HACKATHON 2023

HUMANS VS ZOMBIES

Workshop - 1

Introduction to Fourier Transform

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Physicum, University of Tartu, Estonia

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Outline

- Digital image processing
- What is Fourier transform (FT) ?
  - Why FT needed?
  - How to understand FT?
  - How FT will work?
- Exercise 1
- FT of signals
- Applications of FT : Image filtering
- Exercise 2
- Summary
- Tasks

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Digital Image Processing

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What is digital image processing?

Processing images digitally in a computer

How to process?

What is the use?

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Digital Image Processing

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We need a specialized software to process it digitally in a computer !!!

"Matrix Laboratory"

Role in image processing

- Import, export, edit images (rotate, resize, etc.)
- Extracting channels
- Enhance image resolution using algorithms
- Simulate optical experiments

What is a Fourier Transform in simple words ?

- It transforms the information from space or time domain to frequency domain

- Used to analyze, understand and process signals
- Information is same but represented in different way
- Important tool in image processing

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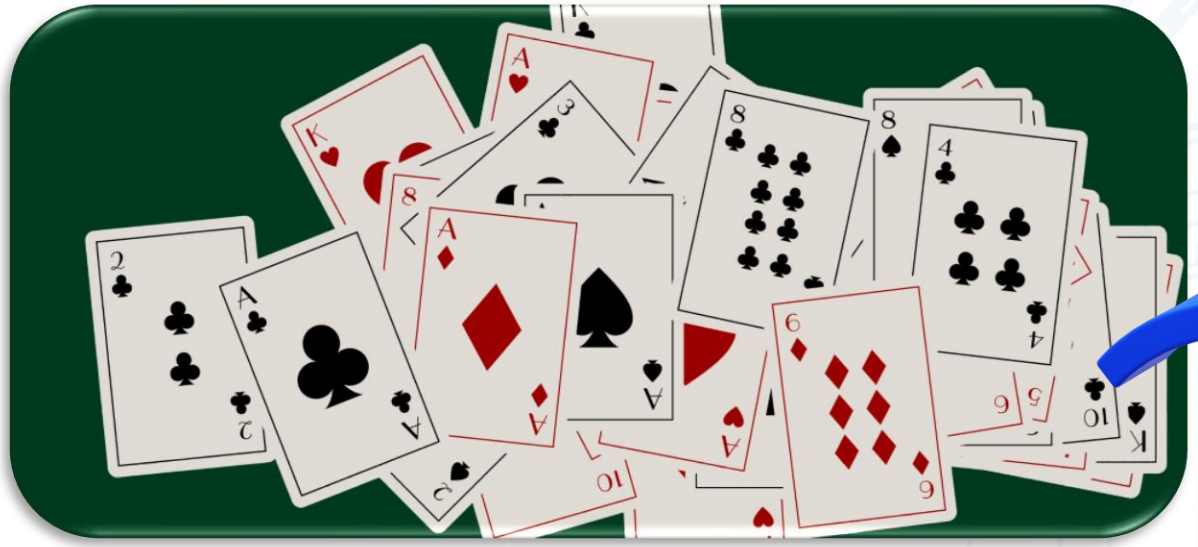
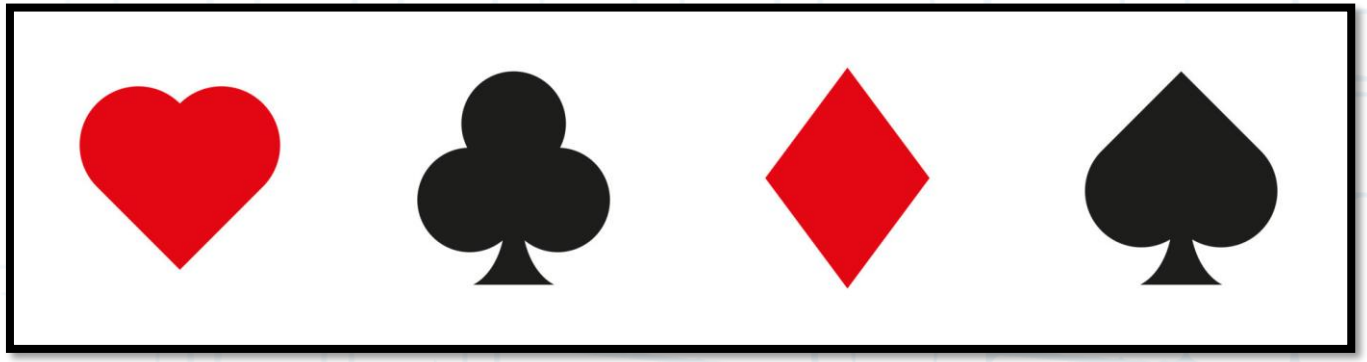
How to understand Fourier Transform ?



