EERI 315
Practical 1

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Introduction

This practical aims to illustrate the development of a software that demonstrates the applications of digital signal processing. The software should implement functionalities that include:

a. *Display a digital color image on a computer screen*.
b. *Display the red, green and blue components of the image.*
c. *Determine and display the edges of the red, green and blue components of the original image – use Sobel operators (edge detection).*
d. *Combine the red, green and blue component images in which the edges have been determined and display therefore the edges originating from the original image.*
e. *Next the chosen image must be displayed as a gray scale image on the computer screen.*
f. *Implement software that can be used to determine the discrete Fourier Transform of the gray scale image. The amplitude and phase components of the image must then be displayed on the computer screen.*
g. *Determine the inverse discrete Fourier Transform (IDFT) of the transformed image and display the image next to original image to demonstrate the effect of the DFT – IDFT operation.*

Background

Digital image processing has become the most common form of image processing. The use of digital image processing makes it much easier to manipulate image processing techniques and is very cost effective.

This report will discuss in detail how digital image processing is used in practice and how to impliment the techniques within real life applications.

Display Color Image

To archieve the displaying of a color image on the screen, an image if loaded from the computer memory and the Qt framework displays this image on the screen. This can be illustrated within the submitted code.

Display RGB components of the image

The red, green, and blue components of an image are extracted using the Qt framework library. This is achieved by only letting a single component be displayed while letting the other components equate to zero.

Sobel Operator

The Sobel Operator is used in image processing to achieve edge detection. The edge detection results in this algorithm creating an image that emphasis the edges. This algorithm works on the basis of checking the overall change of colour intensity of an image.

The formulation of the operator use two 3x3 kernel matrices which are added to each element of the image's local neighbours, weighted by the kernel. The calculation approximate the derivatives for the horizontal and vertical change.

If we define A as the source image and G_x and G_y are images which at each point contain the horizontal and vertical derivatives approximations.

The matrixes are given by:

$G_x = \begin{bmatrix} +1 & 0 & -1 \\ +5 & 0 & -5 \\ +1 & 0 & -1 \end{bmatrix}$ x A

$G_y = \begin{bmatrix} +1 & 0 & -1 \\ +5 & 0 & -5 \\ +1 & 0 & -1 \end{bmatrix}$ x A

The gradient approximation for each pixel is defined as G and is given as:

$$G = \sqrt{G_x^2 + G_y^2}$$

Edge detection is achieved when we display the image matrix of G.

Grey Scale Operation

In order to compute an image into grey value we use the following formula

$$grey_{scale} = \frac{r+g+b}{3}$$

Discrete Fourier transform

The Discrete Fourier transform operation converts a finite sequence of samples, into an equivalent length sequence of samples of the discrete time Fourier transform which is a complex valued function.

We use discrete fourier transform on image pixels across the 2D plane of the image.

The DFT formulation is given as follows, consider an N-length time domain signal $x[n]$:

$$X[k] = \sum_{x}^{N-1} x[n] \times e^{-\frac{j2\pi kn}{N}}, 0 \leq k \leq N-1$$

Before performing any DFT operation we need the image to be in grayscale.

The computation on the image of 2 dimension is done as follows:

$$F(u, v) = \sum_{x}^{M-1} \sum_{y}^{N-1} f(x, y) \times e^{-j2\pi\left(\frac{ux}{N} + \frac{vy}{M}\right)}, u = 0,1 \dots M-1 ; v = 0,1 \dots N-1$$

The output which we get is of the form:

$$a + jb$$

In order to achieve the DFT results on our image we use For Loops to compute a 2D image matrix.

The phase and the magnitude of the DFT is given as follows:

$$\phi = \arctan\left(\frac{b}{a}\right)$$

Magnitude being:

$$\sqrt{a^2 + b^2}$$

Inverse Discrete Fourier Transform

To get back to the original signal we use the inverse Discrete Fourier transform. The DFT is used to recover the original signal. In order to do this in 2 Dimension we use this computation. [1]

$$f(x, y) = \frac{1}{MN} \sum_{u}^{M-1} \sum_{c}^{N-1} F(u, v) \times e^{-2\pi\left(\frac{ux}{N} + \frac{vy}{M}\right)} \; , x = 0,1 \ldots M-1 \; ; y = 0,1 \ldots N-1$$

Results

The figure below shows the results of the written software.

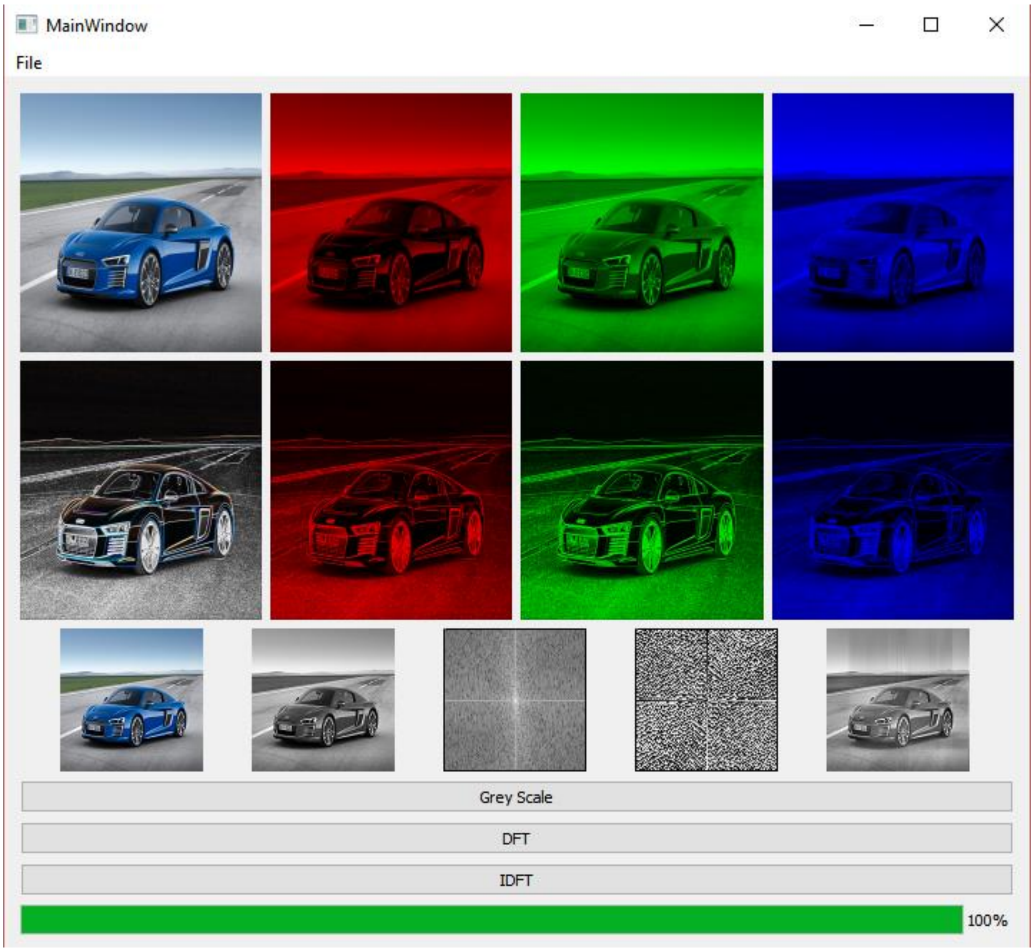

Figure 1: Program Results

Conclusion

The main aim this practical was exhausted through out the digital image processing steps taken to create the software. The challenges faced where namely ensuring that the theory correlates with the program and this was the most difficult exercise within this practical. Also computing speed is heavily required because larger images, require much larger loops that take time to execute.

Overally the results we observed correlated mostly with the theoretical studies done within module EERI 315 and the prescribed outcomes.

Bibliography

[1] S. K. Mitra, Digital Signal Processing A computer based approach, 2006.