Texture based Detection of Chronic Kidney Disease

Mrs.J.Babitha Sujanna
Research scholar, Computer and Information Technology,Manonmaniam sundharanar University, India

Dr.A.Lenin Fred ,
Principal, Mar Ephream College of Engineering and Technology, Elavuvilai, Marthandam ,India.

Abstract –Chronic kidney disease CKD is a irreversible damage to kidney. People affected by CKD increase every year . The symptoms of CKD are not much evident in the early stages .The solutions for CKD is dialysis and kidney transplantation. Early detection of kidney disease plays a vital role in avoiding CKD . Ultrasound imaging is the low cost , convenient, non-ionized imaging technique used for kidney failure diagnosis .The technique used in this paper are noise reduction, segmenting the cortex of kidney from ultrasound image, Texture feature extraction, for spatial frequency image analysis, classification of different stages of CKD .This provide the Doctors a supporting and objective CAD for detection of CKD.

Keywords –CKD, Ultrasound imaging, segmentation, speckle noise, cortex, Texture .

I. INTRODUCTION

People across the world are suffering from kidney diseases. According to Global Burden of disease(GBD) in India , chronic kidney disease is ranked as the eighth leading cause of death[16] More than 5 million people in India[9] suffer by various forms of kidney disease. It is stated that a new type of CKD called CKDu , the exact cause is unknown . Study has stated its multifactorial i.e Different factors such as prolonged exposure to hot weather, dehydration due to water scarcity or water hardness, hard manual labor and consumption of alcohol etc cause these kidney disease[14] . The two main causes of chronic kidney disease are diabetes and high blood pressure. If kidney disease gets worse, wastes can build to high levels in your blood and make you feel sick. Kidney disease is usually a progressive disease, which means that the damage in the kidneys is tend to be permanent and cannot be undone. So it is important to identify kidney disease early before the damage is done. The good news is that kidney disease can be treated very effectively if it is diagnosed in the early stages. This is very important, since kidney disease also makes your risks for heart disease and stroke higher. If one or both kidneys fails completely and the damage cannot be reversed, the condition is called kidney failure or end-stage renal disease (ESRD). When this occurs, your kidneys can no longer filter wastes well enough to keep you healthy. The symptoms for ESRD includes fatigue, weakness, nausea, vomiting, and itching. .Treatments for kidney failure include dialysis or transplantation[7].

There are two major types of dialysis Hemodialysis and Peritoneal dialysis :In hemodialysis, blood is run through an external filter and the clean blood is returned to the body. Hemodialysis is usually done at a dialysis center two to three times a week. Peritoneal dialysis uses the lining of your abdominal cavity (the space in your body that holds organs like the stomach, intestines, and liver) to filter your blood. This kind of dialysis is needed daily but it can be performed at home. A kidney transplant is an operation that places a healthy kidney in your body. The transplanted kidney takes over the work of the two kidneys that failed, and you no longer need dialysis .But its costly and risky.

There are different techniques to diagnose kidney disease, Blood test, urine tests, Imaging ,Biopsy .In Imaging Ultrasound imaging, MRI, CT and combined imaging can also be used for diagnoses. Ultrasound imaging is the low cost , convenient, non-ionized imaging technique used for kidney failure diagnosis. Ultrasound may also be used to diagnose the presence of urinary obstruction, kidney stones and also to assess the blood flow into the kidneys. The main disadvantage of ultrasound images is the poor quality of images, ultrasound images are also affected by speckle noise, hence many of the image segmentation methods may not be suitable in case of ultrasound images .However, segmentation of noisy ultrasound image always leads to over-segmentation. Because of the poor quality of ultrasound image the partition between pelvis and parenchyma is also not clear. The multiplicative noises sometimes lead to inconsistent diagnoses by medical doctors and even delay the best timing for pertinent treatment. The main goal of this method is to provide a consistent and stable indicator to detect and identify early stage of CKD.

