EECE 603

Automated Stenosis Detection

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**Automated Detection**

In order to perform semi-automated stenosis detection, we first locate a vessel boundary. This is done manually by the user, and in this case, we want to have the vessel in question to be as “rectangular” as possible, since we only want one part of the vessel. In this case, we have selected our boundaries to be around one third from the top, and the entire width.

Considering that the image is already filtered out from noise and the boundaries are obvious, we apply the automated edge detection algorithm. The edge detection algorithm takes the average angle of the gradient of all the points we choose. These are the points inside the boundary we have chosen, excluding the edges of the image itself. We then average all the non-zero angles to get the angle of the vessel and rotate by that angle to have the vessel vertical. This allows us to create an algorithm that easily detects stenosis by horizontal detection. Below is the rotated image, beside the image of the cropped and rotated image.

A close-up of a person's chest

Description automatically generated with low confidenceNo image

Description automatically generated

Figure 1: Cropped Stenosis Image Figure 2: Rotated Image of Stenosis

Next, we perform some closing on the image so that all the boundaries are linked, and then we would like to have the boundaries of the vessel detectable easily by an algorithm, so we binarize the image, to get the following image below.

Logo, icon, company name

Description automatically generated

Figure 3: Binarized Image of Vessel

Using this image, we can calculate the percent stenosis by taking the minimum diameter and maximum diameter, then, considering that the vessel is cylindrical, we use the following formula.

% stenosis = 100% \* (1 – (Dstenosis/Dnormal)) (<https://pubmed.ncbi.nlm.nih.gov/10782772/>)

Using the formula, we seem to have 45.6% stenosis in this case. As we can see, the percentage is moderate, as there is not too much closure in the artery. (The higher percentage stenosis, the more dangerous it is).

**Image Filtering for Human Detection in Noisy Images**

Before performing any detection, we must preprocess the image so that that nerve is visible for detection. We started with smoothing the image using a median filter, then we got the gradient similar to – (but not the same, the top left corner was chaged) a Sobel gradient in the direction of the vessel in the image, and then Laplacian twice on the sum of the gradient and the median filtered vessel to sharpen the edges. We added all the results together, and the following image was obtained.

**A close-up of a fetus

Description automatically generated with low confidence**

Figure 4: Noisy Filtered Image

In order to make the image easier to view and remove the relatively large dots, we apply morphological processing, and close the image using a disk (Figure 5). Next, we also plot the edges of the vessel (Figure 6) to allow the user to locate the stenosis, and hence be able to select boundaries and to insert it into the automated detection tool.

We see that the stenosis occurs where the edges become very corrupted.

A picture containing text, blurry

Description automatically generated A picture containing text, metalware, chain

Description automatically generated

Figure 5: Opened Image of Vessel. Figure 6: Edges of Vessel

**Automated Detection for Noisy Images**

In this case, we simply applied median filtering to the noisy signal to reduce the salt and pepper noise found in the original signal. Then, we used morphological processing to remove all the random noise and to accentuate the shape of the vessel more. After that, the same process as above was used (gradient to get the average angle of rotation, binarizing, and then calculation of stenosis).

Using the automated method, the percent stenosis will be calculated to be 46.55%. This is only 1% away from the clean signal, so it is a reliable way to measure stenosis.

Below are four figures representing the original noisy image, the rotated filtered image, the cropped image, and the binary cropped image.

A close-up of a person's skin

Description automatically generated with low confidenceA picture containing text

Description automatically generated

Figure 7: Original Noisy Image(left) and filtered and rotated noisy image(right)

A picture containing text

Description automatically generatedLogo, icon

Description automatically generated

Figure 8: Rotated filtered image(left) and binarized filtered image(right)