ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Segmentation of Abdominal CT Images on Multi-Core Architecture

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ABSTRACT

Image Segmentation is the process of dividing an image into regions with similar properties such as Gray level, colour, texture, brightness, and contrast. The importance of segmentation is to subdivide the objects in an image to extract the features in it. A Computed Tomography (CT) is an imaging method to provide cross sections of a body that uses x-rays. The main objective of this paper is to segment the kidney parts from an abdominal CT image both manually and with automation. First, the abdominal CT image preprocessed using median filter. In manual segmentation, the contour points are selected for the left and right kidneys and computation time is calculated. In automated segmentation the segmentation is done by masking with threads. Parallel automated implementation on multi-core was analyzed and achieved good result with respect to the computation time of serial segmentation.

KEY WORDS: Preprocessing, Segmentation, Multi-core, Computed Tomography, Active Contour.

1. INTRODUCTION

abdominal CT images for feature extraction is a key step in diagnostic, radiotherapy and surgical planning. Segmentation is the process of dividing an image into regions with similar properties such as gray level, colour, texture, brightness, and contrast (Emmanouil Skounakis, 2014). In medical field, the purpose of image segmentation is to study anatomical structure, identify region of interest to locate abnormalities etc. Automated segmentation of medical images is a difficult task as medical images are complex in nature. Also, the output of segmentation may not be accurate due to similarity in gray level of different organs (Chen, 2012). There are different algorithms to segment the abdominal CT images and they are specific to the organ to be segmented. For example, requirements for brain segmentation are different from those of kidney. Motion artifact is more prominent while segmenting the kidney regions. Thus while selecting a segmentation algorithm one is required to consider all these aspects. The issues to be considered for abdominal CT medical images are motion artifacts, ring artifacts, and noise due to sensors and related electronic system (Shu, 2009). The computation time for parallel segmentation of kidney regions is giving considerable performance improvement than manual segmentation (Sanjay Saxena, 2013, 2015).

The rest of the paper is organized as follows: In Section 2, Literature Review regarding kidney segmentation and multi-core architecture journal papers are analyzed. In Section 3, theoretical analysis about Active Contour Model and Parallel Computing Environment is introduced. In Section 4, the methodology including masking and contour segmentation modules are introduced in details. Then, in sections 5 and 6, experimental setup and results are given. In Section 7, results are analyzed to evaluate the performance of the methodology. Finally, Section 8 concludes the paper.

Literature Review: Several prior studies on kidney segmentation exist in the literature on different imaging modalities. The kidney segmentation is done mainly for finding abnormalities such as kidney stone, cancer, tumor etc. Chen (2012), proposed a methodology for comparing automatic and human segmentation of kidneys from CT images. Lin (2006), proposed an adaptive region growing method to identify elliptical kidneys using spine as a landmark and an anatomical model based approach for kidney segmentation on CT images. Spiegel (2009), presented an active shape model for kidney segmentation on CT images. Wu (2006), proposed a method for 2D kidney segmentation for US images by applying probabilistic deformable model. Image segmentation algorithms are reviewed and rated according to how suitable they are for multicore environment (Sanjay Saxena, 2013). Active contours or snakes are used extensively for image segmentation and processing applications, particularly to locate object boundaries (Marian Bakos, 2007; Shi, 2011; Venkatraman, 2011), to optimize the operating parameters for diesel engine with different mode of fuels.

Theoretical Analysis:

Active Contour Model: The concept of this model was first introduced in 1987 and has since been improved by various researchers. An active contour (Lin, 2006) is an energy minimizing spline that detects specified features within an image. It is a flexible curve which can be mapped around the required edges or object in an image. It consists of a set of control points connected by straight lines as shown in Figure.1. Fitting active contours to shape in images is an interactive process. The user must suggest an initial contour which is quite close to the intended shape. The contour will then be attracted to features in the image extracted by internal energy creating an attractor image. Now we can about to see some possibilities of the use of the active contour methods on real picture. The experiment was realised in Matlab with the help of existing method.

As we can see, the initiation point was given in the area where we require a region of interest. The given algorithm will sought contour in the shortest time possible. The number of iterations depends on the size of the scanned surrounding. Now after understanding the underlying functionalities of one of the commonest methods used for segmentation, the essence of this paper is to try to determine their drawbacks as used for medical image segmentation respectively. And we understand that the basic draw back affecting this method and others is their execution time. To overcome this drawback and to improve the performance, we propose a methodology that the segmented images can be processed in parallel on a multi-core architecture.

