Wavelet Based Image Fusion For Kidney Stone Detection

Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology

In

Electronics & Communication Engineering

By

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I hereby declare that the thesis entitled "**Wavelet Based Image Fusion and Kidney Stone Detection**" submitted by me, for the award of the degree of Bachelor of Technology in Electronics and Communication Engineering to VIT is a record of bonafide work carried out by me under the supervision of **Dr. Thanikaiselvan V**.

I further declare that the work reported in this thesis has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Place :- Vellore

Date :- 15th April, 2023

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Executive Summary

The kidneys are two bean-shaped organs, which are located just below the rib cage, one on each side of your spine. Kidneys remove wastes and extra fluid from our body. Kidney Stones have become a most serious problem in recent times. Image fusion is a method in which it involves two or more images to attain the most useful features for some specific applications.

For Instance, doctors can annually combine the CT and MRI medical images of a patient suffering with tumour to make a more accurate diagnosis. Medical fusion image is to combine functional image and anatomical image together into one image. In our first step, we will make a fused image of CT and MRI image, later we will examine the Kidney stone detection test using the Ultrasound, CT images of human kidney.

Kidney-stones can be a life-threatening situation. Therefore, timely diagnosis is very essential. To ensure the efficacy of surgical operations, it is necessary to precisely diagnose kidney stones. Detection of Stones formed in kidneys by using Ultra Sound Images. Through this we can detect the stone located inside the kidney.

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List of Abbreviations

2-D DWT	2 Dimensional Discrete Wavelet Transform
IDWT	Inverse Discrete Wavelet Transform
CT	Computed Tomography
MRI	Magnetic resonance imaging
US	Ultra Sound
WBA	Window based Activity
CBA	Coefficient Based Activity
WA	Weight Average
AWA	Adaptive weighted average
DTCWT	Discrete-time continuous wavelet transform
HWT	Haar wavelet transform
JPEG	Joint Photographic Experts Group
HRCT	High-Resolution Computed Tomography
RGB	Red , Green and Blue

Table 4

Symbols and Notation

$mean_1(p)$	denote the mean value of the coefficients centered at (m, n) in the window of S×T
$\sigma_1(p)$	denote the variance value of the coefficients centered at (m, n) in the window of S×T
B_w	w × w block
$\Lambda(D(p))$	weighting factor
VI(p)	denote the visibility in the block
α	visual constant obtained by perceptual experiment
$\widehat{\sigma}$	Standard Deviation
f (m, n)	pixel value of the fused image at position (m, n)
μ	mean value of the image
Avg	Average Grading
H	Information Entropy
CE	Cross Entropy
$D_x(p)$ is	average value over the neighborhood (say N×M) centered at p

Table 5

1. ***Introduction*** :-

Now a day’s Kidney Stones became a serious problem. Kidney stones form when our urine contains more number of salt substances. If the stone is not identifying in early stage, then it may affect the person severely. Image processing is one of the best ways to detect the stones in the kidney. It is difficult to identify the stones in the scanned images of kidneys such as CT, MRI and Ultrasound images. The Scanned Images contains some noise and we need to pre process the image so that we can able to detect the stone in the scanned image. When it’s come to image fusion, it involves two or more images to obtain the most detailed image. In this technique doctors usually combine the CT and MRI medical images of a patient with a tumor to make a more accurate diagnosis. The fused image gives a better description than the source images and also it has better quality in the aspects of contrast, edge, texture and information. We propose an efficient method of fusion using Wavelet transform. The Wavelet used here is Haar Wavelet. These fused coefficients are reconstructed using inverse wavelet transform. The objective of this project is to provide a novel method for multimodal image fusion based on 2-D Haar wavelet.

Advantages Of Image Fusion :-

- Fused images have high spatial quality.
- Extract main features to minimize redundancy.
- Preserve more spectral information details.
- Image sharpening, Feature enhancement & Improved classification.
- Creation of stereo data sets

Disadvantages Of Image Fusion :-

- The Fused Image has less Spatial resolution
- It takes time for Computation
- It suffers from color distortion problem.

1.1 ***Objective*** :-

Our Main Objective of our project is

- By using wavelet fusion techniques, we are going to create a fused image of a CT and a MRI image.
- Detection of kidney stones in Ultra Sound images by using Image processing
- Detection of kidney stones in CT & MRI images.

1.2 ***Motivation*** :-

A kidney stone usually does not cause symptoms until it has moved into the kidney or passed into one of the ureters. The ureters are tubes that connect the kidneys and bladder. If a kidney stone accumulates in the ureters, it can block the flow of urine and cause the kidney to swell and the ureter to spasm, which can be very painful. During that time, you may experience these symptoms:

- Severe, sharp pain below ribs, side and back
- Pain radiating to the lower abdomen and groin
- Pain that comes in waves and fluctuates in intensity
- Pain or burning when urinating

Kidney Stones are the life threatening situation, if the diagnosis is not done in short time it may leads to the failure of the kidneys. For the operation, it is necessary to locate the stone position accurately. When it comes to scanned images, due to noise and poor contrast it is difficult the identify the stone in scanned images. To overcome this issue image processing technique is used to detect the location of stone.

1.3 ***Literature Survey*** :-

Yong Yang, Dong sun park, Nini Rao [1] proposed a novel wavelet-based approach for medical image, which is developed by taking into not only account the characteristics of human visual system but also the physical meaning of the wavelet coefficients. After the medical images to be fused are decomposed by the wavelet transform, different-fusion schemes for combining the coefficients are proposed: coefficients in low-frequency band are selected with a visibility-based scheme, and coefficients in high-frequency bands are selected with a variance based method. To overcome the presence of noise and guarantee the homogeneity of the fused image, all the coefficients are subsequently performed by a window-based consistency verification process.

S M Mahbubur Rahman M, Omair Ahmad, M.N.s. Swamy [2] proposed a novel contrast-based image fusion algorithm in the wavelet domain for noisy source images. Since noise is inherent in practical imaging systems or sensors, a comprehensive approach of image fusion and noise reduction is required. Discrete wavelet transform has been significantly successful in the development of fusion algorithms for noise-free images as well as image denoising algorithms. A novel contrast-based image fusion algorithm is proposed in the wavelet domain for noisy source images. The novel features of the proposed fusion method are that the noise reduction takes into account the linear dependency between the noisy source images and introduces an appropriate change in the magnitude of the wavelet coefficients depending on the noise strength.

Mahesh K. Jat ,Pradeep Kumar Garg, Susheela Dahiya [3] they described the use of high-resolution images for identification of urban features through pixel-based image fusion techniques. Fusion techniques are used to merge a high spatial resolution panchromatic image with a low spatial resolution multispectral image to improve the visual quality/appearance of certain urban features in the image. They also described nine pixel-based fusion techniques those are Principal Component Analysis (PCA), multiplicative, Brovey transformation, wavelet analysis, subtractive, HPF, modified IHS, Ehlers, and hyperspherical color space. All fusion methods lead to the modification of the statistical parameters of the original images.

Wenlong Zhang, Xiaolin Liu, Wuchao Wang, Yujun Zeng [4] proposed a novel wavelet-based algorithm for multi-exposure image fusion. Brightness is inverted, the brightness of the input images is suppressed by introducing a well exposedness weight and the contrast of the fused image is enhanced. The weighting is used to fuse the approximate sub-bands of the input images in the wavelet domain. The proposed multi-exposure fusion scheme consists of three steps (i) Converting input images to YUV space and Combining color-differential components U and V according to saturation weight, (ii) Changing the brightness Fusing the component Y into the wavelet domain and the corresponding approximation sub-bands and detail sub-bands Well exposed weight and adjusted contrast weight respectively and (iii) Converting the fused image back to RGB space to get the final result.

Michel Roux, M. He , X. Li [5] proposed that image fusion is the process of integrating complementary information from multiple images of the same scene so that the resulting image contains a more accurate description of the scene than any of the individual source images. A method for fusion of multifocus images is presented. It combines traditional pixel-level fusion with some aspects of feature-level fusion. First, the multifocus images are decomposed using an iterative wavelet transform. Edge features are extracted to guide the coefficient combination. Finally, the fused image is reconstructed by performing inverse RWT. Experimental results on several pairs of multifocus images show that the proposed method can achieve good results and exhibits clear advantages over gradient pyramid transform and discrete wavelet transform methods.

