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Kidney Tumor Detection and Classification using Ultrasonography Images

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***Abstract* — Kidney tumor is a disorder where the kidney cells become uncontrollable and develop into a tumor or cancer. This problem is mainly caused due to the improper growth of cells and it also affects the body's immune system badly. It is very important to detect kidney tumors at the initial stages so they can be treated effectively. Therefore, this study proposed an approach for the detection and classification of kidney tumors. The proposed scheme consists of four stages (a) Image Preprocessing (b) Segmentation of images (c) Extraction of Features (d) Image Classification. At the first step image processing techniques are used to enhance the appearance of images, and to detect the edges Sobel Operator is applied. After the preprocessing of CT images, a Graph-based segmentation method is used for image segmentation. And to compute the feature vectors the Grey level co-occurrence matrix is utilized effectively. Finally, for the training and testing phase, a Multi-SVM classifier is used for the classification of different tumor categories. Experimental results show that the proposed scheme has better performance in the detection and classification of kidney tumors as compared to the other methods.**

Keywords — Image segmentation, CT images, Grey level cooccurrence matrix, Support Vector Machine, Kidney Tumor

I. INTRODUCTION

In humans, body cells grow and multiply in a controlled manner as per the body needs whereas; in case of a tumor the uncontrolled division of cells initiates, and they start invading into other tissues and organs [1]. Generally, tumors occur by the imbalance growth of cells and the problems intensifies with the body's immune system. Kidney tumor is a cumulative disease that harm the kidney and leads to the persistent problem. Therefore, detection of kidney tumor in early stages is very important so that the spread can be controlled [2]. Kidney tumor can be a result of many factors such as smoking, obesity, chronic high blood pressure, inherited syndromes, family history of kidney cancer etc [3, 4].

To identify the tumor, different imaging techniques are used including ultrasound, CT (computerized tomography scan), MRI (magnetic resonance imaging), Biopsy, lab tests etc. [5]. Ultrasound is non-invasive, low cost and widely used imaging technique to detect the tumor in kidney. But ultrasound images are low contrast images that's why it is difficult to detect the region of interest moreover, it also depends on the capability of sonographers to detect and analyze it during diagnosis. To remove such dependencies, image preprocessing techniques are required for better visualization of image. The proposed method detects the presence and absence of tumor in a kidney and its position based on the CT scan. This research determines the best kidney tumor detection framework which provides the improved performance in terms of detection and classification accuracy.

II. LITRATURE REVIEW

Previous studies on kidney tumor detection are summarized in this section:

In [6] kidney and kidney tumor segmentation challenge (KiTS19) was accepted to measure and accelerate the state of art in the automatic segmentation of kidney tumor on CT images. In [7] author proposed a method for kidney segmentation in CT images by using the 3D fully convolutional neural network that is combined with pyramid pooling module. Author study [8] used pixel classification network and some regression method for automatically doing kidney segmentation. Experimental results show that proposed method clearly identify the boundaries of ultrasonic images.

Another study [9] proposed a convolutional CNN method for detection of chronic kidney disease and achieves an average accuracy of 96.51%. In [10] classification of kidney cancer id done using cost-sensitive hybrid deep learning approach. The work proposed by [11] used a triple stage self-guided network for the segmentation of kidney. They used CT images taken from the tested dataset of KiTS19. They ranked 2nd place in the KiTS19 challenge by achieving the average dice of 96%. Authors in [12] segmented the kidney tumor by combining the two methods. Evaluation of the method is done on the real CT images and achieves the better performance by comparing with other methods. In [13] author determine a rapid segmentation method for kidney renal tumor by using 3D interpolation method. The proposed method computes the volume of renal kidney tumors in less than a minute time.

