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Artificial Neural Network Based Detection of Renal Tumors using CT Scan Image Processing

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ABSTRACT

The segmentation, as well as analysis of renal tumor, is important to step which is performed by the doctor while deciding the stage of cancer and finding the appropriate method of its treatment. This paper determines a novel approach in order to develop an algorithm which helps in detecting and analysis of renal cancer tumors. The developed algorithm has been employed to segment and pre-processes the image for its better visualization and segment the visible tumor. The pre-processing has a hybrid filter for image enhancement and noise removal. An artificial neural network is also used by Hybrid Self Organizing Maps. It uses the clustering of image data to highlight the detected region. The appropriate output is obtained according to the medical field and it is compared with the resultant image to improve the algorithm. It helps in understanding the affected region in the human body and for better visualization. A region growing method is also applied for finding the same intensity images in images and to segment out the tumor from the processed image. The objective of this paper is to create a CT image database and then apply pre-processing methods on the image. The image segmentation is done by using Haar wavelet. The boundary is also detected by using canny. The feature extraction is applied to the image on the basis of shape, intensity, and texture and after that Fuzzy clustering is applied to get the optimized segmented image.

Keywords: *Renal tumors, Region growing, MRI, CT scan, ultrasound, ANN, Image Processing, Region Growing, SOM*

INTRODUCTION

The Kidney cancers are one of the most common disorders of the urinary tract. Kidney cancer problem occurs as a common problem to every men and woman in India, due to the nature of living. A kidney cancer termed as renal carcinoma is a solid or fluid form in a kidney when substances that are normally found in the urine become highly concentrated. Renal Cancer may occur in the kidney or travel down the urinary tract. The size of the tumor varied from smaller, medium and larger size, as per the diagnosis, if in early stages not diagnosed, growth is to higher. When the size of the cancer is smaller, it may pass on its own, causing little or no pain in the body [1].

Kidney cancer starts in the kidney. Cancer starts when a cell in the human body starts to grow and become out of control. The cells in any part of the body can become cancer and also can spread to some other areas. Most kidney cancer occurs in adults is known as renal cell carcinoma. It forms in the lining of small tubes in the kidney. Cancer mainly found in the center of the kidney which is known as transitional cell carcinoma. Wilms tumor is a kidney cancer from which young children are suffered [2].

The human body has numerous cells. These cells grow and divide for making a body healthy. When the growth of the cell becomes uncontrollable then the extra mass of the cell transforms into the tumor. For identification of tumor, MRI and CT scan are used. The aim of the system is to detect kidney tumor by pattern analysis, image processing and computer vision techniques for segmentation, enhancement, and classification for kidney diagnosis. This system can be used by specialists in healthcare and radiologists. This system helps in improving the specificity, sensitivity, and efficiency of kidney tumor screening [3].

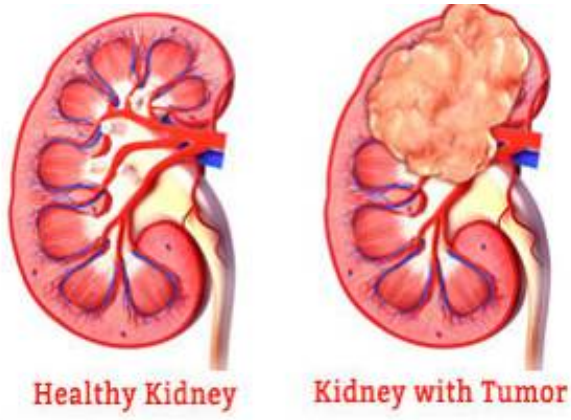

Figure 1: Kidney Cancer [4]

1.1 Symptoms of Kidney Cancer

The kidney cancer is also known as renal cancer which is a disease in which cells of the kidney become malignant and grow out of control that forms a tumor. All the kidney cancer appears inlining of tiny tubes firstly in the kidney. it is known as renal cell carcinoma. Most of the kidney cancer can be determined before they spread to other organs of the body. Cancer can determine at early stages for its better treatment successfully. The tumors can grow large as they were detected. The shape of the kidney is bean-shaped. They lie in the lower abdomen on each side of the spine. Its major job is to clean the blood as well as to remove the waste products and make it urine [5].