Min Fen Shen, Zhi Fei Su, Jin Yao Yang, Li Sha Sun [6] described that due to the depth limitation of the optical lens, objects with different distances are usually not in the same focus in the same image, but multi-focus image fusion can obtain a fusion image with all targets, which improves the utilization rate of image information, which helps further computer processing. A multi-focus image fusion algorithm based on redundant wavelet transform is proposed in this paper. For the different frequency domain of redundant wavelet decomposition, the selection principle of high-frequency coefficients and low-frequency coefficients are discussed respectively.

Michele Griffa, Rolf Kaufmann, Andreas Maier, Christian Riess [7] presented a proof-of-concept study for the differentiation of kidney stones using X-ray dark-field tomography. Kidney stones are a kidney disease that has a high prevalence and is one of the leading causes of emergency room visits. The prevalence of kidney stones is increasing and the lifetime recurrence rate is estimated to be around 50%. Imaging techniques commonly used to detect kidney stones, such as X-ray CT and ultrasound, are inadequate for differentiating the types of kidney stones. The most important advantage of this method is the ability to image non-homogeneous kidney stones.

Viswanath Kala, Dr.Gunasundari R [8] identified the abnormalities of the kidney by ultrasound imaging. There may be structural abnormalities such as swelling of the kidney, changing its position and shape. Kidney abnormalities can also be caused by stones, cysts, cancer cells, congenital anomalies, urinary tract infections etc. It is very important to determine the accurate location of the stone in the kidney for surgical operations. Ultrasound images have low contrast and contain speckle noise. It is a challenging task to diagnose kidney abnormalities. Therefore preprocessing of ultrasound images is done to remove speckle noise. In preprocessing, first image restoration is done to reduce speckle noise, then it is applied to Gabor filter for smoothing. Next the resulting image is enhanced using histogram equalization. The pre-processed ultrasound image is segmented using level set segmentation as it gives better results.

Kalannagari Viswanath, Dr.Gunasundari R [9] used ultrasound imaging, which is one of the available imaging methods to diagnose renal abnormalities, which may include changes in shape and location and swelling of the organs; Other kidney abnormalities like stones, cysts, urinary obstruction, congenital anomalies, and cancerous cells. It is essential to identify the true and accurate location of the kidney stone during surgical procedures. Detection of kidney stones using ultrasound imaging is a challenging task because of their low contrast and speckle noise. This challenge can be overcome by using appropriate image processing techniques. The ultrasound image is pre-processed to get rid of speckle noise using an image restoration process. A pre-processed image with level set segmentation is achieved to identify the rock region. The division process is used twice to get better results.

Anjan Gudigar , Raghavendra U, Jyothi Samanth, U Rajendra Acharya [10] states that chronic kidney disease is a progressive disease that affects more than twenty million people in the United States. Disease progression is often characterized by complications such as cardiovascular disease, anemia, hyperlipidemia, and metabolic bone diseases. Cardiovascular ultrasound imagery demonstrates significant hemodynamic changes secondary to CKD in the form of volume/pressure overload. Because CKD pathology directly affects cardiovascular disease, US imaging shows structural and hemodynamic adaptation. They proposed acquiring a four-chamber heart US image to assess CKD stage. This method combines image and feature fusion techniques under a graph embedding framework to classify cardiac chamber features.

Wang Xin, Wei You-Li, Liu fu [11] Proposed a new fusion method of infrared and visible video sequence, based on shift-invariant discrete wavelet transform. First the approximate target regions of each single-frame infrared image are identified by weighted information entropy. Secondly a new fusion algorithm based on SIDWT is proposed to fuse the target regions of registered infrared and visible images. Finally the fused target regions are merged with the background regions of the visible scenes.

Annameti Rohith [12] proposed that during surgical procedures, it is essential to identify the accurate location of the kidney stone. Kidney stones can be difficult to detect using ultrasound imaging due to low contrast and speckle noise. This challenge can be overcome by using appropriate filter processing techniques. In preprocessing, first image restoration is done to reduce speckle noise, then it is applied to Gabor filter for smoothing. Next the resulting image is enhanced using histogram equalization. The pre-processed ultrasound image is segmented using level set segmentation as it gives better results.

Y.-R. Zhou, A.-H. Geng, Q. Zhang [13] proposed a novel fusion method of infrared and visible images based on non-subsampled dual-tree complex contourlet transform and sparse representation to overcome the shortcomings of traditional image fusion method based on wavelet transform. With the proposed method, morphological transformation was used to deal with the source images, and then NSDTCT decomposition of the source images was performed to obtain low frequency sub-band coefficients and high frequency sub-band coefficients.

X. Li, S.-Y. Qin [14] studied the potential application of the compressive sensing principle in image fusion for infrared and visible images. Some comparative analyzes of different reconstruction methods are performed in view of their performance in multisensor image recovery, and the minimum number of sample measurements one should take to achieve perfect reconstruction of images is then investigated. A novel self-adaptive mean fusion scheme based on the standard deviation of measurements to merge IR and visible images is developed in the unique domain of CS using the enhanced recovery tool of total variance optimization. Both subjective visual effect and objective evaluation indicate that the presented method can greatly increase the definition of fused results, and it achieves a high level of fusion quality in human perception of global information.

Saurabh Prasad, Wei Li, James Edwin Fowler, Lori Bruce [15] in this paper, the hyperspectral imagery consists of high-dimensional reflectance vectors that represent the spectral response over a wide range of wavelengths for each pixel in the image. The resulting high-dimensional feature spaces often lead to statistically ill-conditioned class-conditional distributions. A divide-and-conquer approach is proposed to address the high dimensionality of hyperspectral data for efficient and noise-robust classification. This proposed partition of feature space assigns the collection of all coefficients across all scales at a particular spectral wavelength to a unique classifier.

2. ***Project Description and Goal*** :-

Study of Wavelet Image fusion Technique and obtain a fused image of CT and MRI images. Image fusion involves two or more images to attain the most useful features for some specific applications. Kidney-stones can be a life-threatening situation. Therefore, timely diagnosis is very essential. To ensure the efficacy of surgical operations, it is necessary to precisely diagnose kidney stones. Detection of Stones formed in kidneys by using Ultra Sound Images. Detecting kidney stone by using of CT images

3. ***Technical Specification*** :-

Image fusion is a process of integrating two or more images into a single image with more details and information. The high pass sub-bands in the 2-D DWT domain provide important features for image fusion algorithm. We propose an efficient method of fusion using Wavelet transform. The Wavelet used here is Haar Wavelet. These fused coefficients are reconstructed using inverse wavelet transform. The objective of this project is to provide a novel method for multimodal image fusion based on 2-D Haar wavelet.

Now a day's Kidney Stones became a serious problem. Kidney stones form when our urine contains more number of salt substances. If the stone is not identifying in early stage, then it may affect the person severely. Image processing is one of the best ways to detect the stones in the kidney. It is difficult to identify the stones in the scanned images of kidneys such as CT, MRI and Ultrasound images. Through image processing techniques we can able to reduce the Noice in the scanned images and able to find the location of the stone.

4. ***Designs Approach and Details*** :-

4.1 ***Design Approach*** :-

Image Fusion :-

The image fusion process is defined as gathering all the important information from multiple images, and their inclusion into fewer images, usually a single one. This single image is more informative and accurate than any single source image, and it consists of all the necessary information. The purpose of image fusion is not only to reduce the amount of data but also to construct images that are more appropriate and understandable for the human and machine perception. In computer vision, Multisensory image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images.

Wavelet Transform :-

Wavelet transforms, provides a framework in which a signal or image is decomposed into levels. Each level corresponds to a coarser resolution or lower frequency band and higher frequency bands. There are two main groups of transforms, continuous and discrete. Of particular interest is the DWT, which applies a two-channel filter bank (with down sampling) iteratively to the low pass band (initially the original signal). The wavelet representation then consists of the low-pass band at the lowest resolution and the high pass bands obtained at each step. This transform is invertible and non redundant.

