KIDNEY STONE DETECTION FROM ULTRA SOUND IMAGES BY USING CANNY EDGE DETECTION AND CNN CLASSIFICATION

A Project report in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

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Submitted by

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(*Permanently Affiliated to AU, Approved by AICTE and Accredited by NBA & NAAC with 'A' Grade*)

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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BONAFIDE CERTIFICATE

This is to certify that the project report entitled **"KIDNEY STONE DETECTION FROM ULTRA SOUND IMAGES BY USING CANNY EDGE DETECTION AND CNN CLASSIFICATION"** submitted by N.Amruthalakshmi(316126510032), B.Jyothirmayi(316126510065), M.Sushma(316126510027), A.Sri manoj(316126510061)in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science Engineering of Anil Neerukonda Institute of technology and sciences (A), Visakhapatnam is a record of bonafide work carried out under my guidance and supervision.

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DECLARATION

This is to certify that the project work entitled "**KIDNEY STONE DETECTION FROM ULTRASOUND IMAGES BY USING CANNY EDGE DETECTION AND CNN CLASSIFICATION**" is a bonafide work carried out by **N. AMRUTHA LAKSHMI,**

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We, **N.AMRUTHA LAKSHMI, B.JYOTHIRMAYI, M.SUSHMA, A.SRI MANOJ,** of final semester B.Tech., in the department of Computer Science Engineering from ANITS, Visakhapatnam, hereby declare that the project work entitled **KIDNEY STONE DETECTION FROM ULTRA SOUND IMAGES BY USING CANNY EDGE DETECTION AND CNN CLASSIFICATION** is carried out by us and submitted in partial fulfillment of the requirements for the award of **Bachelor of Technology in Computer Science Engineering** , under Anil Neerukonda Institute of Technology & Sciences during the academic year 2016-2020 and has not been submitted to any other university for the award of any kind of degree.

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ABSTRACT

Nowadays, kidney stone has become a major problem and if not detected at an early stage then it may cause complications and sometimes surgery is also needed to remove the stone. So, detecting the stone precisely paves the way to image processing because through image processing there is a tendency to get the precise results and it is an automatic method of detecting the stone. The detection of kidney stones using ultrasound imaging is a highly challenging task as they are of low contrast and contain speckle noise. This challenge is overcome by employing suitable image processing techniques. The ultrasound image is first pre-processed to get rid of speckle noise using the image restoration process. The restored image is smoothened using one of the filtering technique. The pre-processed image is achieved with image segmentation to detect the stone region. Further the segmented image is processed with wavelet transformation and CNN classification.

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

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1. INTRODUCTION

Digital Image Processing means processing digital image by means of a digital computer. We can also say that it is a use of computer algorithms, in order to get enhanced image either to extract some useful information. Digital image processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output.

Image processing mainly include the following steps:

1. Importing the image via image acquistion tools.

2. Analyzing and manipulating the image.

3. Output in which result can be altered image or a report which is based on analyzing that image.

Advantages:

1. Remove noises.
2. Correct image density and contrast.
3. Helps to easily store and retrieve in computers.
4. Image can be made available in any desired formats like black and white, negative image.

Disadvantages:

1. Initial cost is high depending upon the system used.

2. Once the system is damaged the image will be lost.

1.1 TITLE EXPLANATION

Kidney stone disease is one of the major life threatening ailments persisting worldwide. Kidney stone, also known as a renal calculus is a solid piece of material which is formed in the kidneys from minerals in urine. Kidney stones typically leave the body in the urine stream, and a small stone may pass without causing symptoms. The stone diseases remain unnoticed in the initial stage, which in turn damages the kidney as they develop. A majority of people are affected by kidney failure due to diabetes mellitus, hypertension, glomerulonephritis, and so forth. Since kidney malfunctioning can

be menacing, diagnosis of the problem in the initial stages is advisable. Ultrasound (US) image is one of the currently available methods with non-invasive low cost and widely used imaging techniques for analyzing kidney diseases.

Symptoms for kidney stones:

A kidney stone may not cause symptoms until it moves around within your kidney or passes into your ureter the tube connecting the kidney and bladder. At that point, you may experience these signs and symptoms:

- Severe pain in the side and back, below the ribs
- Pain that radiates to the lower abdomen and groin
- Pain that comes in waves and fluctuates in intensity
- Pain on urination
- Pink, red or brown urine
- Cloudy or foul-smelling urine
- Nausea and vomiting
- Persistent need to urinate
- Urinating more often than usual
- Fever and chills if an infection is present
- Urinating small amounts

Pain caused by a kidney stone may change for instance, shifting to a different location or increasing in intensity as the stone moves through your urinary tract.

Causes of kidney stones:

Kidney stones often have no definite, single cause, although several factors may increase your risk. Kidney stones form when your urine contains more crystal-forming substances such as calcium, oxalate and uric acid than the fluid in your urine can dilute. At the same time, your urine may lack substances that prevent crystals from sticking together, creating an ideal environment for kidney stones to form.

Types of kidney stones:

Knowing the type of kidney stone helps determine the cause and may give clues on how to reduce your risk of getting more kidney stones. If possible, try to save your kidney stone if you pass one so that you can bring it to your doctor for analysis.

Types of kidney stones include:

- **Calcium stones:** Most kidney stones are calcium stones, usually in the form of calcium oxalate. Oxalate is a naturally occurring substance found in food and is also made daily by your liver. Some fruits and vegetables, as well as nuts and chocolate, have high oxalate content.

Dietary factors, high doses of vitamin D, intestinal bypass surgery and several metabolic disorders can increase the concentration of calcium or oxalate in urine. Calcium stones may also occur in the form of calcium phosphate. This type of stone is more common in metabolic conditions, such as renal tubular acidosis. It may also be associated with certain migraine headaches or with taking certain seizure medications, such as topiramate (Topamax).

- **Struvite stones:** Struvite stones form in response to an infection, such as a urinary tract infection. These stones can grow quickly and become quite large, sometimes with few symptoms or little warning.

- **Uric acid stones:** Uric acid stones can form in people who don't drink enough fluids or who lose too much fluid, those who eat a high-protein diet, and those who have gout. Certain genetic factors also may increase your risk of uric acid stones.
- **Cystine stones:** These stones form in people with a hereditary disorder that causes the kidneys to excrete too much of certain amino acids (cystinuria).

Types of Kidney Stone Detection

These may include:

- **Blood testing:** Blood tests may reveal too much calcium or uric acid in your blood. Blood test results help monitor the health of your kidneys and may lead your doctor to check for other medical conditions.

- **Urine testing:** The 24-hour urine collection test may show that you're excreting too many stone-forming minerals or too few stone-preventing substances. For this test, your doctor may request that you perform two urine collections over two consecutive days.

- **Imaging:** Imaging tests may show kidney stones in your urinary tract. Options range from simple abdominal X-rays, which can miss small kidney stones, to high-speed or dual energy computerized tomography (CT) that may reveal even tiny stones.

- **Analysis of passed stones:** You may be asked to urinate through a strainer to catch stones that you pass. Lab analysis will reveal the makeup of your kidney stones. Your doctor uses this information to determine what's causing your kidney stones and to form a plan to prevent more kidney stones.

Other imaging options include an ultrasound, a noninvasive test, and intravenous urography, which involves injecting dye into an arm vein and taking X-rays (intravenous pyelogram) or obtaining CT images (CT urogram) as the dye travels through your kidneys and bladder.

1.1.1 Medical Imaging Techniques:

- **X-rays:** X-rays (radiographs) are the most common and widely available diagnostic imaging technique. Even if you also need more sophisticated tests, you will probably get an x-ray first. X-rays may not show as much detail as an image produced with more sophisticated techniques. They are, however, the most common imaging tool used to evaluate an orthpaedic problem and are readily available in most doctors' offices.

- **Computed Tomography (CT):** Computed tomography (CT) is an imaging tool that combines x-rays with computer technology to produce a more detailed, cross-sectional image of your body. A CT scan lets your doctor see the size, shape, and position of structures that are deep inside your body, such as organs, tissues, or tumors. A CT scan costs more and takes more time than a regular x-ray. It can be done in either a hospital setting or an outpatient imaging center.

- **Magnetic Resonance Imaging (MRI):** Magnetic resonance imaging (MRI) is another diagnostic imaging technique that produces cross-sectional images of your body. Unlike CT scans, MRI works without radiation. The MRI tool uses magnetic fields and a sophisticated computer to take high-resolution pictures of your bones and soft tissues.

- **Ultrasound:** Ultrasound uses high-frequency sound waves that echo off the body. It is painless and noninvasive, and does not require radiation. Ultrasound is used most often to look for blood clots, but can also show other problems, such as a Baker's cyst behind the knee or even a rotator cuff tear in the shoulder or for detection of kidney stones.

- **Bone scan:** A bone scan uses a small amount of radioactive material to identify areas of increased bone activity. The material is injected into a vein and is absorbed by areas that are forming new bone, such as a healing fracture, bone tumor, or bone infection.

1.2 MOTIVATION FOR THE WORK

Almost in every field, digital image processing puts a live effect on things and is growing with time to time and with new technologies. This lead us to think differently and made us to research in medical stream. By this we got to know about kidney stones and its effects when it is not cured in early stage it may lead to surgery. We all have a saying “Prevention is better than cure”, when stones are identified we can cure them without further delay in process.

1) Image sharpening and restoration

It refers to the process in which we can modify the look and feel of an image. It basically manipulates the images and achieves the desired output. It includes conversion, sharpening, blurring, detecting edges, retrieval, and recognition of images.

2) Medical Field

There are several applications under medical field which depends on the functioning of digital image processing.

- Gamma-ray imaging
- X-Ray Imaging
- Medical CT scan
- UV imaging

3) Robot vision

There are several robotic machines which work on the digital image processing. Through image processing technique robot finds their ways, for example, hurdle detection root and line follower robot.

4) Pattern recognition

It involves the study of image processing, it is also combined with artificial intelligence such that computer-aided diagnosis, handwriting recognition and images recognition can be easily implemented. Now a days, image processing is used for pattern recognition.

5) Video processing

It is also one of the applications of digital image processing. A collection of frames or pictures are arranged in such a way that it makes the fast movement of pictures. It involves frame rate conversion, motion detection, reduction of noise and colour space conversion etc.

1.3 PROBLEM STATEMENT

The kidney malfunctioning can be a life intimidating. Hence early detection of kidney stone is essential and this can be done by image processing techniques. One of the method to identify stones is by taking ultrasound images as an input. The identification of stone in kidney using ultrasound images comprise of speckle noise and are of low contrast. As a result , we use a filter to smoothen the image and CNN algorithm is applied for the precise results of kidney stone identification.

1.4 ORGANISATION OF THESIS

The organization of this thesis is as follows.

Chapter-1 is about introduction which gives an idea about of our project domain i.e., Image Processing and title is explained i.e., kidney stone detection using ultrasound images. How stones are formed, what type of stones are present and its symptoms are explained.

Chapter-2 is about literature survey here all previous methods and existing models are examined.

Chapter-3 contains methodology, in this we used Gaussian filter for filtering, canny edge detection for segmentation, wavelet processing and at last CNN is applied. Even architecture of the system is explained thoroughly.

Chapter-4 consists experimental analysis and results in this sample code, testing results, system configurations such as software and hardware requirements, input and output images are displayed .

Chapter-5 explains Conclusion and future work about our project i.e., kidney stone detection using ultrasound images.

2. LITERATURE SURVEY

Literature survey is the most important step in software development process. Before developing the tool it is necessary to determine the time factor, economy and company strength. Once these things are satisfied, then next step is to determine which operating system and language can be used for developing the tool. Once the programmers start building the tool the programmers need lot of external support. This support can be obtained from senior programmers, from book or from websites. Before building the system the above consideration are taken into account for developing the proposed system.

2.1 Level Set Segmentation

K.Viswanath and Dr.R.Gunasundari, 2015 used level set segmentation for identification of Kidney abnormalities such as formation of stones, cysts, blockage of urine, congenital anomalies, and cancerous cells. During surgical processes it is vital to recognize the true and precise location of kidney stone. The detection of kidney stones using ultrasound imaging [1] is a highly challenging task as they are of low contrast and contain speckle noise. This challenge is overcome by employing suitable image processing techniques. The ultrasound image is first preprocessed to get rid of speckle noise using the image restoration process. The restored image is smoothened using Gabor filter and the subsequent image is enhanced by histogram equalization. The preprocessed image is achieved with level set segmentation to detect the stone region. Segmentation process is employed twice for getting better results; first to segment kidney portion and then to segment the stone portion, respectively. In this work, the level set segmentation uses two terms, namely, momentum and resilient propagation (R prop) to detect the stone portion. After segmentation, the extracted region of the kidney stone is given to Symlets, Biorthogonal (bio3.7, bio3.9, and bio4.4), and Daubechies lifting scheme wavelet subbands to extract energy levels. These energy levels provide evidence about presence of stone, by comparing them with that of the normal energy levels. They are trained by multilayer perceptron (MLP) and back propagation (BP) ANN to classify and its type of stone with an accuracy of 98.8%. The prosed work is designed and real time is implemented on both Filed

Programmable Gate Array Vertex-2Pro FPGA using Xilinx System Generator (XSG) Verilog and Matlab 2012a.

2.2 Seeded region growing based segmentation

P.R Tamilselvi and P.Thangaraj ,2011 presented a scheme for ultrasound kidney image diagnosis for stone and its early detection based on improved seeded region growing based segmentation and classification of kidney images with stone sizes. With segmented portions of the images the intensity threshold variation helps in identifying multiple classes to classify the images as normal, stone and early stone stages. The improved semiautomatic Seeded Region Growing (SRG) based image segmentation process homogeneous region depends on the image granularity features, where the interested structures with dimensions comparable to the speckle size are extracted. The shape and size of the growing regions depend on this look up table entries. The region merging after the region growing also suppresses the high frequency artifacts. The diagnosis process is done based on the intensity threshold variation obtained from the segmented portions of the image and size of the portions compared to that of the standard stone sizes (less than 2 mm absence of stone, 2-4 mm early stages and 5mm and above presence of kidney stones). Results: The parameters of texture values, intensity threshold variation and stones sizes are evaluated with experimentation of various Ultrasound kidney image samples taken from the clinical laboratory. The texture extracted from the segmented portion of the kidney images presented in our study precisely estimate the size of the stones and the position of the stones in the kidney which was not done in the earlier studies. Conclusion: The integrated improved SRG and classification mechanisms presented in this study diagnosis the kidney stones presence and absence along with the early stages of stone formation.

2.3 Entropy based segmentation

Jyoti verma, Madhawendra nath, k.k saini and Priyanshu Tripati,2017 published a paper about Kidney stone detection. There are various problem associates with this topic like low resolution of image, similarity of kidney stone and prediction of stone in the new image of kidney. Ultrasound images have low contrast and are difficult to detect and extract the region of interest. Therefore, the image has to go through the preprocessing which normally contains image enhancement. The aim behind this operation is to find the out the best quality, so that the identification becomes easier. Medical imaging is one of the fundamental imaging, because they are used in more sensitive field which is a medical field and it must be accurate. In this paper, we first proceed for the enhancement of the image with the help of median filter, Gaussian filter and un-sharp masking. After that we use morphological operations like erosion and dilation and then entropy based segmentation is used to find the region of interest and finally we use KNN and SVM classification techniques for the analysis of kidney stone images.

2.4 Automated feature description

Nur Farhana Rosli, Musab Sahrim, Wan Zakiah Wan Ismail, Irneza Ismai,Juliza Jamaludin, Sharma Rao Balakrishnan,2018 these authors have designed an automated feature description about the renal size by using Ultrasonography (US) as it is one of the procedures to monitor the growth of renal size in diagnose kidney disease. However considering the complexity of renal size, this procedure leads to inter-observer variability and poor repeatability. Given images from Abdominal CT scan, a level set thresholding and combination of logical and arithmetic operation based method was developed to calculate the automated feature description of renal size. This is achieved by applying 2D CT scan image into image segmentation and feature extraction where thresholding and morphological segmentation method are conducted. Then, parameters of the kidney such as perimeter, area, major axis and minor axis were measured and analyzed in classification step. As a result, analysis on the kidney size between subjects who are normal and the results from the studies has shown capability to classify correctly the size of kidneys about accuracy of 80% to 81% in terms of the kidney’s relative axis which is the ratio of right kidney and left kidneys. In addition, the method in measurement kidney size is compared between manual method and automated method and results shows that the accuracy of the automated method in terms of compactness is about 91% to 95.

2.5 EXISTING SYSTEM

The Present kidney stone detection system include Level set segmentation and Gabor filter for smoothening. Due to the usage of level set segmentation we had a few drawbacks such as level set techniques require considerable thought in order to construct appropriate velocities for advancing the level set function. This means there should be huge data available to get the accuracy rate which is sometimes may not be possible.

