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Renal cell Carcinoma Nuclear Grading using 2D Textural Features for kidney images

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Abstract:** Cancer identification system is proposed based on the features present in the kidney images. Different algorithms such as CLACHE (Contrast limited adaptive histogram equalization), GLCM (gray level Co-occurrence matrices) and SVM (support vector machine) algorithm are used for the identification of cancer. CLACHE algorithm is used for the enhancement of the image. GLCM algorithm is used to improve the overall accuracy of the system and to extract the textural features. SVM algorithm is used to classify the different grading levels to identify the cancer present in the image. Images that are acquired for the identification of cancer are noisy. Noise is removed by the ROI extraction. Then the images are enhanced using CLACHE algorithm. Once the images are enhanced, features are extracted using GLCM. 21 textural features are extracted. Out of the 21 features extracted two best features are selected. The two best features are compared with the trained features for the increase in the accuracy of the system. After that based on the features, different grading levels are obtained for the identification of cancer. Grade 1 indicates the presence of cancer in starting stage, grade 2 indicates the presence of cancer in the moderate stage, grade 3 indicates the presence of cancer in the mild stage, grade 4 indicates the presence of cancer in the severe stage. In this study, 2D textural features are extracted and using these extracted features cancer identification is done which improves the overall accuracy of the system.

Keywords:** 2D Textural Features, Clache (Contrast Limited Adaptive Histogram Equalization), GLCM (Gray Level Co-Occurrence Matrices), SVM (Support Vector Machine).

INTRODUCTION

RCC (Renal cell carcinoma) is typically a sign of cancer that occurs in the kidney. Basically, it occurs in only one kidney; sometimes it occurs in both the kidneys. The occurrence of the cancer is predicted by different cancer. If the cancer is identified in the starting stage then the necessary measure can be taken to prevent the spreading of cancer to other organs of the body.

There are several kinds of renal cell cancers that affect the people. Some of them are;

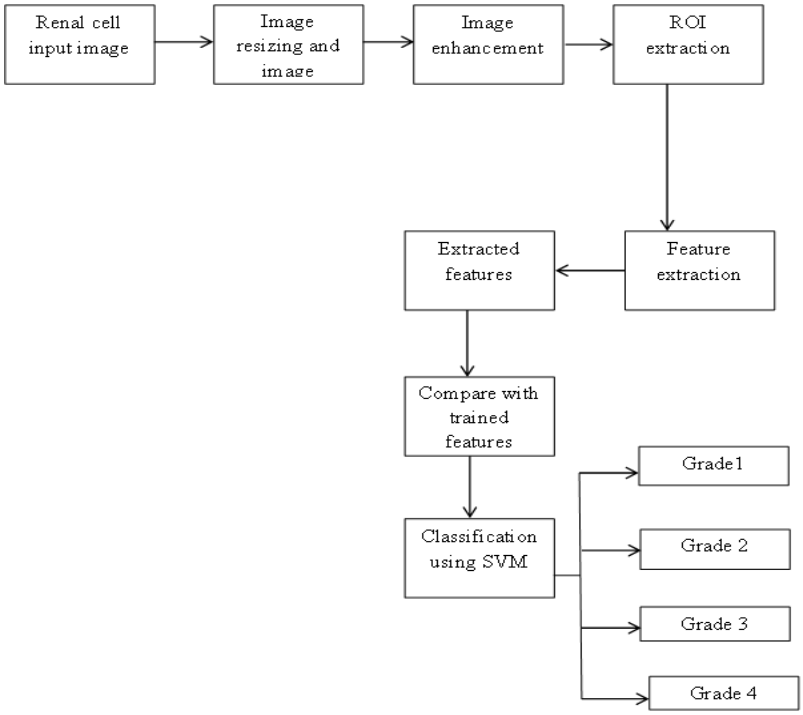
1. Clear cell carcinoma is basically seen in adults. In this, the cells are not so large and are very much visible to the microscope.
2. Papillary cell carcinoma is caused due to a deficiency in water content in the body. They are medium sized cells and are visible to the microscope in the form of pink colour.

3. Chromophobes carcinomas are the very rare type of cancer. The rate of occurrence of this cancer is only up to 5%. The cells are usually very large in size and can be recognized by the microscope in the form of pale

Extracting the nuclei cells present in the image helps to determine the progress of the cancer in different stages. Depending upon the input image various textural features are extracted, where the extraction of textural feature is done because the classification of cancer mainly depends upon the features. Various studies have been demonstrated about the identification of cancer by using the direct kidney images. Using the kidney images leads to decrease in the reproductivity and accuracy of the system. But in this work the nuclei cells present in the image are used, as the nuclei cells contains granularity and chromatin content which gives more information about the presence of cancer. To overcome the accuracy and reproductivity problem, a new method is developed using the textural features present in the kidney images for the identification of cancer.