Parallel Computing Environment: Matlab toolbox, named Parallel Computing Toolbox uses MPI functionality to parallelize application. The main advantage of this toolbox is to develop a parallel application with considerably minimum time of development and with very few modification of the serial code. The Parallel Computing Toolbox has PARFOR loop which can run independent iterations on the different core activated by the configuration. The configuration can be local or on a cluster for large simulations. The biggest limitation of this par for loop is to have independent iterations. This is simple to check: if each iteration can be done in another order, we can conclude that the FOR loop can be changed as a Parfor loop. Technically, Matlab creates a function with the body of the Parfor loop, launch it on the selected core and get back the output of the function at the end of the simulation. Even if Matlab uses advanced technology, for this process, it is really simple to model it with this high level functionality. There are some keys of parallelism granularity, implicit and explicit parallelism, synchronization, latency and scalability which are considered at the time of parallelism (Sanjay Saxena, 2013, 2015).

Methodology

The implementation methodology consist of three stages:

1) Pre-processing using Median filter
2) Masking the region of interest using pixel intensity information
3) Initialize snake and segment

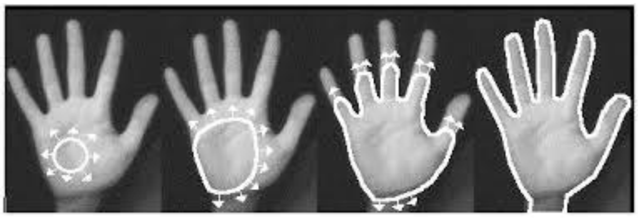
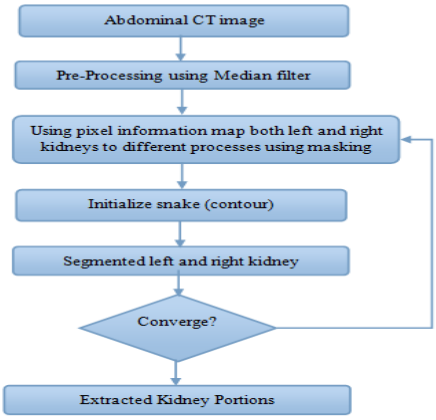


Figure.1.Example of active contour



Fiure.2.Methodology

Pre-processing: Abdominal image pre-processing is an important and demanding factor in the computer-aided diagnostic systems. The pre-processing is very much required for CT images as Marks or labels present can interfere in the segmentation of these images. The image quality needs to be enhanced. Noise in the image needs to be removed. To reduce the noise and in-homogeneities in the image, Median filter is used. The main purpose of pre-processing is to reduce noise and enhancement of the edges of the image. We have set the window size to 3 to enhance smoothing and increase map-ability.

Masking the region of interest: First contour points are selected in the abdominal CT images manually for segmenting left and right kidney portions. Then using the variation in pixel intensity between the region of interest and the background of the image, the same abdominal images are taken for masking. Kidneys are extracted after executing the masking module using PARFOR loop.

Initialize snake and segment: The active contour is initialised within the masked boundary region for segmenting the region of interest. The snake algorithm is iterated number of times to extract the region of interest for higher accuracy.

