APPROVAL

This project title "**Kidney Detection and its Size Estimation from CT Image,**" submitted by Shahriar Hossain Morshed,142-15-3548 and Sudip Sarker,142-15-3598 to the Department of Computer Science and Engineering, Daffodil International University has accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 5th May 2018

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DECLARATION

We hereby declare that, this Project has done by us under supervision of **Ms. Rubaiya Hafiz**, **Lecturer, Department of CSE**, Daffodil International University. We also declare that neither of this project or part of this project submitted for elsewhere for award or any degree or diploma.

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ACKNOWLWDGEMENT

At first, we express our heartiest thanks and gratefulness to Almighty God for his divine blessing make us possible to complete this project successfully.

We are grateful to the Faculty of Science and Information Technology at the Daffodil International University for giving us chance to study here. We deeply thanks to our supervisor **Ms Rubaiya Hafiz** who encouraged and directed us. Her endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting them at all stage have made it possible to complete this project.

We would like to express our heartiest gratitude to **Dr. Syed Akhter Hossain**, Professor and Head, Department of CSE, for his kind help to finish our project and also to other faculty member and the staff of the CSE department of Daffodil International University.

We would like to thank our entire classmates in Daffodil International University. Who took part in the discussion while completing the course work.

Finally, we thank to my family who encourage us and prayed for me throughout educational, professional and personal life.

ABSTRACT

Accurate estimation of kidney area is very much crucial for early detection of kidney disease. Abnormal size in kidney leads to CKD which leads to renal failure. Kidney area estimation from CT image relies on segmentation of the CT image and a segmentation free approach. In this paper we propose a method which require segmentation approach for determining the kidney size. We break down the process in two steps. First we segment the image in two slice where left and right kidney are on each slice based on the spine location of human. Then we use contour based shape finding to detect the kidney size. We tested this method over 40 CT image acquired from online data repository. This method shows very promising result.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Kidneys are two most important organs of human. The size of kidney is not bigger than a fist located just under the rib. One on the right side of the spine and another on the left. Every day, kidneys are important for the filtration process of our blood and to carry out the wastes and the extra fluids out of our body.

Fibrous tissue surrounds the kidneys, the renal capsule, which is itself surrounded by perirenal fat, renal fascia, and pararenal fat. The anterior (front) surface of these tissues is the peritoneum, while the posterior (rear) surface is the transversalis fascia. [1]

The 11th and 12th ribs protects the kidneys upper parts slightly. And then two layers of fat, surrounds the kidney: the perirenal fat present between renal fascia and renal capsule and pararenal fat superior to the renal fascia.

The superior pole of the right kidney is adjacent to the liver. For the left kidney, it is next to the spleen. Both, therefore, move down upon inhalation.

The kidney weighs between 125 and 170 grams in a normal aged man. In females the weight of the kidney is between 115 and 155 grams. A Danish study measured the median renal length to be 11.2 cm (4.4 in) on the left side and 10.9 cm (4.3 in) on the right side in adults. Median renal volumes were 146 cm^3 on the left and 134 cm^3 on the right.

1.2 Problem Statement:

On world kidney day an article was published that in Bangladesh almost 20 million people are affected with some kind of kidney disease. Chronic kidney disease (CKD) turns into End Stage Renal Disease (ESRD). Some eight-lakh people in the country are currently suffering from ESRD that requires either dialysis or kidney transplantation. Almost 40 thousand people die in every year due to renal failure. 75 percent of people doesn't even know about renal failure before failure of the both kidney. [2]

Fetal hydronephrosis, this enlargement of one or both of the kidneys is caused by either an obstruction in the developing urinary tract or a condition called vesicoureteral reflux (VUR**)** in which urine abnormally flows backward (or refluxes) from the bladder into the ureters. Many other kidney diseases are related with the size of both kidney. Many researches on kidney disease shows that kidney size and shape are related to many kidney disease and can play important role in detecting early stage kidney disease.

Detection of kidney shape abnormalities is a gold standard for detecting early stage kidney disease. The cost of chronic kidney disease is very much high in Bangladesh, on an average, most hospital charges at least BDT 3,000 for a four-hour session.

