. In pre-processing stage, kind of filtering or registration technique is done. In segmentation stage, exactly segment objects when it detected (vessels, liver, lung, spine, brain, kidney ...etc.). In analysis stage, make some measurements on segmented objects such as (volume, vessel stenosis, perimeter). In diagnosis stage, classify the output (cancer, not cancer, lesion, not lesion).

Image Segmentation is the process of dividing an image into regions with similar features such as gray level, color, texture, brightness, intensity, and contrast. The role of medical image segmentation is to: study anatomical structure, identify Region of Interest (ROI), i.e. locate tumor, lesion and other abnormalities, measure tissue volume to measure growth of tumor (also decrease in size of tumor with treatment), and also, help in treatment planning prior to radiation therapy; in radiation dose calculation.

Medical Image segmentation is one of the most interesting and challenging problems in computer vision and medical image applications. Medical decisions are rarely taken without the use of imaging technology such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI), or Ultrasound Imaging (US). Liver segmentation from abdominal computed tomography (CT) images is the essential step in many clinical applications.

Liver segmentation from abdominal Computed Tomography (CT) volumes is an important step in many diagnostic and surgical procedures. It is also useful in building many related computers aided diagnosis, computer guided surgery systems, building anatomical atlases for the abdominal area, and many other applications. Automatic liver segmentation is difficult because of the wide range of human variations in the shapes of the liver. In addition, nearby organs and tissues have similar intensity distributions to the liver, making the livers boundaries ambiguous.

This thesis presents a study on different techniques used for liver segmentation from abdominal CTs. An automatic liver segmentation algorithm is introduced in this work that includes three main phases; pre-processing, segmentation and post-processing phase. In pre-processing stage, double thresholding is applied. Watershed segmentation method is used for segmentation phase. In post-processing phase, a region merging method based on distance and variance criteria is applied.

In addition, the thesis proposes a hybrid algorithm for liver segmentation from abdominal CT images that divides into five main phases; preprocessing, segmentation, segmentation post-processing, clustering and clustering post-processing. First, the original image is converted to grayscale image, then the image is binarized. In segmentation phase, the watershed segmentation method is applied. Then, in segmentation post-processing phase, two steps are applied based on median grayscale value replacement from original image. EM algorithm is used for clustering phase. Finally, morphological operations include median filter and hole filling are utilized.

For experimental results, MICCAI SLIVER07 dataset is used to determine the accuracy and performance of the proposed algorithms. The overall accuracy average reaches 91% for the first proposed algorithm. While, the overall accuracy and sensitivity average reach 99.42% and 95.5% respectively for the second proposed algorithm. Also, for performance measurements, our second proposed algorithm achieved 7.03%, 1.77%, 0.44 mm, 1.5 mm and 12.57 mm for VOE, RVD, ASD, RMSD and MSD respectively.

List of Publications

1. A. S. E. Mohamed, M. A. M. Salem, D. Hegazy, and H. A. Shedeed. Probablistic based framework for medical ct images segmentation. In *2015 IEEE Seventh International Conference on Intelligent Computing and Information Systems (ICICIS)*, pages 149−155, Dec 2015.

2. Mohammed A-M Salem, Alaa Atef, Alaa Salah, and Marwa Shams. Recent survey on medical image segmentation. In *Handbook of Research on Machine Learning Innovations and Trends*, pages 424−464. IGI Global, 2017.

3. Alaa Salah El-Din Mohamed, Mohammed A-M Salem, Doaa Hegazy, and Howida A. Shedeed. Improved watershed algorithm for ct liver segmentation using intraclass variance minimization. In *International Conference on Information and Software Technologies*, pages 164−176. Springer, 2017.

4. Alaa Salah El-Din Mohamed, Mohammed A-M Salem, Doaa Hegazy, and Howida A. Shedeed. Hybrid watershed image segmentation and EM clustering for liver CT images. under construction, 2019.

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1.1 Overview

Medical Imaging [48] is a useful tool that can help physician in diagnosis or treatment. Medical imaging is the technique or process of creating visual representations of the interior of a body for clinical analysis. Medical images are being used a lot within healthcare field for diagnosis, guiding treatment, planning surgeries and monitoring disease progression. They seek to detect internal structures hidden by the skin and bones, as well as to diagnose and treat diseases. They also establish a database of normal anatomy and physiology to detect abnormalities.

Medical imaging has several technological types like Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound (US), and so on. Nowadays, medical image processing techniques are used widely in medical fields. The time is a crucial factor for early detection and diagnosis of different diseases.

Medical image processing [6] could be divided into some stages as pre-processing, segmentation, analysis and diagnosis. In pre-processing stage, a filtering, denoising or registration technique is performed. In segmentation stage, try to exactly segment the objects detected in previous stage (vessels, liver, lung, spine, brain, vertebrae ...etc). In analysis stage, measurements on segmented objects are performed such as (volume, vessel stenosis). In diagnosis stage, classify the output (cancer, not cancer, lesion, not lesion).

Image Segmentation [8] is the process of dividing an image into regions or categories with similar features such as gray level, color, texture, brightness, intensity, and contrast. One of the most interesting and challenging open problems in computer vision and medical image applications is medical image segmentation. Segmentation is the critical step in image processing stages. If segmentation stage is performed correctly, then all subsequent image processing stages will be performed simpler. It could be consisting of two main steps: initial segmentation and segmentation enhancement.

Liver segmentation from abdominal computed tomography (CT) images is the essential step in many clinical applications. Diagnosticians often preferred CT images because they provide an accurate anatomical information and for better spatial resolution and lower noise ratio. Liver segmentation [4] from abdominal CT images is very useful in many diagnostic and surgical processes. It is also useful in many computer aided diagnosis systems, computer guided surgery systems, and constructing anatomical atlases for the abdominal area.

1.2 Motivation

According to WHO (World Health Organization) [56] about 1.45 million people die annually from all types of viral hepatitis, mostly from liver disease and liver cancer. Egypt has the highest rates of hepatitis C virus (HCV) in the world. Every year, about 150,000 new infections appear in Egypt and thousands die. Liver diseases could infect people of all ages. It's estimated that over 6 million people between 15-59 years infected with viral hepatitis. The Egyptian National Committee developed new Treatment for HCV. However, other liver diseases and liver cancers treatment is under investigation.

Because the treatment couldn't be reached to all infected people, the Egypt's government lunched a "100 Million Seha" national campaign between October 2018 to April 2019 [31]. The campaign covered 27 governorates. At the end of March 2019, around 35 million people are examined for HCV. More over, people who get positive test, they obtained free treatment. The Egyptian government doing his best to deliver treatments to remote areas.

Liver cancer [82] is the most propagated liver diseases. Hepatocellular Carcinoma(HCC) is the fourth common cancer in Egypt. As well as, it's the second reason of cancer mortality. One of the main cause of HCC is HCV.

1.3 Problem Statement

The automatic detection and localization of different organs in abdominal images is a heavily processed field currently due to its fast progression and fine results.

Liver segmentation from abdominal CT images manually not accurate enough due to the delineation of the liver boundary differ from radiologist to another. The main