The kidney cancel mainly relies on causes signs as well as symptoms in its initial phases or stages. There were no routine tests were used in order to screen kidney cancer in the absence of any symptoms for it. Kidney cancer symptoms and signs in later stages include loss of appetite, pain inside or back which does not go away, blood in the urine that may appear red, pink or cola colored, fever that comes and goes, tiredness and unexpected weight loss [6].

There are several factors that enhance the risk of kidney cancer such as older age, smoking, obesity, high blood pressure, kidney failure, inherited syndromes, family history of kidney cancer and exposure to some substances in the workplace which includes specific herbicides and exposure to cadmium. The people who were having a strong family history of kidney cancer have a greater risk even in the absence of inherited syndrome [1].

It starts when there is any change in DNA structure in cells. A genetic mutation also causes cells to grow in an uncontrollable way which produces tumor cells. Cancer grows as well as spreads through the lymphatic system with a series of glades or nodes that exist throughout the whole body. The renal cell carcinoma begins in the cell which lines the tiny tubes of the nephron. Normally, tumors grow as a single mass but several times, one tumor can grow in one kidney or both the kidneys [7].

The transitional cell carcinoma develops in tissue in the form of tubes. These tubes connect the kidney to the bladder. This cancer begins in ureters and in the bladder. Cancer that caused in childhood is Wilm's tumor. It is caused by inactivation or loss of tumor suppressor gene known as QT1 on chromosome11. The tumor mainly suppressed genes and suppress control of cell growth and tumor growth [8].

1.2 Magnetic Resonance Imaging Scans

The Magnetic resonance imaging uses strong magnets and radio waves rather than using x-rays. The energy from these radio waves was absorbed and then released. It provided a detailed image of inside the body that helps in the diagnosis of disease. It forms such type of pattern by certain diseases and by the type of tissue. A computer transplants the pattern of the radio waves that are given off by the tissue into a detailed information image of inside the body. It also creates cross-sectional slices of the body like CT scanner which makes the slices that are parallel with the length of the body [9].

The MRI scan is a tube which is surrounded by a giant circular magnet. A patient is placed on the moveable bed and it is inserted into the magnet. The magnet makes a strong magnetic field which aligns proton of the hydrogen atom that exposed to a beam of radio waves. It spins proton in the body and produces a faint signal. These signals were detected by the receiver portion of an MRI scanner. A computer processes the information and generates an image [9].

The scans of magnetic resonance imaging help for looking at spinal cord and brain. According to some doctor, magnetic resonance imaging is a better way to determine the growth of endometrial cancer in the human body of the uterus. The MRI scans help in determining enlarged lymph nodes with a technique which uses tiny particles of iron oxide. It is given into vein that settles into lymph nodes in which they can be spotted by magnetic resonance imaging. MRI scans are not used often to look for kidney cancer [9].

1.3 CT SCANS (Computed Tomography)

Computed tomography is a producer of X-ray which used a computer in order to produce a 3D cross-sectional images inside the body. It provides the exceptional detail images of organs, images, and tissues. X-rays are taken from several angles and then combines to make a cross-sectional image. A patient rest on a table during a CT scans which slides into the large and tunnel-shaped scanner. Some tests need a contrast dye that needs to be injected into a vein before the procedure. It helps in making the image better. This procedure is painless and only take a few minutes. It is also used to pinpoint the tumor and to determine the extent of cancer in the body and to access the disease responding to its treatment. Basically, CT technology is used for accurately guiding the treatment of cancer during a procedure [8].