Chronic renal disease, is a progressive loss in renal function over a period of months or years[1]. The symptoms of worsening kidney function are not specific, and might include feeling generally unwell and experiencing a reduced appetite. Often, chronic kidney disease is diagnosed as a result of screening of people known to be at risk of kidney problems, such as those with high blood pressure or diabetes and those with a blood relative with CKD.

Abdominal ultrasound, in which the size of the kidneys is measured, is commonly performed. Kidneys with CKD are usually smaller (< 9 cm) than normal kidneys, with notable exceptions such as in diabetic nephropathy and polycystic kidney disease. Another diagnostic clue that helps differentiate CKD from Acute Renal Failure is a gradual rise in serum creatine for over several months or years as opposed to a sudden increase in the serum creatine for several days to weeks. If these levels are unavailable ,because the patient has been well and has had no blood tests, it is occasionally necessary to treat a patient briefly as having ARF until the renal impairment has been established to be irreversible.

Renal biopsy also known as kidney biopsy is a medical procedure in which a small piece of kidney is removed from the

body for examination, usually under microscope. Microscopic examination of the tissue can provide information needed to diagnose, monitor or treat problems of the kidney.

II. PREVIOUS WORK

Ultrasound imaging a non ionized technique in medical imaging , whereas other imaging techniques like MRI, CT use gadolinium a concentrate , which is to be injected to the patient before imaging . Gadolinium affect the CKD Patient further , Hence it is not a suitable method for imaging.

Wan NurHafsha,[14] has proposed a Statistical based texture features extraction method namely Intensity Histogram (IH), Gray-Level Co-Occurance Matrix (GLCM) [11]and Gray-level run-length matrix (GLRLM) .These methods depends on the spatial distribution of intensity values or gray levels in the kidney region. By using One-Way ANOVA in SPSS(Statistical Package for the Social Sciences), the result indicated that three features (Contrast, Difference Variance and Inverse Difference Moment Normalized) from GLCM are not statistically significant since the p value is >0.05 for the other two methods p<0.05; this concludes that these three features describe a healthy kidney characteristics regardless of the ultrasound image quality in GLCM .Here in this paper Spatial intensity and parameters were not evident.

Fadi Iqbal,[8] proposed a method using MATLAB user interface to perform texture based analysis on ultrasound image in Spatial frequency and gray level intensity. In Spatial frequency Fourier transformation of image from I(x,y) to T(u,v) done and spatial parameters like Root Mean Square (RMS) and First moment (M) were calculated for the US image. In Gray level intensity GLCM was constructed and parameters like Homogeneity and sum average were calculated . These parameter calculations were done on 3 different image regions like Entire kidney, cortex and medulla .It is found that cortex region and spatial parameters are effective in CKD detection.

III. PROPOSED WORK

The proposed system consists of the following modules as shown in figure 1.

A. Image Preprocessing.

An input ultrasonic image might contain significant markers by medical doctors and/or system labeling. Though the diagnosis labeling and measuring markers annotated by physicians could provide rough initial locations of a kidney, these apparent markers also influence the results of boundary detection when they are not removed in advance. For example consider Figure 2 and 3, the original input ultrasound images might have system information and the markers and labeling of Doctors. These markers should be removed before