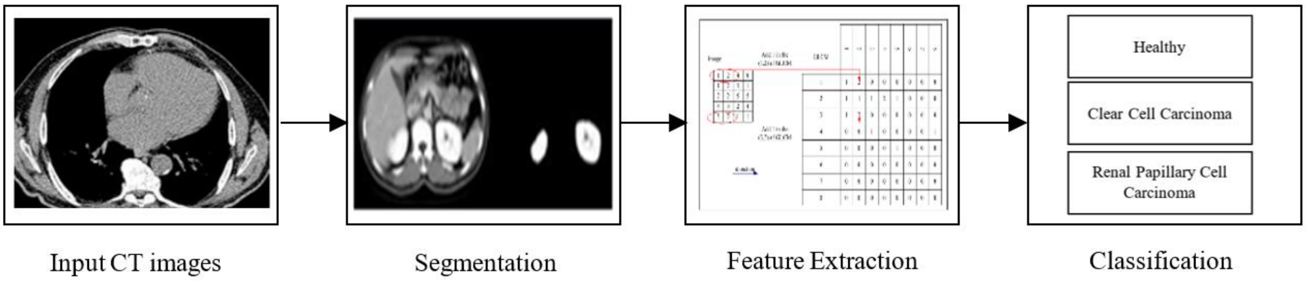


Fig. 1. Illustration of proposed methodology

The research objective of [14] is to use a radiomics scheme to examine the shape of tumor and texture feature on the CT images. The proposed framework uses 735 CT images and distinguishes between the cancerous and non-cancerous renal masses.

III. PROPOSED METHODOLOGY

Fig. 1 shows the proposed methodology diagrammatically. In this section all these phases are explained one by one

A. Input CT Images

Computed tomography (CT) scan is computerized X-ray imaging procedure. It is medical imaging technique use to see inside the body without cutting. The images (often called slices) generated by the machine's computer is called tomographic images. These images contain detailed information as compared to normal X-rays. The kidney CT scans are performed to detect the kidneys for tumor and either to locate obstructive conditions, such as kidney stone, polycystic kidney disease, abscesses, and other genetic anomalies, when other kind of examinations are not conclusive.

B. Image preprocessing

In this phase image contrast is improved by applying adaptive histogram equalization technique. It enhances the edges in each region of image. After that filtering technique is applied that is medium filter to remove the noise from the images. Then these images are passed through the Sobel operator for edge detection.

C. Image segmentation

In image segmentation the tumor part of the CT images is extracted from the input images which helps in the detection and diagnosis the tumor. We use graph-based segmentation method for image segmentation. This segmentation provides a clean, flexible formulation for image segmentation and represents the problem in terms of a graph G = (V, E) where E represents the edges and V represents the nodes $v_i \in V$.

D. Feature Extraction

Features are the unique properties or signatures that are used to describe the image in simple words. In this proposed method, GLCM (grey level co-occurrence matrix) method was used to extract the features. The texture characteristics like energy, correlation, contrast, homogeneity is obtained. The four texture features are obtained for every sub-image block as described below.

1. **Energy**: This feature provides the sum of squared elements in GLCM. Energy is also known as uniformity.

$$\text{Energy} = \sqrt{\sum_{i,j} P_{i,j}^2} \tag{1}$$

2. **Correlation**: is a linear dependency in grey levels of neighbor pixels in the whole image.

$$\text{Correlation} = \sum_{i,j=0}^{N-1} P_{i,j} \frac{(i-\mu)(j-\mu)}{\sigma^2} \tag{2}$$

3. **Contrast**: is used to compute the local variations in the grey level co-occurrence matrix.

$$\text{Contrast} = \sum_{i,j=0}^{N-1} P_{i,j}\,(i-j)^2 \tag{3}$$

4. **Homogeneity**: is a statistical method that is used to measure the closeness of the distribution of elements in the GLCM to the GLCM diagonal.

$$\text{Homogeneity} = \sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2} \quad (4$$

E. Image classification

For image classification multi-SVM classifier was used. The extracted features are passed to MultiSVM classifier to classify the kidney tumor. The SVM classifier compares the extracted features and classify them as heathy, clear cell carcinoma, kidney renal papillary cell carcinoma.

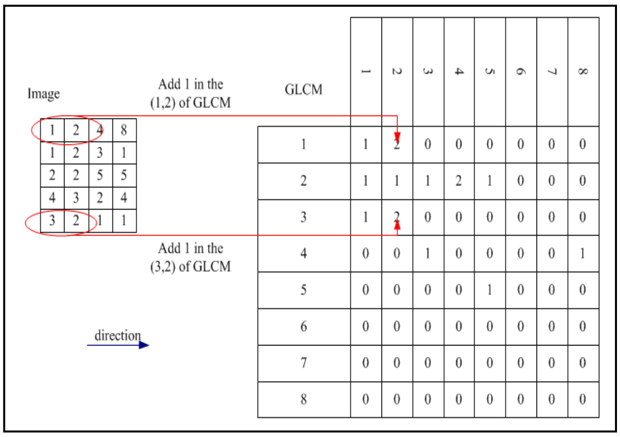


Fig. 2. Feature Extraction using GLCM

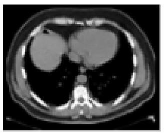
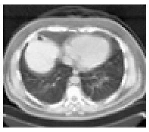
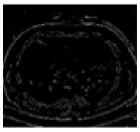
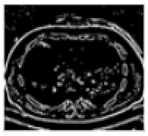
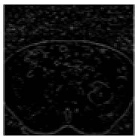
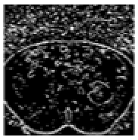
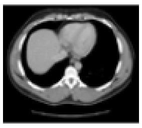
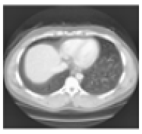
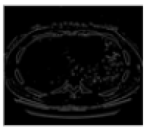
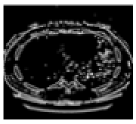
Categories	Original Images	Adaptive histogram equalization	Medium Filter	Sobel Operator	GLCM	Normalized GLCM
Healthy					0 1 2 0 1 0 1 2 1 1 2 0 2 0 1 1	0 0 0.16 0 0.16 0 0 0.80 0 0.16 0.25 0 0.25 0 0.80 0
Clear Cell Carcinoma					0 1 1 0 1 0 1 2 0 2 2 0 1 0 1 0	0 0.25 0.16 0 0.16 0 0 0.16 0 0 0.25 0 0.16 0 0 0.25
Kidney Renal Papillary Cell Carcinoma					2 0 1 1 0 2 2 0 2 1 1 0 1 0 1 0	0.16 0.25 0.16 0 0 0 0 0.16 0 0.25 0 0 0.16 0 0 0.25
	(a)	(b)	(c)	(d)	(e)	(f)

Fig. 3. Experimental Resuts of Proposed method a) Original images b) Adaptive histogram equalization c) Medium filter d) Sobel Operator e) GLCM f) Normalized GLCM

IV. Results and Discissions

A. Dataset Used and Experimental setup

In this section we present the inclusive discussion about our experimental results. The dataset used in this paper is collected from The Cancer Imaging Archive (TCIA). It is a large archive of medical images that are publicly available. The images in TCIA dataset are in DCIOM file format. The dataset contains the most used imaging technique such as MRI, CT, digital histopathology, etc. In total 959 images of kidney cancer disease are further divided into three categories. One of the categories contain healthy images and other two categories are the types of cancer i.e., Kidney Renal Papillary Cell Carcinoma and Clear Cell Carcinoma.

B. Experimental Results

The proposed method provides the better results as compared to other methods. Fig. 3 describe the experimental results of the proposed methodology. Fig. 3(a) shows the original images taken from the TCIA dataset. In Fig. 3(b) adaptive histogram equalization is used to improve contrast in the images. it enhances the edges in each region of an image. Fig. 3(c) shows the results of filtering technique that is medium filter which is used to remove the noise from the images. In Fig. 3(d) Sobel operator is used in preprocessing stage for edge detection. Fig. 3(e) shows the matrix of texture features extracted by using the GLCM method then extracted features are reduced by selecting active features and remove unnecessary features from the real dataset by normalizing them as shown in Fig. 3(f). After that we use multiSVM for image classification and passed extracted features to SVM for classification. The SVM classifier compares the extracted features and classify them as heathy, clear cell carcinoma, kidney renal papillary cell carcinoma.

