# NERVE SEGMENTATION IN ULTRASOUND IMAGES

ECE – 515 Project Report

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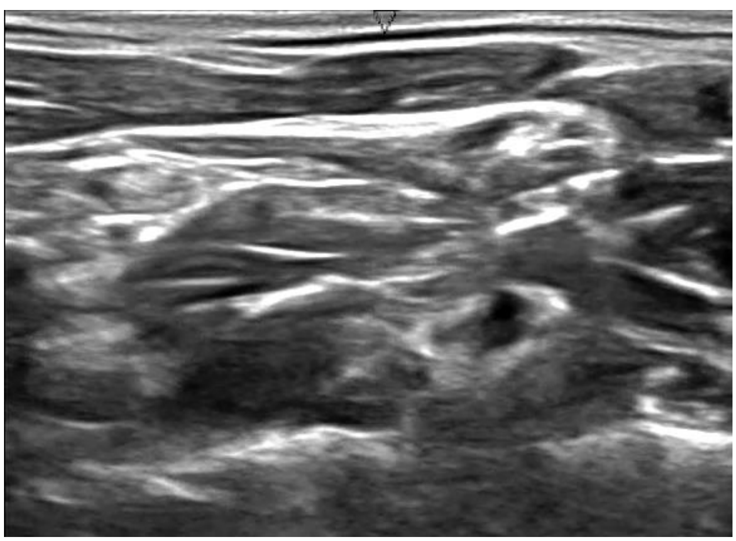
# ABSTRACT

Ultrasound scans are very important as it is useful in scanning the internal tissues of the body which in turn helps to detect any kind of injury or disease in human body. But due to some factors the ultrasound images are distorted and not very explanatory. In this project we do image segmentation on the ultrasound nerve image for the sole purpose of portraying the image in a more significant and worthwhile manner. Doing this we can highlight the important parts in any medical ultrasound image which can be used by doctors for various medical purposes. We perform nerve segmentation with (i) initial seed points (ii) reference mask. Then we are going to compare the accuracy of the segmented nerve area.

# ULTRASOUND

Ultrasound imaging or ultrasonography is an important diagnosis method in medical analysis. The Ultrasound images are low contrast images that uses high frequency sound waves to produce picture of the internal body. It helps to diagnose the cause of pain, swelling and infection in the body's internal organs for effective and correct diagnosis. The Ultrasound scans are preferred in medical field as they are cheap and easy to produce. They do not cause any health problems and they have no known harmful effects on humans.



The major disadvantage in Ultrasound images is that it has huge amount of noise which affects the quality of image. Because of this it becomes very difficult to find the exact location of the nerve which is desired by the doctor to operate. Ultrasound images are corrupted by speckle noise. To make this kind of image more informative we need to do some processing on the ultrasound image. That is why we do image segmentation of the ultrasound image.

# IMAGE SEGMENTATION

Image segmentation is a process of subdividing an image into multiple segments with approximately similar properties i.e., partitioning an image into distinct regions containing each pixel with similar attributes. It helps in identifying the objects and other significant information in the digital images. The Image segmentation plays an important role in successful image analysis.

The major problem in this process is the accurate partitioning of an image with similar attributes. Due to the poor image quality of ultrasound images we need to process the image so that we can get more information to perform the desired operation.

In this project we are performing nerve segmentation, that is we are accurately identifying nerve structures in ultrasound images. Identifying correct nerve structure is important, to reduce the pain caused by damaged nerves for which doctors make use of narcotics. If the accurate nerve structure is not known, then there is a risk of overdose of narcotics. Narcotics overdose has many harmful and life-threatening side effects and can lead to many complications in human body. That is why we perform image segmentation on the ultrasound image so that we can know the correct nerve structure and hence reduce the use of narcotics by restricting its use to the required places only.