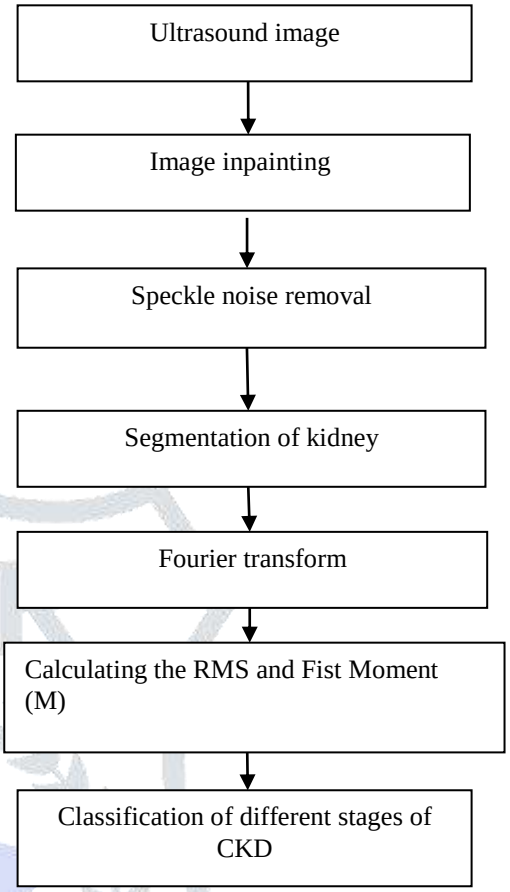

Fig.1. Block diagram of the proposed system

boundary detection. Therefore, the first step in pre-processing module is to detect and remove the markers automatically. The markers can be successfully detected due to their constant gray levels and highly differentiated gray levels among neighboring pixels. After identifying and eliminating the marking's, the left empty spots should be repaired and restored by using Fast marching method (FMM)[17].

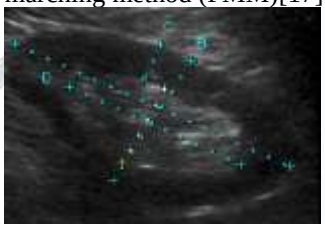

Fig.2. Before inpainting

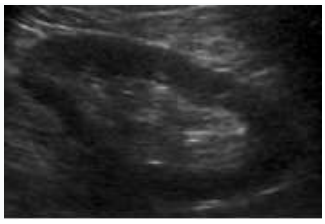

Fig.3. After inpainting

Noise removal is the second important step to be carried out in image preprocessing. Ultrasound image normally has speckle noise . speckle noise is Speckle is a rough noise that inherently exists in and degrades the quality of the medical ultrasound images.

B. Speckle Noise removal

Gaussian filtering, [2] [5] the smoother cutoff process is used rather cutting the frequency coefficients abruptly. It also takes advantage of the fact that the discrete fourier transform (DFT) of a Gaussian function is also a Gaussian function. [10]The Gaussian low-pass filter varies frequency components that are further away from the image center. So, the filter is more effective in speckle noise reduction of US images.

C. Segmentation of Kidney

Segmentation of kidney is done manually , so as to reduce the computational time, Cortex is only separated from the ultrasound image[8] . The cortex is the dark part of the image , the white part is the pelvis and medulla , which we are not considering for feature extraction since the functional unit of a kidney , nephron , is present only in the cortex . The damage of nephron degrades the performance of kidney which decrease the GFR ration and leads to CKD.

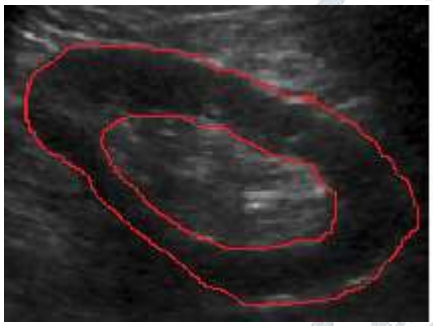

Fig 4. Manually segmented Cortex

D. Fourier Transformation.

The image was converted in to a spectral frequency image Fourier Transformation . The I(x,y) is converted to T(u,v). [8]

`

E. Calculating RMS and First moment(M).

An moving average filter[] 11x11 window is used to smooth the image , where each pixel will have unique values .

