A META-HEURISTIC APPROACH TUNED ARTIFICIAL NEURAL NETWORK FOR KIDNEY DISEASE DETECTION

[1]Furquan Yousuf, [2]Er. Rashmi Raj, [3]Er. Shweta Bala
[1]M.TECH, Department of ECE, UIET, IKG PTU, JALANDHAR PUNJAB, INDIA
[2]Assistant Professor, Department of ECE, UIET, IKG PTU, JALANDHAR PUNJAB, INDIA
[3]HOD, Department of Electrical Engineering, UIET, IKG PTU, JALANDHAR PUNJAB, INDIA

Abstract: - With the advancements in the technology, medical field has gained high maintenance machines and software that made the life easier. Nowadays, it is very easy to determine if the person is healthy. Among different diseases, kidney disease detection is a popular research area. These kidney diseases can be detected by using ultrasound images. Various methods such as ANN, KNN, etc. were proposed by the researchers for detecting various kidney diseases but the problem with these techniques is that the image of ultrasound get easily effected by noise and hence produce blurry ultrasound images which ultimately may lead to lead to wrong output. Therefore, these methods were not much efficacious. To overcome these issues, this paper proposes a novel method that is based on the histogram equalization technique namely Brightness Preserving Bi Histogram Equalization (BBHE) to achieve the ultra sound images with better quality. In addition to this, BAT optimization algorithm is used to enhance the classification rate of ANN that improves the overall performance of the proposed model. The proposed model is simulated in MATLAB environment and the results are obtained for accuracy, sensitivity and specificity. The comparative analysis demonstrated that the proposed BBHE technique along with the BAT optimized ANN algorithm is capable of detecting the kidney diseases by attaining high accuracy through ultrasound images.

Keywords: - Artificial intelligence, kidney disease detection, biomedical applications, machine learning, data mining, etc.

1. INTRODUCTION

In the recent past, diseases of kidney are emerged as one of the most common problems, and rapidly increasing on world level. The kidney is a body organ that helps in regulating the different levels such as pH, salts and potassium inside the body [1]. Kidneys act as a filter of the body that filters out the waste products from the body. It also removes the excess water from the body and also detoxifies the blood that get stored in the bladder by the help of kidneys and removed by the help of urination process [2]. As per a study 26 million adults in America are affected by the kidney disease. The kidney disease is a state where kidney stops functioning at required level due to any damaged condition. The cause of the damage can be due to various reasons of blood pressure, diabetes or other conditions. Due to the kidney diseases various other problems also emerge in the body. IT the condition of disease get worse, there are chances that the kidney completely stops working. In that case the only option available is the dialysis that acts as the kidney functioning. In the process of dialysis the required filtration process is carried out by a machine. It is not a kidney treatment but an artificial way of the filtration for the life support [3]. The kidney disease is further classifies into five types, as shown in fig.1

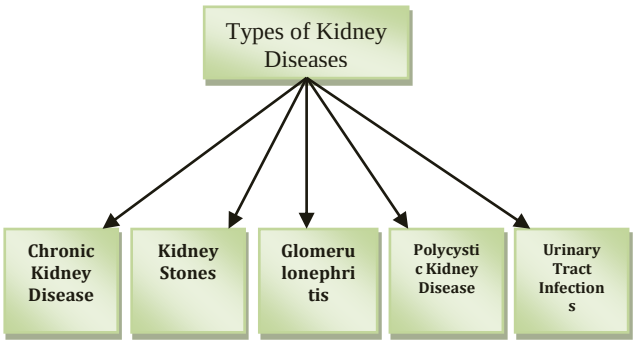


Fig.1 Types of kidney diseases

To diagnose kidney functioning, the doctors conduct various test like glomerular filtration rate (gfr), kidney biopsy, urine test, blood creatinine test, ultrasound or computed tomography (ct) scan [4]. The Ultrasound is an imaging technique that is widely acceptable and popular in the medical field in order to identify the problems like stones in the kidney. It also has other advantages such as the technique of ultrasound imagining is painless and non-invasive and does not expose body to any radiation [5]. By the help of the Ultrasound tomographic view of the organ can be taken. The ultrasound procedure can also give real time mages that can be helpful in different surgeries. Three main kinds of ultrasounds are Amplitude, Brightness, and Motion modulation also known as A, B and M modulation respectively [6]. In ultra sound a precise division of an image is required if specific objects are recognized. The segmentation is a technique of image processing which divides the area or subject [7]. Filtering is a major preprocessing step to smooth or enhance the image. Smoothing is achieved by the removal of high-frequency components and enhancement of low-frequency components. Depending on the noise, the filter should change or enhance the picture. Owing to image processing processes with speckles, ultrasound image quality decreases. A filter is