A kidney patient needing dialysis has to have two or three such sessions every week. Besides, he or she needs to have blood tests and erythropoietin injections. So, the monthly treatment cost ranges between BDT 40,000 and BDT 1 lakh.

So, detection of kidney shape abnormality is very much important for detecting early stage disease. In this report I described a contour-based method for detecting the shape of kidney.

1.3 Objectives

- To detect the kidney shape abnormality.
- To propose a new segmentation-based method for detection of abnormality.
- To improve the existing algorithm.
- Reduce the complex calculation**.**

1.4 Expected Result

Medical image processing is a promising topic in Computer science. Using image processing technique many type of medical image research is conducting now a day. Kidney shape measurement and abnormality finding is still a challenging work. There are many researches on kidney size detection. There are many methods to detect the shape and size of kidney. Upon Successful completion of this project we hope to detect the size and shape of kidney from abdomen CT image.

1.5 OUTLINE OF THESIS

This description is provided to give a clear picture of which chapter covers which topic and their relevant discussion and short description of the chapter.

Chapter 1 contains the introduction of the full report. It contains what is this report about and details about the content. Problem statement, objective of our thesis, and Expected outcome of our project are also in chapter 1.

Chapter 2 is the Literature Review. Here we discussed about the previous research on this area

and the problem and limitation of those research.

Chapter 3 is Our proposed methodology. Here is the details description about our proposed method and working procedure.

Chapter 4 is the test method and result of the proposed method

Chapter 5 is the discussion and conclusion of the project and the future work of this project

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter we have discussed about the previous study of image processing technique in detecting kidney shape and size and research done.

2.2 Literature Review

Processing of medical images using image processing technology is widely used now-a-days with many improved algorithms. Supervised learning is used nowadays upon the knowledge.

Normally kidney shape and size are detected by image segmentation. The existing methods have many limitations, Yan et el [3] proposed a simple intensity-based thresholding algorithm, which shows inaccurate method and was limited to 2D image. There is another intensity-based method which used graph cut algorithm [4]. But these methods are shows in inaccurate results in detecting kidney shape. The problem with

Simple thresholding method is it doesn't work in different CT images as kidney shape and size varies body to body , and in some cases kidney has the same intensity as others organs in the human body . To overcome the limitations of intensity based segmentation methods, a number of kidney segmentation method based on supervised learning have been proposed.

Cuingnet et el. [5] worked on a classification forest to generate a kidney spatial probability map and then deformed an ellipsoidal template to approximate the probability map and generate the segmentations. Due to this restrictive template based approach, it is likely to fail for kidneys having abnormal shape due to disease progression and or internal tumors. There proposed method did not worked for 20% of data. In another paper Glocker et el. [6] suggested a joint classification-regression forest to segment different abdominal organs, but their method fails as it leaks, mainly in kidneys, as told in their tests.

Now a day's knowledge based supervised learning for direct estimation methods are popular as the removes the segmentation process and shows good results. These can bypass the complex computation of segmentation but these fails as the kidney anatomy varies across different patients.

In this paper we propose a contour based kidney shape detection method which will work on prior knowledge to kidney anatomy. As kidney is situated in the lower part of the CT image, first we select the estimated kidney position (EKP) from the CT image and removes other parts from the image. Then we use a thresholding algorithm to remove non kidney area and from image processing feature Contours finding we find the kidney shape.

CHAPTER 3

PROPOSED METHODOLOGY

3.1 INTRUDUCTION

In this chapter we discussed our method in details for detecting kidney area and requirement for this project and details information about the Implementation of our project.

3.2 METHODOLOGY

i) Image simplification

A normal CT image of abdomen is complicated, it contains kidney, liver, fat etc. So detecting kidney shape from the raw image directly is a computationally impossible task. So we go through a series of methods and simplification of the image to know the exact size. From our medical knowledge we know that kidney is situated in the lower part of an abdominal CT image, one on the right side of the spine and another on the left. First we took a sample image for the process [Fig3.1 (b)].We will use this same image in this whole process. As in a abdomen CT , there are many other organs which may lead to error, To remove these false positive results we extracts the Estimated Kidney Position (EKP) from the image [Fig 3.1(c)]. In order to extract the estimated kidney positions we set an anatomical boundary, now in the horizontal axis we set it L and S in the vertical axis. We see that Spine is at 0L-0.16S, so we remove the non-kidney parts from the image by removing the outside area [Fig 3.1(d)].

