International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-05, Issue-12, Mar 2020

Kidney Stone Detection From Ultrasound Images By Using Canny Edge Detection And CNN Classification

[1]Nagireddi Amrutha Lakshmi, [2]Bodasakurti Jyothirmayi, [3]Manjeti Sushma, [4]Attaluri SriManoj, [5]G. Santoshi

[1,2,3,4]Student, [5]Assistant Professor, ANITS, Visakhapatnam, India.

[1]amruthalakshmi40@gmail.com, [2]bjyothirmayi.16.cse@anits.edu.in, [3]sushmamanjeti@gmail.com, [4]asrimanoj.16.cse@anits.edu.in, [5]gsanthoshi.cse@anits.edu.in

Abstract–Kidney stones as not a new subject to being one of the major health concerns of today's day and age, if not detected at early stages might also become life threatening. Detecting a kidney stone might require a technique that ensures precision andalso is in wide use. Hence the technique none other than image processing has a tendency to encompass an automatic method to detect stones precisely leading itself to being one of the more popular methods for performing detecting, sensing, or forecasting processesthrough images. The speckle noise and low contrast of images produced using ultrasound could pose a considerable challenge to detect merely any stones.Therefore is deployedthe befitting image processing technique to overcome the challenge. The image restoration which uses Gaussian filter process helps get rid of the speckle noise by pre-processing the produced ultrasound image.Which is also used to smoothen the ultrasound image thus we obtain restored image. Image segmentation is done to the already pre-processed image for the detection of any possible stones using a canny edge detection technique thereby retaining much prominent edges. Further wavelet transformation and CNN classification is done to the segmented image to identify the presence of stones in a kidney.

Key Words*: Kidney stone detection, CNN classification,wavelet processing,ultrasound images,Gaussian filter,canny edge detection.*

I. INTRODUCTION

Kidney stone diseases and its occurrence is alarming in these days. Renal Calculus, also known as a kidney stone is a solid piece of material which is formed in the kidneys. Minerals in the urine are primary cause for production of renal calculus in kidneys. Kidney stones usually pass in the urine, a small stones may even pass without causing symptoms. The initial stages of these kidney stone diseases are noticed latterly or which cannot be detected easily, in turn damages the kidney as they grow to become larger. Diabetesmellitus, hypertension, glomerulonephritis are major causes for kidney failures and yearly many people are affected by these diseases. Initial stage diagnosis is advisable and can save many lives because after malfunctioning of the kidney it may lead to some serious issues and even to death. Ultrasound (US) image is one of the available low-cost methods and is widely used for imaging kidneys for diagnosis of kidney diseases.

1.1 Types of kidney stones include:

Calcium stones- Calcium oxalate which is the prime content of calcium stones. Oxalate is a naturally occurring substance found in food. Even found in metabolic activities by liver. Foods high in oxalate include nuts, chocolates, dark green vegetables and fruits like berries etc .Increase in the concentration of calcium or oxalate in urine can be caused because higher dosages of vitamin-D. Several metabolic disorders such as irregular intake of food can even cause these. Calcium phosphate is the main content of calcium stones. Renal tubular acidosis which is a metabolic reaction, is one of the major reason for the formation of these stones. Seizure medications, such as to piramate may even also produce these stones. Struvite stones-Frequent diagnosis with urinary tract infections usually cause this type of stones is found in recent studies. These stones are alarming situations as they grow larger with the time which may lead to removal by surgery. Uric acid stones- Humans who usually do not drink enough uids which are sufficient for the body and those who lose more fluids and high content of protein in their diet are more prone to this uric acid stones as they produce more uric acid. Recent studies show genetic dependency in the occurrence of uric acid stones. Cystine stones-A hereditary disorder that causes the kidneys to excrete too much of certain amino acids may cause these stones (cystinuria).