 Copyright 2021.All rights reserved.

required by proper filtering technique to remove the speckle. When converting the domain, the image pixels are converted to a frequency or time-dependent domain and after the transformation the coefficients are processed. The domain filtering process is further split into an adaptive and non-adaptable transformation. Several examples of image transformation are Fast Fourier Transform (FFT), DCT, Wavelet Transform, Curvelet Transform, Ridgelet, Ripplet Transform and Radon Transform. In certain cases, as noise reduction happens, filtering in the frequency field is simpler than in the space domain because noise in the frequency domain can be easily detected.

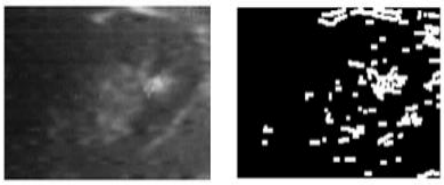
When converting the domain, the image pixels are converted to a frequency or time-dependent domain and after the transformation the coefficients are processed [8]. The domain filtering process is further split into an adaptive and non-adaptable transformation. Several examples of image transformation are Fast Fourier Transform (FFT), DCT, Wavelet Transform, Curvelet Transform, Ridgelet, Ripplet Transform and Radon Transform. In certain cases, as noise reduction happens, filtering in the frequency field is simpler than in the space domain because noise in the frequency domain can be easily detected. Furthermore, image segmentation methods can be classified into four types:-

A. Threshold-based methods:

In this method, the object of concern is segmented, as in (1).

$$f(x) = \begin{cases} 0 \; if \; x < t \\ 1 \; if \; x \geq t \end{cases} \qquad (1)$$

In above equation, x is the intensity value of the gray image and its value is mapped again to a binary value in accordance with threshold. The partitioned image f(x) is a bright object that has a dark background in two portions [9]. Important considerations are the optimum range of threshold values. The threshold value can be reached through interactive manipulation up to the appropriate segmentation or through different automated and semi-automatic methods. The regular gray picture and its threshold segmentation are shown in fig.2.

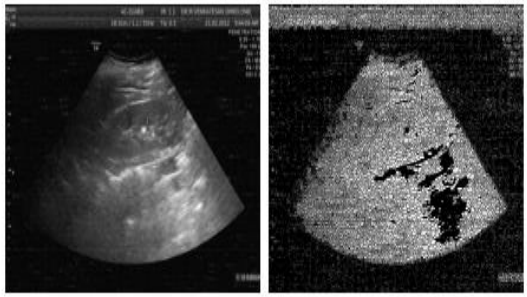


(a) (b)

Fig.2 Binary threshold of (a) Gray image (b) segmented by threshold

B. Edge detection based methods:

The segmentation by the edge of an image is the mechanism by which the area of interest is represented by its boundaries. In this segmentation method, a picture is divided by determining borders into separate objects, as shown in fig.3 [10].

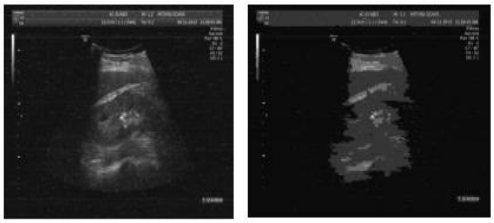


(a) (b)

Fig.3 Edge based watershed segmentation showing (a) original and (b) segmented image.

C. Region based methods:

This cycle of segmentation comprises of finding object area instead of object boundaries. In this technique, the object boundaries are marked, and the object is identified by defining the area it occupies. This method of segmentation has two important tasks called merger of regions and increasing regions. One of the two main operations is used in the segmentation algorithm. The segmentation area consists of the initial segmentation of an image and the combination of the related adjacent segments into one partition. The region's growing algorithm is used to combine segments [11]. The regional segmentation of the gray image is shown in fig.4.