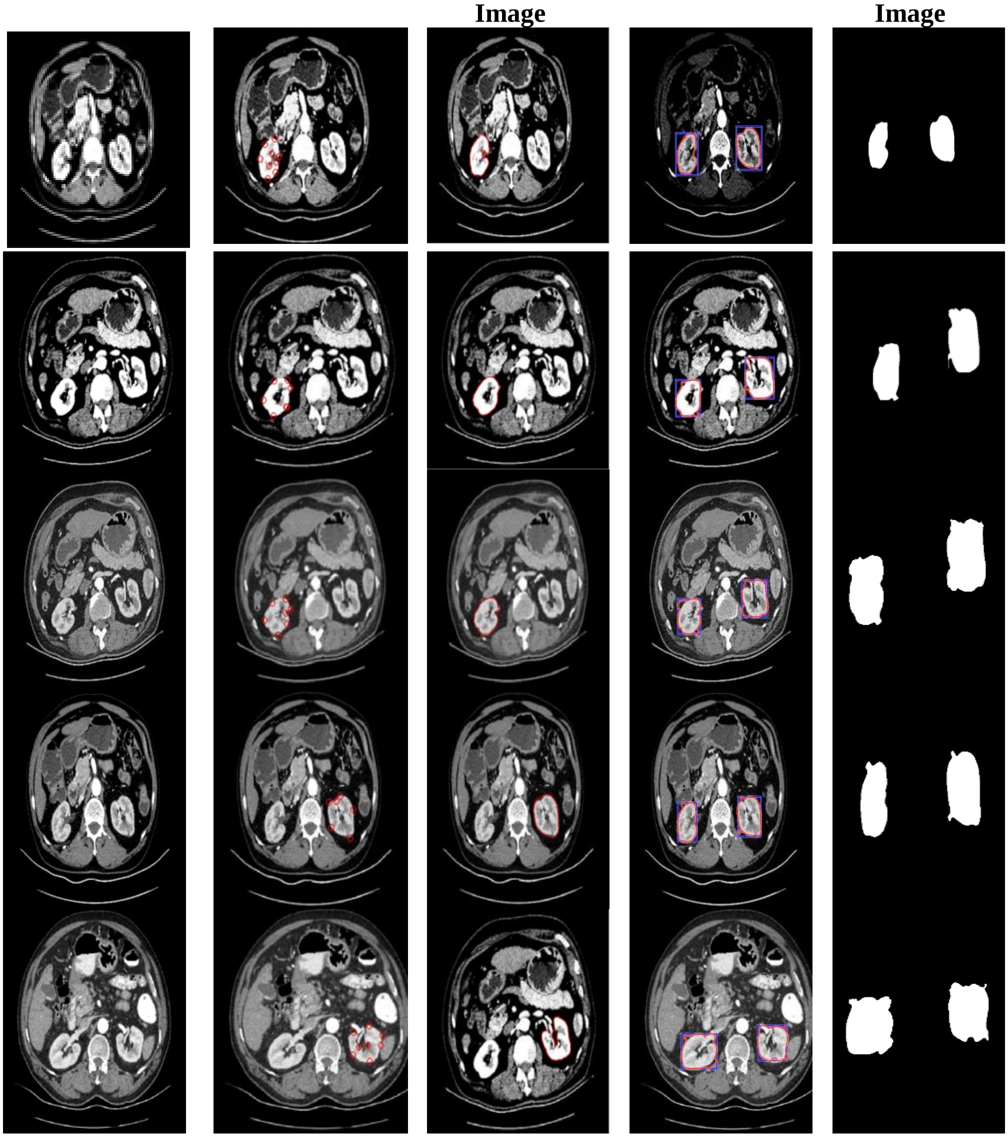
2. EXPERIMENTAL SETUP

The Configuration of the hardware is

CPU	:	Intel Core i5 CPU 2.30 GHz.
RAM	:	4GB.
Hard Disk Drive	:	500 GB
Operating System	:	Windows 10, 64 bit.
Development Tools	:	MATLAB R2015a, Intel Compiler 9.1.

Data Sets: Totally 100 slices of abdominal CT images (512x512) of 10 patients are taken. The proposed method of kidney segmentation is tested with these abdominal CT images. Both manual and automated parallel segmentation are applied for the datasets and parallel speed up is calculated. Initially 25 abdominal CT samples are taken to analyze the intensity distribution of kidney parts. Then threshold ranges for the two kidneys were fixed. About 70 slices are selected for trained data and the remaining is used for testing. The efficiency of the result is dependent on proper selection of the threshold values.

3. EXPERIMENTAL RESULTS

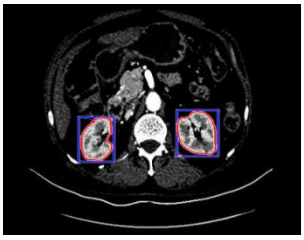


Original Image	Control Point Selection	Manual Segmented Image	Masking	Automated Segmented Image	Manual Computation Time(s)	Automated Computation Time(s)
					50.07	19.20
					55.81	19.40
					50.06	18.87
					56.75	18.97
					57.97	22.55

Figure.3. Manual and Automated Kidney Segmentation with Computation Time

Original image

Filtered Image

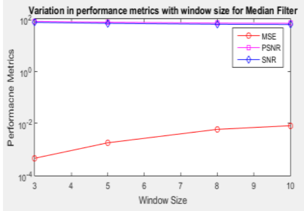


Masked (blue) and segmented ROI (red)

Left and right segmented kidneys

Window size	MSE	PSNR	SNR
3	4.6351e-04	81.4702	74.2232
5	0.0018	75.5482	68.3012
8	0.0059	70.4012	63.1541
10	0.0082	69.0007	61.7536

Metrics Parameters (Median Filter)



Metrics Parameters Graph

Figure.4. Manual and Automated Kidney Segmentation with Computation Time

Findings: This section analyzes the results obtained by implementing this methodology. If the snake is initialized too far from the object boundary, it is possible that the contour may not be able to converge onto object boundary. The segmentation accuracy is good for manual segmentation but the computation time is two or three times greater than the automated segmentation. The efficiency of the automated segmentation is improved when the number of iterations of masking is increased. Also speedup is improved in automated segmentation.

Table.1. Speedup

Input Images	Computation Time (s)		Speedup (s)
	Manual (T_1)	Automated (T_2)	T_1/T_2
1	50.07	19.20	2.61
2	55.81	19.40	2.88
3	50.06	18.87	2.65
4	56.75	18.97	2.99
5	57.97	22.55	2.57

CONCLUSION AND FUTURE WORK

This paper proposed a methodology for manual (serial) and automated (parallel) segmentation on a multi-core architecture. The focus of this implementation is to enhance the performance of segmentation by improving the speed of segmentation process. In terms of speedup, parallel implementation was about three times faster than serial implementation on core 5 Intel processor. Thus it is now expected that the segmentation of any medical images with any sizes can be segmented efficiently with increased speed as the execution is done on multi-core. In future, the efficiency of the segmentation process will be considered more on multi-core architecture.

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