Now this image has only the spine and the two kidneys and some noise of other organs.

Normally spine has the highest intensity value in a Abdominal CT image, so taking that we can set our threshold value.

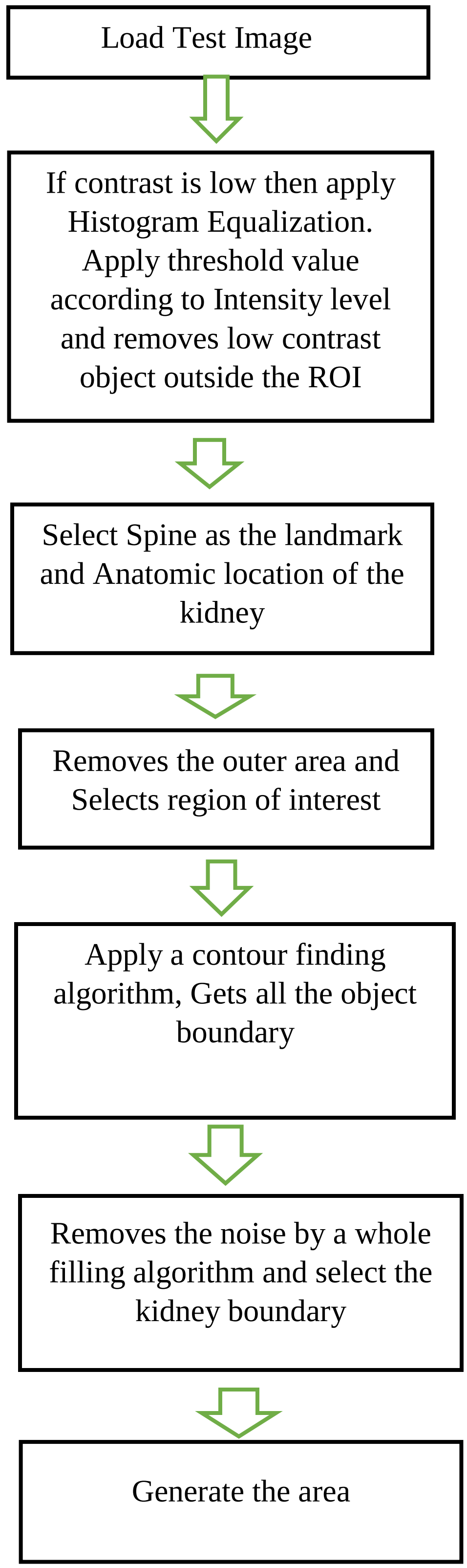


Fig 3.1(a): Block diagram of detecting Kidney

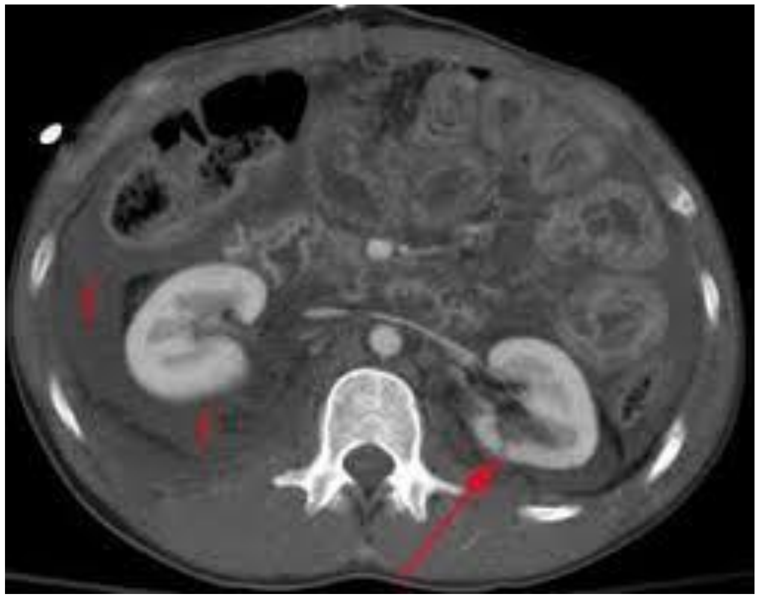


Fig:3.2(a) A sample image pointing kidney(Red arrow)