3. METHODOLOGY

Our project is divided into 4 modules namely

3.1 Image pre-processing

3.2 Image segmentation

3.3 Wavelet processing

3.4 CNN classification

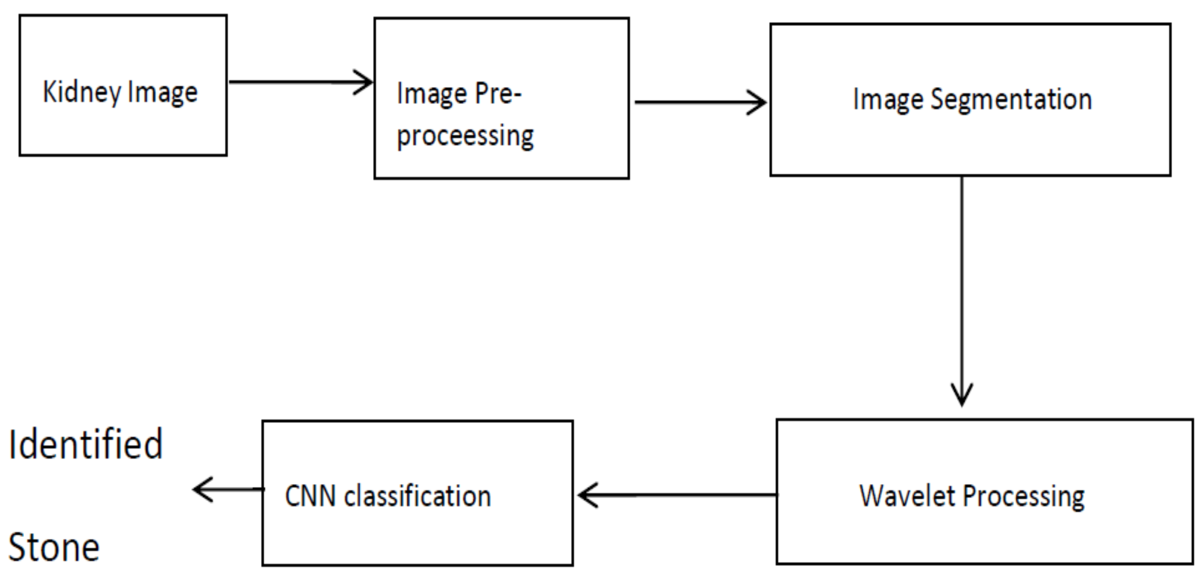


Fig: 3.1Methodology

3.1 Image Pre-Processing

As the ultrasound consists of speckle noise and is of low contrast pre-processing needs to be done. Pre-processing involves Image restoration, Smoothing & sharpening, Contrast enhancement. Pre-processing is a common name for operations with images at the lowest level of abstraction both input and output are intensity images. These iconic images are of the same kind as the original data captured by the sensor, with an intensity image usually represented by a matrix of image function values (brightness). The aim of pre-processing is an improvement of the image data that suppresses unwilling distortions or enhances some image features important for further processing, although geometric transformations of images (e.g. rotation, scaling, translation) are classified among pre-processing methods here since similar techniques are used. For this Gaussian Filtering is used Filtering is a technique for modifying or enhancing an image. For example, you can filter an image to emphasize certain features or remove other features. Image processing operations implemented with filtering include smoothing, sharpening, and edge enhancement. Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel. In image processing, a Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function (named after mathematician and scientist Carl Friedrich Gauss). It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen. Gaussian smoothing is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales—see scale space representation and scale space implementation. Mathematically, applying a Gaussian blur to an image is the same as convolving the image with a Gaussian function. This is also known as a two-dimensional Weier strass transform. Since the Fourier transform of a Gaussian is another Gaussian, applying a Gaussian blur has the effect of reducing the image's high-frequency components; a Gaussian blur is thus a lowpass filter.

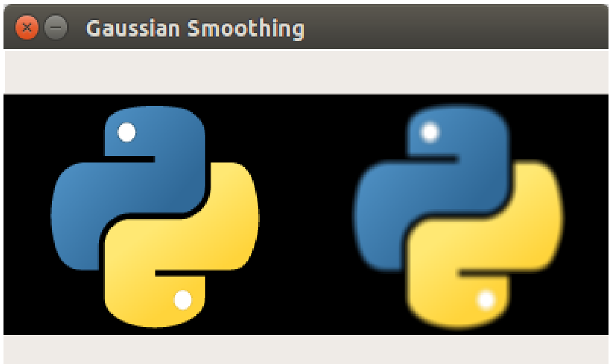


Fig: 3.1.1Gaussian filter example

3.2 Image Segmentation

Segmentation is a vital aspect of medical imaging. It aids in the visualization of medical data and diagnostics of various diseases. Canny edge detection, one of the level set segmentation technique which is used for identifying and sharpening the edge of the kidney and the stone in the kidney. Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as image objects). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity or texture.

Canny edge detection is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed. It has been widely applied in various computer vision systems. Canny has found that the requirements for the application of edge detection on diverse vision systems are relatively similar. Thus, an edge detection solution to address these requirements can be implemented in a wide range of situations. The general criteria for edge detection include:

- Detection of edge with low error rate, which means that the detection should accurately catch as many edges shown in the image as possible
- The edge point detected from the operator should accurately localize on the center of the edge.
- A given edge in the image should only be marked once, and where possible, image noise should not create false edges.

STEPS INVOVLED

1. It is a multi-stage algorithm and we will go through each stages.

2. Noise Reduction

   Since edge detection is susceptible to noise in the image, first step is to remove the noise in the image with a 5x5 Gaussian filter. We have already seen this in previous chapters.

3. Finding Intensity Gradient of the Image

   Smoothened image is then filtered with a Sobel kernel in both horizontal and vertical direction to get first derivative in horizontal direction (Gx) and vertical direction (Gy). we can find edge gradient and direction for each pixel

Edge_Gradient(G)=G2x+G2y−−−−−−−√Angle(θ)=tan−1(GyGx) (Eq: 3.2.1)

Gaussian direction is always perendicular to edges.

Here the below diagram describes the steps involved in canny edge detection.

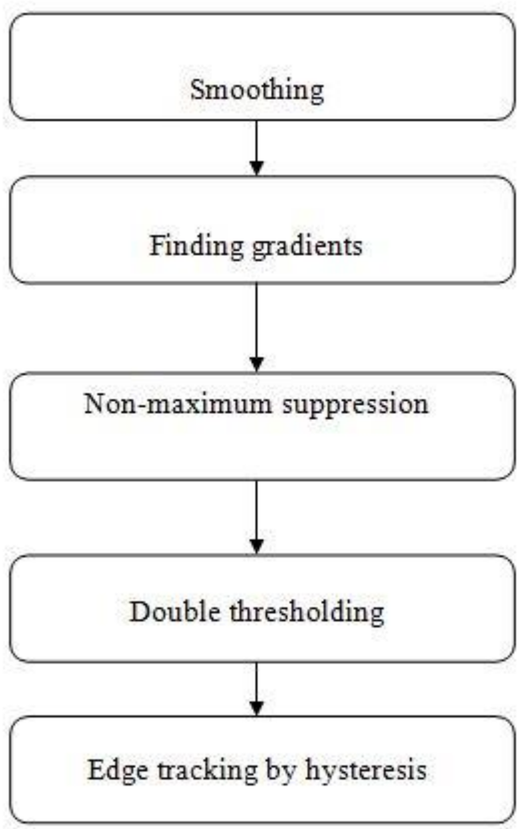


Fig: 3.2.1 Steps involved in canny edge detection

4. Non-maximum Suppression: After getting gradient magnitude and direction, a full scan of image is done to remove any unwanted pixels which may not constitute the edge. For this, at every pixel, pixel is checked if it is a local maximum in its neighborhood in the direction of gradient. Check the image below:

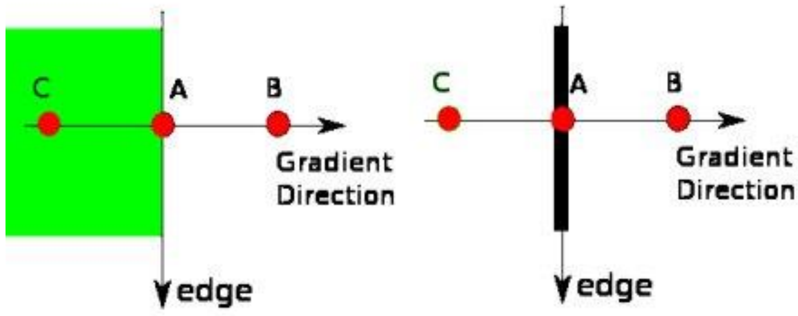


Fig: 3.2.2 Non-maximum suppression.

Point A is on the edge (in vertical direction). Gradient direction is normal to the edge. Point B and C are in gradient directions. So, point A is checked with point B and C to see if it forms a local maximum. If so, it is considered for next stage, otherwise, it is suppressed (put to zero).

5. Hysteresis Thresholding

This stage decides which are all edges are really edges and which are not. For this, we need two threshold values, minVal and maxVal. Any edges with intensity gradient more than maxVal are sure to be edges and those below minVal are sure to be non-edges, so discarded. Those who lie between these two thresholds are classified edges or non-edges based on their connectivity. If they are connected to "sure-edge" pixels, they are considered to be part of edges. Otherwise, they are also discarded.

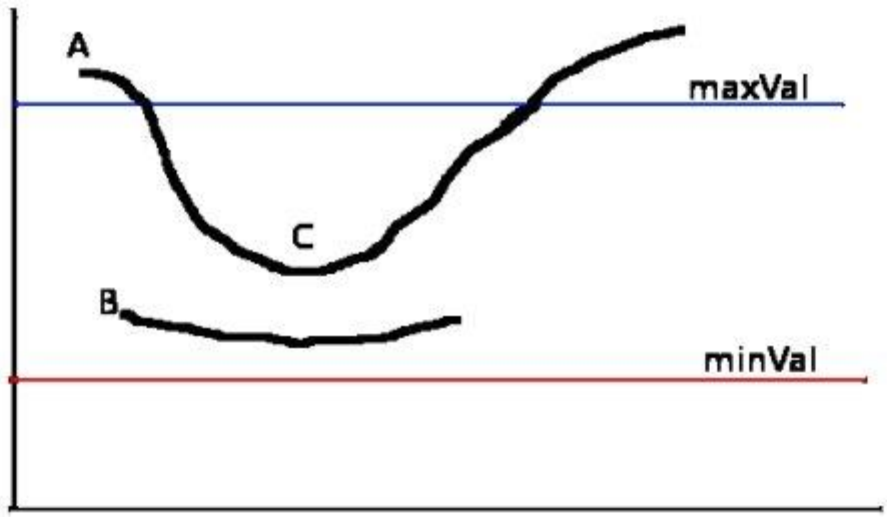


Fig 3.2.3 Threshold representation

The edge A is above the maxVal, so considered as "sure-edge". Although edge C is below maxVal, it is connected to edge A, so that also considered as valid edge and we get that full curve. But edge B, although it is above minVal and is in same region as that of edge C, it is not connected to any "sure-edge", so that is discarded. So it is very important that we have to select minVal and maxVal accordingly to get the correct result.

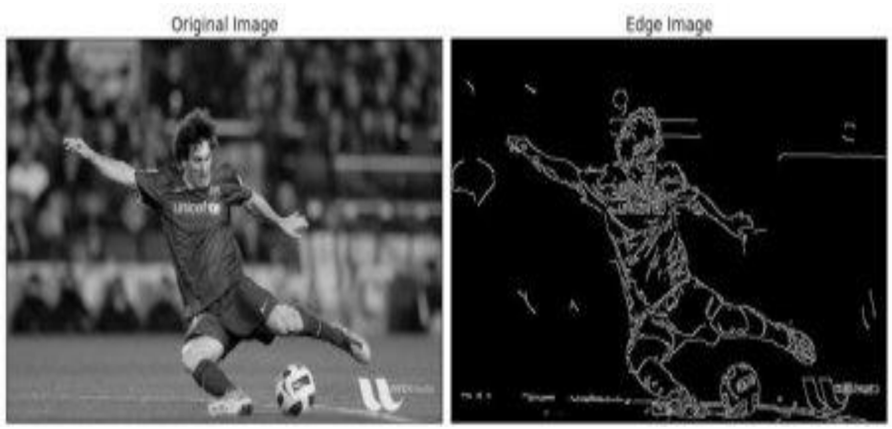


Fig: 3.2.4 Edge detection example

3.3 Wavelet Processing

Wavelet transforms are a mathematical means for performing signal analysis when signal frequency varies over time. For certain classes of signals and images, wavelet analysis provides more precise information about signal data than other signal analysis techniques. Wavelets are commonly used in image processing to detect and filter white Gaussian noise, due to their high contrast of neighboring pixel intensity values. Using these wavelets a wavelet transformation is performed on the two dimensional image. In this project, the segmented image from the input is made to undergo wavelet transform to get compressed image. The image processed in this way can be “cleaned up” without blurring or muddling the details.

3.4 CNN Classification

The convolutional neural network (CNN) is a class of **deep learning neural networks**. CNNs represent a huge breakthrough in image recognition. They’re most commonly used to analyze visual imagery and are frequently working behind the scenes in image classification. They can be found at the core of everything from facebook’s photo tagging to self-driving cars. They’re working hard behind the scenes in everything from healthcare to security. Image classification is the process of taking an **input** (like a picture) and outputting a **class** or a **probability** that the input is a particular class (“there’s a 90% probability that this input is a image”). CNNs can be thought of automatic feature extractors from the image. It effectively uses adjacent pixel information to effectively down-sample the image. A CNN, in specific, has one or more layers of convolution units. A convolution unit receives its input from multiple units from the previous layer which together create a proximity. Therefore, the input units (that form a small neighborhood) share their weights. In this project, the input to CNN classification is series of images processed through wavelet transforms. Every image is given as input to neurons in input layer. The software selects smaller matrix also known as filter. The filter produces convolution and multiplies its values by original pixel values. All these multiplications are summed up to obtain a single value. The convolution continues and a smaller matrix than input matrix is obtained. The output matrix of CNN classification is compared with another image matrix (that contains stone) and classification is done.

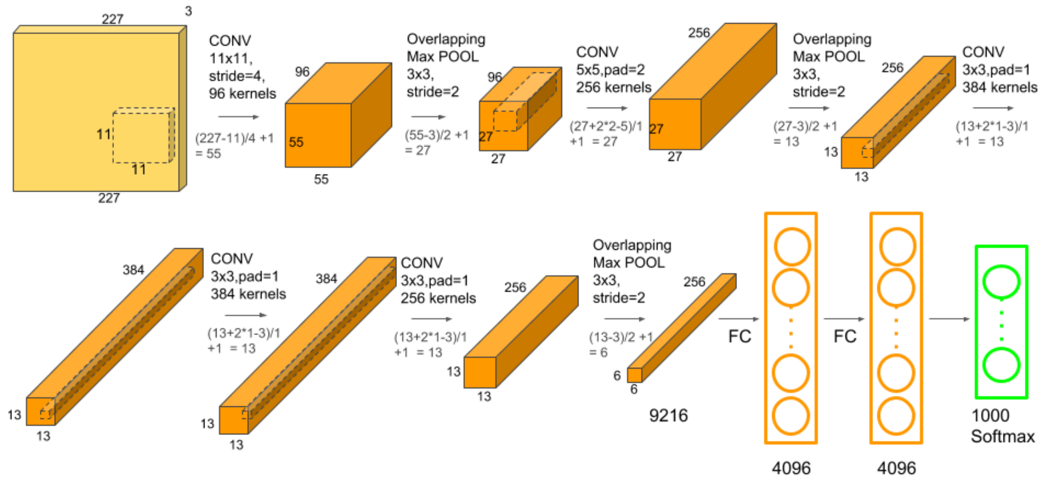


Fig: 3.4.1 CNN classification

1. **Input**: Color images of size 227x227x3
2. **Conv-1**: The first convolutional layer consists of 96 kernels of size 11×11 applied with a stride of 4 and padding of 0.
3. **MaxPool-1**: The maxpool layer following Conv-1 consists of pooling size of 3×3 and stride 2.
4. **Conv-2**: The second conv layer consists of 256 kernels of size 5×5 applied with a
5. Conv-2 consists of pooling size of 3×3 and a stride of 2.
6. **Conv-3**: The third conv layer consists of 384 kernels of size 3×3 applied with a stride of 1 and padding of 1.
7. **FC-1**: The first fully connected layer has 4096 stride of 1 and padding of 2.
8. **MaxPool-2**: The maxpool layer following neurons.
9. **FC-2**: The second fully connected layer has 4096 neurons.
10. **FC-3**: The third fully connected layer has 1000 neurons.

The size of output image of a Conv Layer

O=size(width) of output image.

I=size(width) of input image.

K=size(width) of kernels used in the Conv layer.

N=number of kernels.

S=stride of the convolution operation.

P=padding.

The size(O) of the output image is given by

$$O=[(I-K+2P)/S]+1 \qquad \text{(Eq:3.4)}$$

The no. of channels in the output image is equal to the no. of kernels N.