ARCHITECTURAL DESIGN FOR PROPOSED SYSTEM

The work is on the development of the cancer identification, which is expected to increase the performance over the previously proposed approaches. The input image that is acquired for processing is noisy. Therefore the noise has to be removed. The noise is removed by using the pre-processing technique. Also, segmentation is done to remove the background portion and extract the nuclei cells. After extracting the nuclei cells CLACHE algorithm is applied to enhance the input image. The enhanced image is subjected to binarization using some threshold value. This process is known as ROI extraction. Then the GLCM algorithm is applied to extract the textural features. As a result, 21 features were extracted. Among the 21 features, 2 best features such as auto correlation and entropy are selected. The 2 best features are combined and given as an input to the SVM (support vector machine) which is used to classify the different grading level of cancer. Different grading levels indicate the different stages of cancer. Grade 1 represents the stage 1 (Starting stage of cancer), Grade 2 indicates stage 2 (moderate stage), Grade 3 indicates stage 3 (mild stage) and Grade 4 represents stage 4 (severe stage). Also, the accuracy, sensitivity, and linearity of the system were achieved.



Module 1

Image resizing or rescaling

Renal cell images are acquired as an input image. The acquired input image can be of any size. Therefore the input image is rescaled to a square matrix of size [102,102]. The input image is converted into square matrix because the input image that is acquired should be in the form of a square matrix for feature extraction.

Module 2

Colour channel conversion

The input image that is converted into the square matrix form is an RGB image of 24 bit/ pixel. The image is then converted into 8 bits/pixel. The output obtained is an RGB image of 8 bits/ pixel. The pixel value is reduced in order to decrease the complexity of the system.

Module 3

Image enhancement

Once the image is reduced to 8 bits/pixel, CLACHE algorithm is applied to enhance the input image. The CLACHE algorithm is applied to all the channels that are present in the image. Thus the result is the enhanced image.

Module 4

ROI Extraction

Once the image is enhanced, the enhanced image is subjected to binarization by setting some reference value. This process is known as binarization. Morphological operations are done in order to remove the unwanted portions in the image.

Module 5

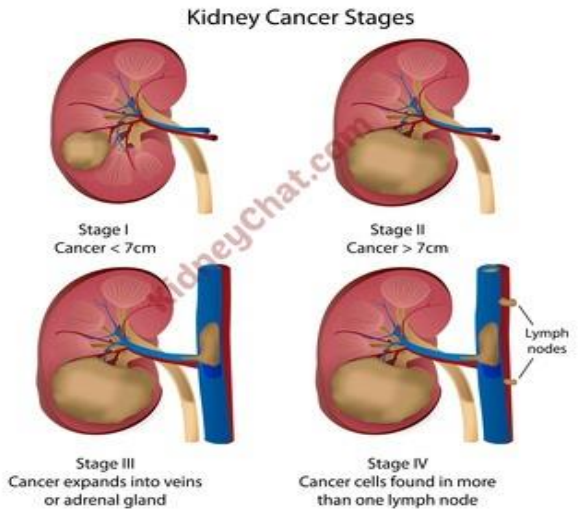
Feature extraction using GLCM

Once the image is enhanced, textural features are extracted using GLCM. As a result, 21 GLCM features were extracted. Among the 21 GLCM features extracted 2 best features are selected. The 2 best features are autocorrelation and entropy.

Module 6

Classification using SVM algorithm

Once the features are extracted 2 best features are selected. 2 best features are combined into pairs and then classified into different grading levels for the identification of cancer. Expected output is the grading level of the patient. Depending on the grading levels different stages of the cancer are identified. Grade 1 indicates cancer is in stage 1, grade 2 indicates cancer in stage 2, grade 3 indicates cancer is in stage 3, grade 4 indicates cancer is in stage 4.