Fusion Rules :-

1. ***Activity level measurement*** :-

- The process of measuring activity level (the quality of a pixel in an image) can be classified into three methods namely coefficient based, window based and area based measurements.
- **Coefficient Based Activity (CBA)** :- In CBA, the activity level is measured as given In Equation
- $A_I(P) = |D_I(p)|$ or A_I (p) $= |D_I(p)|^2$ ----------*Eq(a)*
- A_I(p) - the activity level of a pixel at position p.
- **Window Based Activity (WBA)** :-The WBA employ a small (typically 3 × 3 or 5 ×5) window centred at the current coefficient position.
- Thus, the activity level A_I(p) is determined by the coefficients surrounding p using a small window.

2. ***Coefficient combining methods*** :-

- Coefficient combining involves combining low-frequency and high-frequency coefficients from source images. Choice-Max (CM) is the simplest selection method as given in the equation
- $D_z\ (p) = D_x(p)\ ,if\ A_x(p) \geq A_y(p)$ (or) $D_y(p),if\ A_x(p \leq A_y(p)$ ----------*Eq(b)*
- In high-frequency bands, a large DWT coefficient corresponds to sharpness, luminance changes, and thus leads to important features in the image such as edges, lines, and region boundaries.
- Therefore, the CM method is useful in comprehensive data collection.
- **Weighted Average (WA)** :- For each p, the composite DZ is obtained using the equation

- $D_z(p) = W_x(p)D_x(p) + W_y(p)\ D_y(p)$ ----------*Eq(c)*

- The weighting factors $W_X(p)$ and $W_y(p)$ can be deterministic or dependent on the activity levels of X and Y.
- **Adaptive weighted average (AWA)** :- The AWA scheme is a special WA scheme whose weight $W_X(p)$ is not deterministic or depends on cross-correlation but only for the neighborhood around p, As Give in Equation
- $W_x(p) = |D_x(p) – D'_x(p)|^2$ ----------*Eq(d)*
- Where, $D_x(p)$ is average value over the neighborhood (say N×M) centered at p. Simply speaking, the weight represents the degree of interest of pixel p.

Discrete Wavelet Transform :-

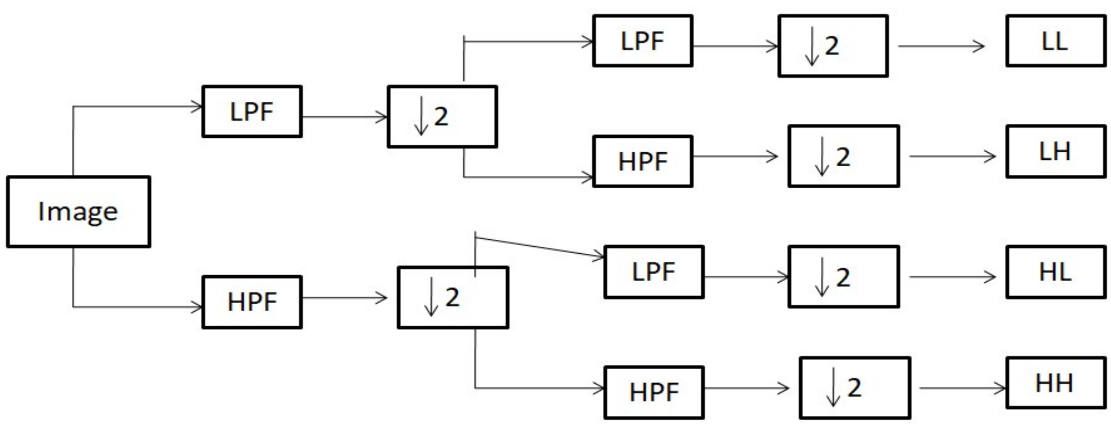


Fig.1 *One stage of 2-D Discrete Wavelet Transform multi resolution image decomposition*

- ***Step 1***:- Images to be fused must be registered to ensure corresponding pixels are aligned.

- ***Step 2***:- These images are decomposed into successive wavelet transformed images based on the wavelet transform. Images transformed with K-level decomposition have one low-frequency component (low-low band) and 3K high-frequency components (low-high bands, high-low bands, and high-high bands).

- ***Step 3***:- The transition coefficients of different components or bands are handled with a specific fusion rule.

- ***Step 4***:- The fused image is constructed by inverse wavelet transform based on the combined transform coefficients from step 3.

The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete-time continuous wavelet transform (DT-CWT). The discrete wavelet transform (DWT), which applies a two- channel filter bank (with down sampling) iteratively to the low pass band (initially the original signal). The wavelet representation then consists of the low-pass band at the lowest resolution and the high-pass bands obtained at each step. This transform is invertible and non redundant. The DWT is a spatial-frequency decomposition that provides a flexible multi resolution analysis of an image.

<u>High Frequency Band Fusion</u> :-

For high frequency bands, because the purpose of image fusion requires that the fused image not discard any useful information and conserve effectively Details of input images such as edges, lines and area boundaries, it is generally believed that the details of a the image is mainly included in the high-frequency picture. For the purpose of image fusion, the useful properties of the fused image elements should not be ignored and the details of the input images such as edges, lines and region boundaries should be effectively preserved. It is generally believed that the details of an image are mainly included in the high-frequency of the image

- $\sigma_1(p) = \frac{1}{(S\times T)} \sum_{-s/2}^{s/2} \sum_{-T/2}^{T/2} (DI(m+s, n+t, k, l) - \text{mean}_1(p))^2$ ------*Eq(e)*
- $\text{Mean}_l(p) = \frac{1}{(S\times T)} \sum_{-s/2}^{s/2} \sum_{-T/2}^{T/2} (DI(m+s, n+t, k, l))$ -------*Eq(f)*

Where $S \times T$ is the neighboring size, and $\text{mean}_1(p)$, $\sigma_1(p)$ denote the mean value and variance value of the coefficients centered at (m, n) in the window of S×T, respectively. The fusion scheme used for the high-frequency bands can be illustrated as follows:

- $D_z(p) = D_x(p)$,if $\sigma_x(p) \geq \sigma_y(p)$ (or) $D_y(p)$,if $\sigma_x(p) < \sigma_y(p)$ ---------*Eq(g)*

<u>Low Frequency Band Fusion</u> :-

To simplify the interpretation of the various alternatives available we also consider in [5, 24], which consists of a fusion rule, two source images, X and Y, and a fused image Z. This method can be easily extended than two films. Since the low-frequency band is the original image at coarser resolution level, the smoother it is considered and a sub sampled version of the original image. Therefore, most of the information of their source images is kept in it Low-frequency band. Based on extensive analysis, here for the low-frequency band, a fusion scheme is chosen maximum local visibility is proposed. Therefore, this method can be done by a human observer who is likely to provide better details. The fusion rule first computes the window-based visibility of all coefficients in the low-frequency band. The visibility of the wavelet coefficients is defined as

- $VI(p) = \frac{1}{W^2} \sum_{(i,j)\in Bw} \Lambda\,(\bar{D}(p))\ .\ \frac{|D(m+i,n+j,k,l)-D'(p)|}{(\bar{D}(p))}$ ---------*Eq(h)*
- $\bar{D}(p) = \frac{1}{W^2} \sum_{(i,j)\in Bw} D(m+i, n+j, k, l)$ ---------*Eq(i)*
- $\Lambda(\bar{D}(p)) = (\frac{1}{\bar{D}(p)})^{\alpha}$ ----------*Eq(j)*

Where B_w is a w × w block, Λ(D(p)) is the weighting factor, VI(p) denote the visibility in the block, α is a visual constant obtained by perceptual experiment, and its range is from 0.6 to 0.7 . After calculating all visibility coefficients in the low-frequency band, corresponding coefficients with high visibility are then selected in the fused image as follows :

- $D_z(p) = \begin{cases} Dx(p), VIx(p) \geq VIy(p) \\ Dy(p), VIx(p) < VIy(p) \end{cases}$ ----------*Eq(k)*