Fig:3.2(b) Raw Sample Image for testing

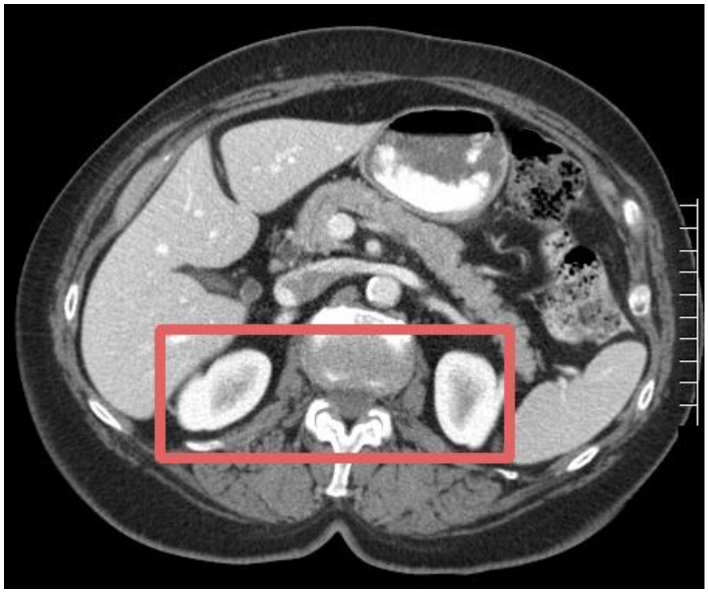


Fig:3.2(c)Estimated kidney position

Fig:3.2(d) Extracting Region of Interest (ROI)

Fig 3.2: Abdominal CT image

In Fig 3.3(a) we show the Intensity distribution of total CT image with kidney and non-kidney parts. In here we see that using threshold value we can remove the non-kidney parts easily. So what we do we remove the area that has lest possibility for kidney area [Fig 3.2(c)].

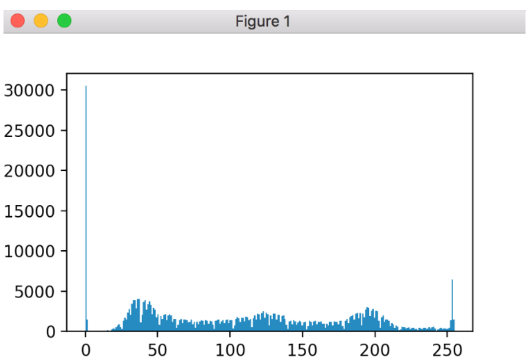
We know that kidney is in the lower part so taking the full image, we divide it by half and take the lower part of the image

$$if\ f(x,y)\ is\ the\ image\ function\ and\ x\ and\ y\ are\ coordinate\ then$$

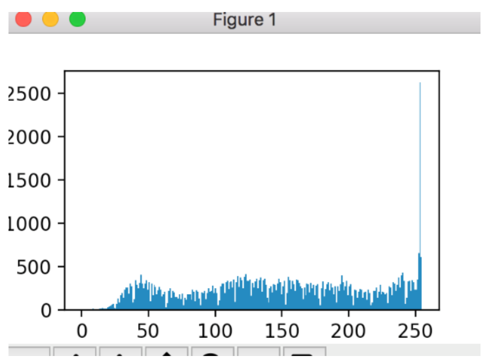
We take r as the row matrix and

And c as the column matrix, so lower half of the image will be $midx = \frac{r}{2}, midy = \frac{c}{2}$

$$midx + 1\ to\ r\ and\ midy + 1\ to\ c$$



a)Full intensity distribution of raw image



b)Intensity distribution of the region of interest

Fig 3.3: Intensity Distribution of the image

After extracting the region of interest (ROI) we again see the intensity distribution of the ROI [Fig 3.3(b)]. Now for low contrast Image we have to increase the contrast of the image to find the kidney area. In low contrast image kidney aren't visible as its intensity is lower or equal to other organs. To increase the contrast, we apply a histogram equalization algorithm.

