Performance Comparison of Gaussian and Elliptic High Pass Filter

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ABSTRACT

In this paper, Gaussian and elliptic high pass filters are analyzed for image sharpening qualitatively and quantitatively. The filters are implemented in frequency domain using matlab software. Experiments are performed to compare the performance of both the filters, processed images are presented. The results demonstrate that elliptic yields better results.

1. INTRODUCTION

A filter that attenuates high frequencies while passing low frequencies is called low pass filter. Low pass filter are usually used for smoothing while high pass filter is used for sharpening.


In this paper, we performed image sharpening on the data set of MR image by gaussion & elliptic high pass filter and evaluated their performance. These sharpened images show increased diagnostic details, and used for many other applications like image registration (Dogra, A 2014, DOGRA, AYUSH, and PARVINDER BHALLA, ayush dogra GJMR (2013) and image fusion(DOGRA, AYUSH 2014).

2. GAUSSIAN HIGH PASS FILTER

The Gaussian high pass filters attenuates frequency components that are near to image centre. The Gaussian high pass is given by(Ayush Dogra 2013, DOGRA, AYUSH and PARVINDER BHALLA).

\[ H(u, v) = -e^{-D^2(u,v)/2 D^2} \]

3. ELLIPTIC HIGH PASS FILTER

An elliptic filter is also known as a Cauer filter, named after Wilhelm Cauer, or as a Zolotarev filter, after Yegor Zolotarev is a signal processing filter with equalized ripple (equiripple) behavior in both the
The gain for elliptical filter is:

$$G_{\text{ell}}(\omega) = \frac{1}{\sqrt{1 + \varepsilon^2 R_n^2(\xi, \omega/\omega_0)}}$$

where $R_n$ is the $n$th-order elliptic rational function (sometimes known as a Chebyshev rational function) and $\omega_0$ is the cutoff frequency $\varepsilon$ is the ripple factor $\xi$ is the selectivity factor.

4. MEAN SQUARE ERROR (MSE)

The mean square error (MSE) is the error metric used to compare image quality. The MSE represents the cumulative squared error between the compressed and the original image, mean square error (MSE) is given by (mathwork, accelerating the pace of engineering and science http://www.mathworks.in/help/vision/ref/psnr.html, B. Girod 1993)

$$MSE = \frac{\sum_{m,n}[I_1(m,n) - I_2(m,n)]^2}{MN}$$

$M$ and $N$ are the number of rows and columns in the input images.

5. METHODOLOGY

Filtering in frequency domain consist of following steps (Yusuf 2014).
1. Pre processing - multiplying the input image by $(-1)^{x+y}$ to centre the transform.
2. Computing $F(u,v)$, using any of the transformation methods.
3. Multiplying $F(u,v)$ by a filter function $H(u,v)$.
4. Computing the inverse transformation of the result.
5. Post processing - multiplying the result by $(-1)^{x+y}$.

6. RESULTS AND DISCUSSION

Here we will only demonstrate the image sharpening using gaussian & elliptic high pass filter by varying cut off frequency $d_0 = 10, 20, 30, 40, 50$. Figure 1 shows MR image. Figure 2 shows the results of GHPF with $d_0 = 10, 20, 30, 40, 50$. For elliptic high pass filter the order $n$ is set at 2, whereas selectivity factor & ripple factor is set at 1, and varying the cutoff frequency $d_0 = 10, 20, 30, 40, 50$. Figure 3 shows results of elliptical high pass filter.

**Figure 1:** Mr Image

**Figure 2:** (SHARPENED MR IMAGES BY GHPF)


7. QUANTITATIVE ANALYSIS

For quantitative analysis, computed the MSE between original input image and reconstructed images using equation 3. The following calculation value for MSE between input image and reconstructed images are shown in table 1.

Table 1.

<table>
<thead>
<tr>
<th>MSE between original MR &amp; sharpened MR images</th>
<th>GHPF</th>
<th>ELLIPTIC HPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>716.9992</td>
<td>2.5023e+03</td>
</tr>
<tr>
<td>20</td>
<td>449.4283</td>
<td>2.5023e+03</td>
</tr>
<tr>
<td>30</td>
<td>317.5338</td>
<td>2.5023e+03</td>
</tr>
<tr>
<td>40</td>
<td>242.7772</td>
<td>2.5023e+03</td>
</tr>
<tr>
<td>50</td>
<td>194.6673</td>
<td>2.5023e+03</td>
</tr>
</tbody>
</table>

8. CONCLUSION

Gaussian and 2nd order elliptic with d0= 10,20,30,40,50 is used. The difference between gaussian & elliptic filter is that the later provides much sharper image than former. In GHPF high pass filters, as the cutoff frequency increases the sharpening decreases but in elliptical filter the sharpening remains same as cutoff frequencies d0 increases. Computing MSE between input image & reconstructed sharpened images depicts that the elliptic high pass filter shows sharper image than GHPF. MSE here indicates change and this change is greater in elliptic high pass filter as compare to GHPF. MSE in elliptic high pass filter remains constant as d0, cutoff frequency is increased.

9. FUTURE SCOPE

Other frequency domain filter like chebyshev type 1, chebyshev type 2 & butterworth can also implemented in frequency domain using matlab software on various medical modalities like CT, MRI, X-RAY, PET, SPECT, etc

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