Haar Wavelet :-

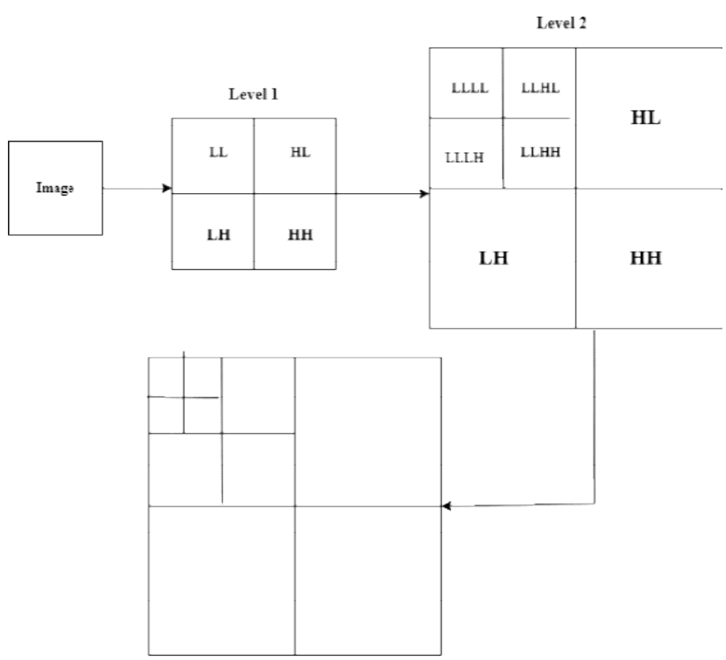


Fig.2 Haar Wavelet transform for an Image

The Haar wavelet transform (HWT) has gained widespread acceptance in signal processing and image compression. Because of their inherent multi-resolution nature, wavelet-coding schemes are especially suitable for applications where scalability and tolerable degradation are important. Haar wavelets are the fastest to compute and simplest to implement. Other types of wavelets might give better results but at a higher cost. Perform a standard 2D Haar wavelet decomposition of every image in the database

Block Diagram :-

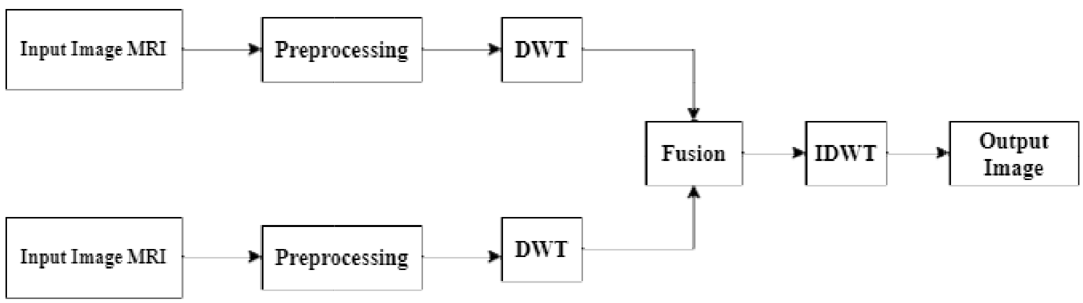


Fig.3 *Wavelet Based Image Fusion*

Magnetic Resonance Imaging :-

Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body in both health and disease. MRI scanners use strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body.

MRI does not involve X-rays or the use of ionizing radiation, which distinguishes it from CT or CAT scans and PET scans. Magnetic resonance imaging is a medical application of nuclear magnetic resonance (NMR). NMR can also be used for imaging in other NMR applications such as NMR spectroscopy.

Magnetic resonance imaging (MRI) makes use of the magnetic properties of certain atomic nuclei. An example is the hydrogen nucleus (a single proton) present in water molecules, and therefore in all body tissues. The hydrogen nuclei behave like compass needles that are partially aligned by a strong magnetic field in the scanner. The nuclei can be rotated using radio waves, and they subsequently oscillate in the magnetic field while returning to equilibrium. Simultaneously they emit a radio signal. This is detected using antennas (coils) and can be used for making detailed images of body tissues.

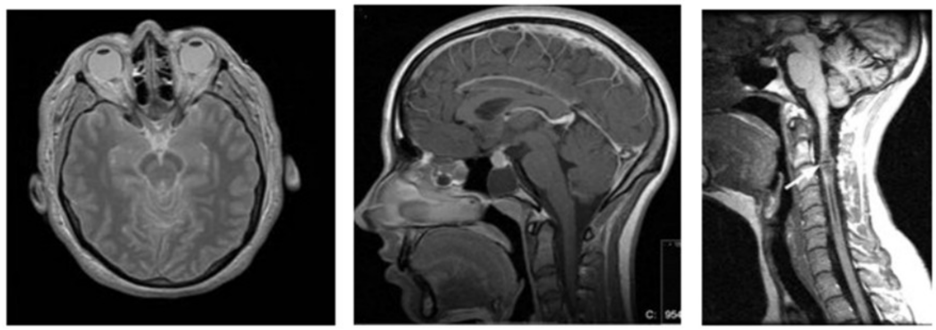
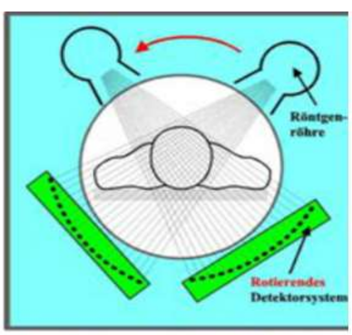


Fig.5 *MRI Images*

Fig.4 *MRI Machine*

<u>CT (Computed Tomography</u>) :-

It makes use of computer-processed many X-ray measurements combinations of taken from different angles to produce cross- sectional (tomographic) images of specific areas of a scanned object, allowing the user to see inside the object without cutting. CT is based on the principle that the density of the tissue passed by the x-ray beam can be measured from the calculation of the attenuation coefficient. Using this principle, CT allows the reconstruction of the density of the body, by two-dimensional section perpendicular to the axis of the acquisition system. It is a diagnostic imaging procedure that uses x-rays to build cross-sectional images ("slices") of the body. Cross-sections are reconstructed from measurements of attenuation coefficients of x-ray beams in the volume of the object studied.



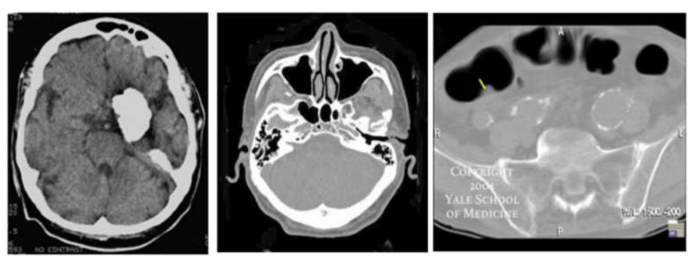


Fig 6 CT Images

Fig.7 CT Machine

Performance Measures :-

1. ***Standard Deviation*** :-

The Standard deviation of an image of size M × N is defines as

- $\widehat{\sigma} = \left(\frac{1}{M \times N} \sum_{m=1}^{M} \sum_{n=1}^{N} (f(m,n) - \hat{\mu})^2\right)^{1/2}$ -----*Eq(l)*

Where f (m, n) is the pixel value of the fused image at position (m, n), μ is the mean value of the image. Standard deviation is the most common measure of statistics, and diffusion is used to estimate how widely the gray values are spread in an image. So, the bigger the standard deviation, the better the result.

2. ***Average Grading*** :-

The mean gradient of an image with size M × N is defined as

- $\text{Avg} = \frac{1}{(M-1)\times(N-1)} \sum_{m=1}^{M-1} \sum_{n=1}^{N-1} \sqrt{\frac{\left[\left(\frac{\partial f(m,n)}{\partial m}\right)^2 + \left(\frac{\partial f(m,n)}{\partial n}\right)^2\right]}{2}}$ ---------*Eq(m)*

where f (m, n) has the same meaning as in the standard deviation. The average reflects the resolution of the fused image. It is used to measure the spatial resolution of fused image, that is, a larger mean gradient means higher clarity.

3. ***Information Entropy*** :-

The information entropy of a classical formulation of an image is defined as

- $H = -\sum_{l=0}^{L-1} P_l \log_2 P_l$ ---------*Eq(n)*

Where L is the number of gray levels, and P_l is the ratio between the l ($0 \le l \le L-1$) number of gray-valued pixels. Information entropy measures the richness of information in a picture. Therefore, the higher the entropy, the better the performance.