1.4 Ultrasonic Image

Sound wave uses ultrasound (ultrasonography) in order to create an image on a video screen. It also screens test for the patients. The trained experts and clinicians can only handle ultrasound. Ultrasound of the kidney uses a handheld probe known as a transducer. It sends out ultrasonic sound waves at too high frequency to be heard. The ultrasonic sound waves move in the skin and other tissue of the body to the organs and structures of the abdomen when the transducer is placed at a certain angle and locations on the abdomen. The rate of change in the velocity is translated by the transducer in various types of tissues when waves are returned to the transducer. Blood flow to the kidney can be assessed during an ultrasound procedure with the help of an additional mode of ultrasound technology [10].

RELATED WORK

R. Gomalavalli, et al. (2017) described feature extraction of tumor in the kidney by implementing Fuzzy inference system. Kidney disease known as renal cell carcinoma is one of the common problems of men and women in their daily lives. The aim of this paper is to propose a computer-aided diagnosis prototype that helps in the early detection of cancer. It helps to change the diet condition as well as prevention from the formation of a tumor. The proposed work is based on pre-processing, image acquisition, feature extraction, and classification, boundary segmentation. Rental CT image is diagnosed in the initial stage for the presence of renal carcinoma and level of its growth that measured in sizes. For designing the fuzzy membership functions, the extracted features were taken as input in order to compare the accuracy. The results were based on the threshold variations, texture feature values, size of the extended tumor from rental CT image samples. The boundary detection of morphological operation and renal segmentation helps in

diagnose the absence and presence of carcinoma and renal cyst. It results in early detection of tumor formation in the kidney. It also improves the accuracy rate of the classification [2].

P. Upadhyay, A. Sharma, and S. Chandra (2018) presented a novel approach of Intuitive K-means Clustering in ultrasound images for rental calculi detection. For discrete boundaries, medical images are too fuzzy. In this paper, the authors presented fuzzy rule-based point optimization with image segmentation in the K-mean clustering method. The prior information helps in determining the target seed point and to elongate the cluster class for the detection of the renal calculi which is known as kidney stone. The kidney is known as the source of the source organ for urology disorder that can be protected by the efficient kidney stone detection technique using ultrasound images. The proposed clustering method helps in decreases iteration in order to elaborate the region in entitled images. The proposed approach provides an accurate solution for the ultrasound images. This method helps in enhancing the image retrieval than classical clustering method. The results show the effectiveness of the proposed method by decreasing the computational time without affecting the quality of segmentation that can be validated by peak signal value to noise ratio value. The results of this paper are validated with six classes of renal calculi on 150 Ultrasound image samples [3].

M. Devi and R. Malathi (2017) presented kidney abscess segmentation as well as detection on computer tomography data. In this paper, the authors proposed a kidney segmentation method for Computed Tomography for data of patient who were having kidney cancer. The segmentation process in this paper is based on the Hybrid Level Set method with some elliptical shape constraints. A fully automated technique is also used for classification of the kidney by using segmentation results. Vascular tree and tumor are based on detection trees techniques and RUSBoost for identification of the kidney. The proposed approach helps in solving the problem that is connected with region classification. The classification is based on a 64-element feature vector which is calculated for the kidney region. This region consists of an orientation, 3D edge region, and spatial neighborhood information. This method was evaluated on the clinical kidney cancer CT data set. The result indicated that segmentation is effectiveness in Dice coefficient and equal to 0.85≠0.04. It is also found that the proposed classification provides 92.15 accuracies [5].

L. Broncy and P. Paterlini-Bréchot (2018) presented circulating tumor cells for the management of the renal cell carcinoma. The renal cell carcinoma is malignant cancer which will provide the benefit to innovative market in early diagnosis as well as recurrence detection. The circulating tumor cells provide a market for tumor invasion that helps in improving the management of patients using RCC. The clinical and analytical studies are an appropriate approach in RCC patients for highly sensitive CTC detection. It is also relevant for clinicians and helps to RCC patients. RCC is used to study the relationship between genetic cellular markers and cytomorphological of malignancy which is the issue of CTC from solid cancer [6].

