3rd National Conference on Enhancement in Biomedical Engineering and Healthcare
Organised by Department of Biomedical Engineering,
Adhiyamaan College of Engineering, Hosur, Tamil Nadu, India
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Detection and Classification of Kidney Stone in CT Images

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ABSTRACT

Kidney stone disease is one of the risks for life throughout the world and the majority of people with the stone formation in the kidney at the initial stage do not notice it as disease and it damages the organ slowly. The current estimation is that 30 million people are suffering from this disease. The currently available widely used imaging techniques for diagnosing kidney diseases include X-ray imaging and Ultrasound imaging. The proposed work is used to detect and classify the kidney stone using CT images. The Bilinear Interpolation and the median filter is used for image resizing and noise removal in preprocessing. Level set segmentation (Fuzzy C means clustering) is proposed for kidney stone segmentation. A novel approach for the classification of different types of Kidney stones using Random Forest and gray level co-occurrence matrix (GLCM). Different types of Kidney stones namely Cystine stones, Staghorn stones, and Renal Calculi stones were analyzed. MATLAB R2013A tool is used for this project.

Keywords : Bilinear Interpolation, clustering, co-occurrence, Staghorn, Calculi

I. INTRODUCTION

Current estimates are that 30 million (1 in 11) Americans will experience a kidney stone within their lifetime, and up to 50% of new stone formers will have a recurrence, within as early as 5 years. The increasing number of patients with kidney diseases leads to high demand for early detection and prevention of kidney diseases. A kidney stone may not cause symptoms until they move within the kidney or until it passes into the urethra (the tube connecting the kidney and bladder). The most common symptom of kidney stones is a pain in the upper back. When the pain is severe there is the possibility of getting nausea as well. There can be blood in the urine and also a urinary tract infection. Stones are diagnosed with CT scans, X-rays, or ultrasound. The proposed method gives preference to CT images because CT gives more information compare to Ultrasound images. These images can be used as an initial evaluation to estimate kidney size and position, and help to diagnose structural abnormalities as well as the presence of cysts and stones. To enhance the quality of these images, some image processing techniques are usually applied for a better understanding of hidden information as well as for extracting some parameters or features that will be useful for kidney stone classification. This proposed method classified three types of stones. When there is too much Cystine in the urine the cystine stone

formed in the kidney. Staghorn stone is most frequently composed of mixtures of magnesium ammonium phosphate (struvite) and calcium carbonate apatite. Urine contains more crystal-forming substances such as calcium, oxalate and uric acid means the Renal Calculi stones are formed.

II. METHODOLOGY

In proposed work, a novel scheme for efficient detection and classification of kidney stones with minimal processing time. The proposed scheme utilizes Bilinear Interpolation for image resizing and Median Filter for noise removal in preprocessing. Fuzzy c-means clustering and level set segmentation technique is used in the segmentation process for segmenting kidney stones alone. From segmented images, several texture features are extracted. The features are namely contrast, correlation, energy, and homogeneity. The Random Forest machine learning techniques are used to perform stone classification in CT images of the kidney. The kidney stone CT is collected from the Bharath scan center. The methods of work represented in workflow diagram Fig:1

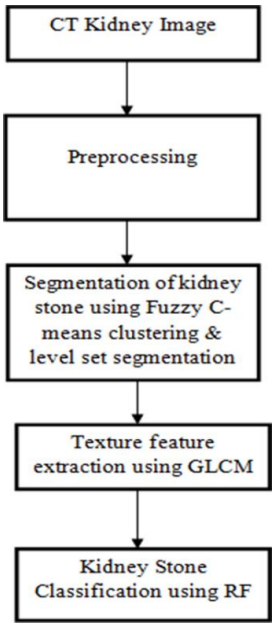

Fig:1 Workflow diagram

A. IMAGE ENHANCEMENT

The objective of the preprocessing phase is to apply possible image enhancement techniques to obtain the required visual quality of the image. Initially, the CT kidney stone images are converted into a grayscale image for further processing. Image resizing is an important role in image processing technique, to enlarge and reduce the given image size in pixel format. It is done by using a bilinear interpolation method. The median filter is used to remove the noise in the CT images.