4. ***Cross Entropy*** :-

Cross entropy is used to measure the difference between the source images and the fused image. A smaller value corresponds to a better fusion result Obtained:

- $CE = \sum_{l=0}^{L-1} P_l \log_2 \frac{P_l}{Q_l}$ ------*Eq(o)*

Where P_l and Q_l represent the gray level histogram of the source image and fused image, respectively

Causes of Kidney Stones :-

Kidney stones often don't have a specific, single cause, but many factors can increase your risk accident. Kidney stones form when too much of the crystal-forming substances calcium, oxalate, and uric acid in your urine dissolve more than the liquid in your urine. At the same time, your urine may lack substances that prevent crystals from sticking together, creating ideal conditions for kidney stones to form. A kidney stone usually does not cause symptoms until it has moved into the kidney or passed into one of the ureters. The ureters are tubes that connect the kidneys and bladder. If a kidney stone accumulates in the ureters, it can block the flow of urine and cause the kidney to swell and the ureter to spasm, which can be very painful.

Symptoms :-

- Severe, sharp pain below ribs, side and back
- Pain radiating to the lower abdomen and groin
- Pain or burning when urinating
- Pink, red or brown urine
- Cloudy or foul-smelling urine
- Constant need to urinate, urinating more often than usual or urinating less
- Nausea and vomiting
- Fever and chills if infection is present

Types of Kidney Stones :-

- ***Calcium Stones*** :-

The most common type of kidney stone is a calcium oxalate stone. They occur when the urine has low levels of citrate and high levels of calcium and oxalate or uric acid. Calcium oxalate stones are associated with foods rich in oxalate, a substance found naturally in plants and animals. Calcium stones can 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 medications used to treat migraines or seizures, such as topiramate.

- ***Struvite Stones*** :-

Struvite stones are caused by urinary tract infection. These stones quickly grow and become large, sometimes occupying the entire kidney. If diagnosis not done, they can lead to frequent and sometimes serious urinary tract infections and loss of kidney function.

- ***Uric Acid Stones*** :-

Uric acid stones form in people who lose too much fluid due to chronic diarrhea or malabsorption and People who don't drink enough water or don't eat a diet high in animal protein. They also occur more often in people who have gout, a family history of this type of kidney stone, or who have had chemotherapy. Certain genetic factors also increase your risk of uric acid stones.

- ***Cystine Stones***:-

Cysteine stones are caused by an inherited genetic disorder called cystinuria, which leads to excessive accumulation of the amino acid cystine in the urine. This leads to the formation of stones in the kidneys, bladder and ureters, which transport urine from the kidney to the bladder.

Methodology :-

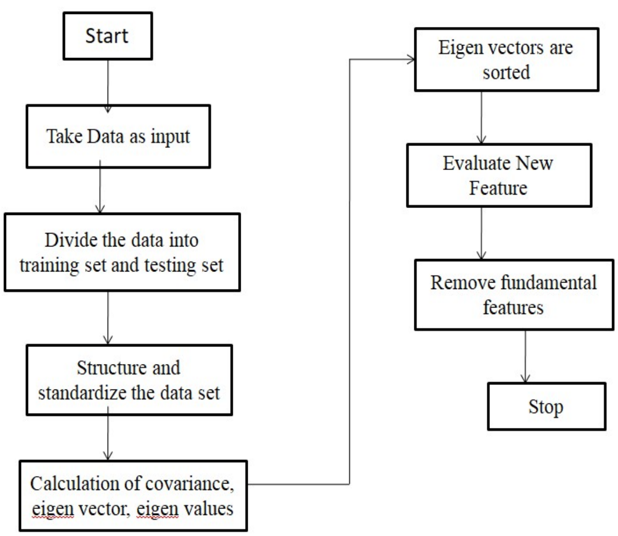


Fig.8 *Steps of PCA-based feature extraction*

1. ***Image Collection*** :-

Let us consider the some of the Ultrasound images were collected in the dataset *d*. The dataset for quality images, q = i(n), n = 1, 2,...,N. The quality is determined using a perception-based image quality evaluator score with score < = 40. An image is selected from the collection and marking process of the stone.

2. ***Feature Extraction*** :-

In this work we feature an unsupervised learning technique called Principal Component Analysis (PCA) extraction technique. Feature extraction technique is mainly implemented with 5 steps : Collecting data set, partitioning the data set, structuring the data set, calculating eigen values & eigenvectors and finally evaluating new features by removing duplicate and unwanted features.

3. ***Image Enhancement*** :-

The goal of image enhancement is to reduce ultrasound image degradation that occurs during imaging scanning acquisition. Noise, blur and camera misfocus can all cause degradation. A level set function is used in this system to ensure proper orientation. It is in the image preprocessing stage. The Merriman and Sethian techniques are popular for image enhancement, especially smoothing and removing curves shrinks. The Average intensity in a small neighborhood is ϕ(m,n) and the median is ϑ(m,n), then the evolution between max(p,0) and min(p,0) is expressed.

- ❖ $w(m)=\begin{cases} \max(p,0)\,, if\ \phi(\mathrm{m,n}) < \vartheta(\mathrm{m,n}) \\ \min(p,0)\,, otherwise \end{cases}$ ------*Eq(p)*

4. ***Image Adjustment*** :-

CT images must be adjusted at the desired location and the gray image area must be binarized. The system in MATLAB initially reads a grayscale image and sets a matrix of images. Any pixel above 20 is classified as a binary 1 and any pixel below 20 is classified as a binary 0 and the comparison is made using a threshold value of 20. As a result, grayscale is binarized.

5. ***Photo Segmentation*** :-

It divides the digital photo into a set of pixels referred to as superpixels. This step uses a clustering technique that divides the input image into several groups based on their internal range to each other. It is used to identify the relevant features or the exact location where most of the study is to be done. Here, 250 pixels is kept as a threshold value to get the region of interest and wash out the extra parts. This is also known as thresholding.

6. ***Morphological Analysis*** :-

Morphological analysis changes the shape of an object from one form to another. Morphological techniques are used to smooth the region of interest. Morphological approaches are used to process images based on their appearance while organizing elements. This removes unnecessary information (pixels) from the outer part of the region of interest during processing. A closed parameter-based planar curve or surface is considered as T(n, t): $[0, 1]mU^{+} \rightarrow U^{k}$. If k = 3 then it is a surface, and k = 2, then it is a planar curve. Here, t is the time generated by the movement of the initial curves $T_0(n)$ in the inward direction of R. If H is the energy function, the curve evolution equation can be expressed as

- ❖ $T(n,t=0) = T_0(n)$ -------*Eq(q)*
- ❖ $T_t = H\bar{R}$ -----*Eq(r)*

The final output shows the shape and location of the stone inside the kidney. After implementing the proposed technique, there are some discrepancies in the exact position of the kidney stone, which can be resolved by adjusting the intensity of each ultrasound imaging of the kidney stone. Using the presented methods, the stone detection accuracy is 96.82%.

Application of Morphological Analysis :-

- Dilation adds pixels to boundary of an object. Dilation makes objects more visible and fills in small holes in the object.
- Erosion removes pixels from the boundary of an object. Erosion removes islands and small objects so that only substantive objects remain.
- You can use morphological opening to remove small objects from an image while preserving the shape and size of larger objects in the image.
- A flood fill operation assigns a uniform pixel value to connected pixels, stopping at object boundaries.
- You can use neighborhood processing to find global and regional minima and maxima in images.

Ultrasound Sound Imaging :-

Ultrasound imaging uses high-frequency sound waves to view inside the body. Because ultrasound images are captured in real time, they show the movement of the body's internal organs as well as the blood flowing through the blood vessels. Unlike X-ray imaging, there is no ionizing radiation exposure associated with ultrasound imaging.

In an ultrasound exam, a transducer is placed directly on the skin or inside a body opening. A thin layer of gel is applied to the skin so that ultrasound waves are transmitted from the transducer through the gel into the body. An ultrasound image is produced based on the reflection of waves from body structures. The strength of the sound signal and the time it takes for the wave to travel through the body provide the information needed to create an image.