Root Mean Square Variation (R) , difference between the input and output can be calculated as

$$R=\sqrt{\int_{-\infty-\infty}^{\infty}\int^{\infty}\left|T(u,v)\right|^{2}dudv} \qquad (1)$$

First moment (M) can be calculated as

$$M=\frac{\int_{-\infty-\infty}^{\infty}\int^{\infty}\sqrt{u^{2}+v^{2}}\left|T(u,v)\right|^{2}dudv}{\int_{-\infty-\infty}^{\infty}\int^{\infty}\left|T(u,v)\right|^{2}dudv} \qquad (2)$$

Moment of an image represent the projections
u and v represent the horizontal and vertical axis of the pixel matrix that is selected. T(u,v) represent the fourier transformation for that particular pixel given by (u,v).

The mask was generated for the selected region as shown in fig. 5 and the number of pixels within the masked region was calculated.

Average RMS = Sum of RMS values within the masked ROI/ Number of pixels within the masked ROI (3)

Average First Moment=Sum of first moment values within the masked ROI / Number of pixels within the masked ROI (4)

Fig 5 Binary mask of selected region from kidney

F. Classification of different stages of CKD

The classification of different stages of CKD is performed based on the mean value we got from the texture based parameter calculation for the cortex region [] , the parameters included RMS and first moment are calculated for all the ultrasound image . The RMS value of the ultrasound image with different stages of CKD increase gradually and similarly the First moment of cortex region feature value will also increase as the disease progress. Based on this the different stages of CKD can be classified.

IV. RESULT AND DISCUSSION

It is evident that T test [8] for the mean value and deviation for the cortex region based on the various parameters of spatial texture detection like the root mean square and the first moment . The p value for RMS of cortex region is calculated based on the mean value of normal kidney and the Diseased Kidney [8]. The RMS and first moment calculations are as follows.

Table 1

RMS Parameters Values for texture detection in cortex sample values

Images	Normal Kidney	Diseased kidney
1	$2.0x\ 10^3$	$2.5x10^3$
2	$1.9\ x\ 10^3$	$2.4\ x10^3$
3	$2.0\ x\ 10^3$	$2.8\ x10^3$
4	$2.0\ x\ 10^3$	$2.6\ x10^3$
5	$2.1\ x\ 10^3$	$2.9\ x10^3$
6	$2.0\ x\ 10^3$	$2.7\ x10^3$
7	$2.1\ x\ 10^3$	$2.5\ x10^3$
8	$2.1\ x\ 10^3$	$2.4\ x10^3$
9	$1.9\ x\ 10^3$	$2.3\ x10^3$
10	$1.9\ x\ 10^3$	$2.9x10^3$

Table 2

First Moment parameter value for texture detection in cortex sample values

Images	Normal Kidney	Diseased kidney
1	$5.4x\ 10^5$	$7.4x10^5$
2	$5.7x\ 10^5$	$6.3x10^5$
3	$5.3x\ 10^5$	$8.5x10^5$
4	$5.8\ x\ 10^5$	$7.1x10^5$
5	$5.9\ x\ 10^5$	$8.6x10^5$
6	$6.0\ x\ 10^5$	$9.4x10^5$
7	$6.3\ x\ 10^5$	$7.7x10^5$
8	$6.1\ x\ 10^5$	$6.5x10^5$
9	$6.0\ x\ 10^5$	$9.2x10^5$
10	$5.8\ x\ 10^5$	$8.7x10^5$

Different patient US images were analyzed to detect the 5 stages of chronic kidney Disease. The values of RMS and First moment of the diseased kidneys have possible variations in the value compared to the mean of RMS$(2.5\pm0.1)x10^3$ and mean First moment $(7.4\pm2.0)x10^5$of the cortex region .

V. CONCLUSION

The texture based classification of CKD helps the Radiologist to identify the progression of CKD better when compared to the other grey level intensity based analysis. It is clear that as the damage in kidney increase the hard exudates generated by the degradation of glomorulus filter can damage the nephron ,which in turn create small projections in the cortex which can be identified by the first moment[4] feature and from the table 2 its understood that as the patient move towards ESDR the values will also increase for these parameters.

More sample images must be taken it to account fir the threshold based classification of different stages of CKD.