Fig 3.4: Low Contrast Image.

ii) Contour Finding

Contour finding algorithm gives us all the boundary of the object inside the image. The contour finding algorithm follows Green's theorem. Green's theorem gives the relationship between a line integral around a simple closed curve and a double integral over the plane region bounded by the curve.

In order to identify objects in a digital pattern, we need to locate groups of black pixels that are connected by line or curve to each other. In other words, the objects in a given digital pattern are the connected components of that pattern.

It usually searches the 4 neighbors [9].

A pixel, Y, is a 4-neighbor of a given pixel, X, if Y and X share an edge. The 4-neighbors of pixel X (namely pixels X2, X4, X6 and X8) are shown in Figure [Fig 3.5] below.

		X4		
	X8	X	X2	
		X6		

Fig 3.5: Four Connected Neighbor of a PIXEL X

A set of black pixels X, is a 4-connected component if for every pair of pixels x_i and x_j in X, there exists a sequence of pixels xi, ..., x_j such that: a) all pixels in the sequence are in the set X i.e. are black, and b) every 2 pixels that are adjacent in the sequence are 4-neighbor

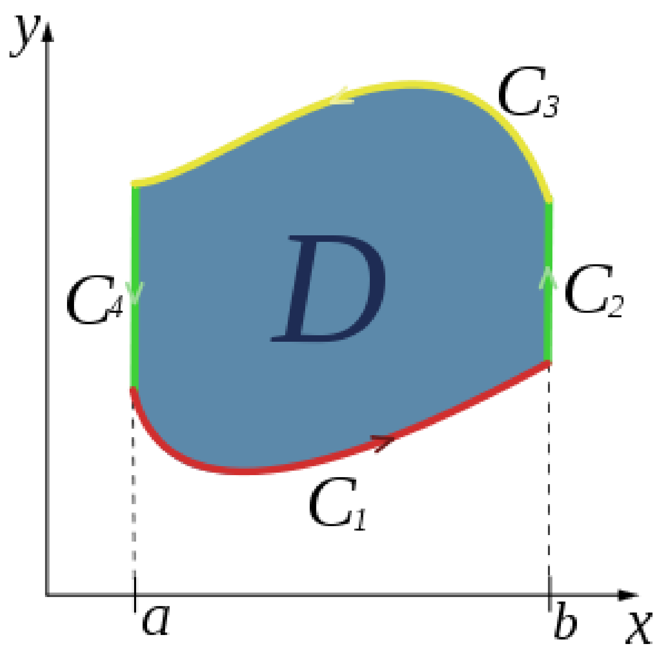


Fig 3.6: Contour finding using the four boundaries

Here D is a simple region with its boundary consisting of the

curves C_1, C_2, C_3, C_4, [7]

iii) Image moment:

An **image moment** is a certain particular weighted average (moment) of the image pixels' intensities, or a function of such moments, usually chosen to have some Attractive property or interpretation.

Image moments are useful to describe objects after segmentation. Simple properties of the image which are found *via* image moments include area (or total intensity), its centroid, and information about its orientation.