3.5 PROPOSED SYSTEM

In this project, we used canny edge detection methodology as it provides the presence of Gaussian filter which allows removing of noise in an image.

This can be enhanced with respect to the noise ratio by non-maxima suppression method which results in one pixel wide ridges as the output. This also detects the edges in a noisy state by applying the thresholding method. The effectiveness can be adjusted by using parameters. It gives good localization, response and is immune to a noisy environment. Later CNN classification is introduced because more than ANN, CNN is suitable for image processing.

3.5.1 Architecture

In this architecture at first input is given, here we give ultrasound image of a kidney it may be normal or abnormal kidney present with stones. As ultrasound images contain lot of speckle noise it is difficult to deal with them, to overcome this image preprocessing is done i.e., Gaussian filter is applied to remove noise. The next step is image segmentation, canny edge detection is used and this contains five steps such as Noise reduction, Gradient classification, non maximum suppression, Double threshold and Edge tracking at last we get an output with edges detected. This segmented image is given for wavelet processing. Later CNN is applied, in this we have Convolution layer, Max pooling layer, Activation layer and at last we find Fully connected layer. Rectified linear unit is used to scale the parameters to non negative values. We get pixel values as negative values too. In this layer we make them as 0's. The purpose of applying the rectifier function is to increase the non-linearity in our images. The reason we want to do that is that images are naturally non-linear. The rectifier serves to break up the linearity even further in order to make up for the linearity that we might impose an image when we put it through the convolution operation. The pooling (POOL) layer reduces the height and width of the input. It helps reduce computation, as well as helps make feature detectors more invariant to its position in the input. The role of the artificial neural network is to take this data and combine the features into a wider variety of attributes that make the convolutional network more capable of classifying images, which is the whole purpose from creating a convolutional neural network. Here we used Relu activation function this process is repeated two times and at last sigmoid is used. Max pooling is done to get better image and flatten method is used .Dropout was used to avoid overfitting. For identifying kidney stone network is fully connected. we obtain output with labels yes or no which tells about the presence or absence of stone.

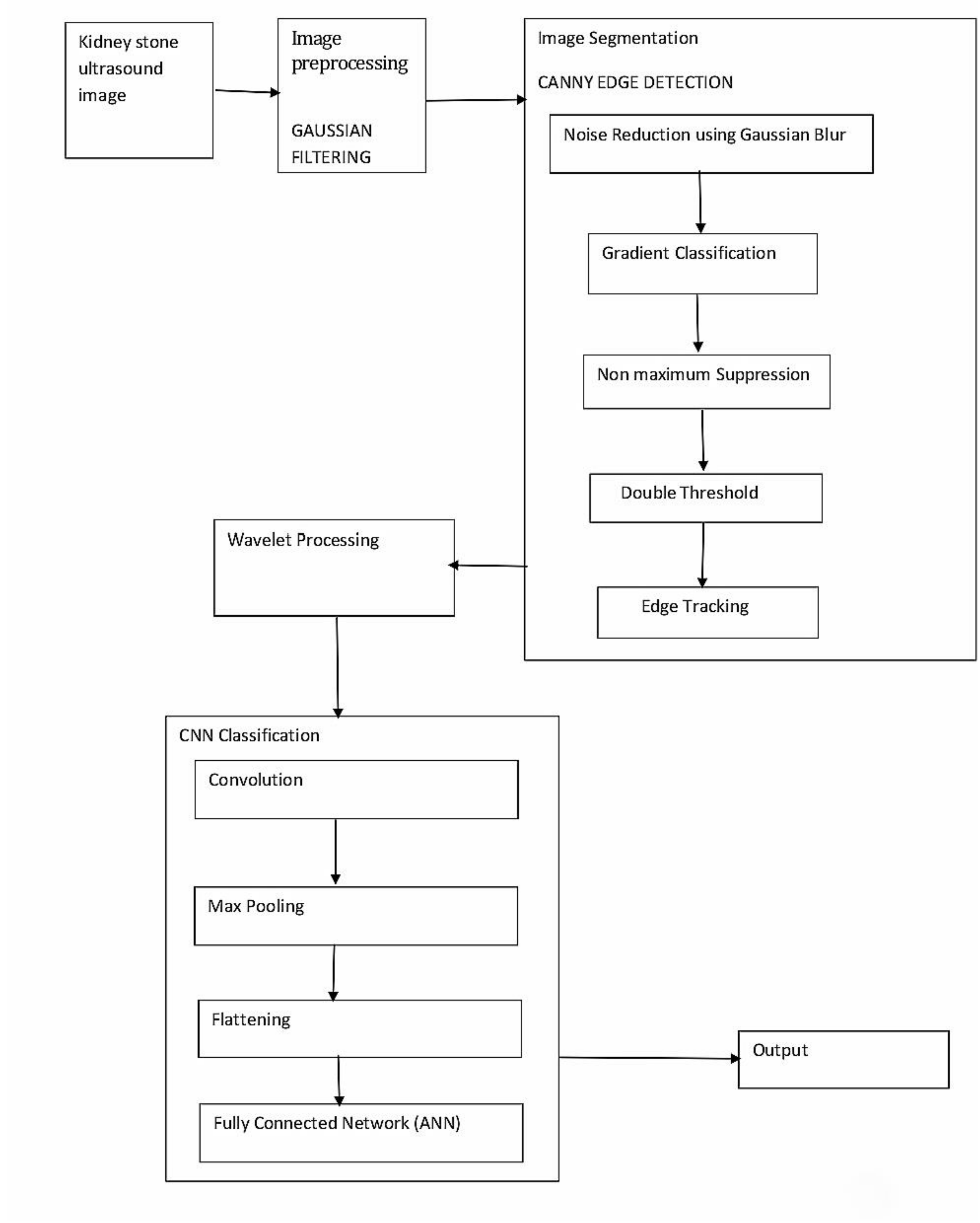


Fig: 3.5.1 Architecture

4. EXPERIMENTAL ANALYSIS 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 project during the implementation of CNN classification module. A data set (or dataset) is a collection of data. In the case of tabular data, a data set corresponds to one or more database tables, where every column of a table represents a particular variable, and each row corresponds to a given record of the dataset in question. In this vast internet world, there are 'n' number of images that can be used in this project but finding the best images is an hectic task. We have collected images from Google and created a file containing images.

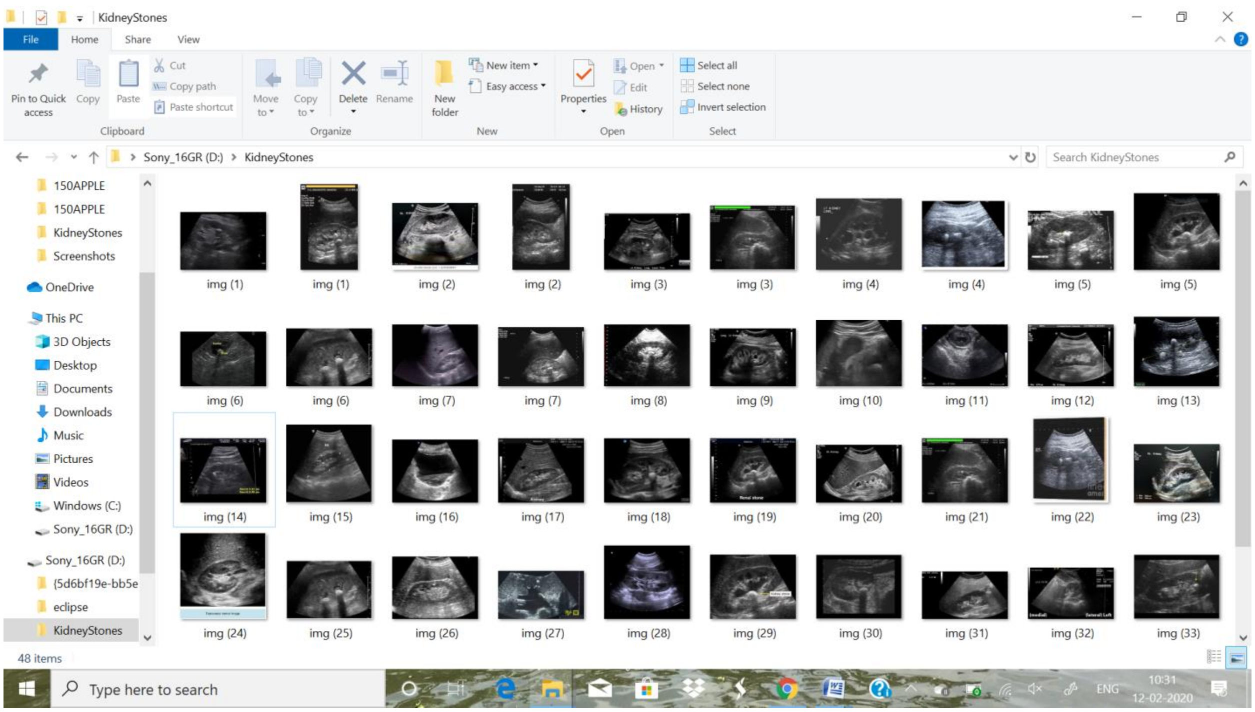


Fig: 4.1.1 Dataset images

The above images collected as a dataset are contained into a csv file after conversion.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Capture.PNG	1	0	0	0	0	0	0	0	0	0	0	0
2	Images (11).jpg	0	0	0	0	0	0	0	0	0	0	0	0
3	Images (13).jpg	0	17	17	17	45	45	45	35	35	35	35	35
4	Images (17).jpg	0	0	0	0	0	0	0	0	0	0	0	0
5	Images (19).jpg	1	19	4	3	22	7	6	22	9	7	22	9
6	Images (2).jpg	1	33	33	33	33	33	33	33	33	33	33	33
7	Images (20).jpg	1	15	15	15	16	16	16	126	126	126	87	87
8	Images (21).jpg	1	15	22	9	12	20	18	4	23	0	14	14
9	Images (23).jpg	1	247	247	247	251	251	251	249	249	249	255	255
10	Images (24).jpg	1	30	28	27	32	30	29	33	31	30	34	32
11	Images (26).jpg	1	0	0	0	0	0	0	0	0	0	0	0
12	Images (28).jpg	1	255	255	255	244	244	244	245	245	245	246	246
13	Images (49).jpg	1	7	7	7	5	5	5	3	3	3	1	1
14	Images (53).jpg	0	0	0	0	0	0	0	0	0	0	0	0
15	Images (54).jpg	1	12	12	12	12	12	12	12	12	12	12	12
16	Images (55).jpg	1	211	211	211	178	178	178	177	177	177	181	181
17	Images (6).jpg	1	21	13	13	51	43	43	28	20	20	21	13
18	Images (66).jpg	1	6	6	6	4	4	4	10	10	10	5	5
19	Images (7).jpg	1	9	9	9	9	9	9	10	10	10	11	11
20	Images (71).jpg	0	23	23	23	169	169	169	157	157	157	28	28
21	Images (75).jpg	1	165	165	165	133	133	133	136	136	136	132	132
22	Images (91).jpg	1	1	1	1	1	1	1	1	1	1	1	1
23	Images (93).jpg	0	6	6	6	10	10	10	2	2	2	4	4
24	Images (96).jpg	1	104	104	104	46	46	46	61	61	61	119	119
25	Images - 2019-10-16	1	26	26	26	26	26	26	26	26	26	26	26
26	[redacted]-10-16	0	24	21	13	24	21	13	24	21	13	24	21

Fig: 4.1.2 Dataset csv file

Fig: 4.1.3 Pixel form of image

In the above (fig 4.1.1) the images are given as input to dataset code and we obtain a csv file (fig 4.1.2) ,later these images are converted into pixels form (fig 4.1.3).

Initially, as the ultrasound kidney image contains the 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 filter technique 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 to extract the useful information from the image by reducing or eliminating the information which is not required thereby reducing the amount of data to be processed. This technique is used to detect the edges which involves various steps. The first step is 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 three 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.

Relu layer: Rectified linear unit is used to scale the parameters to non negative values. We get pixel values as negative values too. In this layer we make them as 0’s. The purpose of applying the rectifier function is to increase the non-linearity in our images (fig 4.1.4). The reason we want to do that is that images are naturally non-linear. The rectifier serves to break up the linearity even further in order to make up for the linearity that we might impose an image when we put it through the convolution operation. What the rectifier function does to an image like this is remove all the black elements from it, keeping only those carrying a positive value (the grey and white colors).The essential difference between the non-rectified version of the image and the rectified one is the progression of colors. After we rectify the image, you will find the colors changing more abruptly. The gradual change is no longer there. That indicates that the linearity has been disposed of.

Pooling layer: The pooling (POOL) layer reduces the height and width of the input. It helps reduce computation, as well as helps make feature detectors more invariant to its position in the input.This process is what provides the convolutional neural network with the “spatial variance” capability (fig 4.1.5). In addition to that, pooling serves to minimize the size of the images as well as the number of parameters which, in turn, prevents an issue of “overfitting” from coming up. Overfitting in a nutshell is when you create an excessively complex model in order to account for the idiosyncracies we just mentioned. The result of using a pooling layer and creating down sampled or pooled feature maps is a summarized version of the features detected in the input. They are useful as small changes in the location of the feature in the input detected by the convolutional layer will result in a pooled feature map with the feature in the same location. This capability added by pooling is called the model’s invariance to local translation.

Fully Connected layer: The role of the artificial neural network is to take this data and combine the features into a wider variety of attributes that make the convolutional network more capable of classifying images, which is the whole purpose from creating a convolutional neural network. It has neurons linked to each other, and activates if it identifies patterns and sends signals to output layer .the output layer gives output class based on weight values.

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 (fig 4.1.4). 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 sigmoid activation is used function to detect the presence of stone.