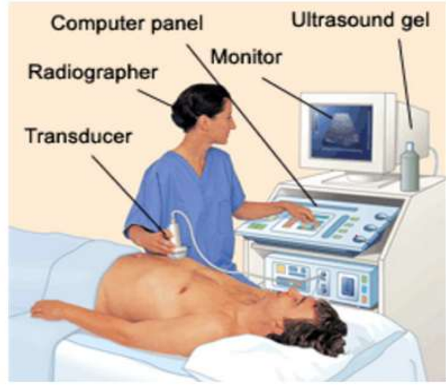


Fig.9(a) *Ultrasound Image of an Embryo*

Fig.9(b) *Procedure Followed During examination*

Difference Between CT and Ultrasound Images :-

CT Scan	***Ultrasound***
A CT scan uses x-rays and computers to create three-dimensional images of your urinary tract	An ultrasound uses sound waves to create a picture of your kidneys and bladder. It is similar to an ultrasound used by a pregnant woman to see the baby in her womb.
A CT scan uses X-rays that enter the body to produce images of internal organs.	In ultrasound, sound waves enter the patient's body and bounce back to create an image.
A CT scan provides a detailed picture of bones, soft tissue and blood vessels simultaneously.	Some ultrasounds with advanced technology can show soft tissue images
A CT scan provides excellent detail about bone structure	Ultrasound does not show a clear picture of the bony structure; It is mostly used for internal organs
A CT scan provides detailed visual information about the interior of a patient's body. It is useful in detecting internal injuries.	Ultrasound is very effective in detecting kidney or gallstones; It also provides information about the fetus during pregnancy.
A CT scan exposes you to radiation. Radiation increases the risk of cancer.	Ultrasound does not expose you to radiation.

Table 6

4.2 ***Code and Standards*** :-

Wavelet Based Image Fusion :-

```
clc;
clear ;
close all;
A = imread('ct2.jpg');
B = imread('mri2.jpg');

[LL1, LH1, HL1, HH1]=dwt2(A,'haar');
[LL2, LH2, HL2, HH2]=dwt2(B,'haar');

D1=[LL1,LH1;HL1,HH1];
D2=[LL2,LH2;HL2,HH2];

figure;
subplot(1,2,1);
imshow(D1,[]);
title('IMAGE 1');
subplot(1,2,2);
imshow(D2,[]);
title('IMAGE 2');

M1=double(D1);
M2=double(D2);


FusedWaveletCoeff= average(M1,M2);
% sX=size(FusedWaveletCoeff);
[r, ~]=size(FusedWaveletCoeff);
CA = FusedWaveletCoeff(1:(r/2), 1:(r/2));%LLH3
CH = FusedWaveletCoeff(1:(r/2), (r/2 + 1):r);%LHL4
CV = FusedWaveletCoeff((r/2 + 1):r, 1:(r/2));%HLH3
CD = FusedWaveletCoeff((r/2 + 1):r, (r/2 + 1):r);%HHH3

RA= idwt2(CA,CH,CV,CD,'haar') ;


figure;
subplot(1,3,1);imshow(A);title('CT');
subplot(1,3,2);imshow(B);title('MRI');
subplot(1,3,3);imshow(RA,[]);title('Fused');
```

__Kidney Stone Detection__ :-

```
clc
close all;
[filename, pathname] = uigetfile('*.*', 'Pick a MATLAB code file');
InputImage=imread(strcat(pathname,filename));%read the image
b=rgb2gray(InputImage); %Convert Gray
c=b<20;%Thresholding
figure;imshow(InputImage);
c=imcomplement(c);
figure;imshow(c);
BW5 = imfill(c,'holes');
M = bwareaopen(BW5, 1000);
b=double(b);
figure;imshow(M);
Inew = b.*M;
a=double(InputImage);
Inewc = a.*repmat(M,[1,1,3]);
figure;imshow(Inewc);
PreProcessedImage=uint8(Inewc);
imshow(PreProcessedImage);
PreProcessedImage = imadjust(PreProcessedImage,[0.3 0.7],[]);
Enhancedimage=imadd(PreProcessedImage,50);
Enhancedimage=rgb2gray(Enhancedimage);
FilterImage= medfilt2(Enhancedimage,[5 5]);
FilterImage=FilterImage> 250;
se = strel('line',1,5);
FilterImage = imdilate(FilterImage,se);
[r, c, p]=size(FilterImage);
bb=[300 258 200 60];
col=[c/3  c/3  (c/3+40)  (c/3+40)];
row=[(r/2+20) 480 480 (r/2+20)];
BW = roipoly(FilterImage,row,col);
Inews = FilterImage.*BW;
M = bwareaopen(Inews, 4);
figure;
imshow(M)
[L, num] = bwlabel(Inews,4);
if num >= 1
   disp('Stone Detected');
else
   disp('Stone Not Detected');
end
```

4.3 ***Constraints and Alternatives***:-

DWT :-

The cost of computing DWT is Higher. The use of longer DWT basis functions or wavelet filters produces blurring and the ringing noise near edge regions in images. Longer compression time and lower quality than JPEG at low compression rate.

Alternatives :-

- ❖ Longer compression time should be shortened
- ❖ We should find ways to Reduce cost of computing DWT
- ❖ Blurring and ringing noise near Edge regions in image should be reduced.
- ❖ Poor Directional sensitivity for diagonal features should be impoved.

Morphological Analysis :-

Many problems challenge us with many possible solutions, yet undiscovered, only a few of which may be new and useful. This process drains the swamp, so to speak, by systematically arranging suitable and promising elements and systematically combining them to identify new and suitable combinations. An object is a system, product, or process that breaks down a problem into its essential parameters or dimensions and places them in a multi-dimensional matrix. To discover new ideas by searching the matrix for creative and useful combinations. Some combinations may already exist, while others may not be possible or appropriate. The rest may suggest new ideas to come. If you can describe a problem situation in terms of its elements or dimensions, morphological analysis can find original and often innovative solutions.

Alternatives :-

- ❖ Determine the appropriate problem characteristics. An individual problem solver or facilitated group brainstorms to define problem characteristics, also referred to as parameters.
- ❖ Make all the suggestions visible to everyone and group them in different ways until there is a consensus regarding the groups.
- ❖ Make all the suggestions visible to everyone and group them in different ways until there is a consensus regarding the groups.

- A grid or grids should be filled with lists of parameters arranged along the axes. Combinations can now be marked on the grid. Depending on the number of items in play, a great number of combinations may be available.
- Eliminate combinations that are impossible to implement or undesirable, set aside those that you do not want to eliminate, but do not want to implement, and develop the rest as much as possible.

5. ***Schedule, Tasks and Milestones*** :-

- The project selection and analysis is started during the month of December.
- Started the study over wavelet based fusion techniques during ending of December
- Started studying CT and MRI image fusion method at the starting of January
- By using DWT method, Developed the mathlab code for Image fusion During the end of January
- Started the study over the kidney stone formation and causes of stone during the month of February.
- Started studying about morphological analysis and image processing steps during February
- Developed the Matlab code such that it can detect the kidney stone location in the Ultrasound and CT images of the Kidney during march.