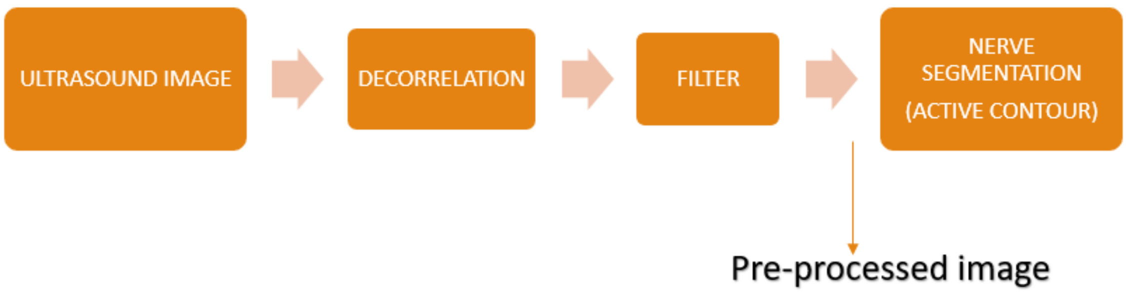
# SPECKLE NOISE

The speckle noise displays a granular pattern due to the dispersion of the electromagnetic waves caused by the transducer. When the waves are reflected on the rough texture, it makes an impact such that it creates interferences which causes noise in the registered image. It is a granular noise that is an intrinsic part of the Ultrasound images. It leads to reduction in the contrast and resolution of the image which in turn degrades the overall quality of the image. Diagnosing an image also becomes very difficult since due to presence of this noise, the edges and other fine details of the image are also compromised.

Presence of this noise has got very negative impacts as the detection of injuries, especially in low contrast images becomes very difficult. For perfect diagnosis, it is important to have an accurate and reliable model. These noises can be removed using various filters. There are different types of filters like Gaussian, Wiener, Median etc.

# METHODOLOGY

We are going to perform decorrelation on the ultra sound image and then we remove the speckled noise by filtering the image. The image after filtering is called as pre-processed image and then we are going to perform nerve segmentation on the pre-processed image to find the exact location of the nerve. The nerve segmentation is done using Active contour with given mask and then using seed points. Here we compare the output of both the process.




# DECORRELATION

We have established earlier that for finding the accurate nerves to be treated we try to do accurate partitioning of the image with similar features. This helps us to differentiate between different parts of the image. But this process is hard. So, to make the process little easy we decorrelate the ultrasound image. The decorrelation is the process of reducing the autocorrelation within a single image or cross-correlation within a group of images. The image we have contains edges. But due to the presence of speckle noise they are not visible because they all look mixed. If we decorrelate the image, then it tends to unmix them. This in turn simplifies the further process.

Decorrelating the image enhances the color difference found in each pixel of an image while preserving the important features of the image. This process of stretching the color difference found in each pixel of an image is called as “decorrelation stretching”. The exaggerated colors that we get after decorrelating the image improves the visual interpretation of the image and makes the process of feature discrimination easier.

# FILTERS

We earlier discussed that how the speckle noise reduces the contrast and the resolution of the image thereby reducing the diagnostic value of the image. Therefore, it becomes necessary to remove the noise from the image.

To remove speckle noise, we can use the following filters: -

1. Gaussian filter: - It is a linear filter. Here based on the gaussian distribution, the noisy pixels are replaced by the average value of the surrounding pixels. This in turn reduces the noise but it also blurs the edges and reduces the contrast. This is faster form of filtering to reduce noise.
2. Median Filter: - It is a non-linear digital filtering technique. It is a typical preprocessing step that helps in making the further processing simpler. It is very widely used in digital image processing as it reduces the noise whilst preserving the important features of the image. Unlike Gaussian filtering, here each pixel is replaced by the median of the neighboring pixels.
3. Wiener Filter: - It is an adaptive noise removing filter. It is based on statistical approach. It inverts the blurring simultaneously. To reduce the noise using the wiener filter approach we should have a prior knowledge of the spectral properties of the original image and the additive noise.

In our project we used median filter on the decorrelated image to remove the speckle noise and getting the preprocessed image.