(a) (b)

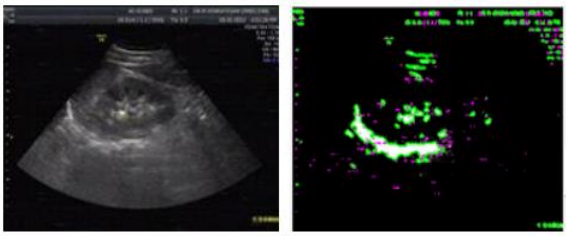
Fig.4 Region based segmentation showing original and segmented image

D. Clustering methods:

Clustering is one of the segmentation methods which try to group the images' levels of intensity. In clustering process, distance matrix has a major role. Every entry in the matrix is the distance between any two pixels of an image that has to be segmented. Partitioning and merging of data points (pixel) merging are two approaches of clustering. Each data point is considered to be an independent cluster when data points are combined. For fusion of the data points, the dissimilarity matrix is formed. The least dissimilar entry in the matrix is grouped into a cluster. The total distance from data points to the respective cluster centers is minimal in partition-based clustering. One way to achieve this is K-means clustering algorithm. The number of required clusters must be set in advance for K-mean clustering. Clustering with fuzzy c-means is another popular image segmentation cluster

 Copyright 2021.All rights reserved.

algorithm used in many medical applications [12]. The FCM segmentation of the image is delineated in fig.5.



(a) (b)

Fig.5 Clustering methods (a) original image and (b) FCM segmented image.

2. LITERATURE REVIEW

A variety of studies have looked at how ultrasound images can be used to identify and segment kidney disease. Among them, some of the works are examined in this paper: A. Nithya, et al. [13], the author had proposed the detection of kidney stones applying the artificial neural network as well as the segmentation utilizing the algorithm of multi-kernel k-means clustering. . Initially, the author removed the disturbance existing in the input picture by applying the median filter. Then, the author discovered the essential features of the GLCM from the picture. Lastly, the picture of abnormal is specified to the stage of segmentation section stone and tumor part differently applying the algorithm of multi Kernel K-means clustering. Moreover, Shi Yin, et al. [14], proposed the consequent boundary distance regression as well as the classification of the pixel networks to the automatically segment the kidneys. The author had adopted a data-augmentation technique dependent on the shape of the kidney registration to produce the enriched training information from the minimum number of Ultrasound images with the manually division of kidney labels. Primarily, Fuzhe Ma, et al., [15], Heterogeneous Modified Artifical Neural Network (HMANN) had been proposed for the segmentation, early detection, and diagnosis of chronic renal failure on the IoMT (Internet of Medical Things) platform. Moreover, the proposed HMANN was classified as a Support Vector Machine and Multilayer Perceptron (MLP) through the algorithm of a Backpropagation (BP). Similarly, Priyanka, Dharmender Kumar [16], researchers gives more attention to preprocessing and discovering the feature as well as the selection phase of kidneys' US images as making the classified model. Moreover, Jean-Michel Correas, et al. [17], authors stated that ultrasensitive Doppler enhanced the recognition of blood flow as well as applied alone or after the supervision of Ultrasound contrast agents. Furthermore, M. B. Subramanya, et al. [18], computer-aided diagnostic system was proposed by authors of this paper to classify normal and medical renal disease using B-mode ultrasound images. In addition K. Dhanalakshmi and V. Rajamani [19], Implemented a technique that integrates discovery of low-level features from pictures with high-level information provided by the expert in order to instruct the latest renal image diagnosis. Similarly, E. Jokar and H. Pourghassem [20], proposed the Shape prior algorithm, to divide the kidney's tissue, signed distance and to improve the picture and remove the noise, by using the nonlinear function on the CT coefficients. S. Sudharson and P. Kokil et al. [21], this paper deals with the automated recognition of kidney abnormalities by applying the joint MSVM classification model. The pre-trained CNN (convolutional neural networks) were applied to discover the features automatically from the ultrasound images of the kidney. The discovered features were specified to the joint multiple-support vector machine model. This model was manufacture by integrating the MSVM so that good quality of classifier was obtained. The Ultrasound picture of the kidney was divided into abnormal and normal classes. K. Bommanna Raja and M. Madheswaran [22], developed a set of unconstraint features that are independently modified in the kidney area for the automatic diagnosis as well as classification of kidney categories. The author classified the renal as abnormal and normal cases. Divide the kidney region and discovered the features of Intensity histogram as well as Haralick features from GLCM (Gray Level Cooccurnace Matrix). These types of features were evaluated for the large set of data consisting of both abnormal and normal cases.