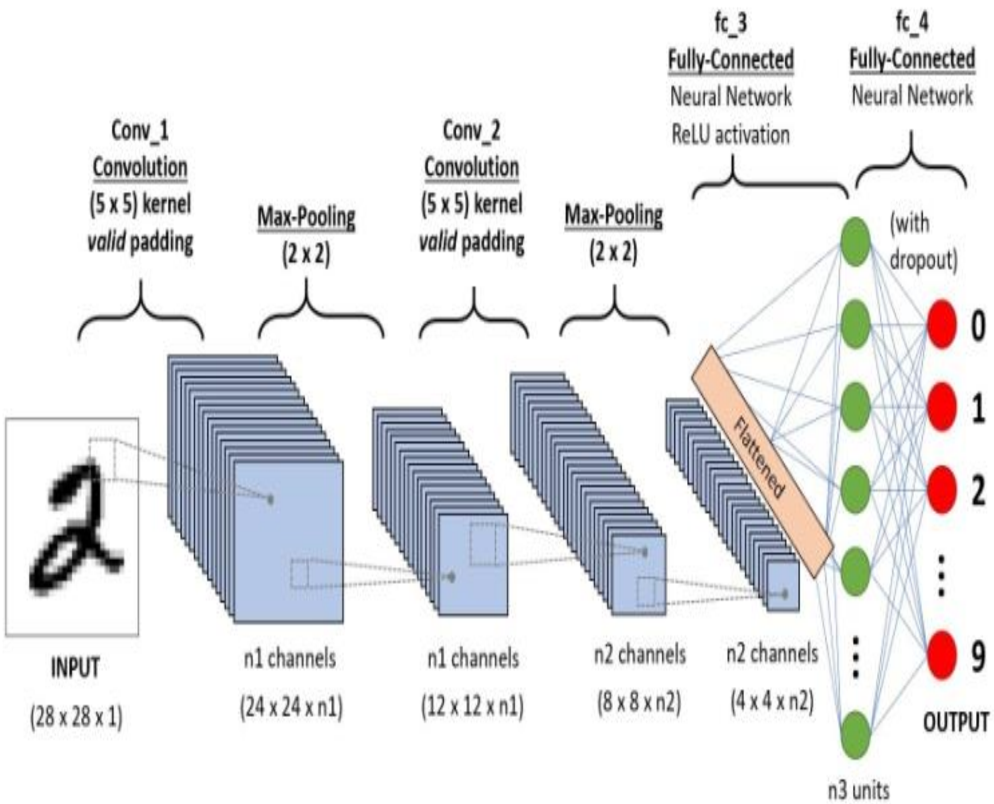


Fig: 4.1.4 Convolution methodology

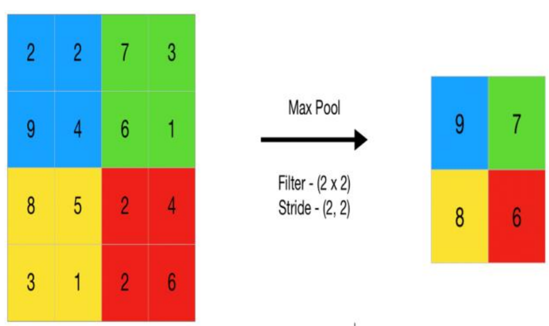


Fig: 4.1.5 Maxpooling

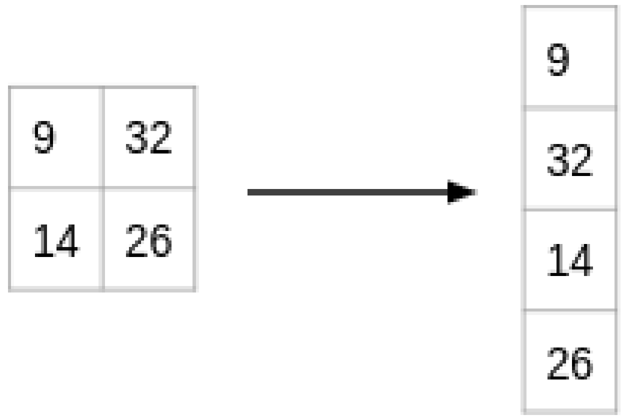
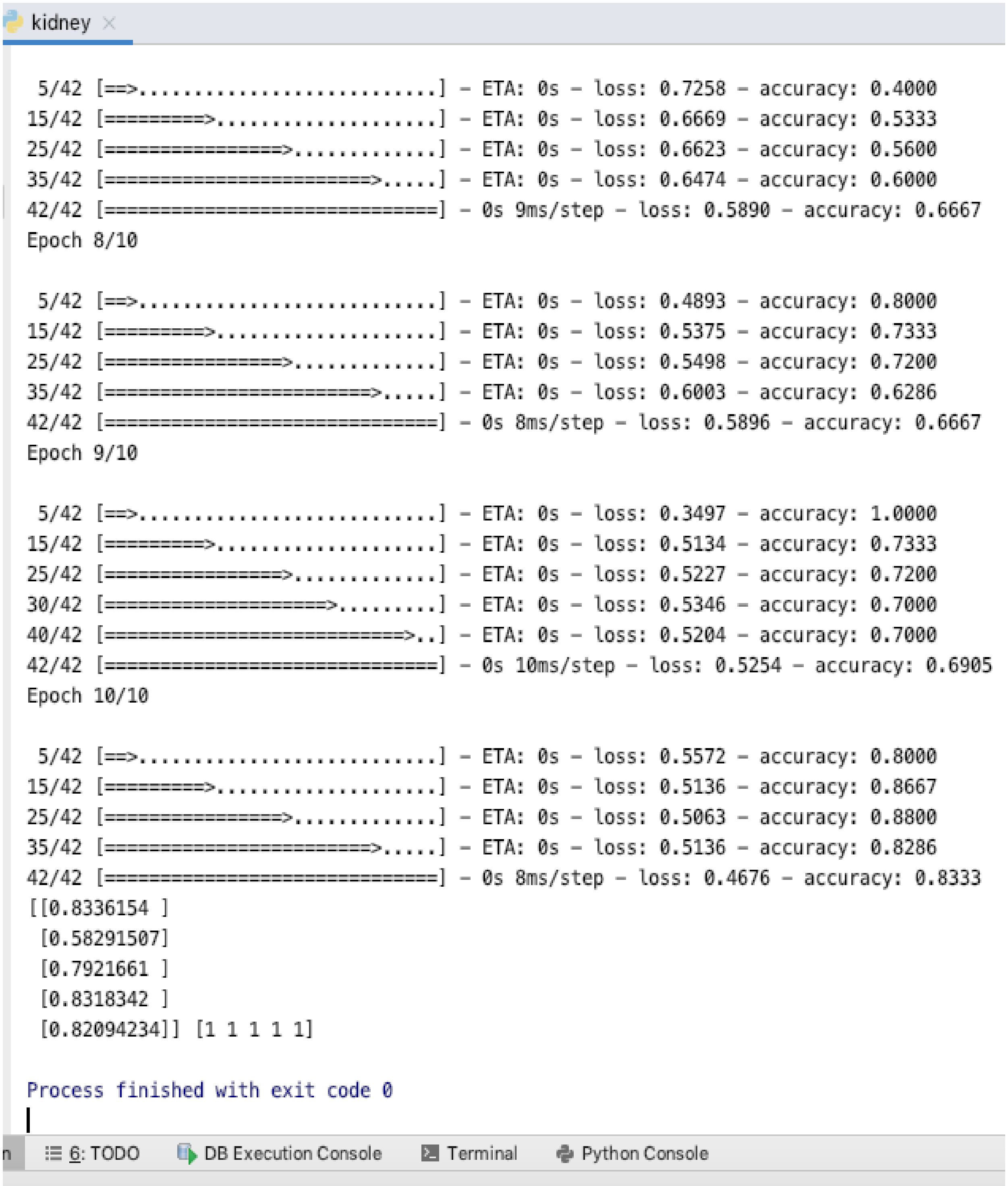


Fig: 4.1.6 Converting matrix into linear array form

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

Table : 4.1 Accuracy measures




```
 5/42 [==>...........................] - ETA: 0s - loss: 0.7258 - accuracy: 0.4000
15/42 [=========>....................] - ETA: 0s - loss: 0.6669 - accuracy: 0.5333
25/42 [================>.............] - ETA: 0s - loss: 0.6623 - accuracy: 0.5600
35/42 [========================>.....] - ETA: 0s - loss: 0.6474 - accuracy: 0.6000
42/42 [==============================] - 0s 9ms/step - loss: 0.5890 - accuracy: 0.6667
Epoch 8/10

 5/42 [==>...........................] - ETA: 0s - loss: 0.4893 - accuracy: 0.8000
15/42 [=========>....................] - ETA: 0s - loss: 0.5375 - accuracy: 0.7333
25/42 [================>.............] - ETA: 0s - loss: 0.5498 - accuracy: 0.7200
35/42 [========================>.....] - ETA: 0s - loss: 0.6003 - accuracy: 0.6286
42/42 [==============================] - 0s 8ms/step - loss: 0.5896 - accuracy: 0.6667
Epoch 9/10

 5/42 [==>...........................] - ETA: 0s - loss: 0.3497 - accuracy: 1.0000
15/42 [=========>....................] - ETA: 0s - loss: 0.5134 - accuracy: 0.7333
25/42 [================>.............] - ETA: 0s - loss: 0.5227 - accuracy: 0.7200
30/42 [====================>.........] - ETA: 0s - loss: 0.5346 - accuracy: 0.7000
40/42 [============================>..] - ETA: 0s - loss: 0.5204 - accuracy: 0.7000
42/42 [==============================] - 0s 10ms/step - loss: 0.5254 - accuracy: 0.6905
Epoch 10/10

 5/42 [==>...........................] - ETA: 0s - loss: 0.5572 - accuracy: 0.8000
15/42 [=========>....................] - ETA: 0s - loss: 0.5136 - accuracy: 0.8667
25/42 [================>.............] - ETA: 0s - loss: 0.5063 - accuracy: 0.8800
35/42 [========================>.....] - ETA: 0s - loss: 0.5136 - accuracy: 0.8286
42/42 [==============================] - 0s 8ms/step - loss: 0.4676 - accuracy: 0.8333
[[0.8336154 ]
 [0.58291507]
 [0.7921661 ]
 [0.8318342 ]
 [0.82094234]] [1 1 1 1 1]

Process finished with exit code 0
```

Fig: 4.1.7 Accuracy of stone detection

In the accuracy of stone detection (fig 4.1.7), the term ETA usually refers to estimated time of arrival but in technology realm it refers as estimated completion time of a computation process in general. The problem is to specific to estimating completion time of a batch of long scripts running parallel to each other, processing data and preparing some lists. The running time for each can be varied depending on the past data we considered.

The term Epoch is once all the images are processed one time individually of forward and backward to the network. Usually, we feed a neural network the training data for more than one epoch in different patterns by which a better generalization can be there when an unseen input data is given. If there is a large but finite training dataset then it gives the network a chance to see the previous data to readjust the model parameters so that the model is not biased towards the last few data points during training.

The term Loss (fig 4.1.7), is nothing but a prediction error of neural network and the method to calculate the loss is called loss function. A loss function is used to optimize the machine learning algorithm. The loss is calculated on training and validation sets and its interpretation is based on how well the model is doing in these two sets. It is the sum of errors made for each example in training or validation sets. Loss value implies how poorly or well a model behaves after each iteration of optimization .

An accuracy metric is used to measure the algorithm's performance in an interpretable way. Accuracy of a model is usually determined after the model parameters and is calculated in the form of percentage. It is the measure of how accurate the model prediction is compared to the true data i.e., training data.

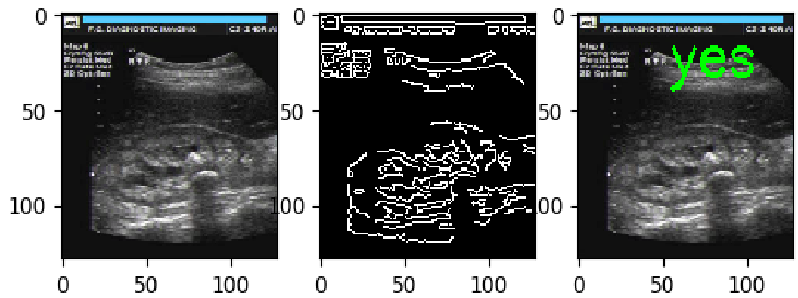


Fig:4.1.8Output with label yes (presence of stone)

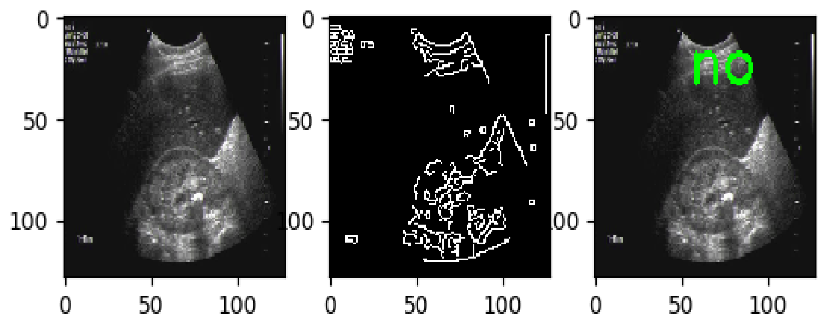


Fig: 4.1.9 Output with label No (absence of stone)

The above two images are our output images with presence and absence of stone in the kidney. In the images (fig 4.1.8) and (fig 4.1.9), the first image is input and the next one is the preprocessed image which is obtained after the completion of Gaussian filter and canny edge detection.

The Gaussian filter is used to blur the image or to reduce noise by applying Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen. Gaussian smoothing is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales—see scale space representation and scale space implementation. Canny edge detection is a multi-step algorithm that can detect edges with noise suppressed at the same time. Smooth the image with a Gaussian filter to reduce noise and unwanted details and textures. Intensity Gradient of the

Image is calculated and non maximum suppression is applied to remove any unwanted pixels which may not constitute the edge. Hysteresis Thresholding is applied in which are all edges are really edges and which are not. For this, we need two threshold values, minVal and maxVal. Any edges with intensity gradient more than maxVal are sure to be edges and those below minVal are sure to be non-edges, so discarded.

The image produced is free from noise and all the edges of ultrasound image are identified and these sent to CNN for further classification of stones.

4.1 SYSTEM CONFIGURATION

4.1.1 Software requirements

These are the software configurations used

Operating system: windows 10, mac os, linux.

IDE: Pycharm.

Python: Python is an interpreted, high-level, general purpose programming language created by Guido Van Rossum and first released in 1991, Python's design philosophy emphasizes code Readability withits notable use of significant Whitespace. Its language constructs and object oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed and garbage collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming.

PyCharm: PyCharm is an Integrated Development Environment (IDE) used in computer programming, specifically for the python language. It is developed by the Czech company JetBrains. It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems (VCSes), and supports web development with Django as well as Data science with Anaconda. Pycharm is cross platform with windows, macos and linux. The community edition is released under the Apache License and there is also Professional Edition with extra features- released under a proprietary license.

OpenCV: OpenCV (*Open source computer vision*) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by willow garage then Itseez (which was later acquired by Intel). The library is cross platform and free for use under the open source BSD license. OpenCV supports some models from deep learning frameworks like TensorFlow, Torch, PyTorch (after converting to an ONNX model) and Caffe according to a defined list of supported layers. It promotes Open Vision Capsules. which is a portable format, compatible with all other formats.

4.1.2 Hardware requirements

These are the Hardware interfaces used

Processor: Intel Pentium 4 or equivalent

RAM: Minimum of 256 MB or higher

HDD: 10 GB or higher

Monitor: 15’’ or 17’’ color monitor

Mouse: Scroll or optical mouse

Keyboard: Standard 110 keys keyboard

4.2 SAMPLE CODE

4.2.1Data set generation code:

```
importos
import cv2
importcsv
defflatten_and_serialize(pixels):
   flattened_pixels = []
forrow inpixels:
```

```
forpixel inrow:
            flattened_pixels.append(int(pixel))
returnflattened_pixels
defprepare_dataset(src_folder, dest_file):
withopen(dest_file, "w") asdataset:
        dataset_writer = csv.writer(dataset)
forfile inos.listdir(src_folder):
try:
                pixels = cv2.imread(src_folder + "/" + file, cv2.IMREAD_GRAYSCALE)
ifpixels isNone:
continue
new_size = (128, 128)
                pixels = cv2.resize(pixels, new_size)

serialized_pixels = flatten_and_serialize(pixels)
                row = [file,None,]

# Remove ,None, to remove column while generating dataset
row.extend(serialized_pixels)

 dataset_writer.writerow(row)
exceptException asexp:
print(file, exp)
if__name__ == "__main__":
    prepare_dataset("KidneyStones", "dataset.csv")
```

4.2.2 Gaussian blur code:

```
importos
importsys
importcv2 ascv
```

```
importnumpy asnp
frommatplotlib importpyplot asplt
importcanny
# [variables]
# [load]
defedgeFindWithGaussianBlurAndCanny(src):
    ddepth = cv.CV_16S
    kernel_size = 3
# Check if image is loaded fine
    # [load]
    # [reduce_noise]
    # Remove noise by blurring with a Gaussian filter
src = cv.GaussianBlur(src, (3, 3), 0)
# [reduce_noise]
    # [convert_to_gray]
    # Convert the image to grayscale
src_gray = cv.cvtColor(src, cv.COLOR_BGR2GRAY)
# [convert_to_gray]
    # Create Window
    # [laplacian]
    # Apply Laplace function
dst = cv.Laplacian(src_gray, ddepth, kernel_size)
# [laplacian]
    # [convert]
    # converting back to uint8
abs_dst = cv.convertScaleAbs(dst)
# [convert]
    # [display]
plt.subplot(121),plt.imshow(src, cmap = 'gray')
    plt.title('InputImage'), plt.xticks([]), plt.yticks([])
    plt.subplot(122),plt.imshow(abs_dst, cmap = 'gray')
```

```
    plt.title('MagnitudeSpectrum'), plt.xticks([]), plt.yticks([])
    plt.show()
    cann = canny.can(src)
returncann
```

4.2.3 Canny edge detection code:

```
importcv2
importsys
# np is an alias pointing to numpy library
importnumpy asnp# capture frames from a camera
    # converting BGR to HSV
defcan(frame):
    hsv = cv2.cvtColor(frame, cv2.COLOR_BGR2HSV)
# define range of red color in HSV

lower_red = np.array([30, 150, 50])
    upper_red = np.array([255, 255, 180])
# create a red HSV colour boundary and
    # threshold HSV image
mask = cv2.inRange(hsv, lower_red, upper_red)
# Bitwise-AND mask and original image
res = cv2.bitwise_and(frame, frame, mask=mask)
# Display an original image
cv2.imshow('Original', frame)
# finds edges in the input image image and
    # marks them in the output map edges
edges = cv2.Canny(frame, 100, 200)
# Display edges in a frame
cv2.imshow('Edges', edges)
```

```
    cv2.waitKey(0)
    cv2.destroyAllWindows()
returnedges
```

4.2.4 CNN code:

```
import numpy as np

from keras import Sequential

from keras.layers import Dense, Conv2D, Flatten, Convolution2D, Activation, Dropout,
MaxPooling2D

class CNN:

    def __init__(self):

        # self.model = Sequential()

       # self.model.add (Conv2D (64, kernel_size=3, activation='relu', input_shape=(128, 128, 1)))

        # self.model.add (Conv2D (32, kernel_size=3, activation='relu'))

        # self.model.add(Flatten())

        # self.model.add (Dense (1, activation='softmax'))

        # self.model.compile (loss='binary_crossentropy',

        #       Optimizer='rmsprop',

        #       metrics=['accuracy'])

Model = Sequential ()

        model.add(Convolution2D(32, 3, 3, input_shape=(128, 128, 1)))

        model.add(Activation('relu'))

        model.add (MaxPooling2D(pool_size=(3, 3)))

        model.add(Convolution2D(32, 3, 3))
```

```
    model.add(Activation('relu'))
    model.add (MaxPooling2D(pool_size=(3, 3)))
    model.add(Convolution2D(64, 3, 3))
    model.add(Activation('relu'))
    model.add(MaxPooling2D(pool_size=(3, 3)))
    model.add(Flatten())
    model.add(Dense(64))
    model.add(Activation('relu'))
    model.add(Dropout(0.5))
    model.add(Dense(1))
    model.add(Activation('sigmoid'))
    model.compile(loss='binary_crossentropy',
           optimizer='rmsprop',
           metrics=['accuracy'])
   self.model = model
  def fit(self, images, labels):
    return self.model.fit(images, labels, epochs=10, batch_size=5)
  def predict(self, images):
    probabilities = self.model.predict(images)
    return probabilities
```

