KIDNEY STONE DETECTION USING IMAGE PROCESSING TECHNIQUES

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ABSTRACT

Kidney stone disease is when a solid piece of material occurs in the urinary tract. If it grows more than 5mm, it causes blockage. Hence, it's necessary to have an approach to detect the stone in the kidney to avoid health issues. The main objective of our project is to detect a kidney stone from a digital ultrasound image of the kidney by performing various image processing techniques. To detect the stone, we will use the acoustic shadow created because the sound waves fail to propagate due to the barrier i.e the kidney stones. These shadows will help us locate the stones. For this we will need to perform various image enhancement techniques and then perform segmentation to detect the stone, if any.

Index Terms— 1. Ultrasound 2. Kidney Stone 3. Otsu' Method 4. Image Enhancement 5. Segmentation

1. INTRODUCTION

The Kidney are the pair of fist size organs located on each side of the spine, at the bottom of the rib cage. For a healthy body, kidneys are essential as they are responsible for filtering impurities, waste and excess water out of the body. Formation of stones in the kidney occurs when urine becomes concentrated (leads to crystallization of minerals) and these stones can affect the parts of our urinary tract. The effect or the harm caused by these stones can be minimized if they are recognized as early as possible. The low cost method widely used by the doctors for the diagnosis of kidney disease is Ultrasound. In this paper, we used the ultrasound images of the kidney to detect the presence of stone. The image produced by the ultrasound has low contrast and contains speckle noise. In preprocessing of the image, we identified our region of interest from the image by performing Otsu thresholding. Then, we did image enhancement by using Gaussian and median filters. At last, we applied image segmentation and reduced our image to locate and mark the position of the stone.

Image with stone:

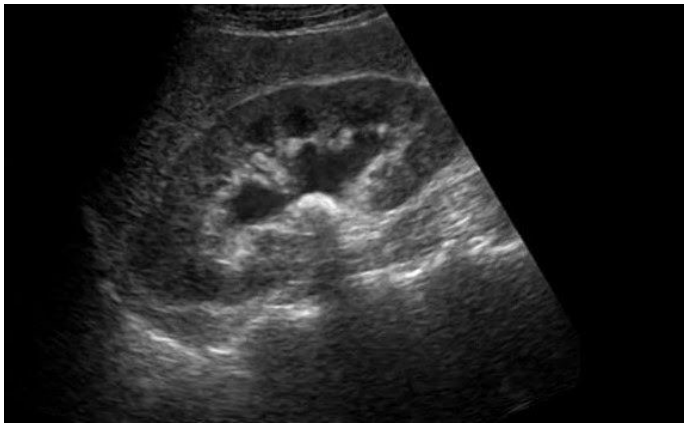
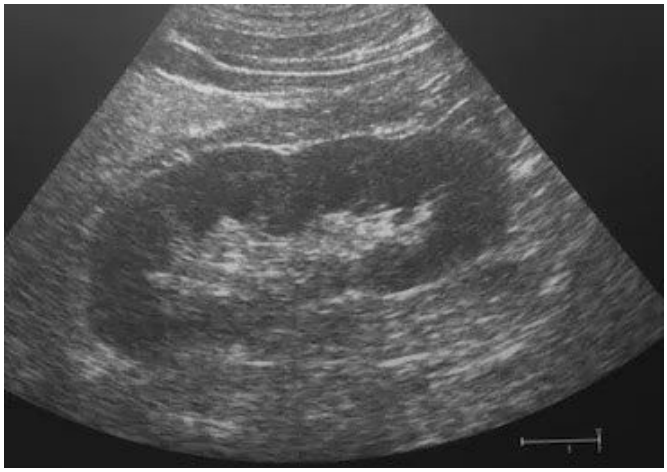


Image without stone:



2. LITERATURE REVIEW

.1. In a study of Speckle Noise Reduction and Segmentation of Kidney Regions From Ultrasound Image by Tanzila Rahman, and Mohammad Shorif Uddin, they used a gabor filter for smoothing and sharpening the image, followed by segmentation to locate the kidney stone regions.