From literature study it is analyzed that Kidney diseases have recently emerged as one of the most common issues growing around the world. From this study it is analyzed that kidney damage may be caused due to various reasons such as high blood pressure, diabetes, glomerulonephritis etc. Since kidney failure is a life- threatening disease it is best to get a diagnosis as soon as possible. Most of the researcher working with ultrasound images to recognize the current state of kidney. But as the ultra sound images may get impacted from the noise the quality may get degraded. This can cause poor quality image which makes the processing complex and difficult. Therefore, it is required to work on maintaining the quality of the image and its content. For this enhancement approaches can be considered. Other than this the traditional model were using ANN, SVM etc. machine learning approaches those are used to identify and segment the kidney disease. But few of the literatures are presented that provide information about tuning of these classifiers. Thus the conventional classification techniques can be improved by tuning its training parameters. In this article a solution to these issues is provided with tuning of conventional neural network.

3. Present Work

As discussed in the previous section that ultrasound imaging strategy is used for detecting different types of kidney diseases. But there are certain factors like noise, and poor image resolution which makes the processing of ultrasound complex and difficult. Therefore, these problems need to be addressed in order to enhance the visualization of

 Copyright 2021.All rights reserved.

ultrasound images. To do so, we proposed a technique that's based on the histogram equalization. In this research, we used the Brightness Preserving Bi-Histogram Equalization (BBHE) technique to improve the contrast in ultrasound images by preserving the mean brightness of the image. Furthermore, in order to enhance the accuracy of classical ANN systems we need to perform tuning in them. From the literature survey, it is analyzed that by varying weights in ANN systems the performance of the system also changes. Therefore, need of developing an algorithm that can update these weights automatically arises. For this we considered a number of metaheuristic algorithms among them we selected BAT algorithm for updating weights automatically because of its advantages over other metaheuristic algorithms. The detailed description on why these techniques were used in our proposed method is given in this section.

A. BBHE (Brightness Preserving Bi Histogram Equalization)

BBHE technique parts the image's histogram into two freely evened out parts. This technique equalizes both the parts independently. This is the approach by which the intensity of the partitions is given by the average light value of the input picture and is the average intensity of all of the pixels that combine to form the image provided by input. After that, BBE autonomously sets the sub-figure with its respective histograms in the condition of mapping the correct samples to a range from base gray level to the average information and mapping the instances in the last set to a range from the aversion gray to the average gray level. The first part of sub image contains the pixels values which are up to the mean and the second part contains pixels which are above the mean of original image. The main advantage of using this method is that BBHE enhances the input image that's used for the consumer electronic while preserving the mean brightness, mean brightness of the image is preserved by improving the contrast of image.

B. BAT algorithm

The BAT algorithm (BA) is used because BA has a distinct advantage over other metaheuristic algorithms. That is, BA has a capability of automatically zooming into a region where promising solutions have been found. This zooming is accompanied by the automatic switch from explorative moves to local intensive exploitation. As a result, BA has a quick convergence rate, at least at early stages of the iterations, compared with other algorithms. Also, BA uses parameter control, which can vary the values of parameters (A and r) as the iterations proceed. This provides a way to automatically switch from one exploration to other when the optimal solution is approaching.

This section presents the methodology and steps followed to implement the proposed model. In the initial phase of implementation, data is collected in form of ultra sound images. The next phase was to preprocess these images to extract the useful information to train the classification section. One of the dataset sample is shown below in fig.4 that demonstrates the original image to be processed.