## Why median filter?

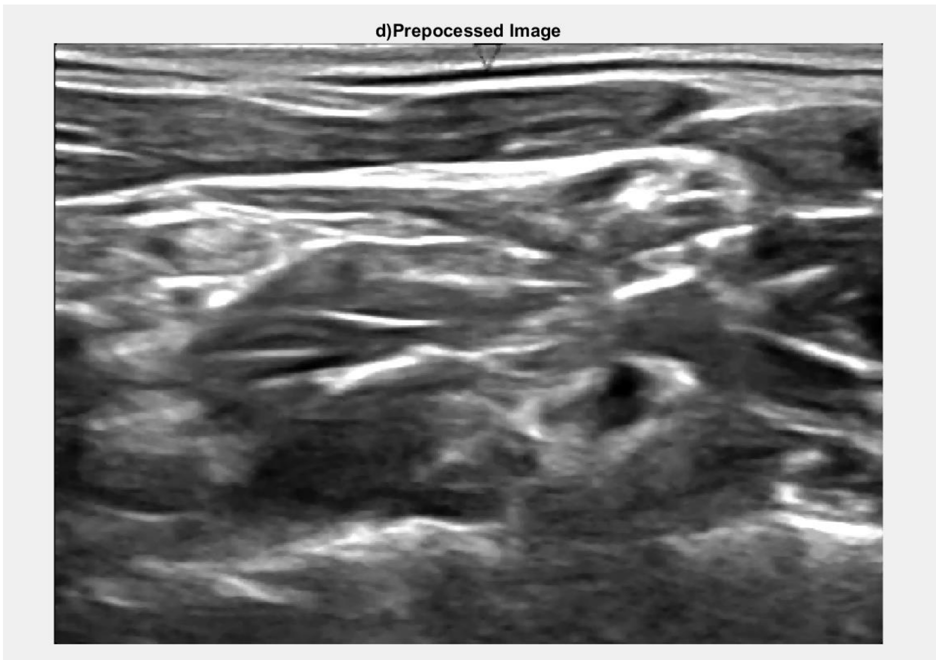
As we mentioned earlier that to use the wiener filter approach we should have prior knowledge about some of the characteristics of the image. So, we need to make few assumptions, but we don’t have any data to support our assumptions. That is why we rule out the use of wiener filter to reduce the noise. Reasons we opted for Median filter ahead of gaussian filter are: -

- Use of non-linear filter (median filter) has got a major advantage over linear filters (gaussian filter) as median filter eliminates the effect of speckle noise with larger magnitude.

- Though gaussian filter is faster than median filter but it compromises with the features of the image while reducing the noise. But in case of median filter, the noise is reduced but important features of the image are also kept intact.

- Since our analysis is based on edge detection, so we go ahead with median filter as it preserves the edges while the gaussian filter doesn't.

So, because of the above-mentioned reasons we use median filter on the decorrelated image. After doing so we get the pre-processed image. Now we will do the process of nerve segmentation on the pre-processed image.




# NERVE SEGMENTATION

We do this by doing the image segmentation on the pre-processed ultrasound image. By using edge detection algorithm (Active contour) we can highlight the important part of nerve structure in any medical ultrasound image.

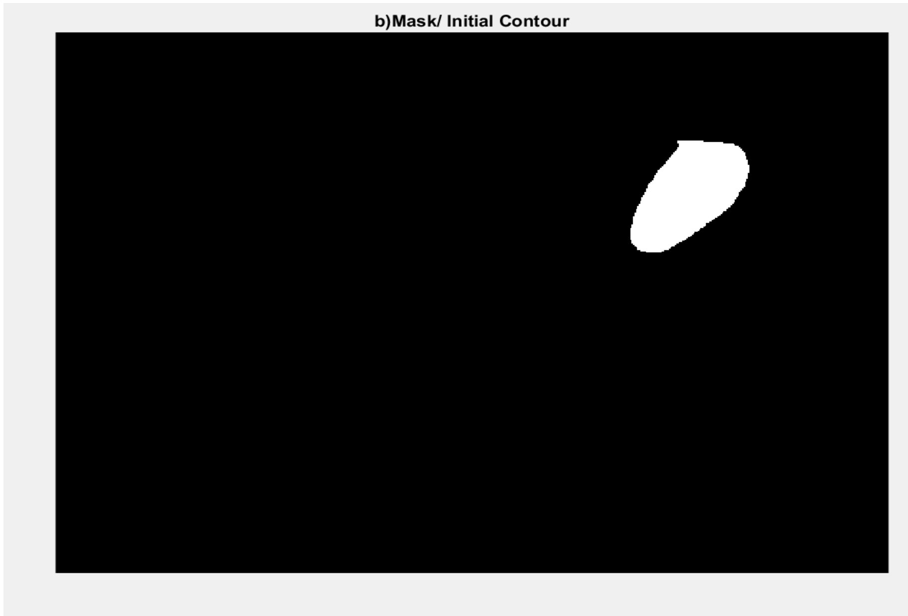
## How It works

**CHOOSING INTIAL CONTOUR**

We need to select the region in the image where we are going to perform image segmentation. There are two ways we could select the initial contour, first is by using mask and the other one is by selecting seed points.