6. ***Project Demonstraton*** :-

Wavelet Based Image Fusion :-

Result :-

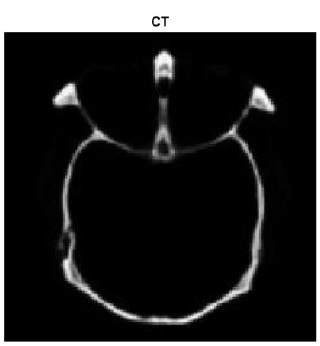


Fig.10 *Input CT Image*

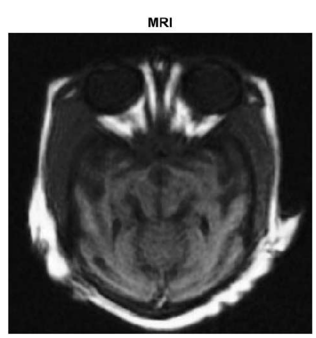


Fig.11 *Input MRI Image*

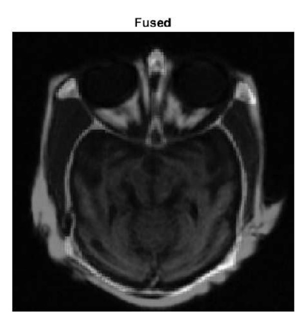


Fig.12 *Output Fused Image*

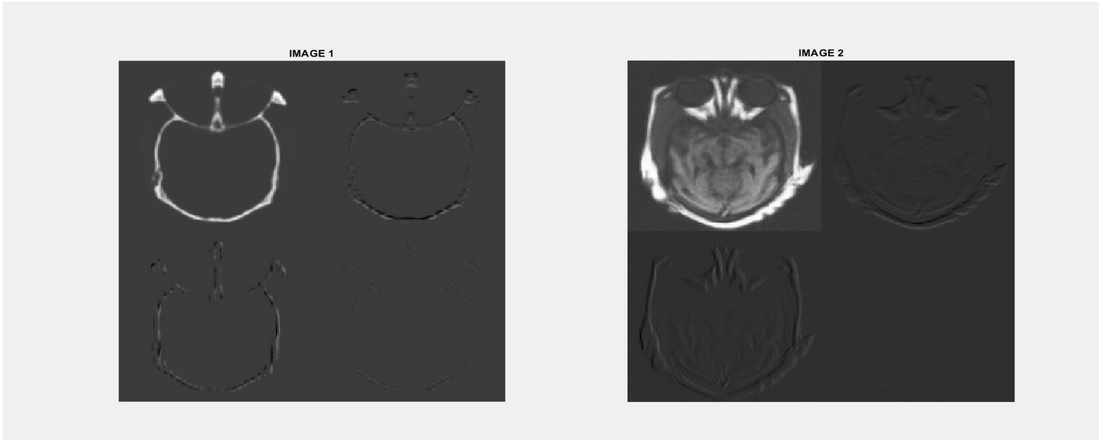


Fig.13 *Fusion results of the CT and MR images*

Explaination :-

- We have to apply Wavelet transform for both CT and MRI images.
- The fused image consists of both CT and MRI information.
- We have to apply LL1, LH1, HL1, HH1 2D wavelet transformation to the input images by using Haar filter.
- Once we separate the matrix then whe have to apply 2D IDWT to get fused image.
- D1=[LL1,LH1;HL1,HH1];
  D2=[LL2,LH2;HL2,HH2];
- After applying wavelet transform, we have to convert it to double
- M1=double(D1);
- To fuse the 2 images I created function called Average
- Where CA, CH, CV and CD represents the adjacent, horizontal , vertical and diagonal matrices of fused wavelet coefficient matrix.

Fusion Method	Standard Deviation	Average Gradiant	Information entrophy	Cross Entrophy
DWT	41.152	6.734	6.178	1.9428

Table 7

Applications :-

The Image fusion helps us to visualize the structure of the body that includes water and fat modules. Image Fusion is a technique for taking very clear and detailed pictures of tissues and internal organs using high frequency radio waves delivered in pulses and a strong magnetic field. It is used to identify inflammation or infection in an organ, degenerative diseases, strokes, musculoskeletal disorders , tumors and other irregularities that exist in tissue or organs in their body.

Kidney Stone Detection :-

Ultrasound Images :-

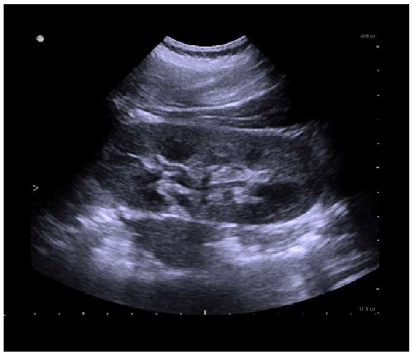
Fig.14 *Input Image*

Fig.15 *Grey image*

Fig.16 *Region of intrest*

Fig. 17 *Pre Processed Image*

Fig.18 *Stone detected image*



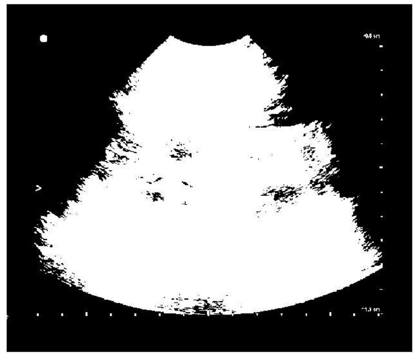


Fig.19 Input Image *Fig.20 Grey Image* *Fig.21 Region of interest*

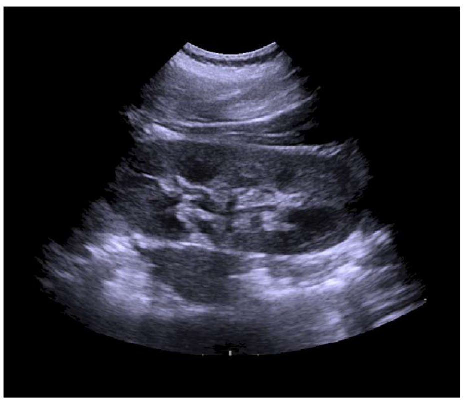
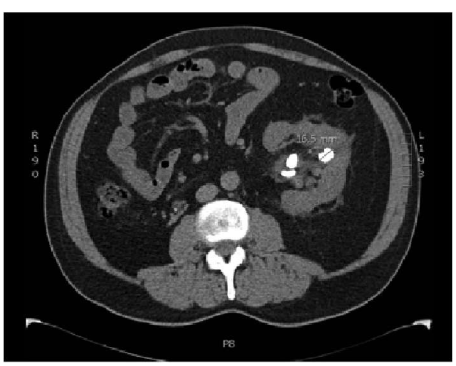
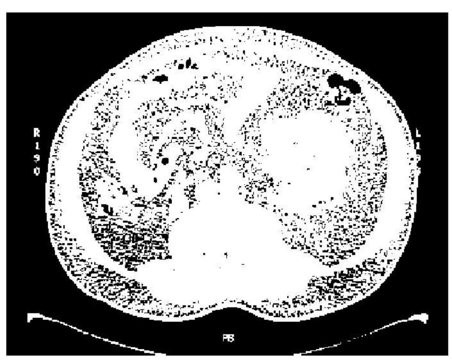


Fig. 22 Pre Processes Image *Fig 23 Image with No stone*

<u>CT images</u> :-





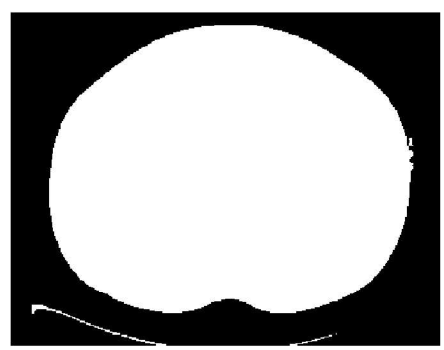
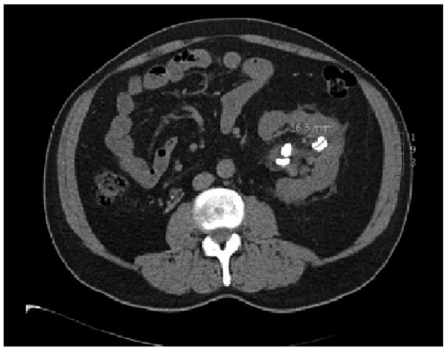


Fig.24 *Input Image* Fig.25 *Grey image* Fig.26 *Region of intrest*



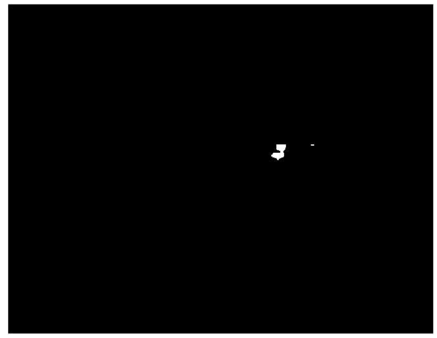
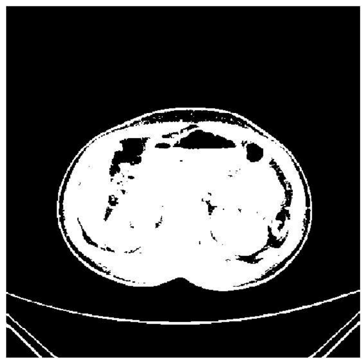