4.2.5 Main code:

```
import numpy as np
```

```
import matplotlib.pyplot as plt

import guassian

import deserialize

import cv2 as cv

from cnnwrapper import CNN

def show_img(title, image):

    cv.imshow(title, image)

    cv.waitKey(0)

    cv.destroyAllWindows()

def find_edge_and_normalize():

    raw_images = []

processed_images = []

    labels = []

    for filename, label, image in deserialize.read_images('dataset.csv'):

        edges = guassian.edgeFindWithGaussianBlurAndCanny(image)

        processed_image = cv.normalize(edges, None, alpha = 0, beta = 1,
norm_type=cv.NORM_MINMAX, dtype = cv.CV_32F)

        # processed_image = np.expand_dims(processed_image, axis=2)

        processed_image = np.reshape(processed_image, (128, 128, 1))

        # print(processed_image)

        # show_img("Normalized Image", processed_image)

        raw_images.append(image)

        processed_images.append(processed_image)

        labels.append(label)
```

```
    return np.array(raw_images), np.array(processed_images), np.array(labels)

if __name__ == "__main__":

    LIMIT = -5

    raw_images, processed_images, labels = find_edge_and_normalize()

    model = CNN()

    model.fit(processed_images[:LIMIT], labels[:LIMIT])

    predictions = model.predict(processed_images[LIMIT:])

    print(predictions, labels[LIMIT:])

    for raw, processed, prediction in zip(raw_images[LIMIT:], processed_images[LIMIT:],
predictions):

        # raw = raw.reshape(128, 128, 3)

        processed = processed.reshape(128, 128)

        if prediction >= 0.75:

            result = 'yes'

        else:

            result = 'no'

        output = raw.copy()

cv.putText(output, result, (55, 32), cv.FONT_HERSHEY_SIMPLEX, 1, (0, 255), 2)

f, axarr = plt.subplots(1, 3)

axarr[0].imshow(raw)

axarr[1].imshow(processed, cmap='gray')

axarr[2].imshow(output)

 plt.show()
```

4.3 SCREENSHOTS

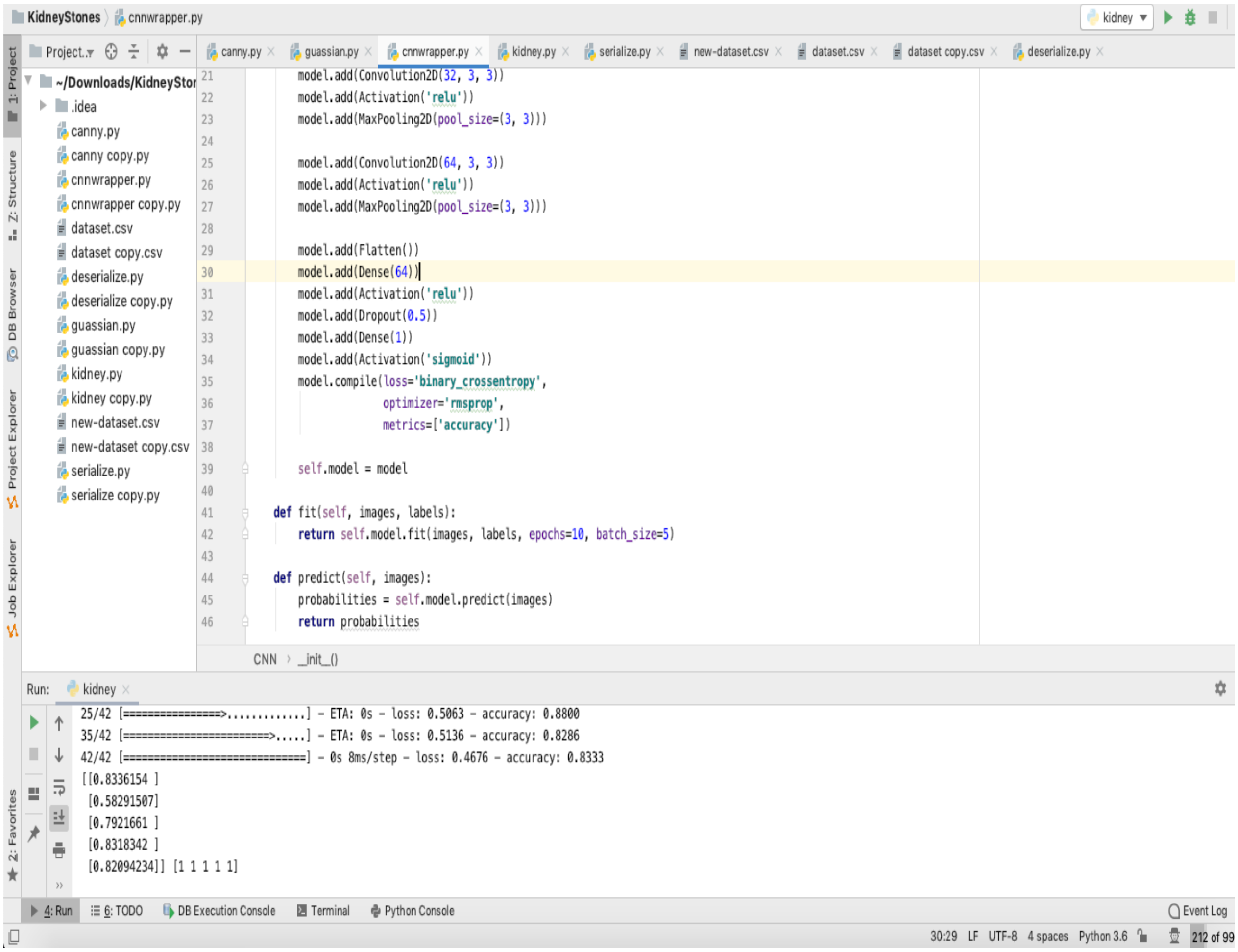


Fig: 4.3.1 Accuracy

This above figure indicates the code that is used to convert an input image which provides accuarcy in the next stage that is shown below.

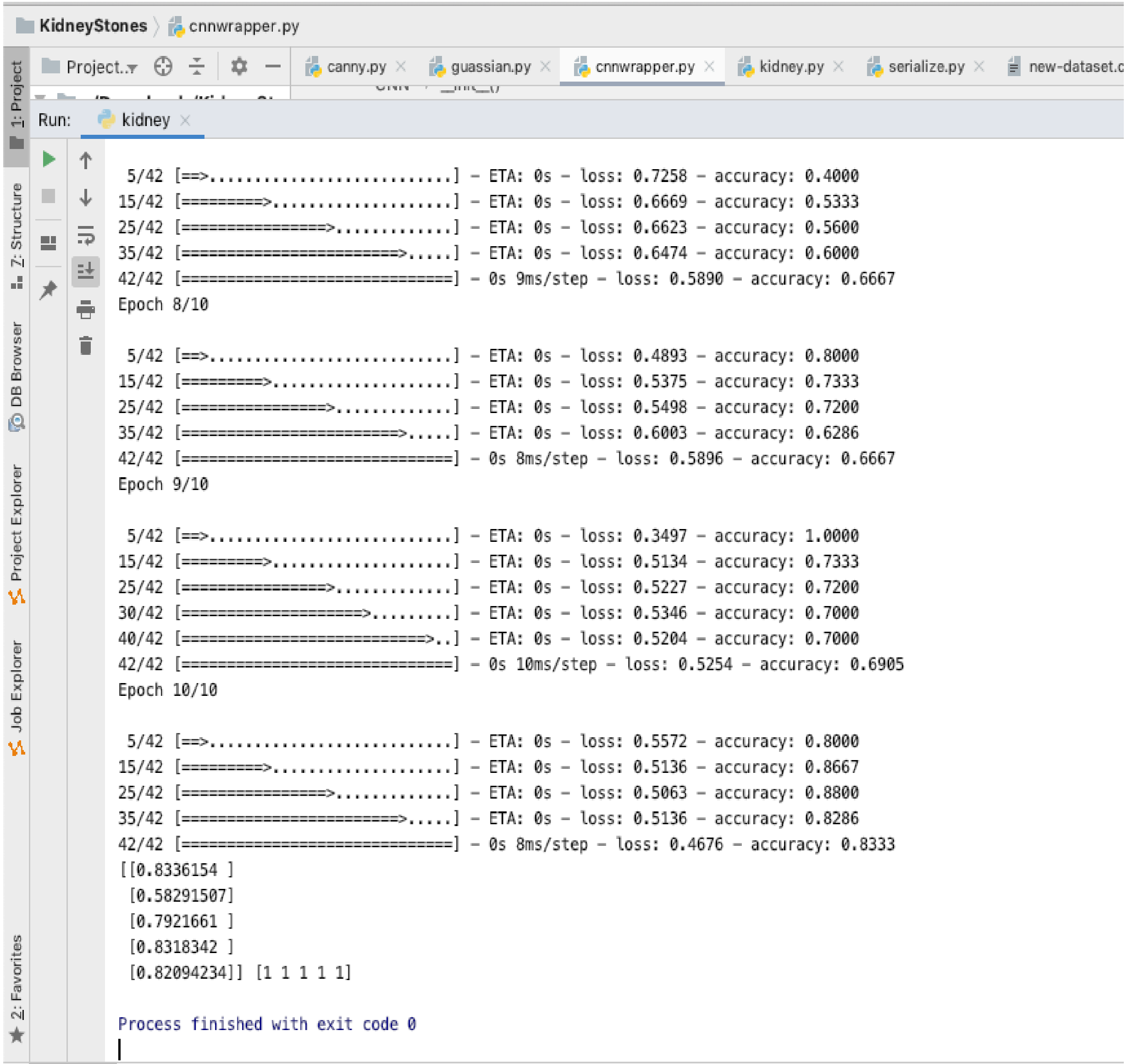


Fig: 4.3.2 Image Accuracies

After the above code is executed, the accuracy levels for each image given as an input is shown in the above figure.

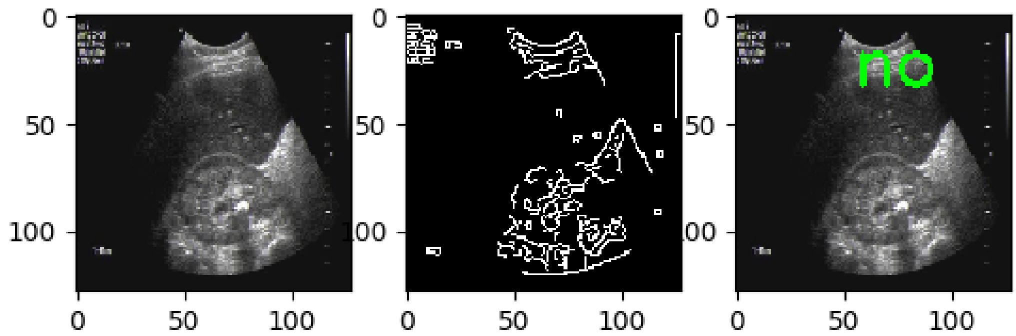


Fig: 4.3.3 Output 1

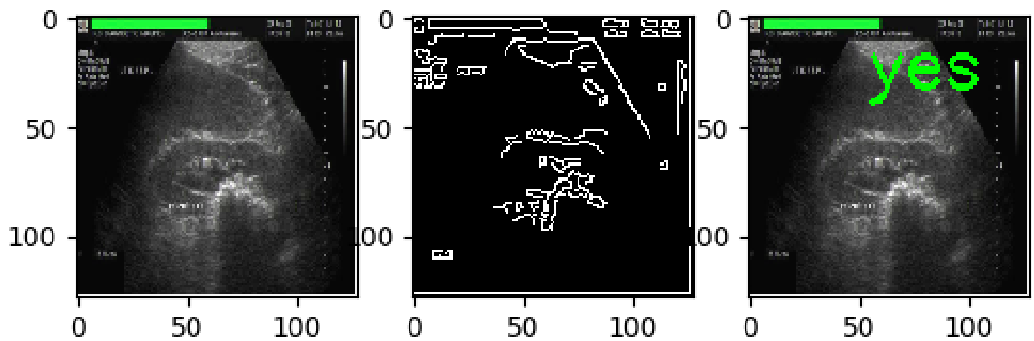


Fig: 4.3.4 Output 2

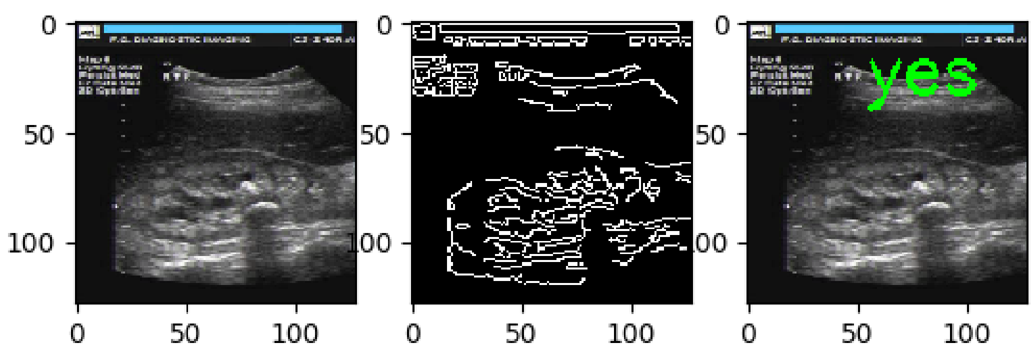


Fig: 4.3.5 Output 3

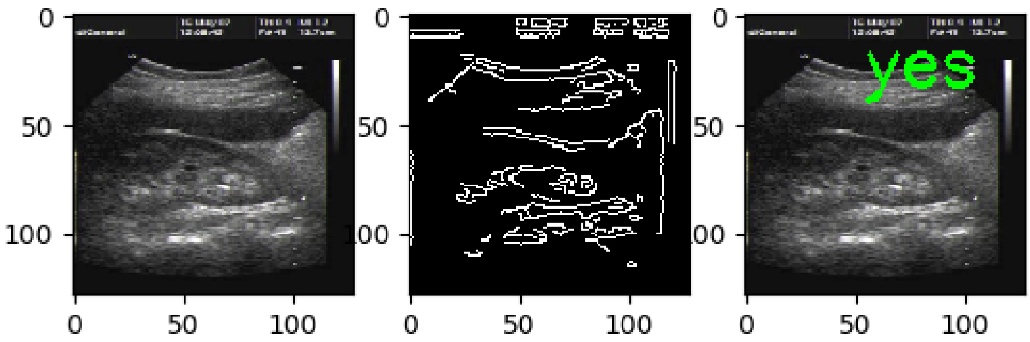


Fig: 4.3.6 Output 4

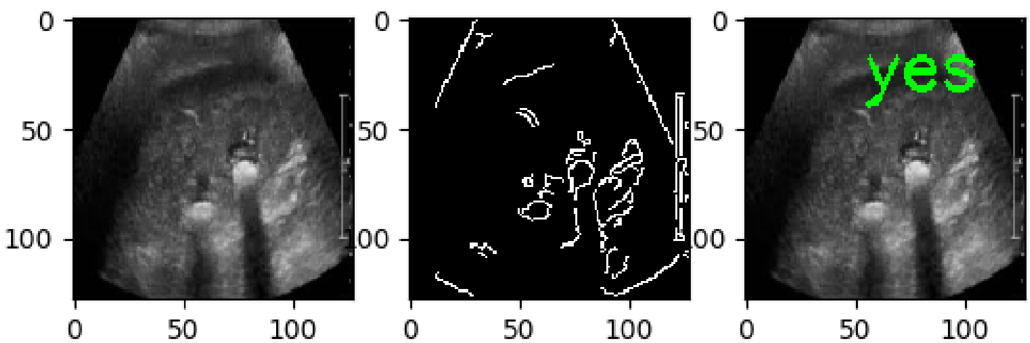


Fig: 4.3.7 Output 5

The above outputs depict the presence or absence of stones through processed images from input images. As in figure 1 when given an input image, a processed image is produced from which no presence of stone is depicted, and in figure 2 and so on when an input image is given, a processed image is produced from which the presence of stone is depicted.

4.4 TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, subassemblies, assemblies and or/a finished product. It is the process of exercising software with the intent of ensuring that the software system meets its requirements and user expectations does not fail in unacceptable manner. There are various types of test. Each test type addresses a specific requirement .