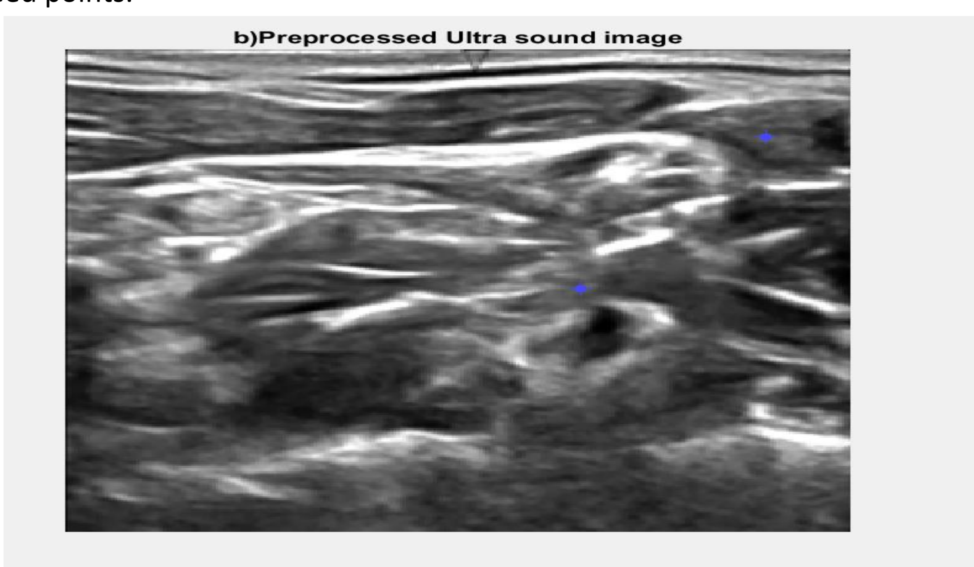
- Mask

  Mask is the data set derived from the nerve structure that is manually annotated by trained expert. There won't be any dependencies if we are using mask.




- Initial Seed Points

  Here we must choose two random seed points on the image near the nerve area to generate a spherical initial contour that bounds the nerve. The accuracy of nerve segmentation if we use initial seed points depends on point selection and on the number of iterations. The two blue points in the below given preprocessed image represents the two seed points.



# ACTIVE CONTOUR

We use this as our edge detection algorithm to segment the nerve area in our preprocessed image. The contour that we choose flows along the different perspective of the image and comes down to a convergence and because of this attribute it is called Active contour. As we know that the contour is mobile and since it must move and converge, the process of nerve segmentation using active contour needs to be an iterative process otherwise it won't converge.

Active contour segments the image into foreground and background regions. Using the active contour algorithm, we specify the mask on the image that in turn moves to find object boundaries. The boundaries of the object regions in mask will be white and it defines the initial contour position used for contour evolution to segment the image. Based on first iteration we will get a position which will be closer to the desired nerve structure. A part of our contour will converge to this position. Now we will repeat the process using the new contour. This way our contour will keep on converging and we will get the more precise area where the nerve structure lies.

# EDGE DETECTION

As mentioned earlier, the nerve segmentation is based on the process of edge detection. Edge detection is the technique that is used to find the boundaries of objects within the image. Its detects the edges by detecting the discontinuities in brightness.