For a 2D continuous function f(x,y) the moment (sometimes called "raw moment") of order (p + q) is defined as[8]

$$M_{pq} = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} x^p y^q f(x, y)\,dxdy$$

for p,q = 0,1,2,... Adapting this to scalar (greyscale) image with pixel intensities $I(x,y)$, raw image moments M_{ij} are calculated by

$$M_{ij} = \sum_x \sum_y x^i y^j I(x,y)$$

In some cases, this may be calculated by considering the image as a probability density function, *i.e.*, by dividing the above by

$$\sum_x \sum_y I(x, y)$$

Area (for binary images) or sum of grey level (for Greystone images): M_{00}
Applying contour finding algorithms we find the boundary of the spine and left and the right kidney. Still there are some other noise remains in the image [Fig 3.5(b)]. This noises are fat, tissue of the human body, or connected components of other organs. This noises intensity level is same as the kidney and the spine and that’s the reason they can’t be wiped using threshold value. There are many noise removing filters in image processing. We could use one them but what we did is that these noise are very small in pixel count. We can remove them easily without affecting the kidney. So we used a iterative process to fill all these small noise with the background color.

Filling all the noise

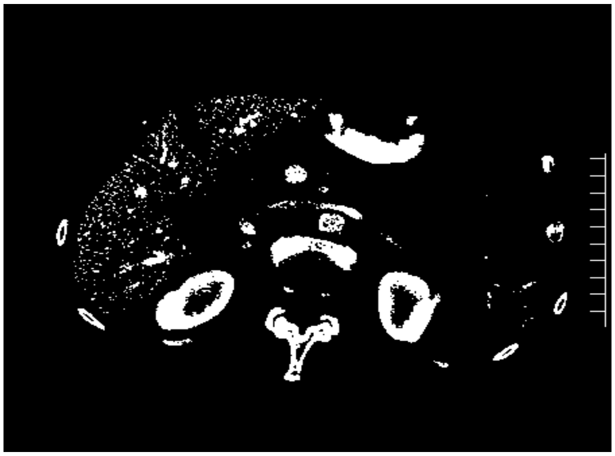
```
For (i in   length (contour))
      If(length(i)<50)
           Color=black
```

So all the noises are removed in the image [Fig 3.4 (e)]

Then there will remain the just the spine and the right and left kidney. From our clinical knowledge we know that spine is in the middle of both the kidneys. So we detect the two big boundary from the two side [Fig 3.6(c)]. We fill the area inside the kidney using a filling method [Fig 3.6(d)].

Now all that left in the image is the shape of the kidney. If we count the grey level pixel from this we can get the area of the kidney and shape are well seen.

All the image for this test process is given below in order to give a clear picture about the process.



a) Full CT Image

b) Region of Interest

c)Detecting kidney area

d) Filling the area inside the kidney

e) Noise removed

f) Extracted kidney area.

Fig 3.7: Process of detection of kidney area

Chapter 4

Testing and Experiment Result

4.1 TESTING

Our recommended method was tested on High contrast and low contrast abdominal CT image and with normal CT images which have all the organs of a typical Abdomen CT image. This CT images was downloaded from online data repository []. The subject are also from different age range. From our data source there were more than 80 picture which doesn’t have any kidney on the CT image. So for result calculation and correctness we didn’t calculate those image.

Below we show the image without kidney from the data set.