TYPES OF TESTINGS

1. Unit Testing

Unit testing involves the design of test cases that validate the internal program logic is functioning properly, and that program inputs procedure valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application. It is done after the completion of an individual unit before integration. This is structural testing that relies on knowledge of its construction and is invasive. Unit test perform basic test at component level and and test a specific business, application and/or system configuration Unit test ensures that each unique path of princess performs accurately to the documented specifications and contains clearly defined inputs and expected results .

2. Integration Testing

lntegration tests are designed to test integrated software components to determine if they actually run as one program. Testing in event driven and more concerened with the basic outcome of screens or fields. Integration test demonstrate that although the components were individually satisfaction, as shown successfully by unit testing the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination, of components

3. Functional Testing

Functional test provide systematic demonstrations that function tests are available as specified by the business and technical requirements requiremments, system documentation and user manuals.

Functional testing is centered on the following items:

Valid input: identify classes of valid input must be accepted.

Invalid Input: Identify classes of id pus must be rejected,

Functions: Identified be exercised identities function must be exercised

Output: identify classes of application outputs must be exercised

Procedures: interfacing systems or procedures must be invoked

Organization and preparation of functions test is focused on requirements, key functions or special test cases in addition , systematic coverage pertaining to identify business process flow; data fields , predefined process and successive process must be considered for testing. Before functional testing is complete, additional tests are identified and the effective value of current test is determined

4. System Test

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results An example on site testing is configuration oriented system integration test.

5. White box Testing

It is a testing in which the software tester has and of the inner workings, structure and language of the software, or atleast its purpose. It is used to test areas that cannot be reached from a black box level.

6. Black Box Testing

Black Box Testing a testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kind of tests must be written from a definitive source document, such as specification requirements document. It is a testing in which the software under test is treated as black box you cannot see into it. The test provides inputs and responds to outputs without considering how the software works.

4.4.1 Test plan:

A document describing the scope, approach, resources and schedule of intended test activities. It identifies amongst others test items, the features to be tested, the testing tasks, who will do each task, degree of tester independence, the test environment the test design techniques and entry and exit criteria to be used, and the rationale for their choice, and any risks requiring contingency planning . It is a record of the test planning process. Follow the below steps to create a test plan as per IEEE 829

Analyze the system: A system/product can be analyzed only when the tester has any information about it i.e, how the system works, who the end users are, what software/hardware the system uses, what the system is for etc.

Design the Test Strategy: Designing a test strategy for all different types of functioning, hardware by determining the efforts and costs incurred to achieve the objectives of the system. For any project, the test strategy can be prepared by

- Defining the scope of the testing.
- Identifying the type of testing required
- Risks and issues
- Creating test logistics.

Define the Test Objectives: Test objective is the overall goal and achievement of the test execution. Objectives are defined in such a way that the system is bug-free and is ready to use by the end-users. Test objective can be defined by identifying the software features that are needed to test and the goal of the test, these features need to achieve to be noted as successful.

Define Test Criteria: Test Criteria is a standard or rule on which a test procedure or test judgment can be based. There are two such test criteria: Suspension criteria where if the specific number of test cases are failed, then the tester should suspend all the active test cycle till the criteria is resolved, Exit criteria which specifies the criteria that denote a successful completion of a test phase.

Resource Planning: Resource plan is a detailed summary of all types of resources required to complete the project task. Resource could be human, equipment and materials needed to complete a project.

Plan Test Environment: A testing environment is a setup of software and hardware on which the testing team is going to execute test cases.

Schedule & Estimation: Preparing a schedule for different testing stages and estimating the time and man power needed to test the system is mandatory to mitigate the risk of completing the project within the deadline. It includes creating the test specification, test execution, test report, test delivery.

Determine Test Deliverables: Deliverables are the documents, tools and other components that has to be developed and maintained in support of the testing effort. Test deliverables are provided before, during and after the testing phase.

Test Plan and different scenarios to be considered for this project are as follows:

1. This project is developed at an aim to detect the stones in a kidney i.e to identify the presence of stone in kidney.
2. Various modules of the project like the kidney detection with noise detection, edge detection are all tested under unit and functional testing. After detecting the stone, check if the system is able to extract required features of the kidney or not through functional testing. Since this is project doesn’t have any form of api, API testing and database testing are out of scope for test plan. Nonfunctional testing such as size of stone, type of

stone or logical database currently will not be tested. At last, the entire system is tested through system testing for the alert of presence of stone.

3. To mitigate the risks of any team member not able to understand the testing, every team member in the project group is made familiar to the testing process. To make the testing faster, two members of this project group have been handled the responsibility to test this system. N.Amrutha lakshmi and M.Sushma have performed the functional and system testing of this system respectively.
4. The suspension criteria for this project is considered as 50% i.e, if whenever the 50% of test cases failed then the testing cycle is suspended and the development team comprising of B.Jyothirmayi and A.Srimanoj have made the required improvement in the code. The exit criteria is that the 95% of the test cases should be successful. We have achieved this success under less clarity ultra sound image conditions and good light conditioned ultrasound images.
5. The resource planning for testing comprised of two members from the project team namely, N.Amrutha lakshmi who identified different scenarios for testing amd can be considered as the Developer in test cum Test Administrator, M.Sushma who executed the given tests, logged the results and reported the defects to the project team.
6. The system resources and the test environment comprised of the Windows 10 PC run under an i5 6th Gen processor and 8GB RAM with a 1TB HDD. The entire project is run and tested under PyCharm IDE .
7. The schedule for this project is as follows:
    - The test specification for this project is created by N.Amrutha lakshmi which comprised of testing the different modules of the project under different conditions and excluding certain scenarios.
    - The test execution is performed by M.Sushma which included executing all various test cases provided by N.Amrutha lakshmi. Logging the results and reporting the outcomes along with defects is performed by her carefully.
    - The test reports are generated accordingly by both the members of the testing team. Defects are dealt accordingly by the development team which included B.Jyothirmayi and A.Srimanoj. Later again these test cases have been tested and are proved successful in achieving the correct results.

4.5 TEST REPORT

The testing of the system is performed for various test cases under different conditions considering most of the possible scenarios.

To list a few, some of the test reports have been listed below.

Test Case	UTC-1
Name of the Test	Kidney stone detection
Item Tested	kidney images
Sample Input	Ultrasound kidney images
Expected Output	Presence of stone in kidney image
Actual Output	Same as expected output
Remarks	successful

Table 4.4.1

Test Case	UTC-2
Name of the Test	Kidney stone detection
Item Tested	Kidney images
Sample Input	Ultrasound kidney images
Expected Output	Absence of stone in kidney image
Actual Output	Same as expected output
Remarks	successful

Table 4.4.2

5. CONCLUSION AND FUTURE WORK

CONCLUSION:

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.

FUTURE WORK:

The work can be extended by identifying the region of kidney stone and also predicting the size of the stone. The same can be utilized in an efficient way a possible victim can get worried or just cautious depending on the results, contradicting to waiting for prolonged periods without any closure.

6. APPENDIX

Python

Python is an interpreted, high-level, general purpose programming language created by Guido Van Rossum and first released in 1991, Python's design philosophy emphasizes code Readability withits notable use of significant Whitespace. Its language constructs and object oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed and garbage collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming.

PyCharm

PyCharm is an Integrated Development Environment (IDE) used in computer programming, specifically for the python language. It is developed by the Czech company JetBrains. It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems (VCSes), and supports web development with Django as well as Data science with Anaconda. Pycharm is cross platform with windows, macos and linux. The community edition is released under the Apache License and there is also Professional Edition with extra features-released under a proprietary license.

OpenCV

OpenCV (Open source computer vision) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by willow garage then Itseez (which was later acquired by Intel). The library is cross platform and free for use under the open source BSD license. OpenCV supports some models from deep learning frameworks like TensorFlow, Torch, PyTorch (after converting to an ONNX model) and Caffe according to a defined list of supported layers. It promotes Open Vision Capsules which is a portable format, compatible with all other formats.

SciPy

The scipy package contains various toolboxes dedicated to common issues in scientific computing. Its different submodules correspond to different applications, such as interpolation, integration, optimization, image processing, statistics, special functions, etc. The SciPy library depends on NumPy, which provides convenient and fast Ndimensional array manipulation. The SciPy library is built to work with NumPy arrays and provides many user-friendly and efficient numerical practices such as routines for numerical integration and optimization. Together, they run on all popular operating systems, are quick to install and are free of charge. NumPy and SciPy are easy to u The basic data structure used by SciPy is a multidimensional array provided by the NumPy module. NumPy provides some functions for Linear Algebra, Fourier Transforms and Random Number Generation, but not with the generality of the equivalent functions in SciPy. se, but powerful enough to depend on by some of the world's leading scientists and engineers.

Numpy

NumPy is a library for the python programming language, adding support for large, multi-dimensional arrays and matrices, along with a large collection of high level mathematical functions to operate on these arrays. The ancestor of NumPy, Numeric, was originally created by Jim with contributions from several other developers. In 2005, Travis created NumPy by incorporating features of the competing Numarray into Numeric, with extensive modifications. NumPy is open source software and has many contributors.

Dlib

Dlib is a modern C++ toolkit containing machine learning algorithms and tools for creating complex software in C++ to solve real world problems. It is used in both industry and academia in a wide range of domains including robotics, embedded devices, mobile phones, and large high performance computing environments. Dlib's open source licensing allows you to use it in any application, free of charge. There is no installation or configure step needed before you can use the library. Among other applications of Dlib, this packge aslo contributes mostly to image processing techniques such as

- Routines for reading and writing common image formats.
- Automatic color space conversion between various pixel types
- Common image operations such as edge finding and morphological operations
- Implementations of the SURF, HOG, and FHOG feature extraction algorithms.
- Tools for detecting objects in images including frontal face detection and object pose estimation.
- High quality face recognition.

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Design and analysis performance of Kidney Stone Detection from Ultrasound Image by Level Set Segmentation and ANN Classification

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***Abstract*--The abnormalities of the kidney can be identified by ultrasound imaging. The kidney may have structural abnormalities like kidney swelling, change in its position and appearance. Kidney abnormality may also arise due to the formation of stones, cysts, cancerous cells, congenital anomalies, blockage of urine etc. For surgical operations it is very important to identify the exact and accurate location of stone in the kidney. The ultrasound images are of low contrast and contain speckle noise. This makes the detection of kidney abnormalities rather challenging task. Thus preprocessing of ultrasound images is carried out to remove speckle noise. In preprocessing, first image restoration is done to reduce speckle noise then it is applied to Gabor filter for smoothening. Next the resultant image is enhanced using histogram equalization. The preprocessed ultrasound image is segmented using level set segmentation, since it yields better results. In level set segmentation two terms are used in our work. First term is using a momentum term and second term is based on resilient propagation (R_{prop}). Extracted region of the kidney after segmentation is applied to Symlets, Biorthogonal (bio3.7, bio3.9 & bio4.4) and Daubechies wavelet subbands to extract energy levels. These energy level gives an indication about presence of stone in that particular location which significantly vary from that of normal energy level. These energy levels are trained by Multilayer Perceptron (MLP) and Back Propagation (BP) ANN to identify the type of stone with an accuracy of 98.8%.**

Keywords— Kidney Stone detection , Level Set Segmentation , Multilayer Perceptron (MLP) and Back Propagation (BP),Wavelet transform, and Ultrasound imaging.

I. INTRODUCTION

Kidney stone disease is one of the risks for the life in throughout the world, and majority people with stone formation in kidney initial do not notice it as disease and it damages the limb (organ) slowly. Before viewing symptoms, many people affected by continual kidney failure due to diabetes mellitus and hypertension, glomerulonephritis etc. Since kidney malfunctioning can be life threatening, diagnosis of diseases in the earlier stages is crucial. The currently available options include Ultrasound (US) image which is one of the non-invasive low cost, widely used imaging techniques for diagnosing kidney diseases [1]. Shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), relative super saturation (RSS) are the techniques to test urine. The Robertson Risk Factor Algorithms (RRFA) are open and are used for laparoscopic surgery, these algorithms are reserved for uncommon [15].Special cases. Hyaluronan is a large (>106 Da) linear glycosaminoglycan composed of repeating units of glucuronic acid (GlcUA) and N-acetyl glucosamine (GlcNAc) disaccharides [16]. Hyaluronan has a central role in a number of processes that can ultimately lead to renal stone disease, including urine concentration, Uric acid, Salt form crystal, crystallization inhibition, crystal retention, Magnesium ammonium phosphate and amino acid.

Tanzila Rahman, Mohammad Shorif Uddin proposed reduction of speckle noise and segmentation from US image is discussed. It not only detect kidney region, but also enhance image quality [1]. The wan Mahani Hafizah proposed kidney US images were divided into four dissimilar categories: normal, bacterial infection, cystic disease, kidney stones, based on gray level co-occurrence matrix (GLCM). From these categories doctors identify that the kidney is normal or abnormal [2]. Gladis Pushpa had proposed Hierarchical Self Organizing Map (HSOM) for brain tumours using segmentation, wavelets packets, and the results were correct up to maximum 97% [3]. Norihiro Koizumi proposed high intensity focused ultrasound (HIFU) technique, used for destroying tumours and stones [4, 13]. Bommanna Raja proposed content descriptive multiple features for disorder identification and artificial neural network (ANN) for classification and the results says that the maximum efficiency is 90.47%, and accuracy 86.66% only [5]. The MLP- BP ANN is found as better performance in terms of accuracy having 92%, speed is 0.44 sec and sensitivity [8, 24]. The Non-invasive combination of renal using pulsed cavitation US therapy proposed shock wave lithotripsy (ESWL) has become a standard for the treatment of calculi located in the kidney and ureter [10]. Mohammad E. Abou EI-Ghar projected location of urinary stones with unenhanced computed tomography (CT) using half-radiation (low) dose compared with the standard dose and of the 50 patients, 35 patients had a single stone while the rest of them had multiple stones[11]. In order to solve the local minima and segmentation problem the thord Andersson, Gunnar Lathen proposed modified gradient search and level set segmentation [12]. For 3D detection of kidneys and their pathology in real time, the Emmanouil Skounakis proposed *templates based technique* with accuracy of 97.2% and abnormalities in kidneys at an accuracy of 96.1% [13].

The paper proceeds as follows: In section II problem statement defined, section III describes proposed method, in section IV image segmentation to locate the kidney stone, in section V calculation of energy optimization for segmentation, in section VI wavelets based energy extraction, in section VII artificial neural networks classifiers used is described, in section VIII experiments results are discussion and in the last section we conclude the paper with future work.

II. Problem Statement

The kidney malfunctioning can be life threatening, thus detection of kidney stone in the earlier stages is crucial. In order to carry out surgical operation to remove kidney stone it is important to locate the kidney stone. The ultrasound images of kidney contain speckle noise and are of low contrast which makes the detection of kidney abnormalities a challenging task. As a result the doctors may have problem to identify the small kidney stones and their type properly. To address this issue a modified level set segmentation to identify location of the stone, Wavelets subbands to extract the energy levels of the stone and MLP-BP ANN algorithms for classification is proposed and analyzed [9].

III. Methodlogy

Fig.1. shows the overall block diagram of proposed method. It consists of the following blocks Kidney Image Database, Image Pre-processing, Image Segmentation, Wavelet processing and ANN Classification.

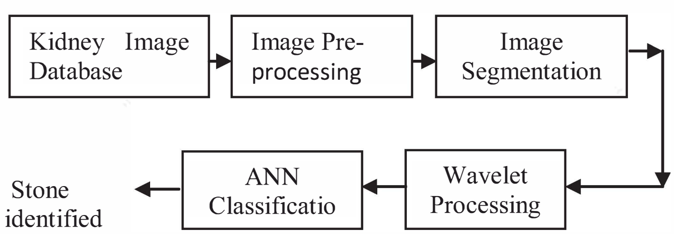

Fig.1. Block Diagram of proposed method

A. Kidney Image Database

The 500 US kidney images of both normal and abnormal kidney are collected from different hospitals of different patients and are stored in database. One of the image is taken from the database and subjected to stone detection.

B. Image Pre-Processing

The acquired ultrasound (US) image consists of speckle noise and is of low contrast. Due to this, the image quality is may not be good for analyzing. For surgical operations it is very important to identify the location of kidney stone. To overcome speckle noise and low contrast, pre-processing of US image needs to be done. Fig.2. shows pre-processing of US image, which consists of the following steps:

1. Image restoration
2. Smoothing and sharpening
3. Contrast enhancement

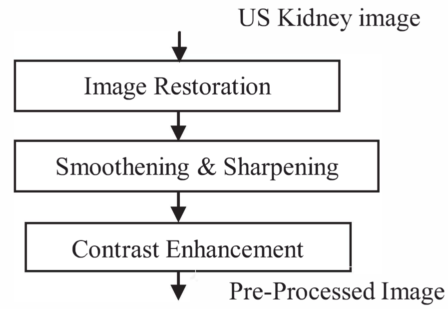

Fig.2. Pre-processing of kidney image

1. Image Restoration

The very purpose of image restoration is to reduce the degradations that are caused during acquisition of US scanning. In this system for proper orientation, level set function is used. By the use of plan curve motion, curve smoothers, shrinks are eventually disappeared [1].