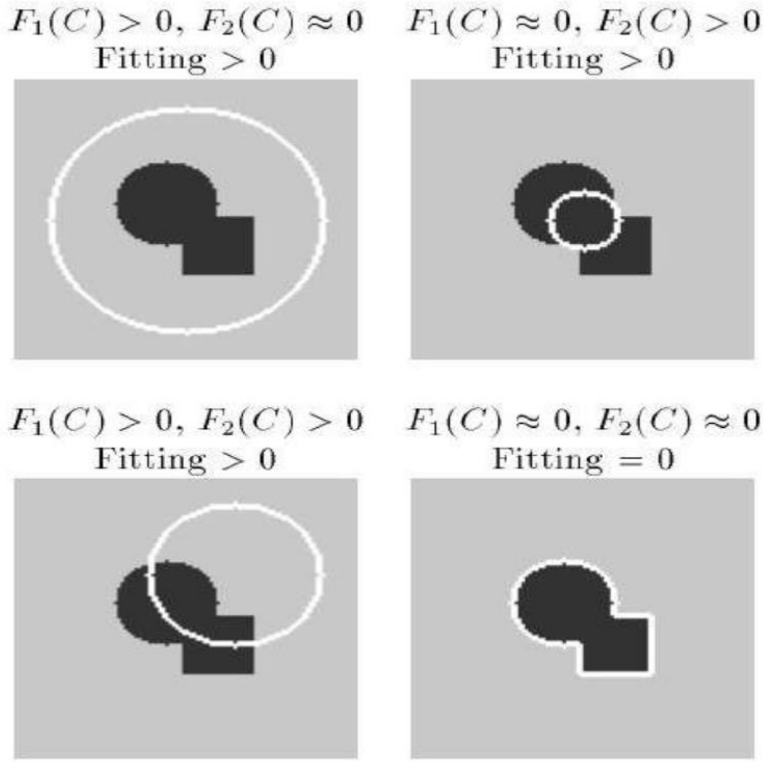
## Segmentation Framework

Here for Initial seed points we use level set method for active contours without edges. The First two terms were defined to be two different forces. First term defines the force to shrink or reduce the contour. Second term defines the force to enlarge the contour. Both the forces cancel out each other when the evolved contour reaches the boundaries of the region of interest.

$$F_1(C) \qquad + \qquad F_2(C)$$

$$\int_{inside(C)} |u_0 - c_1|^2 dx + \int_{outside(C)} |u_0 - c_2|^2 dx$$

There are four possible cases to analyze: the below image will be denoted as $u0$. Let us consider black = -1 and the rest of the region in gray = 1. Let $c1$ $and$ $c2$ be the mean of the region inside




the contour and the mean of the region outside the contour respectively. In case (1), we observe that the initial contour engulfs the whole region of interest (black) as well as a few gray regions. Hence $c1$ is approximately zero and $c2$ is equal to 1. Note that the integration in only with respect to inside of C or outside of C. Thus, the second term (F2) will be zero, because we are subtracting c2 from region outside the contour. The First term (F1) will be positive because $c1$ is zero and we subtract $c1$ from region inside the contour and compute the squares and sum them up, which eventually resulting a larger positive number. Hence, we have F1>0 and F2=0. Thus, there will be shrinking of the contour in the next iteration. At the end of the fourth iteration, the contour C evolves to the boundary of the region of interest and hence, $F1$ $and$ $F2$ will be equal to zero. Thus, Contour C has attained the steady state and the resulting contour is the segmentation achieved.

# CONTRIBUTION

ANIMESH JAIN:

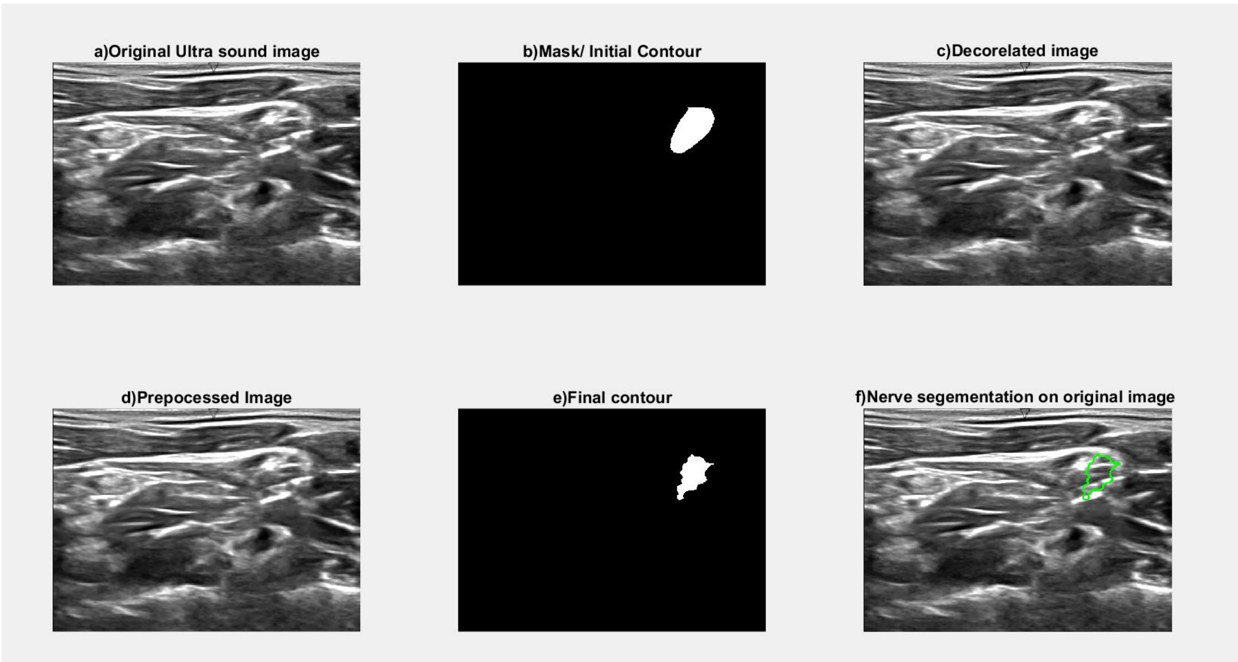
Worked on Active Contour MATLAB code, and presented the localized segmentation initial contour using seed points. Apart from this did the entire research on how to get the preprocessed image.