S. di Martino, et al. (2018) presented new models as well as an approach for personalizing the theory of renal cancer. This paper shows the predictive molecular models and indicators for therapy decision making for renal cancer patient management. In this paper, the authors developed new models as well as tools for ameliorating renal cancer patient management. They isolate fresh tumor specimens from heterogeneous multi-clonal populations which show mesenchymal and epithelial characteristics that couples to stem cell phenotype. This cell retained long-lasting tumor-propagating capacity. It provides therapy monitoring approach in vivo and vitro that able to form parental tumors when serially transplanted and orthotopically injected in immunocompromised murine hosts. The high-grade neoplasias result in the efficient serial transplantation mainly in mice. The engraftment recurrence frequency and capacity paralleled grading advocate for the prognostic value of the developed model system. Reverse-Phase Protein Arrays (RPPA) is used in this paper in order to analyze phosphorylated proteins in isolated populations in search of molecular indicator for therapy decision-making. The results indicated that analysis of tumor-propagating cells helps in improving the prediction of therapy assignment and disease progression [7].

C. Kubendran and R. Malathi (2017) presented a neural network which is based on segmentation of kidney from MRI images. Robust and automated kidney segmentation from the medical images is difficult due to the gray level similarities of adjacent organs, injections of contrast media and partial volume effects. The variations in kidney positions, shapes, and gray levels make the automated segmentation and identification of kidney difficult. The various image characteristics with various scanners enhance the difficulty of segmentation. In this paper, the authors presented an automated kidney segmentation method using a multi-layers perception approach. The efficient segmentation performance is achieved by taking the information from the segmented kidney image. The proposed approach is efficient for processing time but it does not include training stages and pre-processing because they are time-consuming. The unsupervised segmentation approach removes the problem of neural network based approaches which depend on selecting data in training stages [9]

B. Shah et al. (2017) presented classification and segmentation of kidney tumor on abdominal CT scans. The authors present a systematic study of simple segmentation as well as classification algorithms for a tumor in the kidney by using computed tomography images. The kidney tumors having different types and different characteristics. The treatment of various types of tumors is also different. It is very important to detect the tumor and to classify its early stage for their appropriate treatment. The CT scan of the tumor can be examined by the physician for detection as well as the diagnosis of a tumor in the kidney. The method presented in this paper lacks accuracy as well as the detection of the size of the tumor. The accuracy in the results was obtained by incorporating noise removal steps by doing the fuzzy c means clustering. The final stage of tumor detection helps in deciding whether the tumor is cancerous or non-cancerous. The classification is done by designing the neural network with the help of KNN and by implementing the SVM algorithm. The result indicated that improvement in algorithms can be done by training the network and more image features by rigorous testing [10].

D. Moitra (2018) presented the comparison of various multimodal tumor image segmentation techniques. The use

of multimodal imaging is increasing for the classification of tumors in the human body. Segmentation is known as one of the most important steps for the classification process. A benchmark study is needed for considering the leading segmentation techniques. This paper helps in selecting the better segmentation technique. The result indicated that Watershed segmentation and Active Contour techniques are useful. It also shows that the performance of other techniques was not consistent. FCM is also an effective method for segmenting Renal tumors or Head & Neck Tumors. In the future, some other prominent multimodal imaging techniques like MRI-PET is also used [11].