II. LITERATURE SURVEY

There has been many research carried in the fields of this image processing for kidney stone detection, researchers

 DOI : 10.35291/2454-9150.2020.0196

used many kinds of algorithms for finding the stone in a kidney.[2] In this paper they studied about the early stage detection of kidney stones by using improved seeded region growing based segmentation and classified kidney images according to the stone size, intensity threshold change was extracted from the segmented parts of image and size of stone was compared with normal standard stone size. (less than 2 mm absence of stone, 2-4 mm early occurrence stage , 5mm and above presence of kidney stones) Ultrasound kidney image samples taken from the clinical laboratory their results included diagnosing the kidney stones by varying the intensity threshold presence and absence along with the early stages of stone formation. [3] In this system kidney stone disease is diagnosed using two different neural architectures, those are Learning Vector quantization (LVQ) and Radial basis function(RBF) these are compared among them to get the best result. They used Waikato Environment for Knowledge analysis (WEKA) version 3.7.5 as simulator. They took real world dataset with 1000 instances and 8 attributes.[4] In this paper, we first proceed for the enhancement of the image with the help of median filter, Gaussian filter and un-sharp masking.some operations like erosion,dilation and entropy based segmentation employ to discover the region of interest. At last KNN and SVM classification methods are used for the survey of kidney stones. [5]CAD algorithm based on FGPA was used for detection of abnormality in kidneys. Noise present in ultra sound image is removed first and then segmented .Features like intensive histogram and haralick were obtained from the segmented image. Later classification was performed following two process one is differentiating between healthy kidney and unhealthy kidney by using lookup table approach, if the abnormality in the kidney is confirmed further the image is processed with the help of support vector machine(SVM) and MLP trained with specific features to identify the presence of cyst or stone. [6]Developed a method of automated feature description of renal size. Analysis on kidney size compared within a normal and abnormal are performed. The accuracy between manual method and automated method varied a lot i.e a difference of 10% manual gave an accuracy of 81% and automated with 91%.

III. PROPOSED ALGORITHM

The project is divided into 4 modules
3.1. Image pre-processing.
3.2. Image segmentation.
3.3. Wavelet processing.
3.4. CNN classification.

3.1 Image Pre-Processing

Ultrasound images are prone to have some noise in their initial stage because of its low contrast. Pre-processing consists of Image restoration, Smoothing, sharpening, Contrast enhancement. Pre-processing is a operation with images at the lowest level of abstraction both input and output images. The image which is usually represented by a matrix of brightness function has to made as the original images which are captured by some sensor may have low intensity. The prime aim of image pre-processing is an enhancement of the image data those image features important for further processing. Geometric transformations of images such as rotation, scaling, translation are done among pre-processing methods which are quite similar methods.

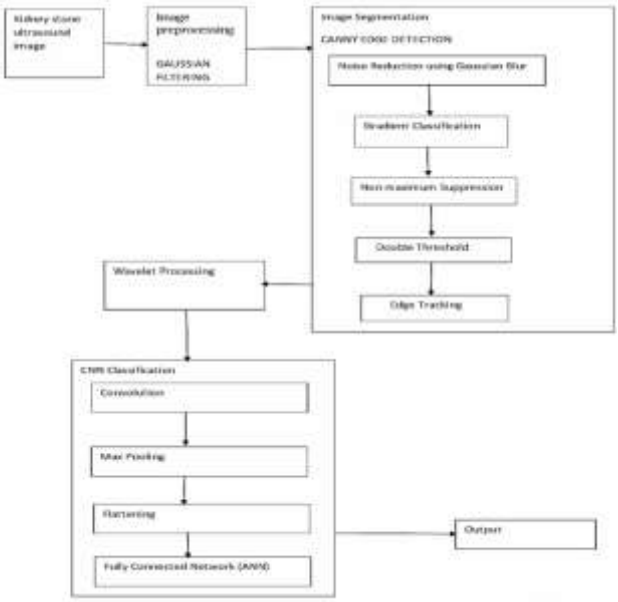

Fig 1: Architecture

3.2 Image Segmentmaation

Segmentation is an important and major aspect of medical imaging and digital image processing. It helps in visualizing the data available by providing diagnostics for various diseases depending on the given dataset. Canny edge detection, identifying and sharpening the edge of the kidney and the stone in the kidney are two major functionalities of it. It is one of the level set segmentation technique. The process of dividing a digital image into multiple segments is termed as segmentation of the image. The image is divided into various sets of pixels which are called as image objects. Segmentation prime aim is to simplifyand to represent given image into particular pattern which even can be used to analyze. The lines, curves, boundaries are located in the process of image segmentation and even image objects. Assigning labels to every pixel of the image and segregating labels having same labels which have common characteristics and this process is termed as image segmentation. The result produced isimage segmentation, a set of segments which cover the entire image or a set of contours of the image. The characteristic or property such as colour, intensity and texture of each of the pixels in a region is similar.