RAMANATHAN MURUGAPPAN:

Worked on Initial contour using seed points in MATLAB code and presented nerve segmentation using Active contour. Researched on active contour concept and importance of iterations.

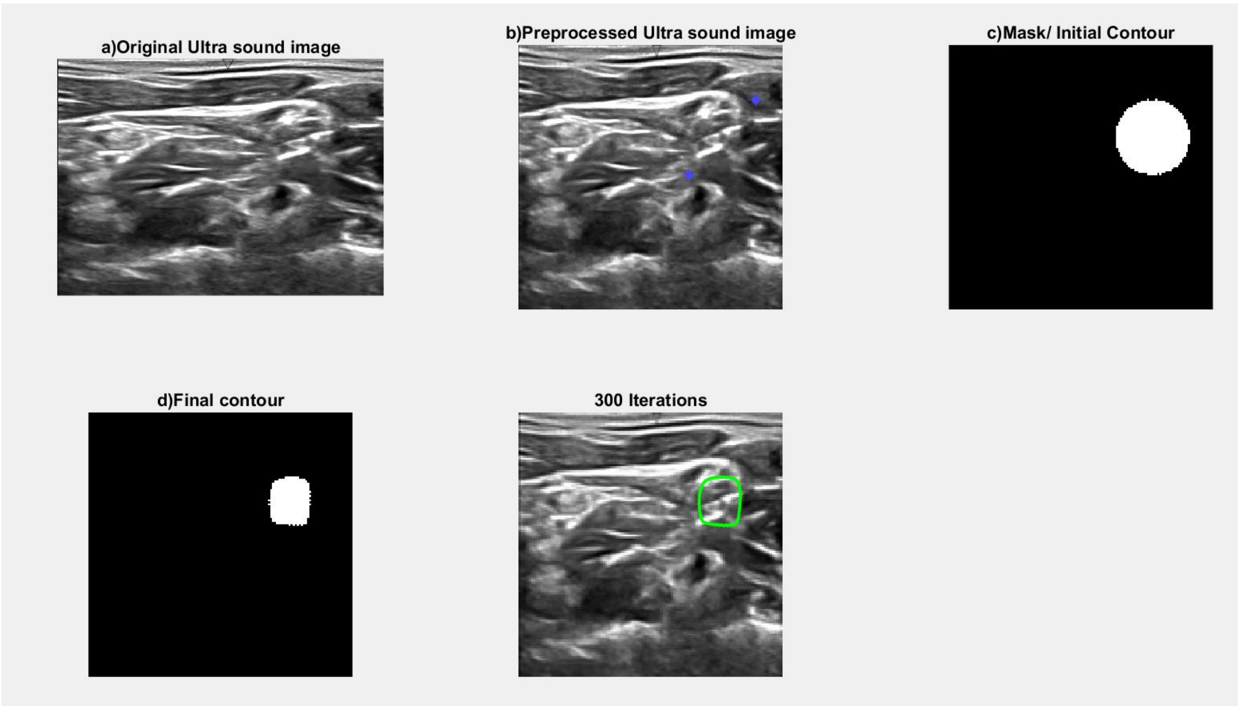
# OUTPUT

## a) Using Active contour




The original ultrasound image and the mask/initial contour image in the above diagram are the pictures that we already have. Initial contour is provided by the trained expert. Now we perform the decorrelation and filtering techniques on the ultrasound image to get the preprocessed image. Now we perform nerve segmentation on this preprocessed image using the Mask. After performing 300 iterations we get the final contour. **The contour we get has accurate edges and they are very sharp**. In the final image the nerve is segmented, and the green color part is the nerve area in the ultra sound image. It is more accurate when compared to initial seed points.