B. FUZZY C-MEANS CLUSTERING ALGORITHM

This algorithm works by assigning membership to each data point corresponding to each cluster center based on the distance between the cluster center and the data point. More the data is near to the cluster center means its membership towards the particular cluster center. The summation of membership of each data point should be equal to one. After each iteration membership and the cluster centers are updated according to the formula:

$$\mu_{ij} = 1 / \sum_{k=1}^{c} (d_{ij} / d_{ik})^{(2/m-1)}$$

$$v_j = (\sum_{i=1}^{n} (\mu_{ij})^m x_i) / (\sum_{i=1}^{n} (\mu_{ij})^m), \forall j = 1, 2, \ldots . c$$

'n' is the number of data points. 'vj' represents the jth cluster center. 'm' is the fuzziness index m ∈ [1, ∞]. 'c' represents the number of cluster center. ' μ ij' represents the membership of ith data to jth cluster center. 'dij' represents the Euclidean distance between ith data and jth cluster center. The main objective of the fuzzy c-means algorithm is to minimize:

$$J(U,V) = \sum_{i=1}^{n} \sum_{j=1}^{c} (\mu_{ij})^m \left\| x_i - v_j \right\|^2$$

C. RANDOM FOREST CLASSIFIER

Random forests are a way of averaging multiple deep decision trees, trained on different parts of the same training set, to overcome the over-fitting problem of the individual decision tree. In other words, random forests are an ensemble learning method for classification and regression that operate by constructing a lot of decision trees at training time and outputting the class that is the mode of the classes output by individual trees. The test image is passed down each random tree until it reaches a leaf node. All the posterior probabilities are then averaged and the maximum is taken as the classification of the input image.

III. RESULT AND DISCUSSIONS

A. PREPROCESSING

Totally 30 kidney stone images were collected and processed. In the preprocessing phase the test image shown in Fig:2. The resize is done by the bilinear interpolation method. This is shown in Fig:3. The noise is removed by using a median filter it is shown by Fig:4.

B. SEGMENTATION

After the preprocessing stage, segmentation of kidney stone is performed by fuzzy c- means and level set segmentation it is shown in Fig:5 and Fig:6. The goal of a fuzzy c means clustering analysis is to divide a given set of data or objects into a cluster, which represents subsets or a group. The partition should have two properties

homogeneity and heterogeneity. This algorithm based on fuzzy optimization of the quadratic criterion of classification where each class is represented by its center of gravity. The algorithm requires knowing the number of classes in advance and generates classes through an iterative process minimizing an objective function. Thus, it provides a fuzzy partition of the image by giving each pixel a degree of belonging to a given region. Finally, the level set is used to only detect the stone region in the clustered image.

C. FEATURE EXTRACTION

In the feature extraction stage, texture features are extracted from the segmented kidney stone image. Features are computed from the statistical distribution of observed combinations of intensities at specified positions relative to each other in the image. According to the number of intensity points (pixels) in each combination, statistics are classified into first-order, second-order and higher-order statistics. The Gray Level Co- occurrence Matrix (GLCM) method is a way of extracting second-order statistical texture features. The approach has been used in several applications, Third and higher-order textures consider the relationships among three or more pixels. Gray Level Co- Occurrence Matrix (GLCM) has proved to be a popular statistical method of extracting a textural feature from images. In this project Energy, Contrast, Correlation, and Homogeneity texture features are extracted.

D. CLASSIFICATION

The classification process is done over the segmented images. RF classifier is applied over the segmented images and the classification is done. It is shown in Fig:7 and The performance analysis of this proposed method shown in Fig:8