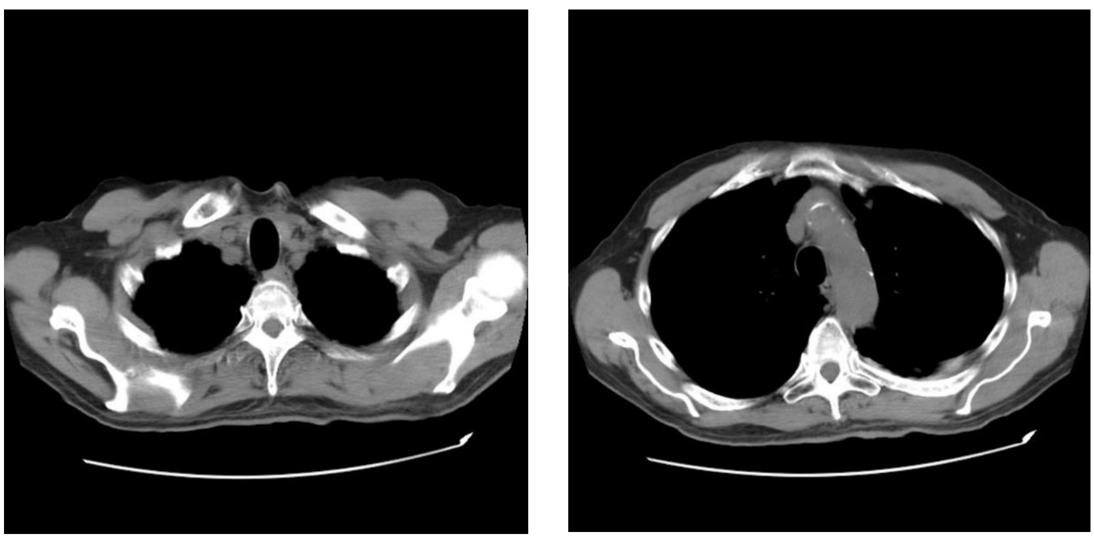


Fig 4.1: Example of CT image without kidney

Again, there was image in which either left or right kidney was present and the other one couldn’t be identified due to very low contrast or the kidney was mixed with other organs.

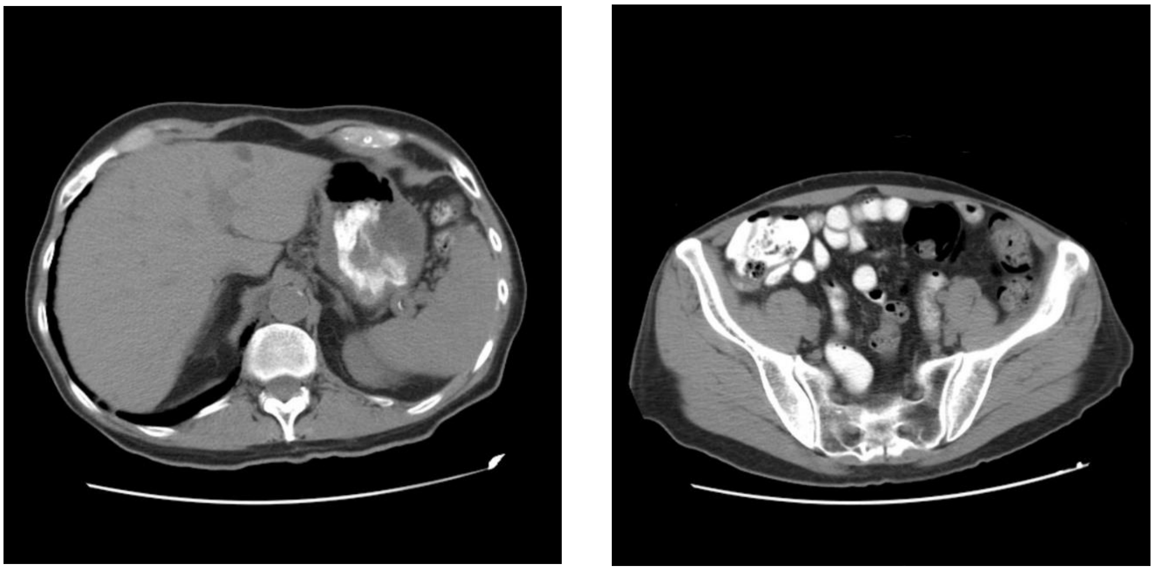


Fig 4.2: Left or right kidney mixed with other organs

4.2 Result

Total Number of Image (Either left or right kidney or both found): 52

Table 1: Result table

Kidney	Contrast level	Number Of Test Image	Accurately Identified	False
Left Kidney	High Contrast	10	9	1
	Low Contrast	29	19	10
Right Kidney	High Contrast	10	8	2
	Low Contrast	32	21	11

CHAPTER 5
DISCUSSION & FUTURE WORK

5.1 DISCUSSION

Image processing technique is now a proven technique for medical image processing, computer vison and Artificial Intelligence. Many new research has been conducted using image processing. Now a days image processing and machine learning are combined in many research.

Kidney is one of the main organs in human body. Previously doctors in Bangladesh used to measure kidney length using scale. Again fine CT image was required to measure the kidney size. Image processing has improved the medical related research a lot. Not only just kidney is measured using Image processing but also detecting liver and other organs are conducted using image processing.