3.3 Wavelet Processing

Wavelet transforms are a mathematical procedure of performing signal analysis when signal frequency varies over time. Wavelet Transform is particularly selected for this project as for certain classes and signals this provides

 DOI : 10.35291/2454-9150.2020.0196

better precise results. Wavelets are commonly used in image processing to detect and filter white Gaussian noise because of their high contrast of intensity values ofthe neighbouring pixel. The two-dimensional image in the form of the matrix is feed into wavelet transform. The segmented image from the input opted to perform wavelet transform to get a compressed image. The image processed in this way can be cleaned without destroying the image quality such as blurring and muddling.

3.4 CNN Classification

The convolutional neural network (CNN) is a sub-part of deep learning neural networks. CNN is abundantly used in image recognition and digital imageprocessing. Analysis of visual imagery and image classification are major functionalities of CNN and are quite often used in these fields. Applications of CNN are be seen from social media to scientific research. Healthcare and security arefields where we can find CNN used majorly because of its functionalities. Image classification is the process of taking an input and passing it through a black box and outputting a class or to which probability that the input is a particular class. CNN can be introspected as automatic feature extraction from the image and using it further in pattern recognition. The adjacent pixel information is used productively down-sample the image. CNN has one or more layers of convolution units. A convolution unit id feed with input from multiple units from the previous layer which together creates proximity. Therefore, the input unitsshare their weights. The input is in the form of wavelet transform by takinga series of input images. Each image is given as input in the form of a matrixto neurons in the input layer of the CNN. A smaller matrix termed as filter is selected for the filtering process. The filter multiplies its values by original pixel values and produces another image matrix. These values are summed up. The convolution continues. Finally, a smaller matrix than the input matrix is obtained. The output matrix of CNN classification is compared with another ground truth image matrix and classification is performed.

IV. EXPERIMENT AND RESULTS

The first phase involves the dataset preparation. In our case, we have collected some sample ultrasound kidney images with and without stones and converted them into a csv file which can be used as a dataset in our projectduring the implementation of CNN classification module. Initially, as the ultrasound kidney image containsthe speckle noise and is of low contrast, one of the image pre-processing technique is being applied to remove the speckle noise. In this project, Gaussian filtertechnique is used to blur the image by using gaussian function to remove the noise. This pre-processing involves Image restoration, smoothing and sharpening.In the implementation of image segmentation module, canny edge detection technique is used toextract the useful information from the image by reducing or eliminating the information which is not requiredthereby reducing the amount of data to be processed. This technique is used to detect the edgeswhich involves various steps. The first stepis noise reduction using gaussian blur in which a 5x5 gaussian filter is used to remove the noise from the obtained pre-processed image. The second step is Gradient calculation in which the edge intensity and direction are detected by calculating the gradient using edge detection operation. The output of this step involves image containing thick edges. The third step is Non-maximum Suppression. As the output of the algorithm should contain thin edges,the algorithm finds the pixels with maximum value in the edge directions by going through the points on the gradient intensity. The fourth step is Double threshold.In this step we aim at identifying 3 kinds of pixels: strong, weak, and non-relevant. Pixels that contribute to the final edge are classified as strong edges. Pixels with intensity values that are not sufficient to be classified as strong edges, but not small enough to be considered as non-relevant are classified as weak pixels. The remaining pixels are considered as non-relevant pixels. Double threshold is used for categorizing pixels based on the intensity.High threshold identifies strong pixels, Low threshold identifies non-relevant pixels, and the other pixels are marked as weak. The result of this step includes an image consisting only strong and weak pixels. The fifth step is Edge Tracking, here transformation of weak pixels into strong pixels take place if and only if the pixels around the one being processed is a strong one.The output of the Image segmentation module is sent to the Wavelet Processing module.A wavelet decays swiftly just like an oscillation which has zero mean. Unlike sinusoids which extend to infinity, a wavelet exists for a finite duration.The image processed in this way can be “cleaned up” without blurring the details. The output of this module is in matrix form containing pixel values of the image.

The fourth module is CNN Classification. The output from wavelet processing module is a greyscale matrix of size 128*128*1. CNN Classification involves 4 steps namely Convolution layer, Activation function, max Pooling, Fully connected network. In Convolution layer a 3*3 kernel is applied on the input matrix with stride 1, so that the size of the image is reduced. The obtained matrix is sent to the activation function layer, here ReLU(Rectified Linear Unit)activation function is used to eliminate negative values. The next step is max pooling, here the rectified map goes through a pooling layer, pooling is down sampling operation that reduces the dimensionality of feature map.The output of this layer is a matrix with reduced size containing all the features. These 3 steps are repeated for two times, in which 32 filters are used each time. The next step is Flattering in which we convert the 2D array from pooling into a long continuous linear vector to which a filter of size 64 is applied followed by activation function. Later a Drop Out of size 0.5 is applied to prevent over-fitting. In the next step ANN model is applied, in which

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sigmoid activation is used function to detect the presence of stone.