FOURIER TRANSFORM

Signals

What ?
How much ?



How Fourier Transform Works ?

- It decomposes the spatial frequency components of the image.
- If the input image is in the spatial domain, the transformation is represented in frequency domain

Note : Information is same, represented differently !!!

Applications

- Image analysis, image filtering, image reconstruction and image compression

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Fourier Transform

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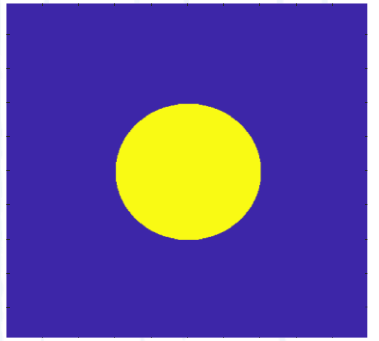
Defining the parameters

clear; - Clears the workspace data
N=500; - Defines the matrix size
x=-N/2:N/2-1; - Creates the x co-ordinate axis
y=-N/2:N/2-1; - Creates the y co-ordinate axis
pixel=8*10^-6; – Defines the pixel size
[X,Y]=meshgrid(x*pixel,y*pixel); - Calibrated workspace
R=sqrt(X.*X+Y.*Y); – Defines the radius
Aperture=zeros(N,N); - Creates a matrix
Aperture(R<100*pixel)=1; – Aperture size
imagesc(Aperture);– Displays the aperture

Aperture



Diffraction through a circular aperture

Exercise_1.m

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Fourier Transform

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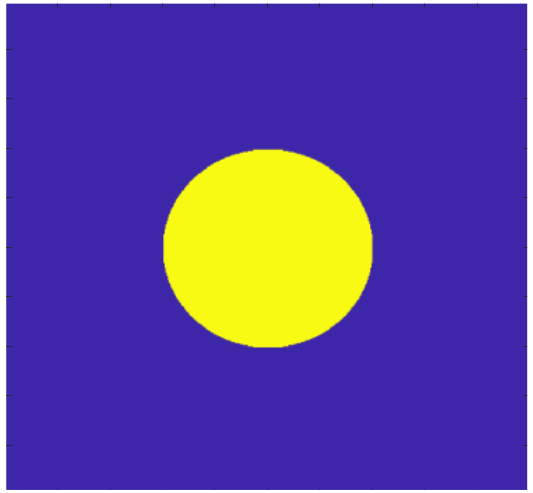
MATLAB

