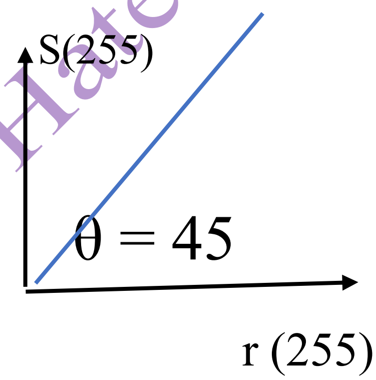
(4-3) Image Mapping (Gray level Transformation)

Enhancing an image provides better contrast and more detail than a non-enhanced image. Image enhancement has many applications. It is used to enhance medical images, images captured in remote sensing, images from satellites e.t.c

The identity transformation function is given below

$$S = r$$



$$S = T(r) \quad \ldots\ldots\ldots\ldots(4\text{-}5)$$

Where $r = f(x, y)$ input image (الاصلية)

$S = g(x, y)$ output image (المعالجة)

In the above equation, we note that there is no effect on the output image, and the angle between the input and output images is $\theta = 45^{\circ}$

➢Gray level transformation

There are three basic gray-level transformations

1- Identity

S= r تم شرحها سابقا

Gray level = 0 ⟶ 255

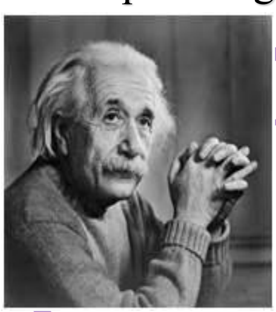
S = g(x,y) / 255 , r = f(x,y) / 255

2-Image Negative

The second linear transformation is a negative transformation, which is an invert of the identity transformation. In negative transformation, each value of the input image is subtracted from the L-1 and mapped onto the output image.

The result is somewhat like this.

Input Image



Output Image

In this case, the following transition has been done.

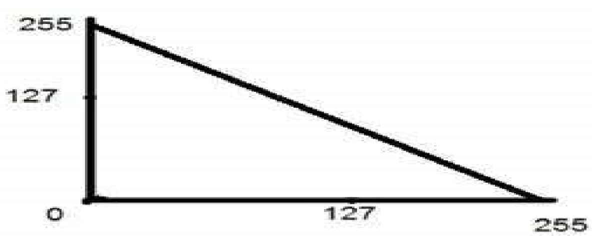
$$S = (L - 1) - r \; .... \; (4\text{-}6)$$

Since the input image of Einstein is an 8 bpp (bit per pixel) image, the number of levels in this image is 256. Putting 256 in the equation, we get this

S = 255 – r مستويات الصورة الداخلة**...(4-7)**

So, each value is subtracted by 255, and the resulting image is shown above. So, what happens is that the lighter pixels become dark and the darker picture become light. And it results in an image negative.
It has been shown in the graph below.

- ✓ أذا كان المستويات الرمادية للصورة في المدى (0 , L-1)، **L= 256**
  يقصد بالتحويل السالب إذا كان البكسل اسود يصبح ابيض وبالعكس.



3-Logarithmic transformations

Logarithmic transformation further contains two types of transformation. Log transformation and inverse log transformation.

a) Log Transformation: -

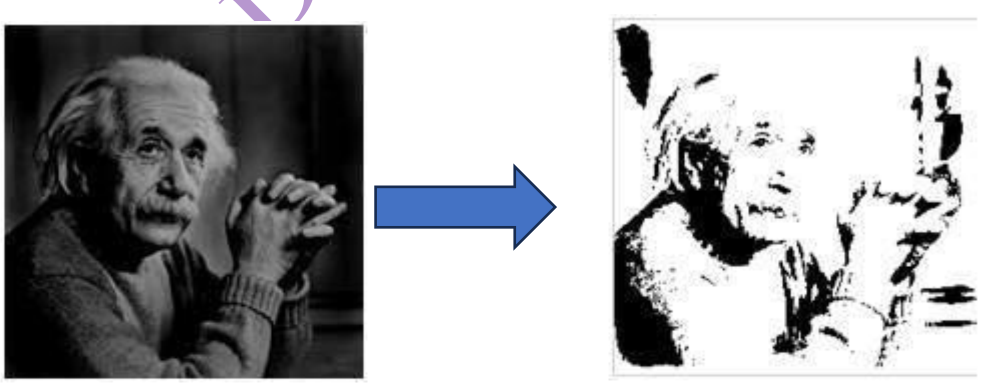
The log transformations can be defined by this formula

$$S = c \log (r + 1) \ldots\ldots\ldots\ldots (4\text{-}8)$$

Where s and r are the pixel values of the output and the input image, and c is a constant. The value 1 is added to each of the pixel values of the input image because if there is a pixel intensity of 0 in the image, then log (0) is equal to infinity. So, 1 is added to make the minimum value at least 1.

During log transformation, the dark pixels in an image are expanded as compared to the higher pixel values. The higher pixel values are kind of compressed in the log transformation. This results in the following image enhancement.

The value of c in the log transform adjusts the kind of enhancement you are looking for.



b) Inverse Log transformation

The inverse log transform is opposite to the log transform.

It is given by the following equation: -

$$S = C\, 10^{r} \ldots\ldots. (4\text{-}9)$$

1- Power – low Transformation

There are two further transformations power law transformations, which include nth power and nth root transformation. The transformations can be given by the expression:

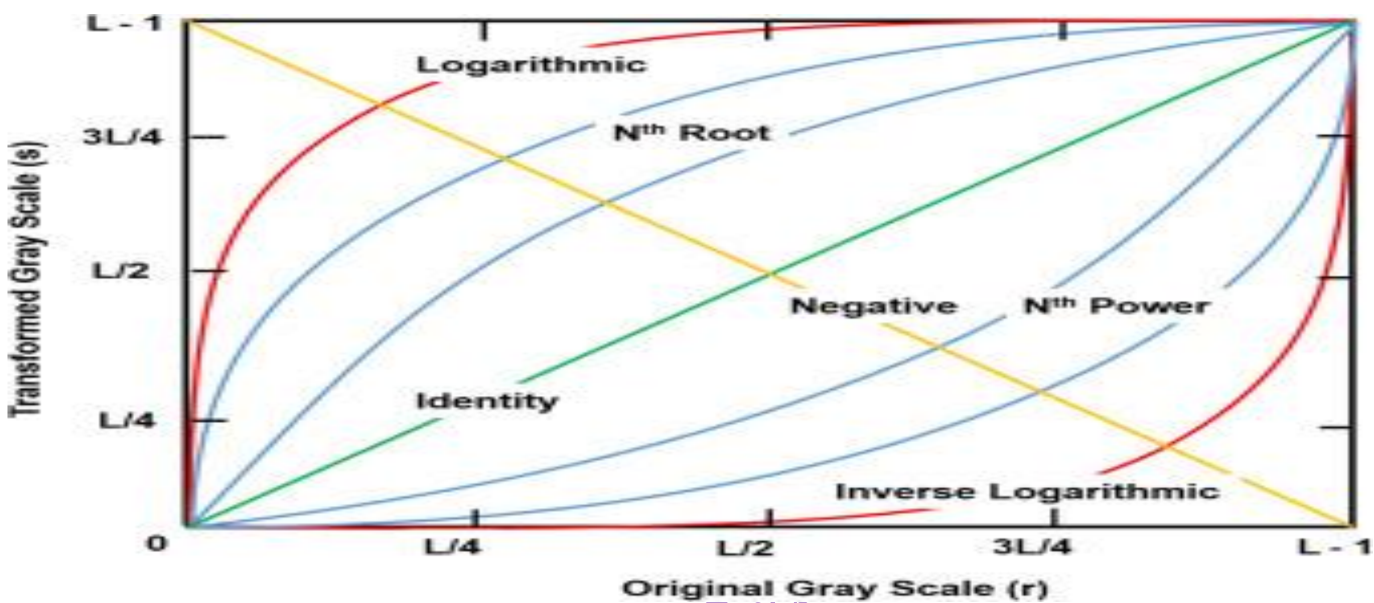
$$S = c\, r^{\gamma} \ldots\ldots..(4\text{-}10) \text{ power}$$

$$S = C\, r^{1/\gamma} \ldots\ldots(4\text{-}11) \text{ root}$$

This symbol γ is called gamma, due to which this transformation is also known as the gamma transformation.