P. G Hiremath, et al. (2016) detect renal tumors by artificial neural network using CT scan image processing. In this paper, the authors proposed a divide and conquer algorithm for growing SOM to ANN and cluster to check whether the tumor is malignant or benign. The result indicated that the average execution time is 0.85 sec according to a method that iterates dynamically until the coverage is reached to data sets. The probable error value is increased and increased and make a more efficient algorithm to improve the complexity of the algorithm. It is found that the proposed method compromised the accuracy of the clustering. The medical procedures rely on the accuracy of the clustering that maintains a low level of the probable error values. The feature extracted will be useful in case of renal ureter bladder CT scans for recognizing the normal or abnormal images by testing and training using classifiers. The various values were obtained by various methods of the segmentation. This method shows the variation in the feature value for the same type of image. The feature extracted method of segmentation helps in decreasing the false positive result and for efficiently detecting the infiltration areas of CT scans [12].

PROBLEM FORMULATION

The detection and analysis of renal tumor detection are one of the important steps for doctors. It helps in deciding the stage of the cancer and the method for the treatment of tumor. There are different types of kidney tumors that were having different characteristics. The treatment of kidney tumor still one of the biggest challenge in the field of biomedicine. It is very important to detect kidney tumor and classify it at an early stage so that appropriate treatment of kidney tumor can be planned.

In this research, Fuzzy C means algorithm is used which helps in early detecting of kidney tumor. The proposed algorithm has been employed to pre-process as well as segment the image for better visualization of images and for the segmentation of visible tumor. The pre-processing that involve in the hybrid filter is used for image enhancement and noise removal.

METHODOLOGY

For the implementation of research objectives, the following steps were considered:

- To read the image imread() function is used.
- For preprocessing the image is converted into grayscale using rgb2gray() function.
- After that filtering and image sharpening is done using wiener2() and imsharpen ().
- After the image preprocessing the Discrete Wavelet Transform of 2-Dimensions is performed on the image using dwt2() function with the haar parameter.
- After that edge detection is done using edge() function using canny parameter.
- After that, the Fuzzy c means clustering is performed using fcm () function with 4 clusters.
- After that select, the anyone from the 4 images obtained convert it into a binary image and remove the unwanted small blobs using bwareaopen() command.
- Then extract the features using PCA and DWT (such as Contrast, Energy, Correlation, etc).

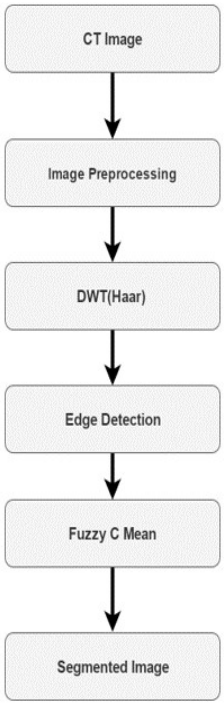

Figure 2: Flow Chart

In the above flowchart, the methodology of research work is shown. In this, the Weiner Filter was used for noise filtering. It minimizes the overall mean square error in the process of noise smoothing and inverse filtering. DWT decomposed an image into two levels such as coarse approximation and detail information each half of original length. Average running sub signal is known as a trend and the difference running sub signal is known as fluctuation. DWT Haar transform is simple and low cost and easy to apply. Fuzzy C Mean Clustering assigns membership to each data point corresponding to each cluster center on the basis of the distance between the data point and the cluster center. In this one piece of data can belong to two or more clusters with varying degrees of membership.

FCM is based on the minimization of the following objective function

$$J_m = \sum_{i=1}^{D}\sum_{j=1}^{N} \mu_{ij}^{m} \|x_i - c_j\|^2,$$

Where,

D is the number of data points, N is the number of clusters, m is fuzzy partition matrix exponent for controlling the degree of fuzzy overlap, X_i is the ith data point, cj is the center of the jth cluster and μ_{ij} is the degree of membership of x_i in the jth cluster. For a given data point, x_i, the sum of the membership values for all clusters is one [13].

RESULTS AND DISCUSSIONS

In this section, we are performing CT scan image processing in order to detect renal tumor based on artificial neural network. It helps in determining whether the proposed method is efficient in detecting a tumor or not. We have shown the results with images after applying the image processing techniques. Figure 3 shows the original image of the kidney in which we have to detect the presence of a tumor. The renal tumor is detected by performing some operations and analysis of obtained results.