2. In another study by Kalannagari Viswanath and Ramalingam Gunasundari, they performed histogram equalization and a gaussian filter for denoising, again

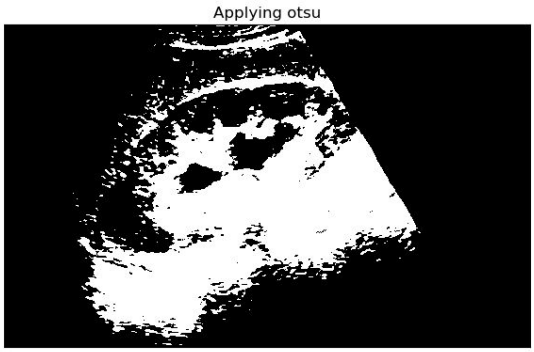
followed by segmentation.

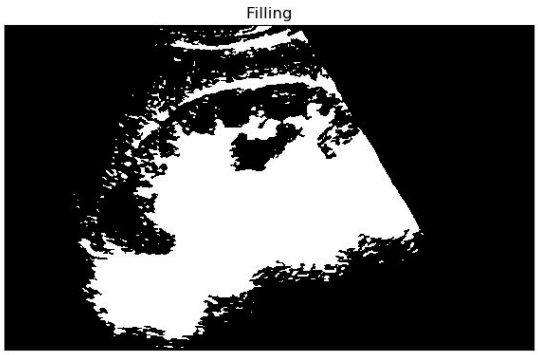
3. METHODOLOGY

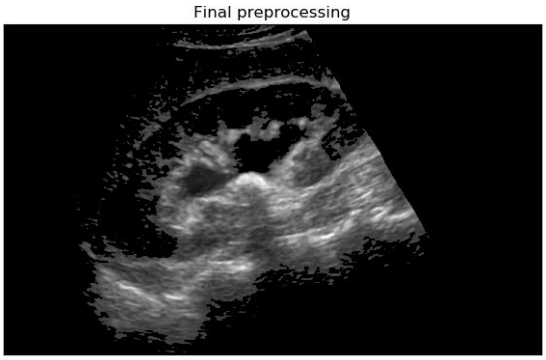
We propose four stages of image processing:

3.1 Image Pre-processing

The input image has various speckle noise and as we have to identify the stone region, we only require our area of interest for further processing. Therefore, firstly we removed the smaller objects and then we applied Otsu thresholding for separating the pixels into two classes, i.e. foreground and background. Then filling of the foreground region of the image was done to fill the region of our interest. At last, we use this filter to separate out this region from the input image.







3.2 Image Enhancement

To enhance the pre-processed image for further processing, we tried various enhancement methods including Histogram equalization, median filter, gaussian filter and Laplacian filter. After testing these various enhancement methods, we found that we get the best results by using a Gaussian filter followed by a Median filter in order to remove the unnecessary noise from the image. This stage denoises the image for further processing.

3.2.1 Gaussian Blur

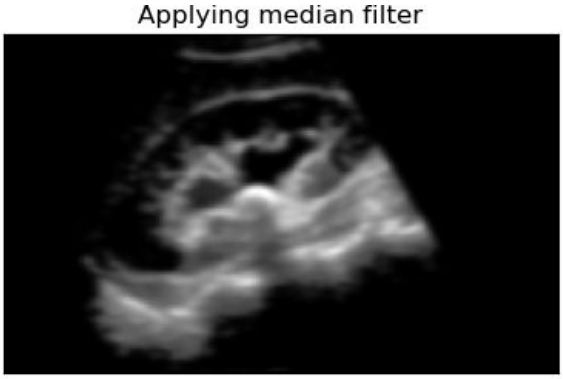
The image is passed through a low pass Gaussian filter. It is used to blur the image in order to remove the speckle noise from the image.

Image after applying Gaussian Filter

3.2.2 Median Filter

Since our image also contained salt and pepper type noise, we performed a median filter in order to remove these types of noise.

