# CENG 466 Digital Image Processing

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## 1. FOURIER DOMAIN FILTERING

To take the Fourier transform, fftw library is used and its functions are applied to the image. Blurring is achieved by multiplying the first quarter of the image by Butterworth filtering function, and multiplying the other quarters by the corresponding symmetries of this filter with respect to the center of the image. Butterworth function is :

$H(u,v) = \dfrac{1}{1+(\sqrt{2}-1)*(D(u,v)/D_0)^{2n}}$, where $D(u,v) = \sqrt{u^2+v^2}$ , $D_0$ and n are constants. Graph of this filter is given in the appendix 1.

Similar procedure is followed for sharpening, but with a different filtering function. The modified Butterworth filtering function used for sharpening is

$H(u,v) = 1 + \dfrac{1}{1+(\sqrt{2}-1)*(D_0/D(u,v))^{2n}}$ The coefficient $(\sqrt{2}-1)$ is taken from the textbook.

In the implementation part, two extra command line arguments are added (optional) for changing $D_0$ and n values in the filtering functions in order to obtain better results for different kinds of images. After the standard --sharpen or --blur argument, one or two numbers first of which is the new $D_0$ value and second is the new n value can be entered.

While designing the blurring filter, we tried to decrease the magnitudes of high frequency information in the image while preserving the low frequency information. A smooth pass is obtained by using Butterworth function.

Sharpening filter must amplify the high frequency information while keeping the low frequency information, so we added 1 to Butterworth highpass filter.

# 2.WAVELET DOMAIN FILTERING

Since no library functions exist for wavelet transformation, we had to make our own implementation. We used Mallat's fast wavelet transform algorithm, stated in Castleman's Wavelet Transform notes, in order to eliminate matrix multiplication.

Filters are similar to those used in the previous part except that they have rectangular form rather than being circular.

Function of the filter used for blurring is : $H(u,v) = \dfrac{1}{1 + (\sqrt{2}-1) * (\lfloor \max(u,v) \rfloor / D_0)^{2n}}$

Function of the filter used for sharpening is :

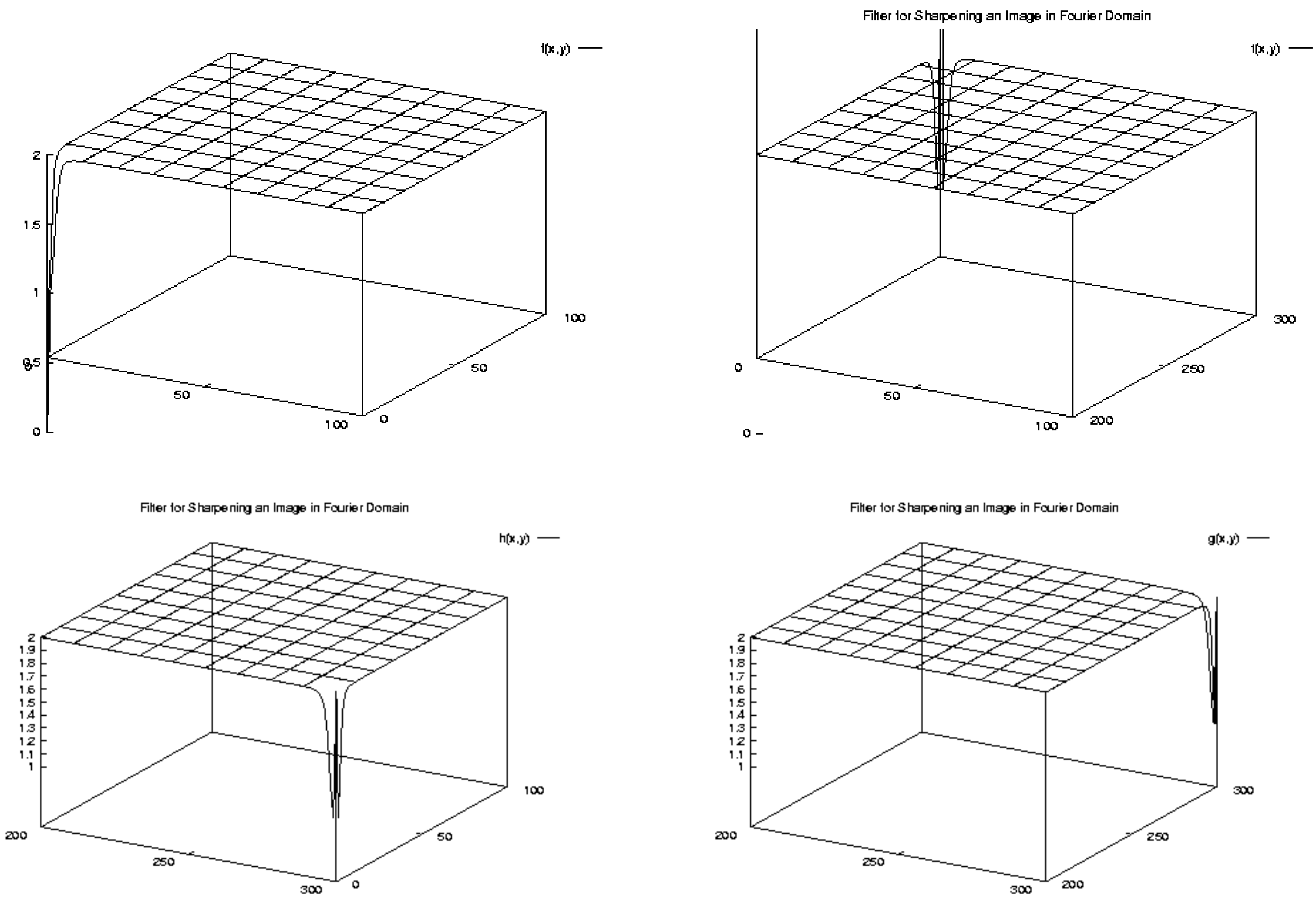
$$H(u,v) = \frac{1}{1 + (\sqrt{2}-1) * (D_0 / \lfloor \max(u,v) \rfloor)^{2n}} + 1$$