.

REFERENCES

[1] *Abubakr A.Sanusi, Fatiu A. Arogundade,O.C Famurewa "Relationship of ultrasnographically determined kidney volume with measuredGFR, Calculated creatinie clearanceand other parameters in CKD" ,Nephrology Dialysis Transplantation , Vol 24, Issue 5 ,May 2009,Page 1690-1694.*

[2] *Arpana M.Kop, Ravindra Hegadi, "Kidney Segmentation from Ultrasound Image using Gradient Vector Force", Recent Trends in Image Processing and Pattern Recognition,IJCA, 2010.*

[3]*B.S.Manjunath and W.Y.Ma,"Texture features for browsing and retrival of imagenadta" IEEE trans. Pattern Anal.Machine Intell.,vol,18.no.8.pp.837-842 Aug 1996.*

[4] *Chapter1" Introduction to moments"http://zoi.utia.cas.cz/files/chapter_moments_color1.pdf*

[5]*Dhaka, "Speckle Noise Reduction and Segmentation of Kidney Regions From Ultrasound Image ",Jahangirnagar University Bangladesh ,IEEE 2013.*

[6] *Dinkel E, Ertel M. Peter H ,et al. "Kidney size in childhood. Sonographical growth charts for kidney length and volume", Pediatr Radiol,1985 vol.15,page 38-43.*

[7] *Elizabeth Palermo "Chronic Kidney Disease Symptoms and Treatment" live Science March 9,2015.*

[8] *Fadi Iqbal, Aruna S, Janaka P. Wansapara , " Texture analysis of Ultrasound Image of Chronic Kidney Disease", International Conference on Advances in ICT forEmergingRegions,IEEE 2017,299-303.*

[9] *Ilangovan Veerappan, Georgi Abraham,* "Chronic Kidney Disease: Current Status, Challenges and Management in India", Chapter 130 *Chronic Kidney Disease: Current Status, Challenges and Management section 17.*

[10] *Juan L.Mateo, Antonio, Fernandez-Caballero, "Finding out General Tendencies in speckle noise reduction in ultrasound Images". Expert System with Application, vol-36, pp 7786-7797, 2009.*

[11]*Jun Xie, Yifeng Jiang and Hung-Tat Tusin,"Segmentation of kidney from ultrasound Image Based on Texture and Shape Prior",IEEE Trans,Medical Imaging , vol.24,Jan 2005.*

[12] *Renuka Marutirao Pujari, Mr. Vikas D. Hajare"Analysis of Ultrasound Images for Identification of Chronic Kidney Disease Stages" IEEE conference publications Networks & Soft Computing (ICNSC), 2014 First International Conference on Publication Year: 2014 , Page(s): 380 – 383.*

[13] Tanzila Rahman, Mohammad Shorif Uddin "*Speckle Noise Reduction and Segmentation of Kidney Regions From Ultrasound Image"* IEEE conference publications Informatics, Electronics & Vision (ICIEV), 2013 International Conference on Publication Year: 2013 , Page(s): 1 – 5.

[14] *The Hindu "Chronic kidney disease on the rise"March 8 2018.*

[15] *Tiexiang Wena,b,c,1, Qingsong Zhua,c,1, Wenjian Qina,c, Ling Li a,c, Fan Yanga,b,c, Yaoqin Xiea,c, Jia Gua,c," An accurate and effective FMM-based approach for freehand 3DUltrasound reconstruction", Elsiver, Biomedical Signal Processing and Control ,2013.*

[16] *Vivekanand Jha, Gopesh Modi"Uncovering the risk of kidney failure death in India"The Lancet Global Health ,Vol 5 ,Jan 2017.*

[17] *Wan NurHafsha, wan Kairuddin and Wan Mahani Hafizah , "Texture Feature Analysis for Different Resolution level of kidney Ultrasound Images" IOP conference series: Materials Science and Engineering ,226,2017*