5.2 FUTURE WORK

We have done this project using just image processing technique. However, for successful or for considerable result, image quality and high-contrast image must be provided. Again, kidney size and shape and anatomical location varies in physical structure and people to people. Our proposed method just works in a given process, so we are planning to improve it. We have a plan to add learning process in our method so that our proposed method can learn through the image once tested in it.

5.3 CHALLENGES

We faced many difficulties in doing this project. Abdomen CT is difficult to find. Finding CT image data for testing is difficult. Hospitals in our country doesn’t have rich database of CT images. Again, they don’t appreciate much in helping in this kind of research.

5.4 CONCLUSION

In this project report we have analyzed a contour-based process for detecting kidney size and described the process in details. In this paper all the processes are not fully automated. The threshold value we used is still manual as we are trying to combine our project with Artificial Intelligence. We selected the region of interest on the basis of anatomical location of the kidney. So, if there is any change in the anatomical location of the kidney for any reason like problematic kidney or anything else, this method won’t work properly. We tested our proposed method on a small amount of data as abdomen Data can’t be found easier. However more work and data is necessary for validation of this project.

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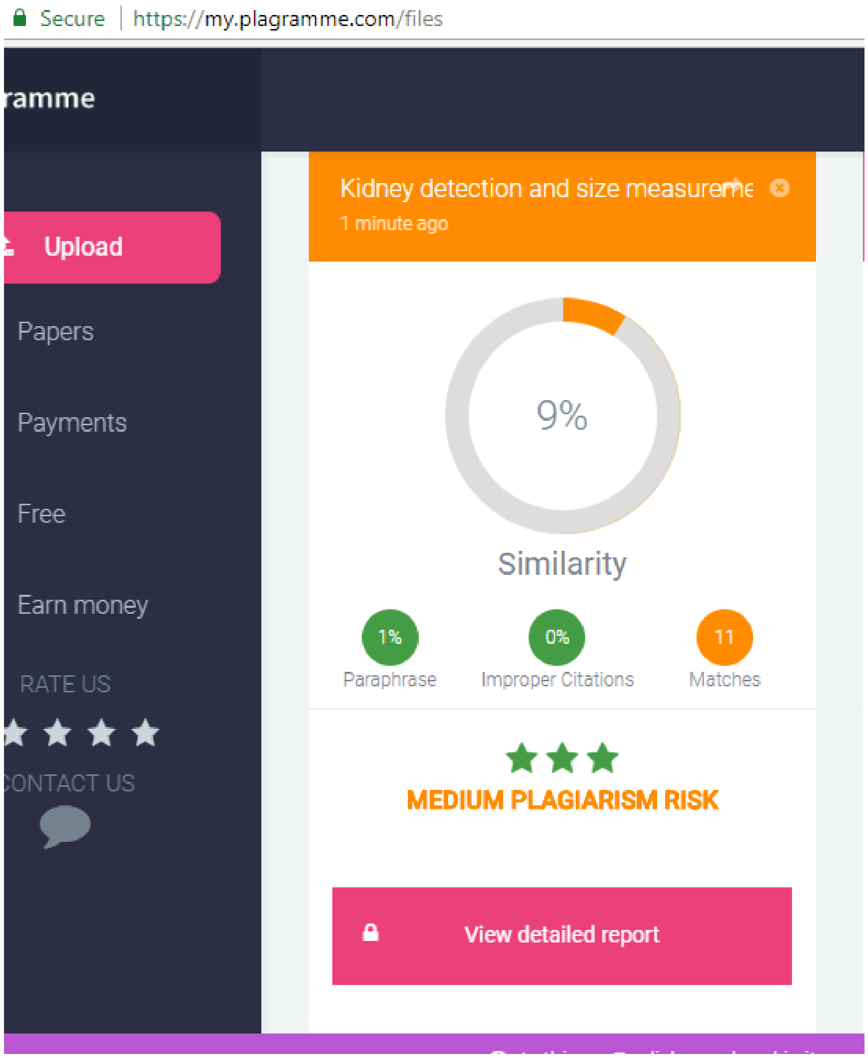
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