Figure 3: Input Image

In the input image, image processing is performed and filtered is applied to it for better visualization of the image. Figure 4 shows the filtered image. After that, the image is sharpened to view the boundary of the kidney. It helps in visualization of everything in the kidney that will help in detecting the renal tumor easily.

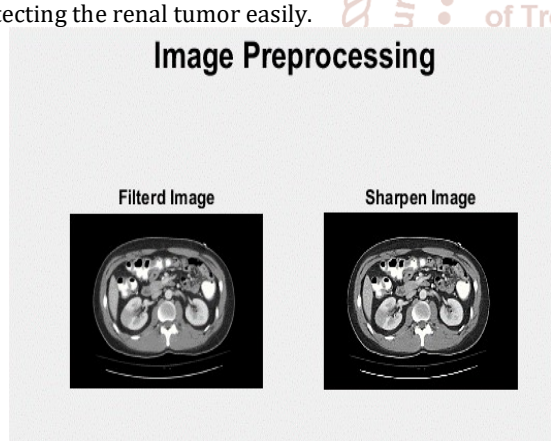

Figure 4: Pre-processed Image

After applying pre-processing, DWT transform is applied to the image which helps in the compression of the image. Figure 5 shows the horizontal view, vertical view, and diagonal view image after performing the DWT transform.

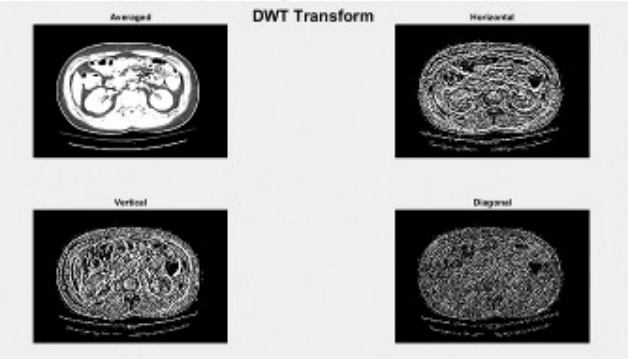

Figure 5: DWT (Haar)

fter that segmentation is applied to the image in which image of both the kidney is segmented so that we can detect the exact location of the tumor in this kidney. If the exact location of the tumor is determined, then it helps in its treatment.

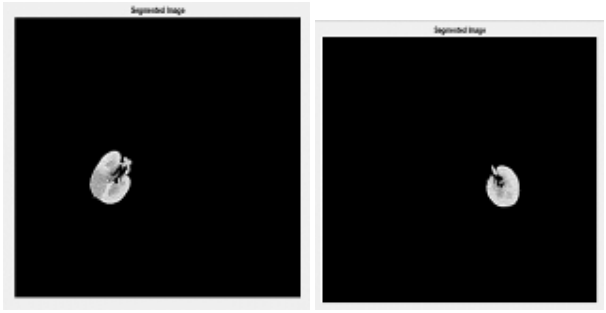

Figure 6: Segmented (Kidney 1 and Kidney 2)

Figure 5 shows the images after performing Fuzzy C mean clustering in kidney 1. The clustering helps in detecting the exact location of the tumor in the kidney.

Figure 7: Fuzzy C Mean Clustering (Kidney 1)

The below image shows another original image of the kidney from which tumor is needed to detect

Figure 8: Test Image 1

The below image shows the segmented image of the kidney in which the tumor is present after performing the pre-processing operation.