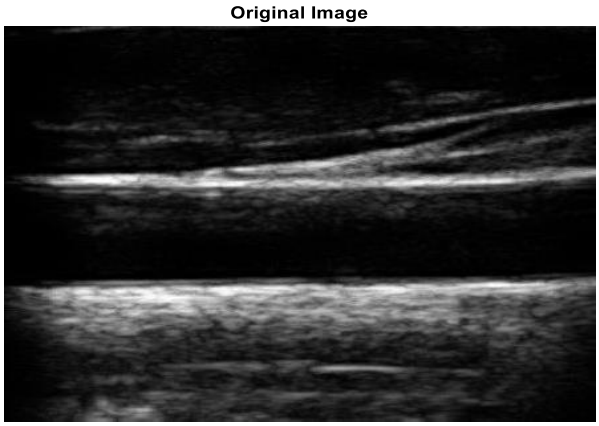


Fig.4 Original ultrasound image

Once the image is selected to be processed, the next phase is to apply the BBHE histogram equalization approach. After performing the operation, the visualization of enhanced image is shown below in figure 1.3, the output image demonstrates the content of image get more brighten and informatics to extract the information for further processing.

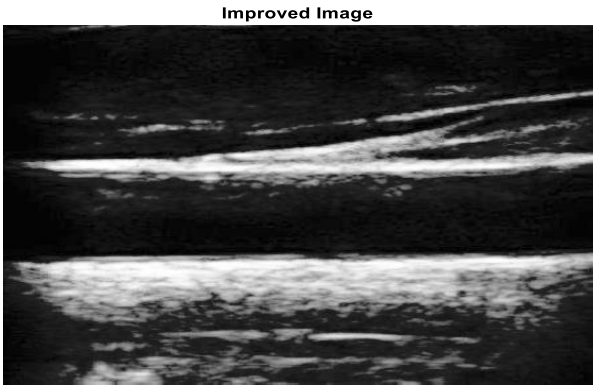


Fig.4 Improved image

From both the images in fig (2 and 3), it can be seen that the original image is having poor quality, and after implementing the proposed BBHE approach along with the BAT algorithm, a better version of original ultrasound image is obtained that have an improved visualization as compared to original one.

The above-mentioned process is applied to the whole dataset. Then, the features are extracted from the enhanced images. The model utilizes these extracted features for training and testing purpose. For training purpose, neural network is initialized and training dataset is given to it. The weights are then initiated in the ANN model. With the help of the BAT optimization algorithm, the value of these weights is changed continuously unless and until the classification error rate in the proposed system is reduced. Once the optimized weights are achieved these optimized weights are embedded to the ANN model. Thus, the final trained network with optimized weights is further used for the testing purpose and on basis of the predicted results the performance of the system is

 Copyright 2021.All rights reserved.

evaluated in terms of accuracy, sensitivity and specificity that is discussed in the next section.

4. RESULT AND DISCUSSION

The main motive of this research is to detect the kidney disease from ultrasound images by improving the image quality and classification rate of ANN. In order to enhance the quality of ultrasound images BBHE technique is used Along with this, BAT optimization algorithm helped in tuning the ANN weights to increase the detection accuracy. The simulations are performed in MATLAB software and the results obtained are mentioned in this section.

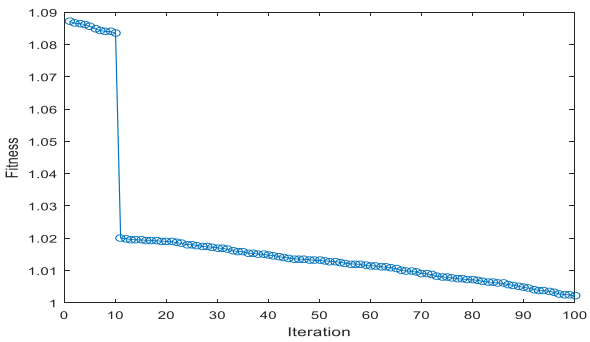


Fig.4 Fitness function of the proposed approach

Fig.4 demonstrates fitness values of BAT optimization in terms of the classification error rate for proposed tuned ANN system. In the graph, the y-axis represents the values of fitness that ranges from 1 to 1.09, and the x-axis represent the varying iteration numbers ranging from 0 to 100. From the graph it is observed that, at the beginning of the error rate of the classifier was near to 1.09 which after a number of iterations of BAT algorithm get reduced near to 0. The iterations are performed continuously till the classification error rate is decreasing. Thus, proving that by changing the weights of ANN classifier the performance of system gets improved.