Fig: Converting matrix into linear array form

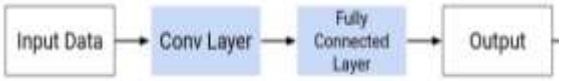

Fig: convolution methodology

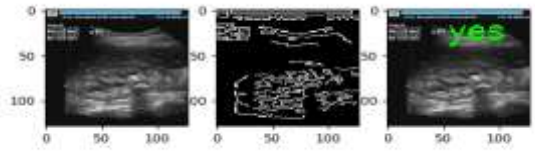

fig: output with label yes (presence of stone)

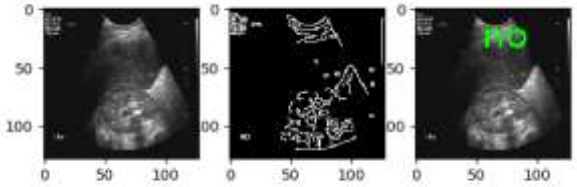

Fig: output with label No (absence of stone)

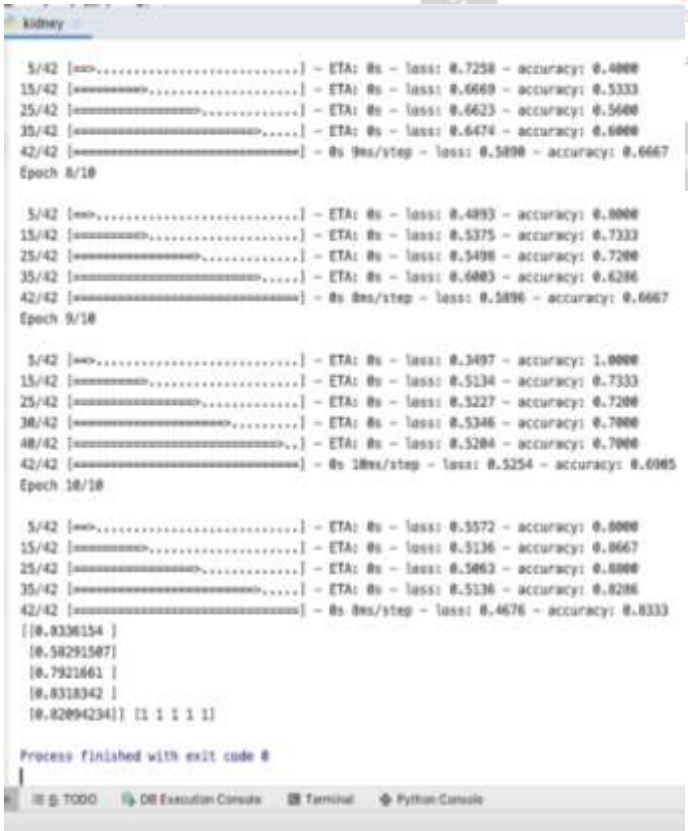

Fig: accuracy of stone detection

Algorithm	Source	Accuracy
CNN	Ultrasound images	83%
ANN's LVQ	Blood samples	80%
Median filter noise reduction ROI	UltraSound images	70%

Table: accuracy measures

V. CONCLUSION AND FUTURE SCOPE

In this project, the survey of different algorithms and classifications are analyzed followed by the detection of stone present in the kidney. From this implementation, the existing system limitations are inferred and a new design is proposed to address the limitations such as level set techniques require considerable thought in order to construct velocities to get a perfect advanced level set function. This means there should be a huge data available to get the accuracy rate which is sometimes may not be possible. We planned to rectify these issues using CNN classification. The energy levels extracted from the wavelet subbands i.e., Daubechies, Symlets and biorthogonal filters gives the clear indication of difference in the energy levels compared to that of normal kidney image if there is stone. The CNN trained with normal kidney image and classified input into normalor abnormal by considering extracted energy levels from wavelet filters. By using CNN classification we obtained an accuracy in between 70-85%. Python above 3.6 was used to implement and pycharm software tool was used.

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