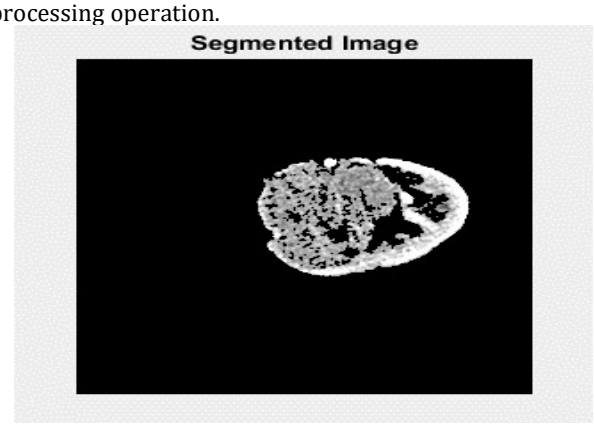

Figure 9: Segmented Kidney In Which Tumor Present

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ans =

Chromophobe  Renal Cell Carcinoma Tumor
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There are mainly three types of tumor. In the last step, we match the characteristics and features of the segmented image with the three different types of tumors. The features and characterizes of the obtained image is matched with Chromophobe renal cell carcinoma tumor. So, the Chromophobe renal cell carcinoma tumor is present in the given input image.

1.5 Comparison of Results

The below table shows the statistical features for 4 images such as mean, standard deviation, skewness, kurtosis, energy and entropy.

Table 1: Statistical features for few images

Images	Mean	Standard deviation	Skewness	Kurtosis	Energy	Entropy
Image 1 (Chromophobe)	0.005	0.088	2.976	29.949	0.837	2.217
Image 2 (Chromophobe)	0.0052	0.088	4.044	45.263	0.874	1.433
Image 3 (Clear cell)	0.001	0.088	1.454	16.6	0.807	2.088
Image 4 (Papillary)	0.004	0.088	4.503	51.43	0.874	1.471

The below table shows the textural features with smoothness and inverse difference movements of four images

Table 2: Textural features with Smoothness and Inverse Difference Movements

Images	Contrast	Homogeneity	Correlation	Smoothness	Variance	Inverse Difference Movement
Image 1 (Chromophobe)	0.404	0.952	0.138	0.954	0.008	2.958
Image 2 (Chromophobe)	0.460	0.962	0.125	0.954	0.008	4.261
Image 3 (Clear cell)	0.281	0.946	0.194	0.872	0.008	0.277
Image 4 (Papillary)	0.447	0.962	0.129	0.951	0.008	4.506

The below table shows the area of the extracted tumor for four images including original image size, area in pixel, area of extracted tumor and are ratio.

Table 3: Area of the extracted tumor

Images	Original image size	Area in pixel	Area of extracted tumor	Area ratio
Image 1 (Chromophobe)	256 X 256	65536	3318	0.05
Image 2 (Chromophobe)	256 X 256	65536	1749	0.02
Image 3 (Clear cell)	256 X 256	65536	7679	0.11
Image 4 (Papillary)	256 X 256	65536	2237	0.03

The below table shows the performance analysis parameters for four images

Table 4: Performance analysis parameters

Images	MSE	PSNR
Image 1 (Chromophobe)	0.58	50.4 dB
Image 2 (Chromophobe)	4.95	41.1 dB
Image 3 (Clear cell)	5.06	41.08 dB
Image 4 (Papillary)	1.23	47.2 dB