2. Smoothing and Sharpening

To obtained optimal resolution in both spatial and frequency domains, Gabor filter is used which act as band pass filter for the local spatial frequency distribution [4]. The standard deviation of the Gaussian function can be varied to adjust degree of smoothening.

3. Contrast Enhancement

To improve contrast and to obtain uniform intensity histogram equalization is used. This approach can be used on whole image or part of an image. In this system, enhancing the contrast of images is done by transforming the values in an intensity image, such that the histogram of the output image approximately matches a specified histogram. The output signal is of same data type as the input signal.

IV. Image Segmentation

Fig.3. shows the level set segmentation method used to segment the location of kidney stone. Proposed work consists of two modified gradient descent methods. First is using a momentum term and second is based on resilient propagation (R_{prop}) term. The intention of the segmentation is to overcome difficulties involved in energy function. The energy function depends on properties of the image such as gradients, curvatures, intensities and regularization terms, e.g. smoothing constraints. These are simple, but effective modifications of the basic method are directly compatible with any type of level set implementation. The first proposed method is based on a modification which essentially adds a momentum to the

motion in solution space [15, 19]. This simulates the physical properties of momentum and often allows the search to disregard local optima and take larger steps in positive directions. In order to avoid the typical problems of gradient descent search, R_{prop} provides a modification which uses individual adaptive step sizes and the signs of the gradient components.

1. *Momentum term*

Spinning to gradient descent with Momentum will adopt the machine learning community and choose a search vector according to:

$$a_l = -\eta(1 - w)\nabla f_l + wa_{l-1} \quad ------(1)$$

Where η is the *learning rate* and $\omega \in [0, 1]$ is the *momentum*. Note that $w = 0$ gives standard gradient descent $\boldsymbol{a}_l = -\eta\nabla f_l$, while $w = 1$ gives "infinite momentum" $\boldsymbol{a}_l = \boldsymbol{a}_{l-1}$.

2. *R_{prop} term*

The disadvantages of standard gradient descent (SGD) is overcome by incorporating adaptive step-sizes ∇_1 called *update-values* in which each dimension will have one update value i.e. dim (∇_l) = dim $(\boldsymbol{x}_l)$. The gradient size is never used in R_{prop}. The update rule considers only the signs of the partial derivatives. Another advantage of R_{prop}, which is very important in practical use, is the stoutness of its parameters; R_{prop} will work out of the box in many applications using only the standard values of its parameters [18, 20].

We will now describe the R_{prop} algorithm briefly, but for implementation details of R_{prop} we refer to [23. 21]. For R_{prop}, we choose a search vector $\boldsymbol{s}_l$ according to:

$$s_l = -sign\ (\nabla f_l) * \nabla_l \quad ------(2)$$

Where ∇_l is a vector containing the current update-values and sign $(\cdot)$ the element wise sign function.

V. Energy Optimization for Segmentation

The segmentation problems can be approached by using the calculus of variations where energy functions is defined representing the objective of the difficulty. The extreme to the functional are found using the Euler-Lagrange equation [10, 22] which is used to derive equations of motion, and the corresponding energy gradients, for the contour [17]. Using these gradients, a gradient descent search in contour space is performed to find a solution to the segmentation problems. Consider, for instance, the derivation of the *weighted region* described by the following functional:

$$f(p) = \iint_{\Omega_p} g(x, y)\,dxdy \quad -----(3)$$

Where p is a 1D curve embedded in a 2D space, Ω_p is the region inside of p, and $g(x, y)$ is a scalar function. This functional is used to maximize some quantity given by $g(x, y)$ inside p. If $g(x, y) = 1$ for instance, the area will be maximized. Calculating the first variation of Eq. 1 yields the evolution equation:

$$\frac{\partial p}{\partial t} = -g(x, y)\eta \quad ------(4)$$

Where η is the curve normal. Using $g(x, y) = 1$ which is constant flow in the negative normal direction. The contour is often implicitly represented by the zero level of a time dependent signed distance function, known as the level set function. The *level set method* was introduced by Osher and Sethian [6]. Formally, a contour p is described by $p = \{\boldsymbol{x}\boldsymbol{:}\ \varphi(\boldsymbol{x}, t) = 0\}$. The contour p is evolved in time using a set of partial differential equations (PDEs). A motion equation for a parameterized curve $\frac{\partial p}{\partial t} = \gamma\eta$ is in general translated into the level set equation $\frac{\partial \varphi}{\partial t} = \gamma|\nabla \varphi|$ Eq. 2 gives the familiar level set equation:

$$\frac{\partial \varphi}{\partial t} = -g(x, y)|\nabla \varphi| \quad ------(5)$$

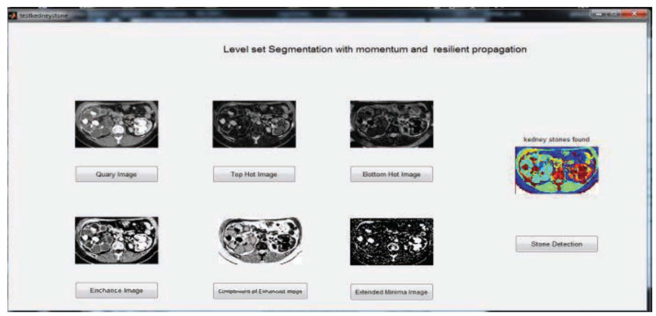

Fig.3. Level set segmentation of kidney stone detection

VI. Wavelet Processing

The segmented image which has got from previous block is applied to wavelet processing block. It consists of Daubechies filter (Db12), Symlets filter (sym12) and Biorthogonal filter (bio3.7, bio3.9 & bio4.3). *Daubechies filter (Db12)* in this the number 12 refers to the number of vanishing moments. Basically, the higher the number of vanishing moments, the smoother the wavelet (and longer the wavelet filter) and the length of the wavelet (and scaling) filter is two times that number [3]. *Symlets filter (sym12)* extract features of kidney image and analyse discontinuities and abrupt changes contained in signals, one of the 12^{th} - order Symlets wavelets is used. *Biorthogonal filter (bio3.7, bio3.9 & bio4.4)* filter's wavelet energy signatures were considered and averages of horizontal and vertical coefficients details were calculated. Each filter will give different energy levels or energy features. These energy features will show significant difference, if there is any stone is present in the particular region or location. The identification of type of stone is described in next section.

VII. ANN CLASSIFICATION

In ANN Classification two architectures are used namely, Multilayer Perceptron and back propagation which are described in detail in the following sections.

1. Multilayer Perceptron (MLP)

A multilayer perceptron is a feed forward artificial neural network algorithm that maps sets of energy values obtained from wavelets subbands energy extraction shown in the table1. These energy values are fed to input layer and multiplied with initial weights as in equation (6). The back propagation is modified version of linear perceptron in which it uses three or more hidden layers with nonlinear activation function. The back propagation is the most widely applied learning algorithm for multilayer perceptron in neural networks and it employs gradient descent to minimize the squared error between the network output value and desired output value as in equation (7). These error signals are used to calculate the weight updates which represent power of knowledge learnt in the network [7]. Multilayer Perceptron with Back Propagation (MLP-BP) are the main algorithms. Based on the literature survey, MLP-BP algorithm was found to be better than the others in terms of accuracy, speed and performance [14].

The phases involved in ANN are forward phase and backward phase as shown in fig4. In back propagation, weights are updated after each pattern and by taking one pattern m at a time as follows:

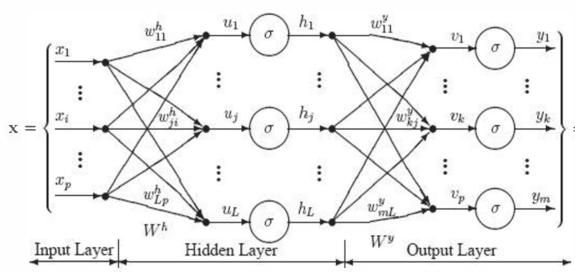

Fig.4. Multilayer Perceptron architecture

A. Forward Phase

Apply the pattern $X_j^{(l)}$ to the input layer and propagate the signal forward through the network until the final outputs X_j^L have been calculated for each i and L

$$X_j^{(l)} = \theta\left(s_j^{(l)}\right) = \theta\left(\sum_{i=0}^{D(L-1)} x_j^{(l)} w_j^{(l)} + w_j^{(l)}\right) ------(6)$$

Where D (L-1) is the number of neurons in layer (L-1), $X_i^{(l-1)}$ output of the jth neuron in the (l-1) th layer, $W_{ij}(i)$ synaptic weight contained in the current neuron, $W_{ij}(i)$ current neuron's bias weight, $X_j^{(l)}$ output of the current neuron.

B. Backward Phase

In this phase, the weights and biases are updated according to the error gradient-descent vector. After an input vector is applied during the forward computation phase, a network output vector is obtained. A target vector t is provided to the network, to drive the network's output toward the expected targeted value [10, 14].

Starting with the output layer, and moving back towards the input layer, calculates the error terms and gradient as follows:

$$e_j^{(l)} = \begin{cases} \left(u - x_j^{(l)}\right) & for \quad l = L \\ \sum w_{ij}^{(l+1)} s_j^{(l+1)} & for \quad l = 1,2,3, ... L-1 \end{cases} ------(7)$$

where e_j^l is the error term for jth neuron in the lth layer

$$s_j^{(l=1)} = e_j^{(l+1)} \theta(s_j^{(l)}) \quad for \quad l = 1,2,....... \quad ----(8)$$

where $\theta(s_j^{(l)})$ is the derivative if the activation function.

Calculate the changes for all the weights as follows:

$$\Delta w_{ij}^{(l)} = \eta\ s_j^{(l)} x_j^{(l-1)} .... l = 1,2,......... L \quad ------(9)$$

where η is the learning rate. Update all the weights as follows:

$$w_{ij}^{(l)}(L+1) = w_{ij}^{(l)}(L) + \Delta w_{ij}^{(l)}(L) \quad ------(10)$$

Where l=1, 2...L $^{(l)}$ and j=0, 1 ...L $^{(l-1)}$, $W_{ij}^{(l)}$ (L) is the current synaptic weight.

$W_{ij}^{(l)}$ (L+1) is the updated synaptic weights to be used in the next feed forward iteration. The Fig.4 show the complete cycle of period, in neural networks training the term period is used to describe a complete pass through all of the training patterns. The weight in the neural net may be updated after each pattern is presented to the net, or they may be updated just once at the end of the period.

C. Naive Bayes classification

Naive Bayes classifiers can handle an arbitrary number of independent variables whether continuous or categorical. Given a set of variables, X = {x_1,x_2...,x_d}, to construct the posterior probability for the event Cj among a set of possible outcomes C = {c_1,c_2...,c_d} where X is the predictors of energy values of kidney and C is the set of categorical levels present in the dependent variable. Using Bayes' rule:

$$P\left(c_J \mid x_1, x_2, ..., d_d\right) \propto P\left(x_1, x_2, ..., d_d \mid c_j\right) P(c_j) --(11)$$

Where p (C_j | x_1, x_2, ...,x_d) is the posterior probability of class membership , i.e., the probability that X belongs to C_j. Since Naive Bayes assumes that the conditional probabilities of the independent variables are statistically independent we can decompose the likelihood to a product of terms:

$$P\left(x \mid c_j\right) \propto \prod_{k=1}^{d} P(x_k \mid c_j) ----------(12)$$

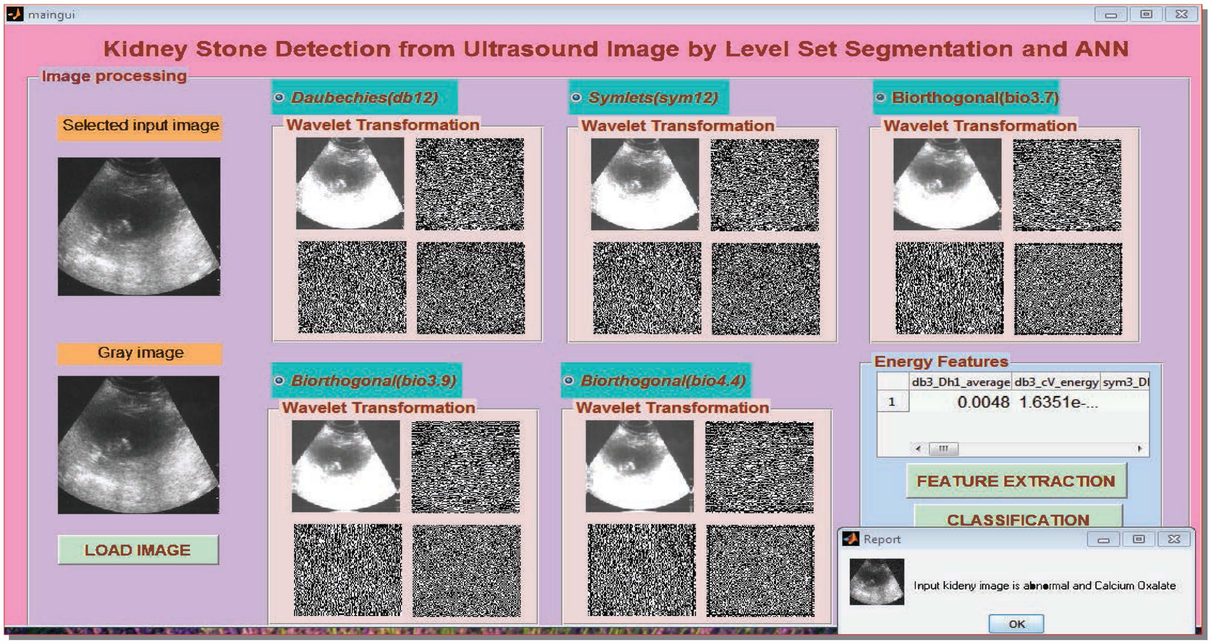

Fig.5. Wavelets subbands energy extraction

VIII. IMPLEMENTATION AND RESULTS

The implementation is done using Matlab 2012a. The Graphical User Interface (GUI) is created and as shown in the Fig.5. From the database of the US kidney images, one kidney image is loaded through the GUI. The loaded image pre-processed and is shown in the GUI. The image segmentation option given in the GUI is selected next to get segmented image. The segmented image is applied for Wavelet processing by selecting one of the wavelet filters shown in the GUI. After selecting the particular filter, that particular wavelet code will be invoked to get resultant image. Then the feature extraction option is selected to get list of energy levels extracted from the segmented image.

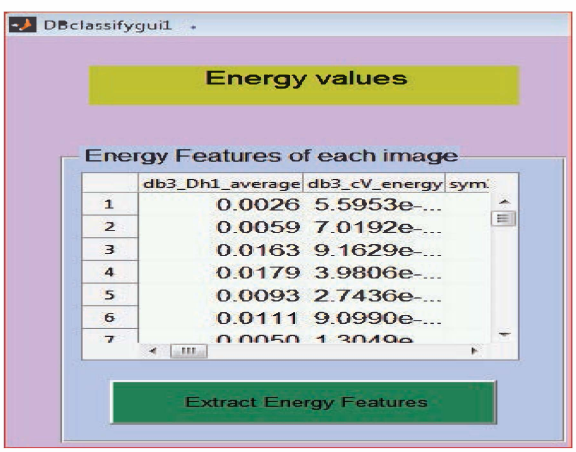

Fig.6. Wavelets subbands energy extracted values

In the GUI shown in the Fig.6 there is another table which lists energy levels of all the kidney images present in the database. This is done to test the accuracy of MLP-BP ANN system in identifying the kidney images as normal or abnormal and the stone type. Essentially in the database we have both normal and abnormal images which we already know how many of them are normal and abnormal. During the test it is found that our system can classify the kidney images as normal and abnormal almost with accuracy of 98.8%.

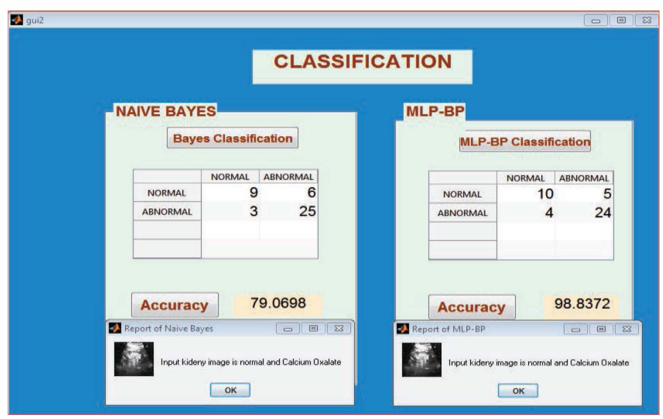

Fig.7. Naive bayes and MLP-BP Classifications for normal

The energy levels of kidney image are applied for classifications to classify the image which is found to be normal is shown in Fig.7 and Fig.8. shows the abnormality of another kidney image.