Image after applying Median Filter



3.3 Image Segmentation using Morphological Operations

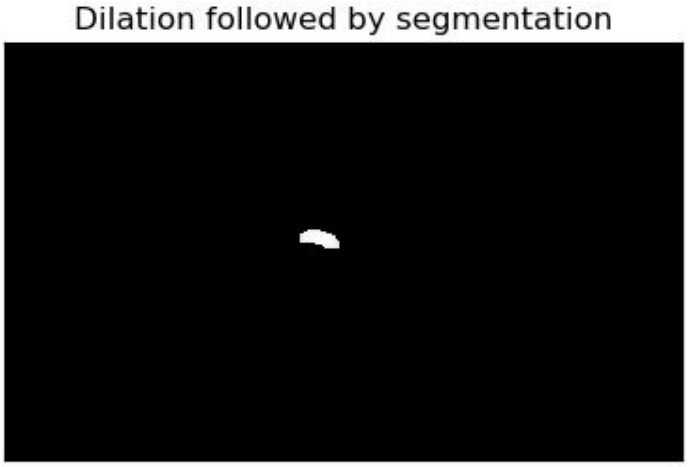
Next, on our enhanced image, we performed morphological operation segmentation. We tried out Erosion and Dilation techniques.

Erosion: This technique is used to remove boundary pixels due to which areas of those pixels shrink in size and holes of those areas become larger. It basically

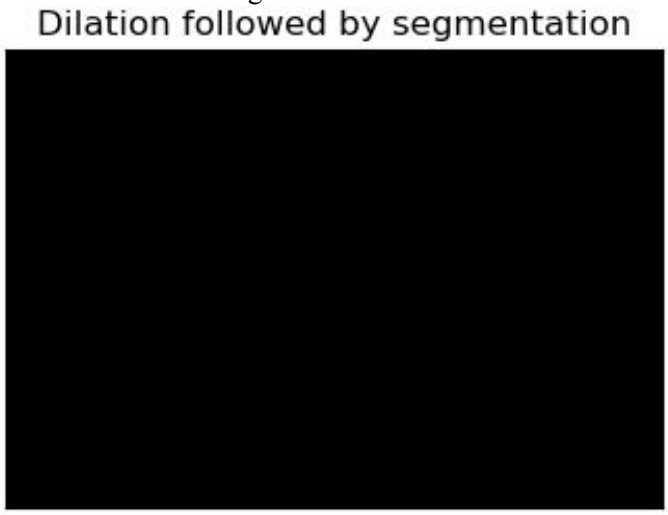
removes small areas so that the substantive objects remain. But there may be cases where the size of stone is much smaller, thus in those cases, this operation removes them too.

Dilation: This technique adds pixels to the boundary. Morphological dilation makes objects more visible and fills in small holes in objects. For this reason, we saw that the stone detection was better when using dilation rather than erosion.

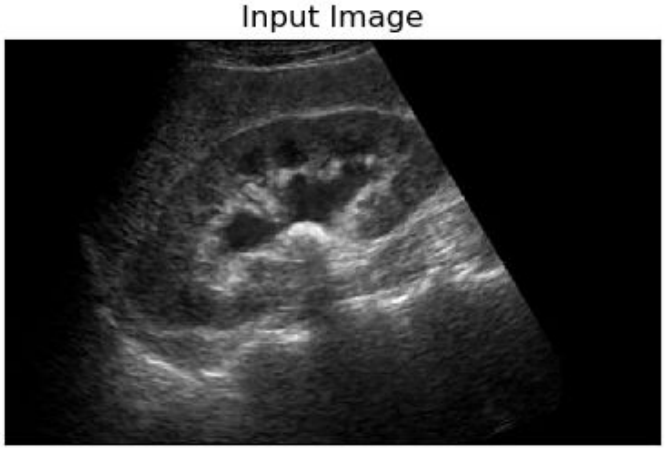
Final outcome for image with stone:

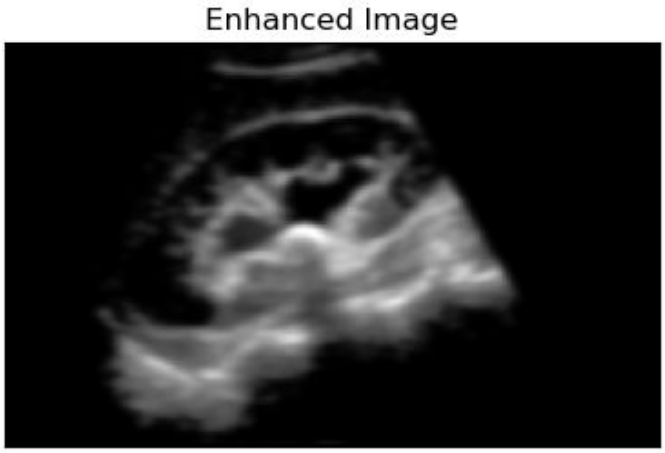


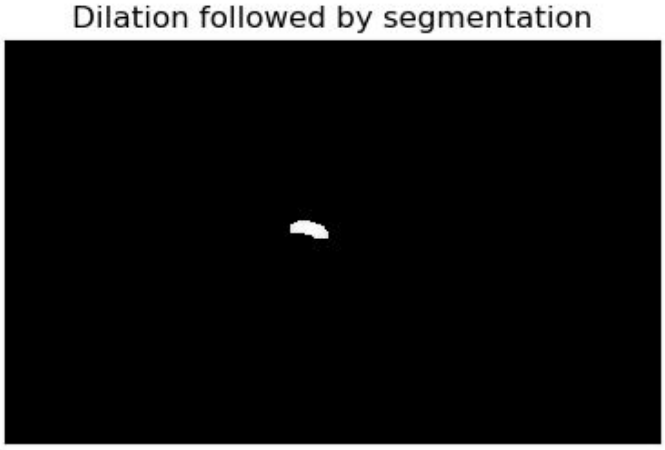
Final outcome for image without stone:



Results of the image with stone:





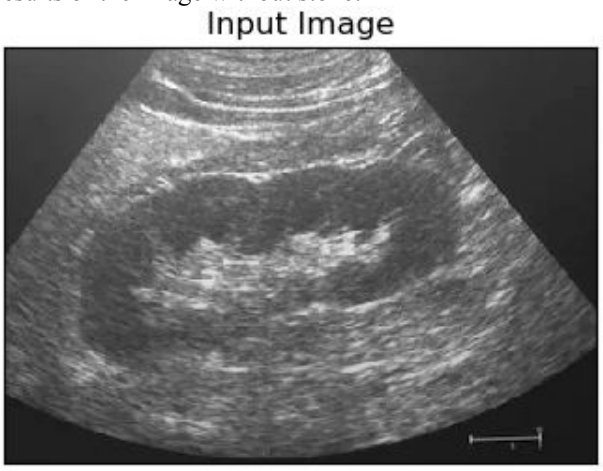


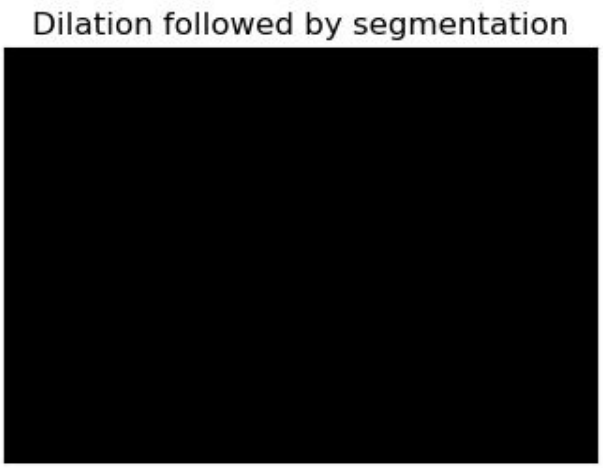
4. Result and Conclusion

After applying all the techniques discussed above, we found that we are able to detect the region of the stone in the images containing stones and for those images which don't have any stone, the final image formed is a black image.

From the above results, we can conclude that image enhancement and segmentation plays a huge role in detecting the regions of the kidney stone.

Results of the image without stone:





5. References

1. T. Rahman and M. S. Uddin, "Speckle noise reduction and segmentation of kidney regions from ultrasound image," 2013 International Conference on Informatics, Electronics and Vision (ICIEV), Dhaka, 2013, pp. 1-5, doi: 10.1109/ICIEV.2013.6572601. https://ieeexplore.ieee.org/document/6572601
2. Kalannagari Viswanath and Ramalingam Gunasundari, “Analysis and Implementation of Kidney Stone Detection by Reaction Diffusion Level Set Segmentation Using Xilinx System Generator on FPGA” https://www.hindawi.com/journals/vlsi/2015/581961/