Syntax

```
FT=fftshift(fft2(Aperture));
imagesc(abs(FT))
```

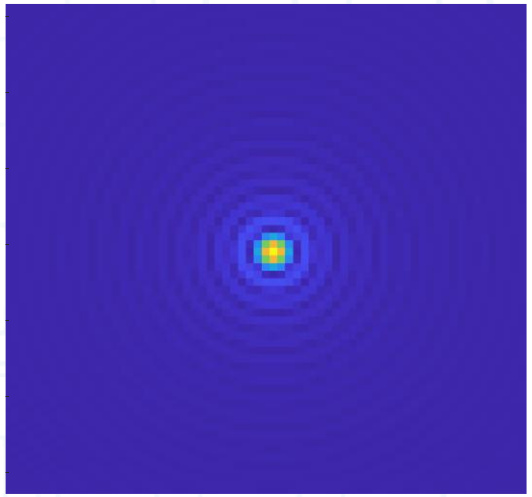
Aperture



Spatial domain

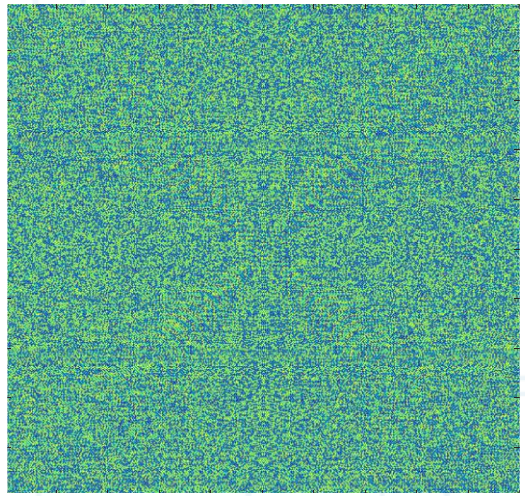
FT

Magnitude



Frequency domain

Phase



Frequency domain

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Fourier Transform

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MATLAB

Syntax

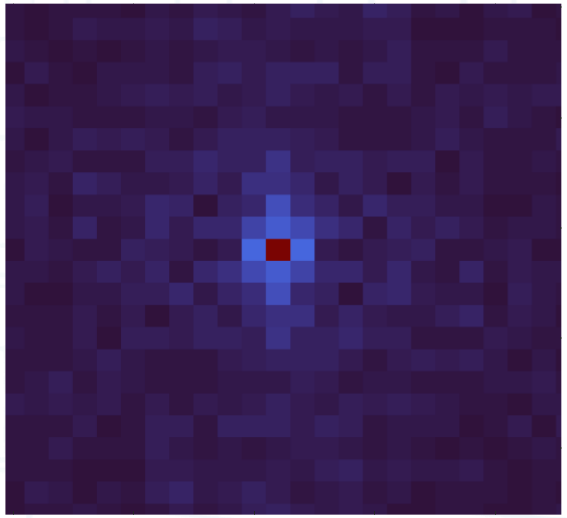
```
I=double(imread("file location"));
I=(:,:,1);
I=imresize(I,[500 500]);
imagesc(I);
FT=fftshift(fft2(I);
imagesc(abs(FT))
```

Zombie image

Spatial domain

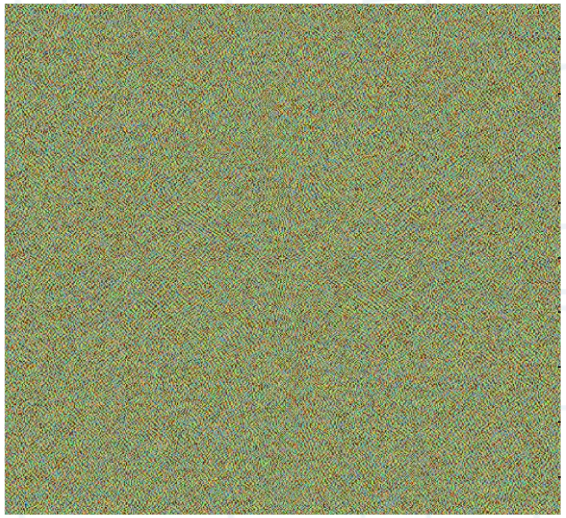
FT

Magnitude



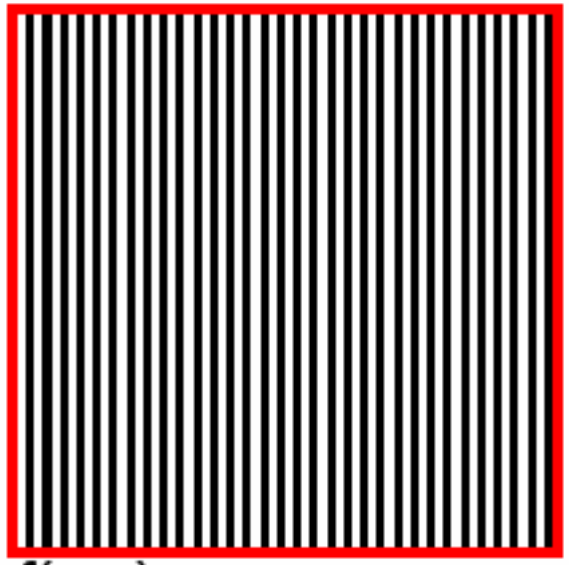
Frequency domain

Phase

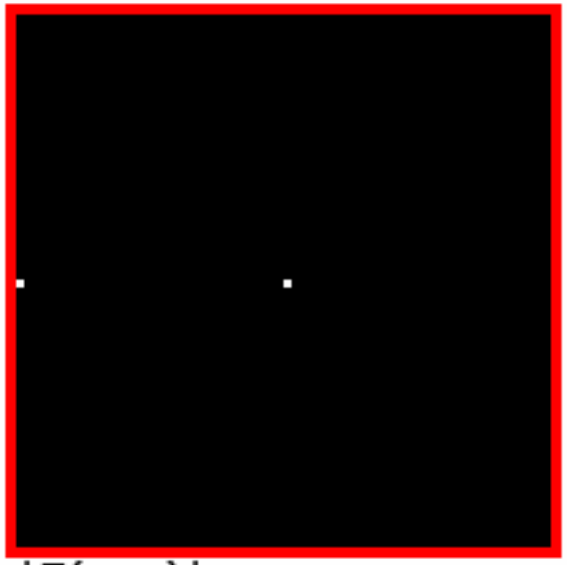


Frequency domain

Fourier Transform of Square Wave



f(x,y)
spatial domain
wavelength = 2px

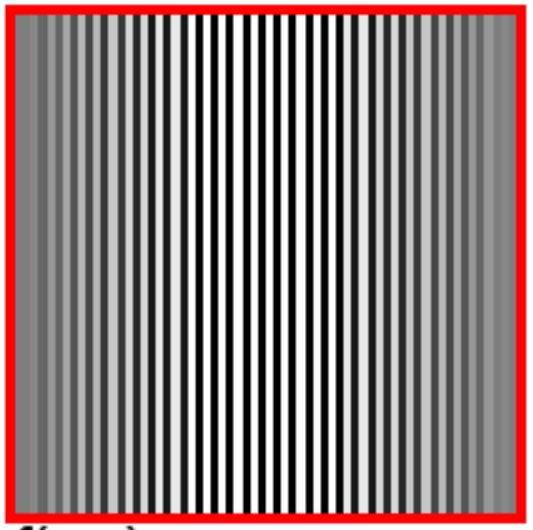


|F(u,v)|
frequency domain, magnitude

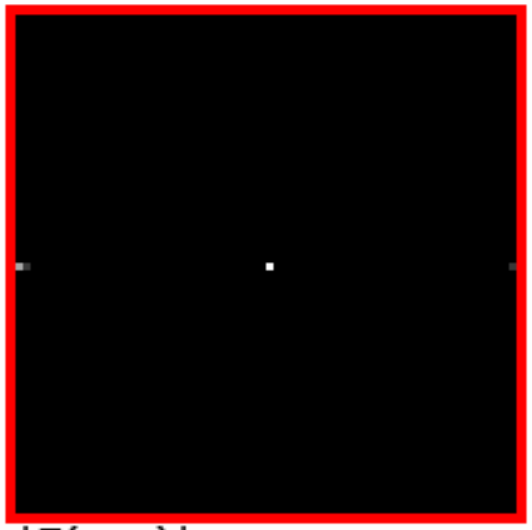
Φ(u,v)
frequency domain, phase

GIF courtesy : *mbedded.ninja*

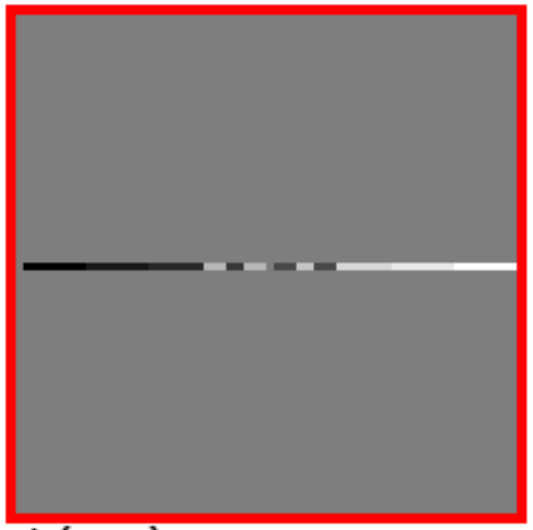
Fourier Transform of Sinusoidal Wave



f(x,y)
spatial domain
wavelength = 2px



|F(u,v)|
frequency domain, magnitude

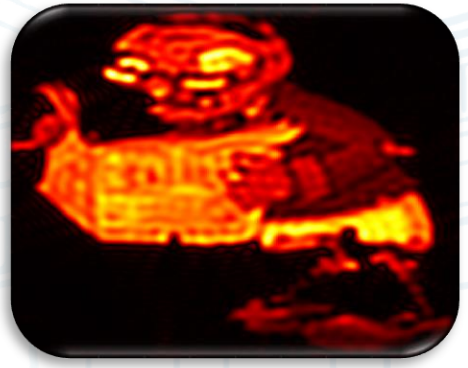


Φ(u,v)
frequency domain, phase

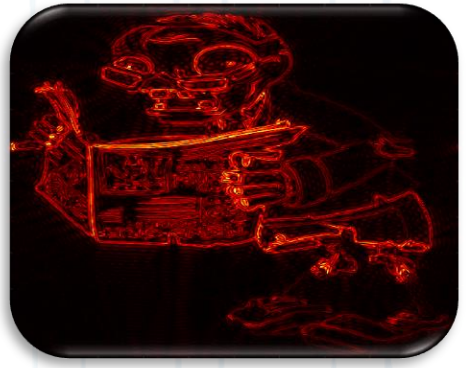
GIF courtesy : *mbedded.ninja*

Applications : Image Filtering

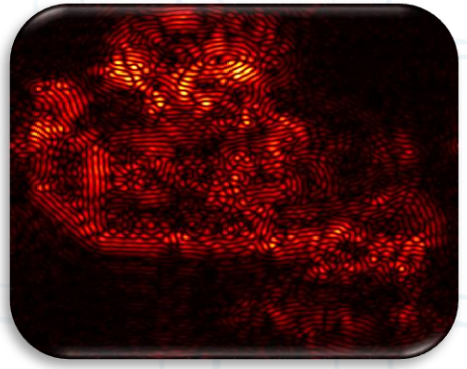
Low pass filtering



High pass filtering



Band pass filtering



Exercise_2.m

Load the image

```
A1=double(imread("Enter file location"));
A2=A1(:,:,1);
A3=imresize(A2,[500 500]);
A3=A3/max(max(A3));
figure;imagesc(A3);
```

```
F=fftshift(fft2(A3));
imagesc(abs(F))
```

Low pass filter

```