Fig. 27 *Pre Processed Image*

Fig.28 *Stone detected image*



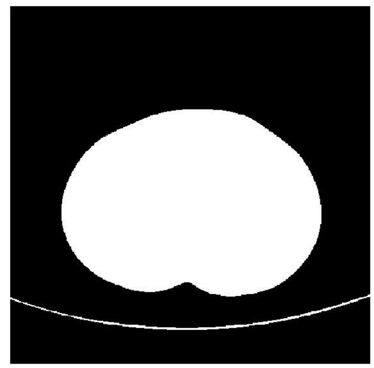


Fig.29 *Input Image*

Fig.30 *Grey image*

Fig.31 *Region of interest*

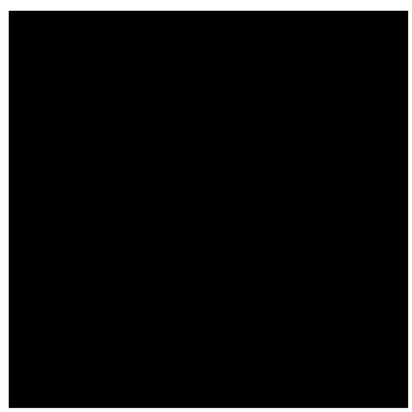


Fig. 32 Pre Processes Image

Fig 33 Image with No stone

Explaination :-

- First takes a fresh RGB image as input
- In this process uigetfile is used to get file in any location.
- With imread command we canread the image
- We convert the image from RGB to grayscale and set pixel values greater than 20 (threshold value) to binarize the grayscale image.
- After that we apply a complement image which is inverse of the input image
- For the command figure; imshow(c) we will get complement image.
- For the command figure; imshow(m) we will get the region of interest where the stone is located
- Preprocessed image is that where all the text on the image will be removed
- After that, the pre-processed RGB image converted to a gray scale image. To reduce the noise, we perform a median filtering process in the preprocessing step of the image.
- In the 3rd figure mentioned in the output result, the shaded region is the region of interest where the stone is located
- After that we use imadd to enhance image and applying threshold of 250. We usually try to keep the pixel above 250 to reduce noise.
- The imdilate is a morphological operator to dilate the image and bb, col and row are the value of region of interest.
- The value of bb is given to roipoly so that we will get particular region of interest
- Apply filter image over the region of interest image
- Apply boundary level if num>1, Stone is detected

7. ***Cost Analysis /Result and Discussion*** :-

Cost Analysis :-

A CT scan allows a better imaging and positioning method than an X-ray, which provides only a limited perspective. The person is given a contrast reagent either orally or intravenously. This factor helps structure boundaries to be different from each other. The person is then asked to lie down on a sliding platform and is then slid into the CT machine. After a few hours the body discards the contrast reagent. Let us know about CT scan cost in diagnostic centers in India. An average high-resolution CT scan or HRCT costs around INR 5000-1000. But most of the time, you can expect an average price of Rs 1,500. However, the cost varies a lot depending on the body part scan you are going to undergo, so you can expect it to cost between Rs 1,500 to Rs 5,000.

MRI systems are expensive because they are expensive to build, but the effort that goes into manufacturing and quality testing and assurance ensures accuracy, efficiency and improved patient care. The Magnets which are used to build the MRI system create the magnetic force that allows images to be created in the first place. The stronger the magnetic field, the better the images. MRI costs range from INR 1500 to 25000 because the systems are expensive, as well as expensive to install and maintain.

Ultrasound uses high-frequency sound waves to create real-time images of various organs in the body. It also produces images of various tissues and blood circulation in the body. Ultrasound is the most common and important diagnostic test advised by the doctor along with X-ray and other pathology tests. Ultrasounds can cost anywhere from INR 600 to 1500 or more, and can easily cost 1,000 if you go to an out-of-network provider. In general, larger hospitals with higher administrative costs charge more for ultrasounds than a doctor's office or stand-alone clinic.

Results :-

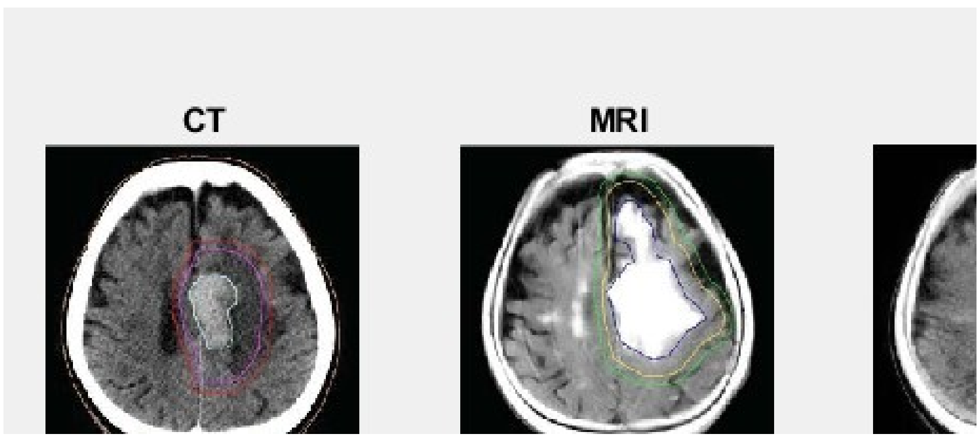


Fig.34 Fused Result of CT and MRI image

- We combined wavelet transform and various fusion rules to fuse CT and MRI images. Using this method we fused other head and abdomen images. The images used here are grayscale CT and MRI images. The image fusion process is defined as gathering all the important information from multiple images, and their inclusion into fewer images, usually a single one. This single image is more informative and accurate than any single source image, and it consists of all the necessary information. The purpose of image fusion is not only to reduce the amount of data but also to construct images that are more appropriate and understandable for the human and machine perception.

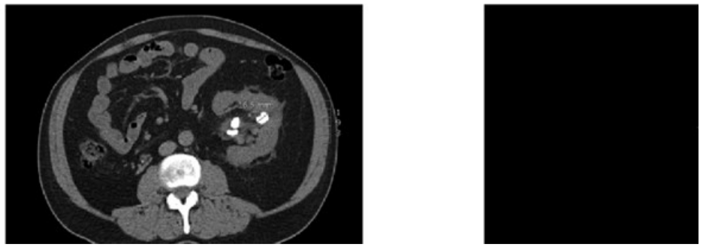


Fig.35 Stone Detection Result in CT image

Fig.36 Stone Detection Result in Ultrasound Image

- ❖ Pre-processing, fragmentation and feature extraction on the input image are the basic and crucial functions of our proposed scheme for detecting the presence of kidney stones. A feature extraction procedure was used to measure the exact coordinates of the stone and the overall appearance of the stones created from the image. The accuracy of this method is 96.82%.

8. ***Summary*** :-

The fusion of two modality images such as CT/MRI is combining the complimentary and redundant information both image in one, which increases the ease of perception, less time, and reduced storage space. The Image fusion helps us to visualize the structure of the body that includes water and fat modules. Image Fusion is a technique for taking very clear and detailed pictures of tissues and internal organs using high frequency radio waves delivered in pulses and a strong magnetic field. It is used to identify inflammation or infection in an organ, degenerative diseases, strokes, musculoskeletal disorders, tumors and other irregularities that exist in tissue or organs in their body. The fused image contained the information of both CT & MRI. There need a post processing for best visuals. And also fused image requires less space (memory) than two modality images.

First examines images of ultrasound and CT scans of patients with stones on the MATLAB platform. Next, we create the organizing component before moving on to the rest of the process. This method can be extended by identifying the area of the kidney stone and estimating the size of the stone. It can be used to make the accurate position of the stone. 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. By using this morphological analysis we can able to identify stones formed in the kidneys.

9. ***References*** :-

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Appendix A

MATLAB

MATLAB is a programming platform designed specifically for engineers and scientists to analyze and design the systems and products that change our world. The heart of MATLAB is the MATLAB language, a matrix-based language that allows the most natural expression of computational mathematics. MATLAB combines a desktop environment tuned for iterative analysis and design processes with a programming language that directly expresses matrix and array mathematics. It includes a live editor for creating scripts that combine code, output, and formatted text in an executable notebook. Millions of engineers and scientists worldwide use MATLAB for a wide variety of applications in industry and academia, including deep learning and machine learning, signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology.