Assignment 3: Gradient and Laplacian Operators

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# Overview:

This assignment is designed to understand and apply derivative operators to data by discretizing the continuous equations and building matrices that represent these operators. We will be focusing specifically in gradient and laplacian filter applications in images. These images contain mysterious photos from Nazca Desert, Peru. The Nazca lines are difficult to see on earth, but become visible at high altitude or in space. For this task we will use 2D change and peak detection filters to process the images and clearly see the hidden images in the Nazca Desert.

# Method:

## Problem 1

Determine and plot the frequency response of the gradient operator in the analog form .

## Outcome

Figure 1

Figure 1 shows the frequency response of the gradient operator. It is a cone shaped plot.

## Problem 2:

Formulate a 3 x 3 matrix operator as the gradient operator in the discrete form and plot

the DTFT frequency response of the filter in the discrete form

.

## Method:

Following the conversion of operator method:

## Outcome:

Figure 2

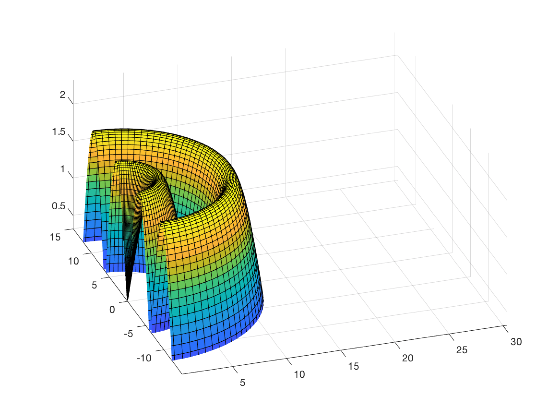
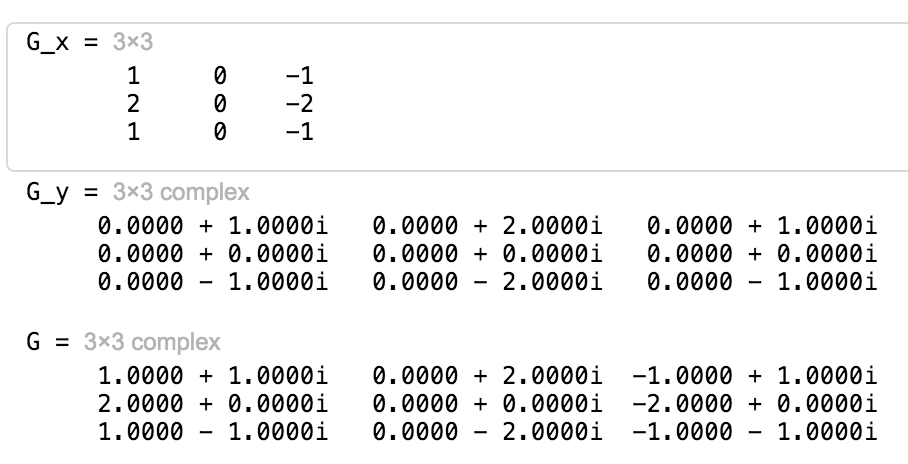


Figure 3

Following the conversion of operator method and plotting DTFT frequency response, we get Figure 2 and 3. I have plotted these two from 0 to 4pi to show the repetitive nature of it. Figure 3 specially gives us some insight into the high pass characteristics of this operator as it peaks at multiples of and is attenuated at 0 and multiples of .

Furthermore, following our derived formula, we can assemble a 3x3 matrix that represents the gradient operator.



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## Problem 3:

Apply the gradient filter to the image for edge detection. Your results should include (a)

edge profile of the images in the horizontal direction, (b) edge profile in the vertical

direction, (c) the combined form, and (d) superposition onto the original image.

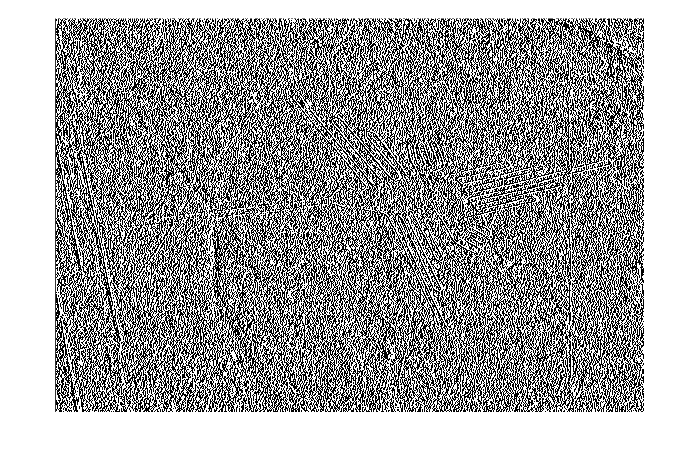


Figure 4. (edge profile of the images in the horizontal direction)

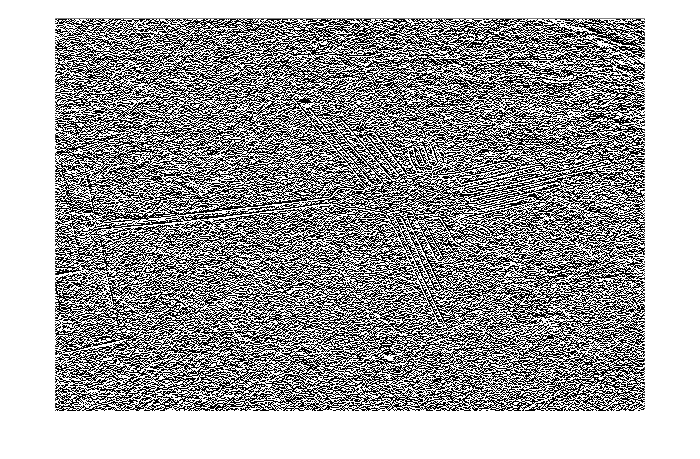


Figure 5. (edge profile in the vertical

direction)

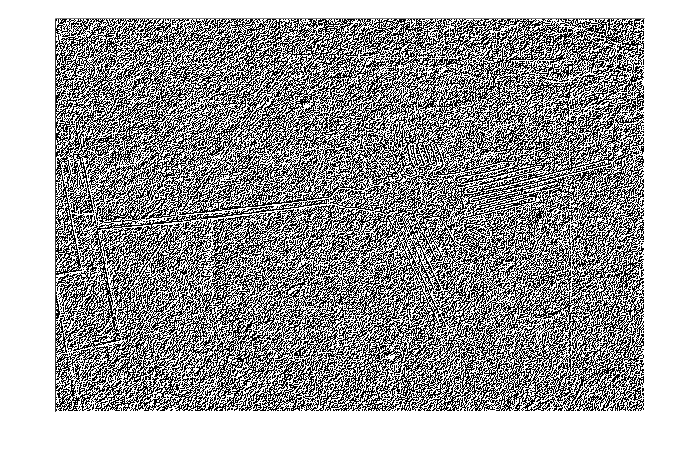


Figure 6. (edge profile in both directions)

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## Problem 4:

Determine and plot the frequency response of the Laplacian operator in the form

H 2 ( jω x , jω y ) = G 2 ( jω x , jω y )/P( jω x , jω y )

## Method:

## Outcome:

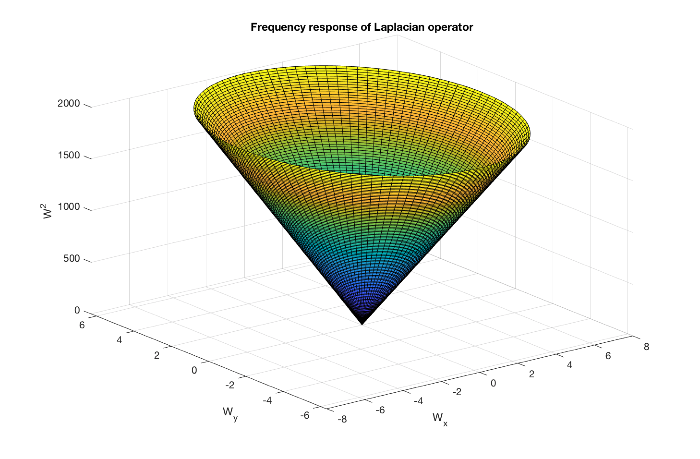


Figure 7.

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## Problem 5:

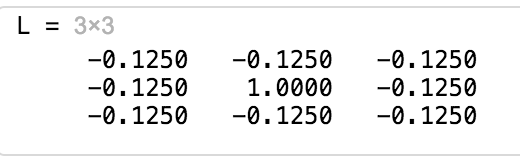
Formulate a 3 x 3 matrix operator as the Laplacian operator in the discrete form and plot

the DTFT frequency response of the filter in the form of

H 2 ( e jθ , e jφ ) = G 2 ( e jθ , e jφ )/P( e jθ , e jφ ).

## Method:

This result indicates that the Laplacian operator equals the value of the center pixel minus the average of neighboring pixels.



## Outcome:

## Figure 8.

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Figure 8 shows the repetitive nature of the filter as well as peak in the higher frequencies, while attenuating lower frequencies.

## Problem 6:

Apply the Laplacian filter to the attached image for peak detection. Show the result of (a)

peak detection and (b) the superposition onto the original image.

## Outcome:

Figure 9

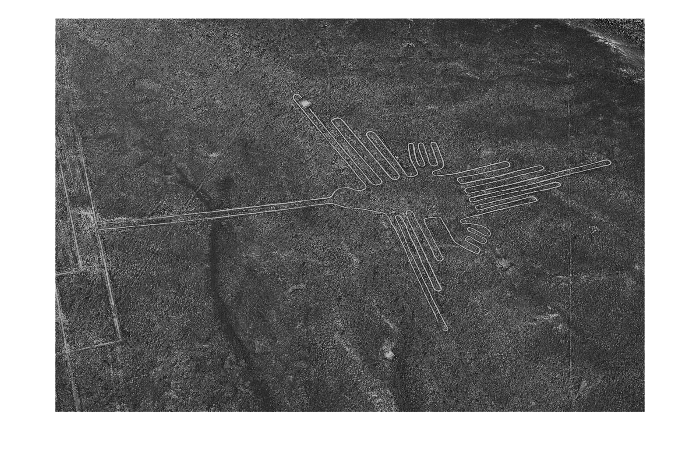


Figure 10