C. Performance evaluation

In this study, performance of proposed framework is compared with other methods [3,8,15,16] for kidney tumor detection and classification. Table I shows the performance evaluation of proposed methodology. The accuracy of proposed method shows the significant amount of enhancement as compared to the other methods. Proposed methods achieve better results because of using adaptive histogram equalization to improve the contrast of images. Medium filter is used for noise removal because it preserves the edges, but other noise removal technique disturbs the pixels value. We obtain better edges by applying Sobel operator. Experimental results show that the proposed method has improved performance for detection and classification of kidney tumor. Fig. 4 and Fig.5 shows the confusion matrix and ROC curve of the classification procedure.

TABLE I. Performance Evaluation

References	**Performance Evaluation Features**			
	Acc %	***Recall %***	***Precision %***	***F-1 Score %***
Proposed	98.00	97.00	97.00	97.00
[15]	93.45	60.00	----	----
[8]	----	93.00	----	---
[16]	89.00	84.00	----	----
[3]	88.00	84.00	----	----

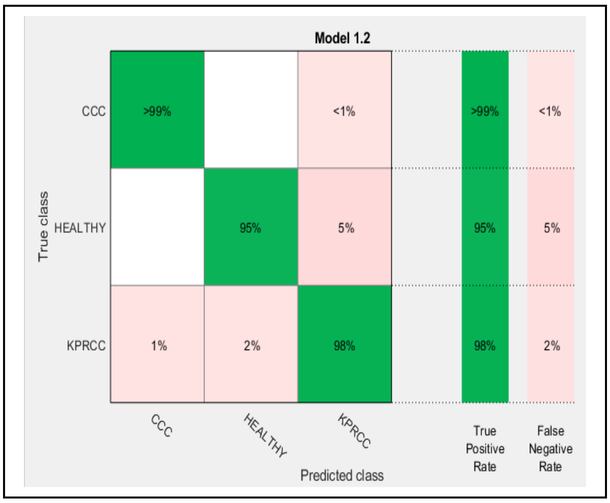


Fig. 4. Confusion Matrix

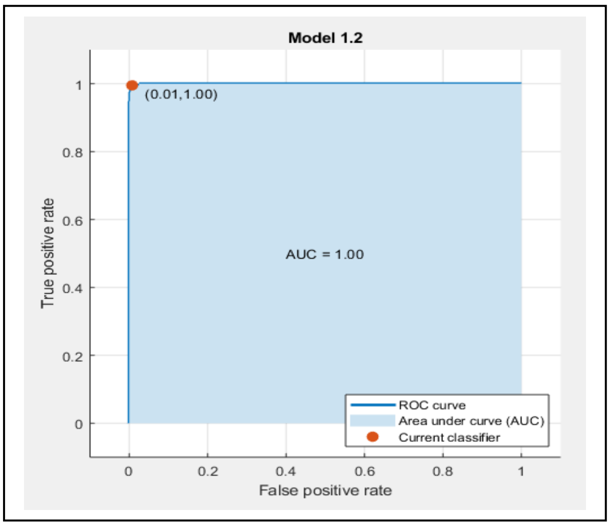


Fig. 5. ROC Curve

V. CONCLUSION:

This paper proposed a kidney tumor detection and classification system by using machine learning multi-SVM classifier. The proposed scheme classifies the kidney tumor into healthy, clear cell carcinoma and kidney renal papillary cell carcinoma. The proposed framework uses grey level cooccurrence matrix (GLCM) for extraction of features, and after normalizing passed them to the SVM classifier for classification. The use of efficient algorithm for the classification makes the whole framework more efficient. To evaluating the performance of the proposed framework accuracy, recall, precision, and F1 Score is used. The values were obtained as 98%, 97%, 97%, 97% respectively. Results of the proposed framework shows the better performance for the detection and classification of kidney tumor.

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