Graph of these filters are given in the Word document format file filter_wavelet.doc

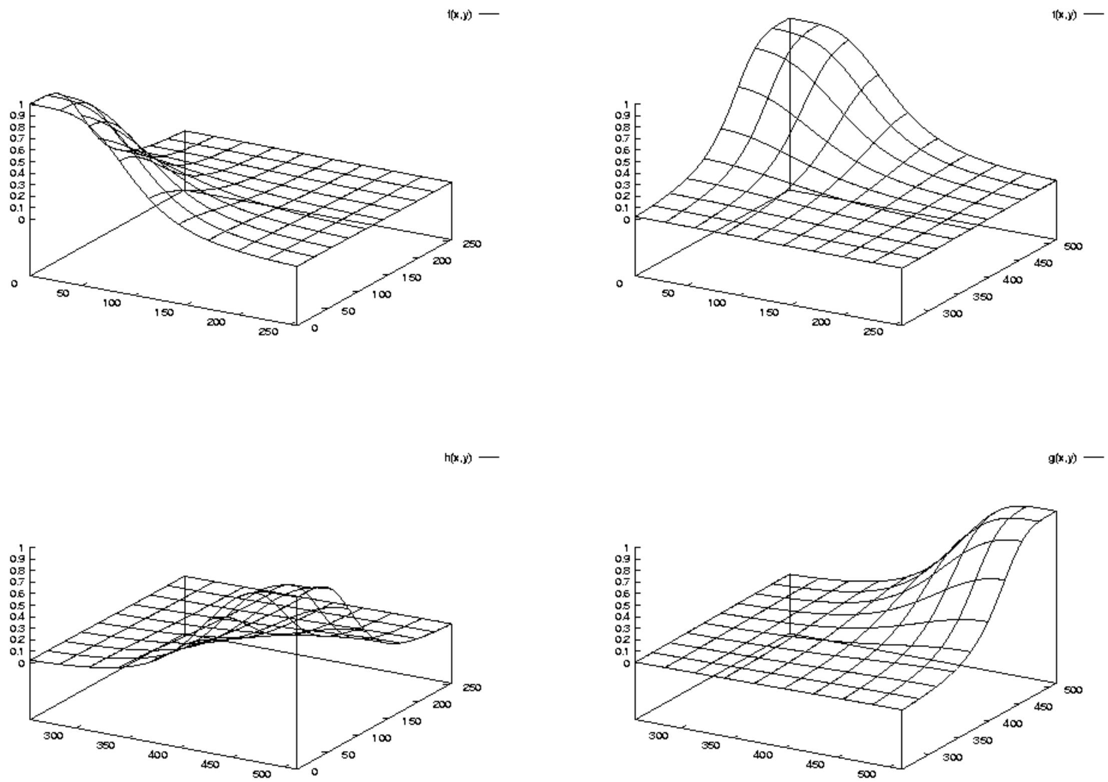
Command line arguments similar to the Fourier Domain case are included in the implementation.

# Appendix 1

Graphs of filters in Fourier Domain.




Sharpening Filter




Blurring Filter