PROPOSED ALGORITHMS

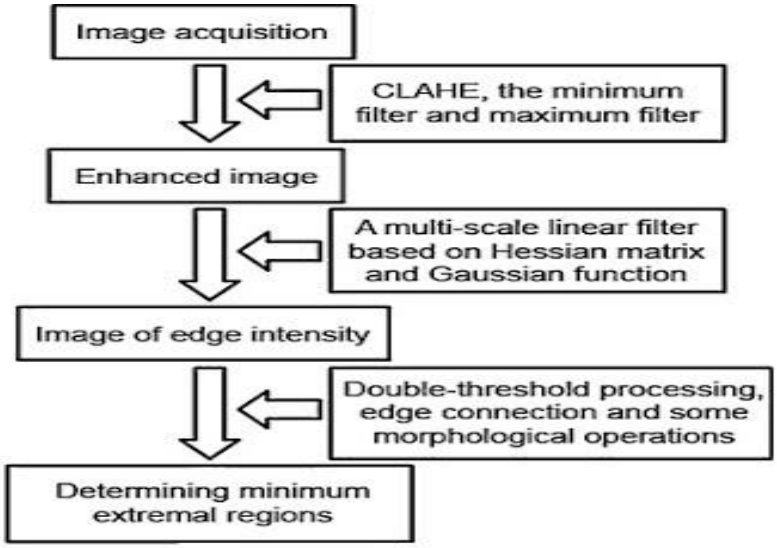
1. Contrast limited adaptive histogram equalization (CLACHE)
2. Gray level co-occurrence matrices (GLCM)
3. Support vector machine (SVM)

1. Contrast limited adaptive histogram equalization (CLACHE) algorithm

CLACHE algorithm is one of the most important methods commonly used in the field of biomedical. In this algorithm, the image given as an input is divided (split) into a number of parts and then the process of equalization is made to apply for all the split part. As a result, the background portion is eliminated. CLACHE algorithm is applied to the edges of the image since the images are not clear on the edges. When the CLACHE algorithm is applied intensity at the edges are increased. In this work the CLACHE algorithm is applied to enhance the input image, i.e. to remove the background portions and to enhance only the nuclei cells present in the image. Using CLACHE algorithm different transformations can be calculated by assuming the intensity value. Consider an image 'Q' of N×N pixel of range P (i, j). The image 'Q' produces an image 'R' of the same N×N pixel. Then the equation is given by;

$$P_n = 255\left(\frac{[\phi w(P) - \phi w(\min)]}{[\phi w(max) - \phi w(\min)]}\right)$$

$$\Phi_w(P) = \left[1 + \exp\left(\frac{\mu w - P}{\sigma w}\right)\right]^{-1}$$



2. Gray level Co-occurrence Matrices (GLCM)

Once the image is enhanced using CLACHE algorithm, features are extracted using GLCM algorithm. GLCM algorithm enhances the range of frequency and brightness values. GLCM algorithm is used to extract the features; textural features are extracted since it provides accuracy to the system. Here 21 features are extracted; among the 21 features, 2 features autocorrelation and entropy are selected as it provides good accuracy to the system. These features are implemented in a MATLAB tool. Once the features are extracted, depending upon the intensity values, numbers of the order of statistics are decided. GLCM extract the features based upon the number of elements present in the matrix. GLCM prefers square matrix. Here the number of elements in a row is equal to a number of columns. Thus it computes a square matrix. 21 features were extracted. Among these features autocorrelation and entropy are selected.

Auto correlation

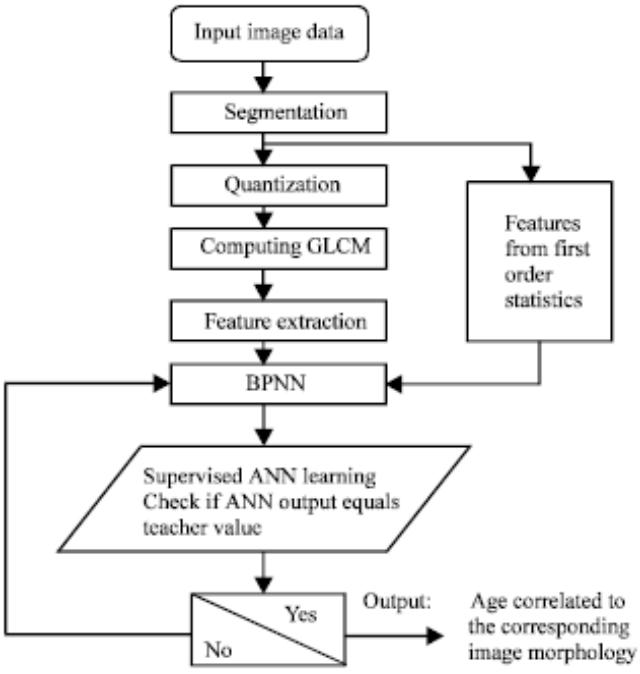
Autocorrelation is mainly used to calculate the value of the pixels of the gray level.