## b) Using initial seed points




In this method we don't get mask from any trained expert. So, we only choose a contour by taking two random seed points near the nerve area. We get a circular mask using these seed points. After getting the pre-processed image we segment it using the circular mask. After this localized segmentation we get the final contour. After looking at the contour after 300 iterations we get the final segmented nerve area. The green color part is the nerve area in the ultra sound image.

**If we compare the results from the above two methods, we see that the segmentation using mask given by trained expert gives more accurate idea about the presence of nerve as compared to the segmentation done using the mask derived by two seed points. But when we don't have a mask that we got from a trained expert we can create our own mask depending upon the area in the preprocessed image that could have a possible nerve structure and proceed further.**

# CODE

Nerve segmentation using Active Contour with the given mask (Edge detection for 300 iterations)

```
clc;
clear all;
close all;

a=imread('C:\Users\mrram\Desktop\cv2pro\train\1_1.tif');
m=imread('C:\Users\mrram\Desktop\cv2pro\train\1_1_mask.tif');
figure;
subplot(2,3,1)
imshow(a);
title('Original Ultra sound image');
subplot(2,3,2)
imshow(m);
title('Mask/ Initial Contour');
subplot(2,3,3)
A=decorrstretch(a);
imshow(A);
title('Decorelated image')
C=medfilt2(A);
subplot(2,3,4);
imshow(C);
title('Prepocessed Image');
bw=activecontour(C,m,300,'edge');
subplot(2,3,5);
imshow(bw);
title('Final contour')
BWoutline = bwperim(bw);
thickOutlines = imdilate(BWoutline, true(3));
SegoutR = A;
SegoutG = A;
SegoutB = A;
%now set yellow, [255 255 0]
SegoutR(thickOutlines) = 0;
SegoutG(thickOutlines) = 255;
SegoutB(thickOutlines) = 0;
SegoutRGB = cat(3, SegoutR, SegoutG, SegoutB);
```

```
%Segout(BWoutline) = 255;
subplot(2,3,6);
imshow(SegoutRGB);
title('Nerve segementation on original image ');
```

## Nerve Segmentation using Local segmentation with initial seed points (300 iterations)

```
clc;
clear all;
close all;

A = imread('C:\Users\mrram\Desktop\cv2pro\train\1_1.tif');
figure;
subplot(2,3,1)
imshow(A)
title('Original Ultra sound image')
subplot(2,3,2)
A=decorrstretch(A);
C=medfilt2(A);
imshow(C);
t = (imresize(C,[256 256]));% +50.*uint8(t);
imshow(t);
title('Preprocessed Ultra sound image');
h = impoint;
p = getPosition(h);
h1 = impoint;
p1 = getPosition(h1);
rad = abs(p1(2)- p(2))/2;
centre = [ (p1(1)+p(1))/2 , (p(2)+p1(2))/2];
m = createCirclesMask(t,centre,rad);
m = imresize(m,.5);
phi_init = m;
subplot(2,3,3)
imshow(m);
title('Mask/ Initial Contour');
```

```
subplot(2,3,5)
imshow(m);
title('Nerve segementation on original image');
I = (imresize(C,[256 256]));
I = imresize(I,.5);
[seg,phi] = localized_seg(I, phi_init,300);  %-- run segmentation
subplot(2,3,4);
imshow(seg);
title('Final contour');




function mask = createCirclesMask(varargin)

narginchk(3,3)
if numel(varargin{1}) == 2
% SIZE specified
xDim = varargin{1}(1);
yDim = varargin{1}(2);
else
% IMAGE specified
[xDim,yDim] = size(varargin{1});
end
centers = varargin{2};
radii = varargin{3};
xc = centers(:,1);
yc = centers(:,2);
[xx,yy] = meshgrid(1:yDim,1:xDim);
mask = false(xDim,yDim);
for ii = 1:numel(radii)
mask = mask | hypot(xx - xc(ii), yy - yc(ii)) <= radii(ii);
end
```

# REFERENCES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