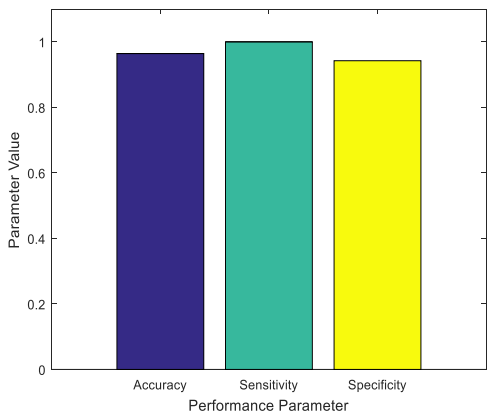


Fig.5 Performance parameter values

The performance of the proposed model is further analyzed in terms of the three main performance parameters i.e. accuracy, sensitivity and specificity. The values of these parameters for the proposed approach are shown as a bar graph in figure 1.4. The purple color bar depicts the accuracy of the proposed model while as the sky-blue and the yellow colored bars represent the sensitivity and the specificity of the proposed model. By analyzing the graph, it is observed that the accuracy of the proposed approach comes out to be 0.964, specificity is 0.94 and sensitivity is 1. Thus, these high values of accuracy, sensitivity and specificity demonstrate the high efficiency and stability of the proposed neural model. Furthermore, the performance of the proposed system is compared to the previously proposed techniques such as ANN, KNN and Naïve Bias in terms of accuracy, sensitivity and specificity. Table 1 represents the exact values of these various parameters for different schemes.

Table 1: illustrates values of parameters for different approaches

Algorithm	Accuracy (%)	Specificity (%)	Sensitivity (%)
ANN	83.6400	89.7000	63.5700
KNN	84.6100	90.0000	66.6600
Naïve bias	93.4500	90.0000	100.00
Proposed	96.4300	94.2300	100.00

The values recorded in the above table are depicted in terms of accuracy; the proposed approach is the most efficient technique than all other conventional ones as it has the higher value of accuracy i.e. 96.43 %, however, that of conventional ANN, KNN and Naïve bias is 83.64 %, 84.61 % and 93.45 % respectively. Also, in terms of specificity and sensitivity, the proposed approach has the highest values i.e. 94.23 % and 100 % respectively when compared to other techniques, which demonstrates the efficiency and stability of the proposed model.

5. CONCLUSION

In this research a technique is presented to detect kidney diseases using ultra sound images. It is very important to achieve accurate results in medical field when it comes to technology as it affects the patients' lives. Various techniques were proposed by a number of researchers in order to detect different kidney diseases but it is analyzed that these techniques faces issue related to the quality of ultra sound images. In order to enhance the quality of ultra sound images, we proposed a technique that is based on Histogram equalization. To improve the visualization of ultrasound images, BBHE technique is used. In addition to this the ANN network bears the responsibility of processing the data extracted from the images to detect the disease but it lacks in some aspects, thus by applying optimization technique over the network, the output of the model is improved. The performance of the proposed model is analyzed in the MATLAB software under three parameters i.e. accuracy, sensitivity and specificity. The simulation results were compared to the previously proposed techniques like ANN,

 Copyright 2021.All rights reserved.

KNN etc. and it is observed that the proposed model works more efficiently and effectively as compare to these techniques. Thus, proving the supremacy of the proposed method while detecting kidney diseases.

REFERENCES

[1] Dirks, J., Remuzzi, G., Horton, S., Schieppati, A,. "Disease Control Priorities in Developing Countries", New York: Oxford University Press. pp.695-706; 2006.

[2] A. Maurya, R. Wable, R. Shinde, S. John, R. Jadhav and R. Dakshayani, "Chronic Kidney Disease Prediction and Recommendation of Suitable Diet Plan by using Machine Learning," 2019 International Conference on Nascent Technologies in Engineering (ICNTE), pp.1-4, 2019.

[3] Shannon Johnson, "Kidney Health and Kidney Disease Basics", healthline, 2018.