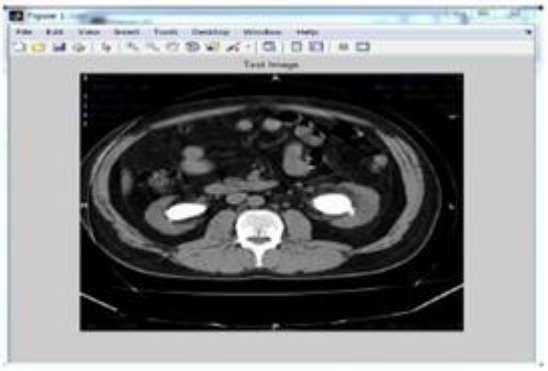

Fig:2 Test image

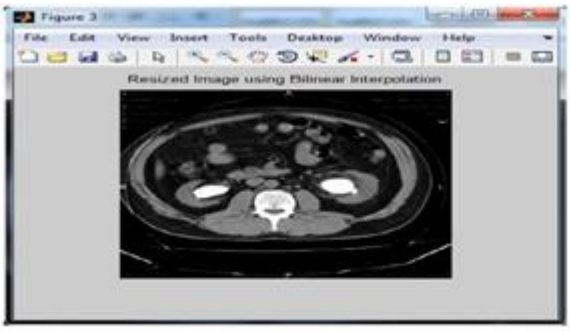

Fig:3 Resized image

Fig:4 Filtered image

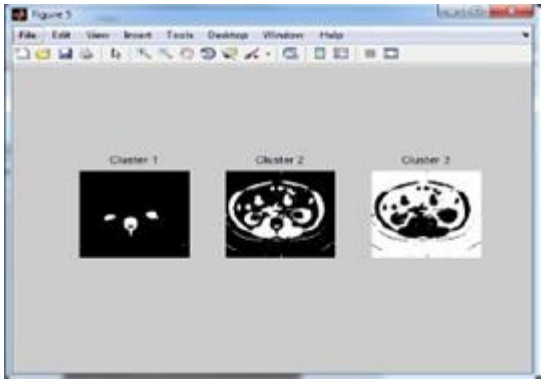

Fig:5 Clustered image

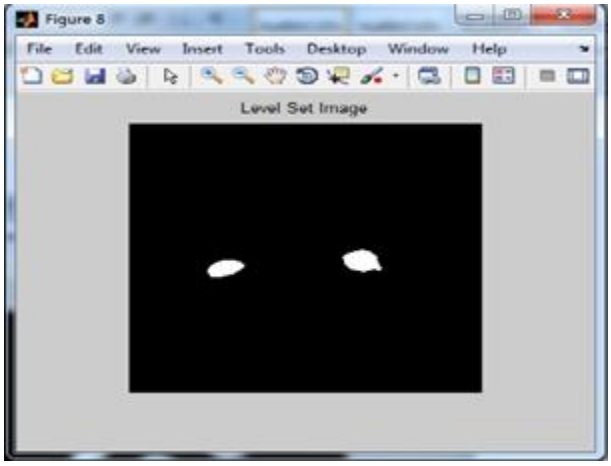

Fig:6 Level set segmented image

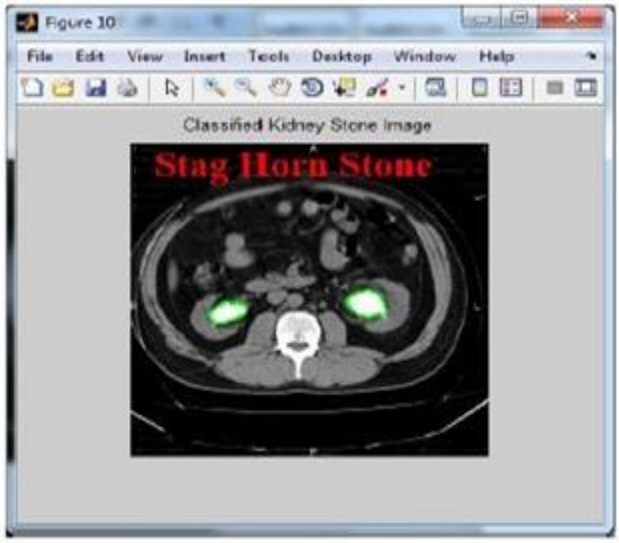

Fig:7 Classified kidney stone image

Table 1. Performance Analysis

	Proposed method
Accuracy	93.33%
Sensitivity	87.50 %
Execution Time	31.64 s

IV. CONCLUSION

This work describes a method for the detection and classification of the kidney's stone using fuzzy c-means clustering and random forest. Preprocessing

involves image resizing and noise removal. A kidney stone is effectively detected from the segmented image. Finally, three types of classification are performed. This proposed method is efficient and time taken to process the image is lower.

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Cite this article as :

Porkodi. J, Thenmozhi. M, Priyadharshini. R, "Detection and Classification of Kidney Stone in CT Images", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 5 Issue 5, pp. 184-188, March-April 2020.
Journal URL : http://ijsrst.com/EBHGR036