Auto correlation = $\frac{\Sigma(k,l)\, r(k,l) - \mu p\, \mu q}{\sigma p\, \sigma q}$

Entropy

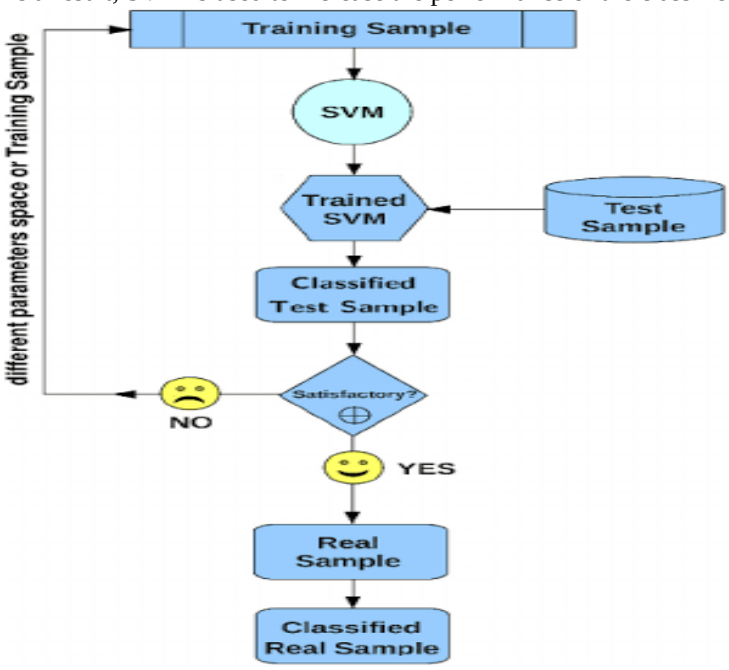
Entropy is one of the textural analysis methods. Entropy is the sum of the statistical measures and randomness. Entropy consists of 256 bits counts of the histogram.

Entropy = $\Sigma - S(k,l) * log\ S(k,l)$



3. Support Vector Machine (SVM) algorithm

Support vector machine is used for the classification stage. In support vector machine 2 different features are selected among the 11 features are selected for testing two best features are used in combination in order to reduce the storage, increasing the accuracy and to enhance the dimensionality. As a result, SVM is used to increase the performance of the classifier.



OUTPUT

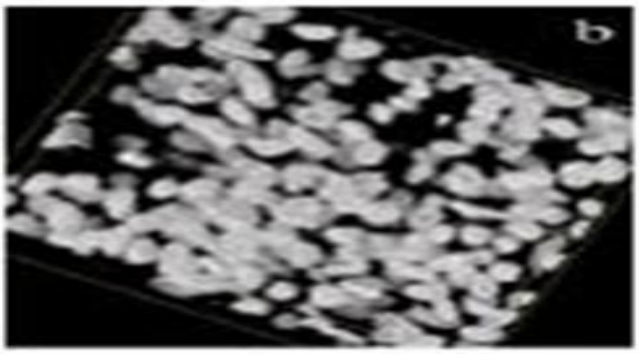


Fig 1.Input RCC signal

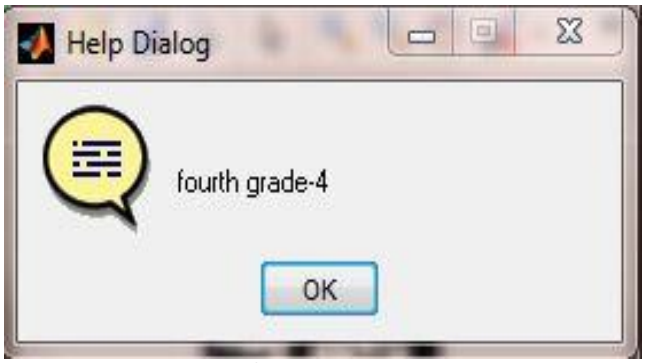


Fig 2.Presence of cancer in stage 4 (severe stage)

RESULT CALCULATION

The tabulations were made for the extracted features and accuracy, the sensitivity of the system was determined.
Sensitivity of the linear kernel SVM is 66.667%
Accuracy of the linear kernel SVM is 98.3871%
Specificity of the linear kernel SVM is 100%

CONCLUSION

The project investigates on the development of cancer identification, which is expected to improve the performance over previously proposed approaches. The renal cell images that are acquired are noisy. As a result first, the acquired renal cell images are segmented to remove background noise using ROI extraction. CLACHE algorithm is applied to enhance the image. The acquired renal cell images are subjected to binarization. After that GLCM features are extracted. 21 GLCM features are computed. Among the 21 features, 2 best features are selected.
The selected features are combined into pairs and given as an input to SVM (Support vector machine), which is used to classify into different grading levels. Finally based on the features the grading level of the patient such as grade1, grade2, grade3, and grade4 are performed. Identification of the cancer is done on the basis of grading levels. Also, the overall accuracy, sensitivity, and specificity of the system were achieved.

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