The below image shows the performance analysis parameters of four images

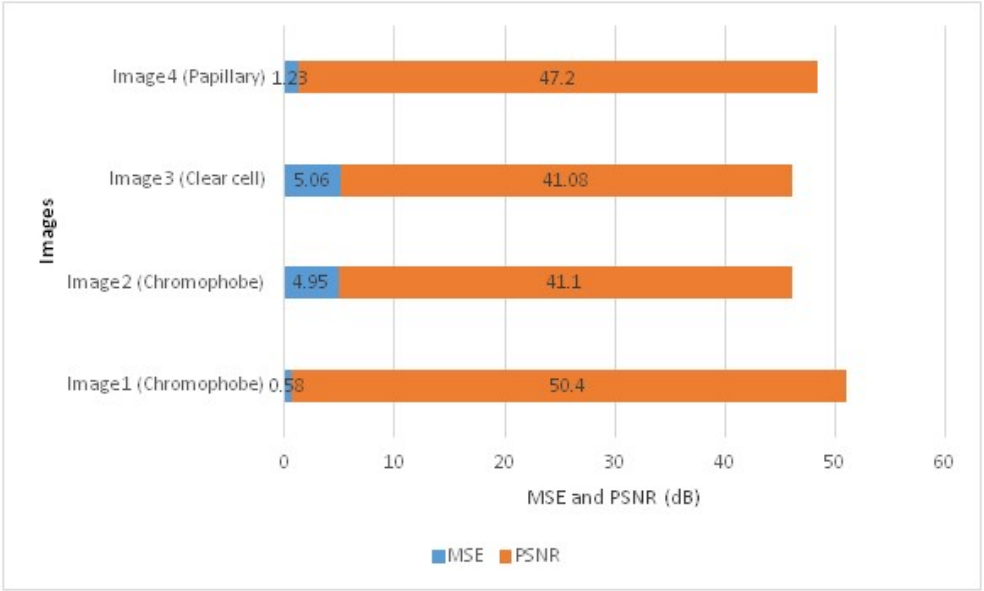

Figure 10: Performance analysis parameters

The below table shows the accuracy, sensitivity and specificity calculation

Table 5: Accuracy, sensitivity, and specificity calculation

Quality parameter	Formula
Accuracy	$\frac{TP + TN}{TP + TN + FP + FN}$
Sensitivity	$\frac{TP}{TP + FN}$
Specificity	$\frac{TN}{TN + FP}$

The below table shows the quality parameters for various classes i.e. Class A, B and C

Table 6: Quality parameter table for Different Classes

Evaluation parameter	Class A	Class B	Class C
True Negative	11	11	11
False Positive	2	2	3
True Positive	4	5	4
False Negative	3	2	2
Specificity (%)	84.62	84.62	78.57
Sensitivity (%)	57.14	71.43	66.67
Precision (%)	66.67	71.43	57.14
Accuracy (%)	65		

The below image shows the confusion matrix

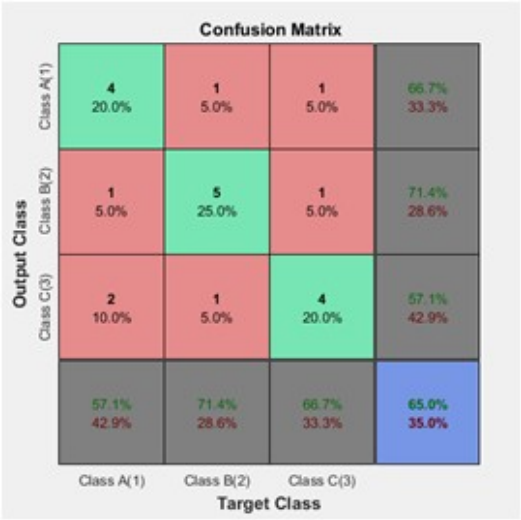

Figure 11: Confusion Matrix (MATLAB)

CONCLUSION

In this paper, we had a review of different methods of renal tumor detection. Renal Cancer may occur in the kidney or travel down the urinary tract. The size of the tumor varied from smaller, medium and larger size, as per the diagnosis, if in early stages not diagnosed, growth is to higher. This paper presents a review of renal cancer and techniques that are used for renal tumor detection. Various papers have been reviewed on renal tumor detection. We also increased all possible error value in order to improve the complexity of the proposed algorithm. It is found that this will result in compromised the accuracy of clustering. The medical procedures are depending on accuracy that is needed to maintain at a low level of error values. The feature extracted is useful in ureter bladder and renal CT scans in recognizing the class of the image by testing and training classifiers. The values that were obtained by various methods show variation for the same image in the feature values.

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