[4] Frank O'Brien, "Overview of Kidney Filtering Disorders", MSD Manual Consumer Version, 2020.

[5] S. Sudharson and P. Kokil, "Abnormality classification in the kidney ultrasound images using singular value decomposition features," 2019 IEEE Conference on Information and Communication Technology, pp.1-5, 2019.

[6] N. A. Zulkiflli et al., "Ultrasound Tomography Hardware System for Multiphase Flow Imaging," 2019 IEEE International Conference on Signal and Image Processing Applications (ICSIPA), pp.264-268, 2019.

[7] G. Chen et al., "Prediction of Chronic Kidney Disease Using Adaptive Hybridized Deep Convolutional Neural Network on the Internet of Medical Things Platform," in IEEE Access, vol. 8, pp. 100497-100508, 2020.

[8] Gonzalez, RC & Richard Ewoods, "Digital image processing", Prentice Hall, pp.1- 976, 2002.

[9] Maintz, T, "Digital and medical image processing", Universite it Utrecht, 2005.

[10] C. Ho et al., "Ultrasonography Image Analysis for Detection and Classification of Chronic Kidney Disease," 2012 Sixth International Conference on Complex, Intelligent, and Software Intensive Systems, Palermo, Italy, 2012, pp. 624-629, 2012.

[11] Shi Yin, "Automatic kidney segmentation in ultrasound images using subsequent boundary distance regression and pixelwise classification networks", Medical Image Analysis, vol 60, pp.1361-8415, 2020.

[12] Siavash Alipour & Jamshid Shanbehzadeh, "Fast automatic medical image segmentation based on spatial kernel fuzzy c-means on level set method", Machine Vision and Applications, vol.25, pp. 1469-1488, 2014.

[13] A. Nithya, et al., "Kidney disease detection and segmentation using artificial neural network and multi-kernel k-means clustering for ultrasound images", Elsevier, 2019

[14] Shi Yin, Qinmu Peng, Hongming Li, Zhengqiang Zhang, Xinge You, Katherine Fischer, Susan L. Furth, Gregory E. Tasiand, Yong Fan, "Automatic kidney segmentation in ultrasound images using subsequent boundary distance regression and pixelwise classification networks", Medical Image Analysis, vol.60, 2020.

[15] Fuzhe Ma, Tao Sun, Lingyun Liu, Hongyu Jing, "Detection and diagnosis of chronic kidney disease using deep learning-based heterogeneous modified artificial neural network", Future Generation Computer Systems, Vol 111, pp. 17-26 , 2020.

[16] Priyanka, Dharmender Kumar, "Feature Extraction and Selection of kidney Ultrasound Images Using GLCM and PCA", Procedia Computer Science, vol.167, pp 1722-1731, 2020

[17] Jean-Michel Correas, Dany Anglicheau, Dominique Joly, Jean-Luc Gennisson, Mickael Tanter, Olivier Hélénon, "Ultrasound-based imaging methods of the kidney—recent developments", Kidney International, vol.90, pp 1199-1210, 2016

[18] M. B. Subramanya, V. Kumar, S. Mukherjee and M. Saini, "Classification of normal and medical renal disease using B-mode ultrasound images," 2015 2nd International Conference on Computing for Sustainable Global Development (INDIACom), pp. 1914-1918, 2015.

[19] K. Dhanalakshmi and V. Rajamani, "An efficient association rule-based method for diagnosing ultrasound kidney images," IEEE International Conference on Computational Intelligence and Computing Research, Coimbatore, pp. 1-5, 2010.

[20] E. Jokar and H. Pourghassem, "Kidney Segmentation in Ultrasound Images Using Curvelet Transform and Shape Prior," 2013 International Conference on Communication Systems and Network Technologies, pp. 180-185, 2013.

[21] S. Sudharson and P. Kokil, "Abnormality Detection in the Renal Ultrasound Images using Ensemble MSVM Model," 2019 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET), pp. 378-382, 2019

[22] K. Bommanna Raja and M. Madheswaran, "Determination of kidney area independent unconstrained features for automated diagnosis and classification," International Conference on Intelligent and Advanced Systems, pp. 724-729, 2007.

 Copyright 2021.All rights reserved.