Aperture1=zeros(N,N);
Aperture1(R<30*pixel)=1;
F1=F.*Aperture1;
LP=(ifft2(F1));
imagesc(abs(LP));
```

High pass filter

```
Aperture2=zeros(N,N);
Aperture2(R>50*pixel)=1;
F2=F.*Aperture2;
HP=(ifft2(F2));
imagesc(abs(HP))
```

Band pass filter

```
Aperture3=zeros(N,N);
Aperture3(R>50*pixel)=1;
Aperture4=zeros(N,N);
Aperture4(R>30*pixel)=1;
Aperture5=Aperture4-Aperture3;
F3=F.*Aperture5;
BP=(ifft2(F3));
imagesc(abs(BP))
```

Exercise_2.m

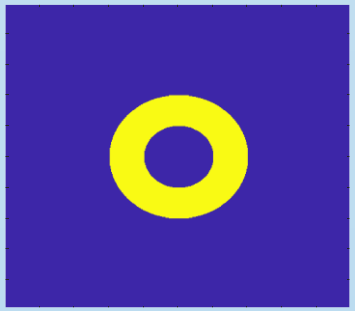
Summary

- Fourier transform in image processing.
- How to take FT in MATLAB?
- Applications of FT

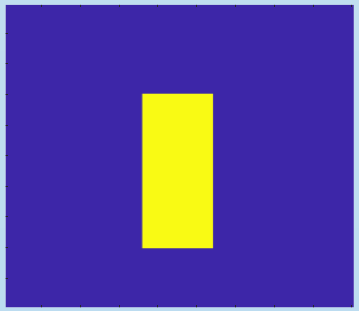
TASKS

1) Create a periodic signal (Eg: Square wave) by your own using any tools (Eg: MS Paint,MS Powerpoint) and load it it MATLAB, then take Fourier transform and show the magnitude and phase in frequency domain.
2) Create the two shapes as shown below in MATLAB and perform Fourier transform and show the results in frequency domain.

Ring



Rectangle



3) Create a grating and show the diffraction pattern.

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THANK YOU!

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