Db12 Dh1 average	Db12 cV energy	Sym12 Dh1 average	Sym12 cV energy	rbio3.7 Dh1 average	rbio3.7 cD energy	rbio3.7 cV energy	rbio3.7 Dh1 average	rbio3.9 cD energy	rbio3.9 cV energy	rbio3.9 cV average	rbio4.4 Dh1 average	rbio4.4 cH energy	rbio4.4 cV energy
0.0026	5.5953e-05	0.0026	5.5953e-05	0.0052	1.3895e-04	1.6450e-04	0.0043	1.0764e-04	1.0719e-04	0.0039	1.7720e-04	9.9153e-05	9.0838e-05
0.0059	7.0192e-05	0.0059	7.0192e-05	0.0127	2.2286e-04	1.8849e-04	0.0128	1.7324e-04	1.5039e-04	0.0129	3.9994e-04	1.6002e-04	1.3280e-04
0.0163	9.1629e-04	0.0163	9.1629e-04	0.0316	0.0010	0.0021	0.0306	7.6544e-04	0.0023	0.0303	0.0051	6.9376e-04	0.0022
0.0179	3.9806e-04	0.0179	3.9806e-04	0.0255	5.4659e-04	4.8874e-04	0.0263	3.9515e-04	5.3478e-04	0.0267	0.0051	3.5862e-04	5.7644e-04
0.0093	2.7436e-04	0.0093	2.7436e-04	0.0249	6.8200e-04	9.5594e-04	0.0214	5.2108e-04	8.9330e-04	0.0198	0.0031	4.9557e-04	9.0662e-04
0.0111	9.0990e-04	0.0111	9.0990e-04	0.0239	5.5269e-04	0.0033	0.0197	4.1572e-04	0.0023	0.0179	0.0031	3.8182e-04	0.0019
0.0050	1.3049e-04	0.0050	1.3049e-04	0.0094	5.6388e-04	3.4976e-04	0.0087	3.9534e-04	2.5024e-04	0.0085	7.2749e-04	3.4186e-04	2.1581e-04
0.0073	7.8642e-05	0.0073	7.8642e-05	0.0136	2.6317e-04	2.4022e-04	0.0132	1.8109e-04	1.5338e-04	0.0133	8.1203e-04	1.5963e-04	1.2771e-04
0.0105	2.3515e-04	0.0105	2.3515e-04	0.0137	7.1012e-04	4.0684e-04	0.0131	5.2176e-04	3.7809e-04	0.0133	0.0013	4.5959e-04	4.0670e-04
0.0145	1.3983e-04	0.0145	1.3983e-04	0.0154	6.6207e-04	3.3536e-04	0.0144	4.8498e-04	2.4507e-04	0.0184	0.0018	4.3049e-04	2.1859e-04
0.0173	2.1550e-04	0.0173	2.1550e-04	0.0278	6.2009e-04	4.9155e-04	0.0262	4.7615e-04	4.1534e-04	0.0260	0.0042	4.4141e-04	4.0481e-04
0.0128	3.7797e-04	0.0128	3.7797e-04	0.0256	5.8045e-04	5.3523e-04	0.0234	4.5160e-04	5.7497e-04	0.0238	0.0038	4.1888e-04	6.8299e-04
0.0074	0.0018	0.0074	0.0018	0.0132	8.6715e-04	0.0043	0.0133	6.7642e-04	0.0040	0.0140	8.5301e-04	6.2365e-04	0.0040
0.0043	2.0368e-04	0.0043	2.0368e-04	0.0072	6.4413e-04	4.8808e-04	0.0066	5.2519e-04	3.7235e-04	0.0065	4.2114e-04	4.8302e-04	3.3005e-04
0.0204	3.3482e-04	0.0204	3.3482e-04	0.0379	7.3661e-04	9.6556e-04	0.0353	5.1190e-04	8.2002e-04	0.0344	0.0043	4.3896e-04	7.5465e-04
0.0077	0.0012	0.0077	0.0012	0.0169	5.8343e-04	0.0030	0.0158	4.5069e-04	0.0028	0.0153	6.8829e-04	4.1780e-04	0.0027
0.0080	1.7951e-04	0.0080	1.7951e-04	0.0161	5.8455e-04	3.1453e-04	0.0155	4.8010e-04	2.9501e-04	0.0154	0.0017	4.4850e-04	3.1878e-04
0.0079	2.9445e-04	0.0079	2.9445e-04	0.0151	4.5209e-04	0.0010	0.0134	3.6543e-04	9.2231e-04	0.0126	0.0011	3.3598e-04	8.9855e-04
0.0171	5.9446e-04	0.0171	5.9446e-04	0.0325	0.0010	8.2026e-04	0.0214	8.0706e-04	8.5152e-04	0.0180	0.0016	7.2994e-04	9.7450e-04
0.0111	1.3944e-04	0.0111	1.3944e-04	0.0224	4.9967e-04	3.9034e-04	0.0211	3.9642e-04	3.4776e-04	0.0202	0.0021	3.7177e-04	3.4225e-04
0.0074	2.6753e-04	0.0074	2.6753e-04	0.0153	3.5545e-04	8.2306e-04	0.0141	2.8304e-04	7.1102e-04	0.0136	0.0011	2.7166e-04	8.4002e-04
0.0036	2.0845e-04	0.0036	2.0845e-04	0.0065	5.9565e-04	5.5595e-04	0.0061	4.5940e-04	4.5326e-04	0.0061	4.0954e-04	4.1321e-04	4.4339e-04
0.0048	1.6351e-04	0.0048	1.6351e-04	0.0083	6.4050e-04	4.1405e-04	0.0086	5.0618e-04	3.0850e-04	0.0085	5.2424e-04	4.5489e-04	2.7296e-04
0.0056	8.0388e-05	0.0056	8.0388e-05	0.0106	1.5185e-04	2.4317e-04	0.0115	9.1844e-05	1.8853e-04	0.0139	6.2159e-04	7.8351e-05	1.7249e-04
0.0128	2.9260e-04	0.0128	2.9260e-04	0.0255	2.4498e-05	0.0019	0.0272	1.0831e-05	0.0024	0.0258	7.3530e-04	7.3841e-06	0.0022
0.0087	6.3554e-04	0.0087	6.3554e-04	0.0157	0.0013	0.0021	0.0143	5.8765e-04	0.0014	0.0146	0.0018	3.7878e-04	0.0012
0.0099	8.3973e-04	0.0099	8.3973e-04	0.0123	3.7739e-04	7.3807e-04	0.0163	1.9745e-04	9.0590e-04	0.0189	7.7251e-04	1.4336e-04	0.0010
0.0094	0.0011	0.0094	0.0011	0.0219	0.0015	0.0028	0.0239	0.0010	0.0024	0.0247	0.0015	8.7336e-04	0.0024
0.0059	2.5405e-04	0.0059	2.5405e-04	0.0112	4.3833e-04	7.4134e-04	0.0105	2.6179e-04	6.1060e-04	0.0105	6.9152e-04	2.1206e-04	5.9138e-04
0.0063	7.7728e-04	0.0063	7.7728e-04	0.0124	6.3668e-04	0.0024	0.0112	4.0345e-04	0.0020	0.0109	0.0011	3.3200e-04	0.0019
0.0074	8.2789e-04	0.0074	8.2789e-04	0.0152	8.4256e-04	0.0020	0.0128	6.0219e-04	0.0019	0.0118	0.0011	5.2250e-04	0.0018
0.0167	4.1325e-04	0.0167	4.1325e-04	0.0156	5.3976e-04	4.7820e-04	0.0140	2.9495e-04	4.2729e-04	0.0136	0.0018	2.1938e-04	5.2332e-04
0.0069	5.5092e-04	0.0069	5.5092e-04	0.0122	0.0010	0.0018	0.0113	6.9704e-04	0.0016	0.0119	0.0012	5.8484e-04	0.0014
0.0148	9.2528e-04	0.0148	9.2528e-04	0.0298	8.8080e-04	0.0017	0.0214	5.8155e-04	0.0015	0.0163	0.0011	4.8485e-04	0.0016
0.0045	2.3998e-04	0.0045	2.3998e-04	0.0080	3.3799e-04	6.2947e-04	0.0069	2.5098e-04	5.5864e-04	0.0065	4.1366e-04	2.1907e-04	5.0073e-04
0.0169	0.0011	0.0169	0.0011	0.0336	5.8337e-04	0.0016	0.0241	3.8469e-04	0.0016	0.0182	8.5080e-04	3.4381e-04	0.0018
0.0056	8.0388e-05	0.0056	8.0388e-05	0.0106	1.5185e-04	2.4317e-04	0.0115	9.1844e-05	1.8853e-04	0.0139	6.2159e-04	7.8351e-05	1.7249e-04
0.0128	2.9260e-04	0.0128	2.9260e-04	0.0255	2.4498e-05	0.0019	0.0272	1.0831e-05	0.0024	0.0258	7.3530e-04	7.3841e-06	0.0022
0.0087	6.3554e-04	0.0087	6.3554e-04	0.0157	0.0013	0.0021	0.0143	5.8765e-04	0.0014	0.0146	0.0018	3.7878e-04	0.0012
0.0099	8.3973e-04	0.0099	8.3973e-04	0.0123	3.7739e-04	7.3807e-04	0.0163	1.9745e-04	9.0590e-04	0.0189	7.7251e-04	1.4336e-04	0.0010
0.0094	0.0011	0.0094	0.0011	0.0219	0.0015	0.0028	0.0239	0.0010	0.0024	0.0247	0.0015	8.7336e-04	0.0024
0.0059	2.5405e-04	0.0059	2.5405e-04	0.0112	4.3833e-04	7.4134e-04	0.0105	2.6179e-04	6.1060e-04	0.0105	6.9152e-04	2.1206e-04	5.9138e-04
0.0063	7.7728e-04	0.0063	7.7728e-04	0.0124	6.3668e-04	0.0024	0.0112	4.0345e-04	0.0020	0.0109	0.0011	3.3200e-04	0.0019

Table 1Enlarged table of the table in the GUI of Fig.6

Table1 shows the lists of energy levels extracted from segmented image. This table is the enlarged version of the table shown in the GUI. The rows of the table are individual energy level of each kidney images of database. The Columns of the table shows energy level extracted from the images of database with respect to each wavelet filter. First two columns are corresponding to Daubechies filter, the third and fourth columns are corresponding to symlets12. The fifth, sixth and seventh columns are corresponding to Biorthogonal filter (Bio3.7). The eighth, ninth and tenth columns are corresponding to Biorthogonal filter (Bio3.9). The eleventh twelfth and thirty columns are corresponding to Biorthogonal filter (Bio4.4).

The Bayes and MLP-BP classifications have given type of stone with maximum accuracy of 79.1% and 98.8% respectively.

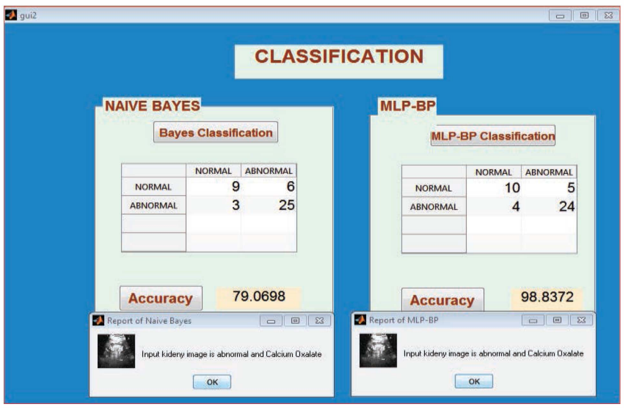

Fig.8. Naive bayes and MLP-BP for abnormal and identifying type of stone

IX. Conclusion and Future work

The level set segmentation with momentum and resilient propagation are very effective in identifying the region of stones in the US kidney image. The energy levels extracted from the wavelet subbands i.e. Daubechies (Db12), Symlets (sym12) and Biorthogonal filterers (bio3.7, bio3.9 & bio4.4), gives the clear indication of difference in the energy levels compared to that of normal kidney image if there is stone. The ANN trained with normal kidney image and classified image input into normal or abnormal by considering extracted energy levels from wavelets filters. The system is tested with different kidney images from database and has classified successfully with the accuracy of 98.8%. So this system can be readily used in the hospitals for detecting abnormality of individuals US kidney image. Thus in this work it is proved that the combination level set segmentation, wavelet filters, multilayer Perceptron with back propagation the better approach for the detection of stones in the kidney In the future work the system will be designed and implement on FPGA using hardware description language (HDL) to display kidney image and stone with colour for easily identification and visibility of stone on monitor.

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

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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

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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.

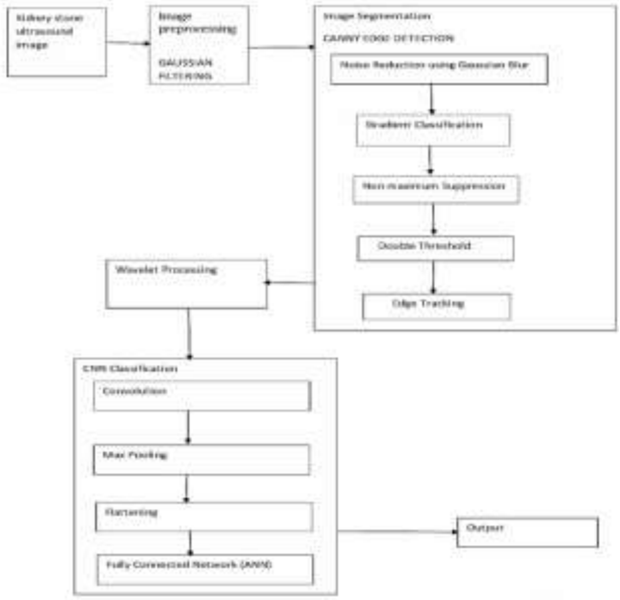

Fig 1: Architecture

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

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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.

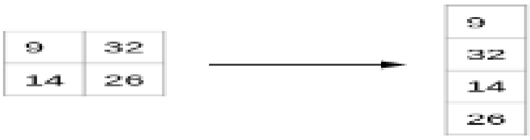

Fig: Converting matrix into linear array form

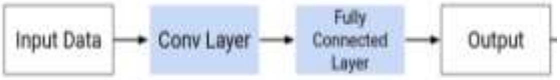

Fig: convolution methodology

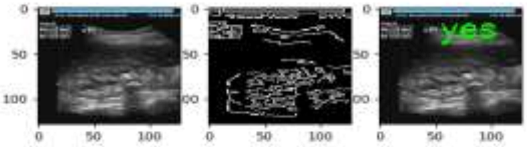

fig: output with label yes (presence of stone)

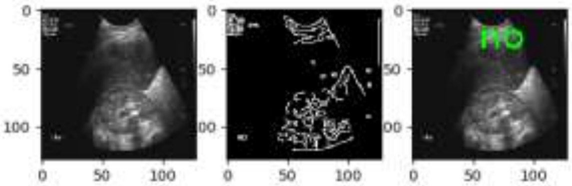

Fig: output with label No (absence of stone)

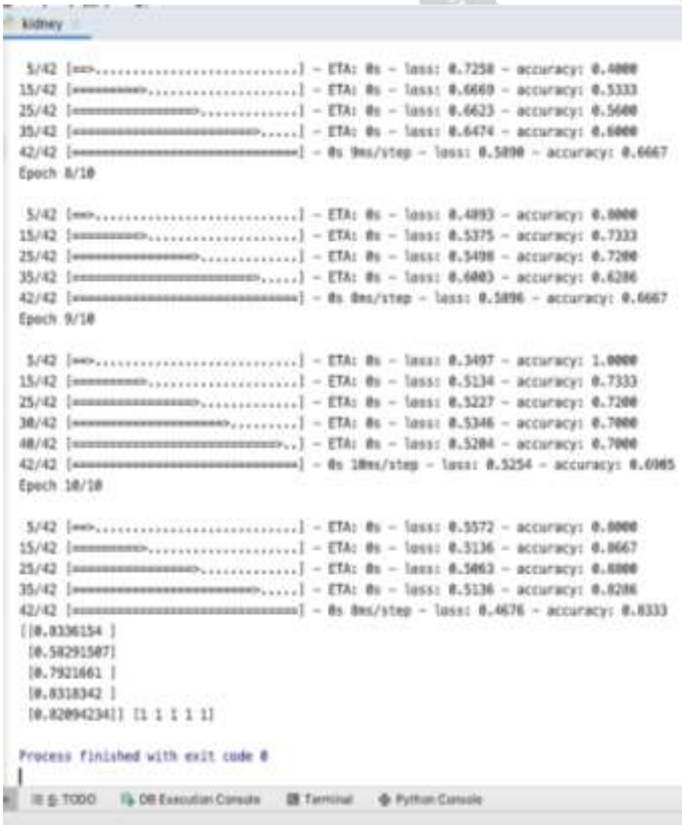

Fig: accuracy of stone detection

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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