Variation in the value of γ varies the enhancement of the images. Different display devices/monitors have their own gamma correction, which is why they display their images at different intensities.

The following figure shows the types of transformations: -



Example: - Find a Negative image for the following image?

Sol.

Origin image

0	1	0	0
2	1	3	1
200	255	251	1
255	1	0	1

Negative image

255	254	255	255
253	254	252	254
5	0	1	254
0	254	255	254

كل ما تم شرحه سابقا هي الفلاتر (المرشحات) المكانية التي تعتمد على الموقع المكاني. اما النوع الثاني فهي الفلاتر الترددية.

(4-2-2) Frequency domain: -

A frequency filter is an electrical circuit that sometimes changes the amplitude and phase of an electrical signal for frequency. Filters are used in many electronic and communications applications

It is another type of filter that converts the image from spatial coordinates (x , y) to frequency coordinates (u , v) by applying the Fourier transform.

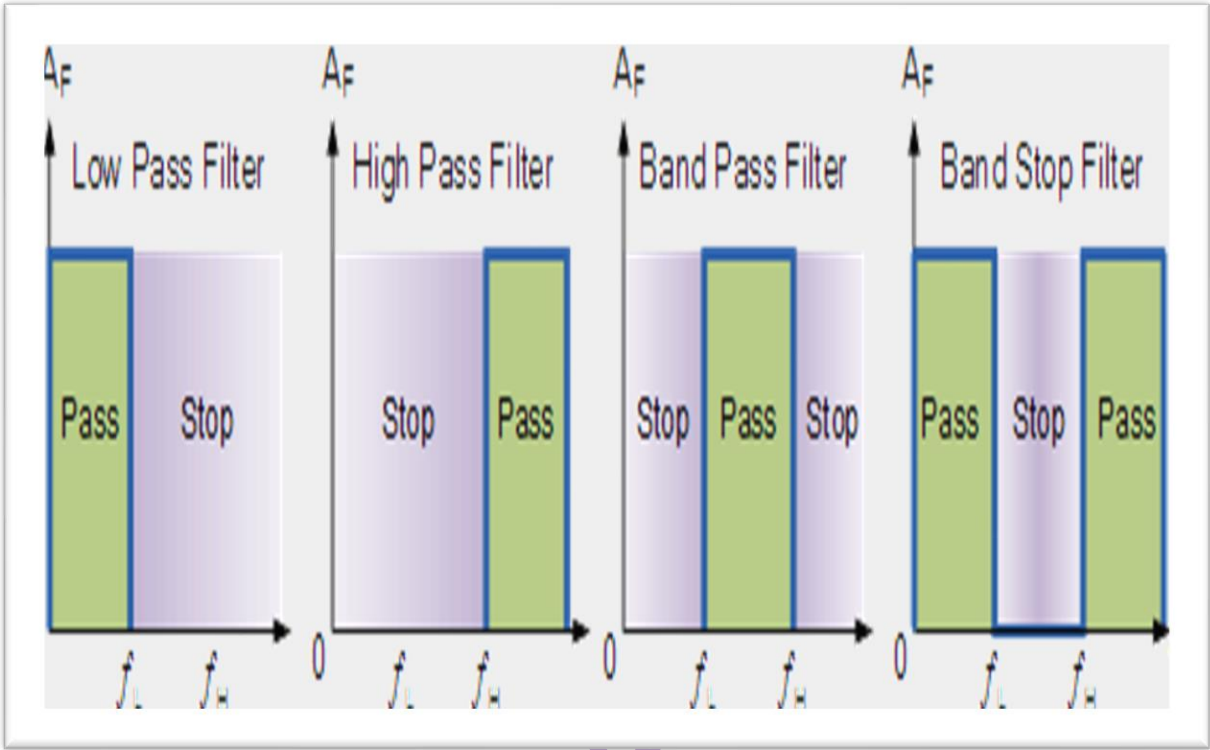
The classification is based on the frequency range that the filter allows to pass through

1-The low-pass filter allows low-frequency signals ranging from 0 Hz to the designed cut-off frequency point and attenuates higher frequencies

2-The high-pass filter allows those signals above the cut-off frequency and blocks all signals below.

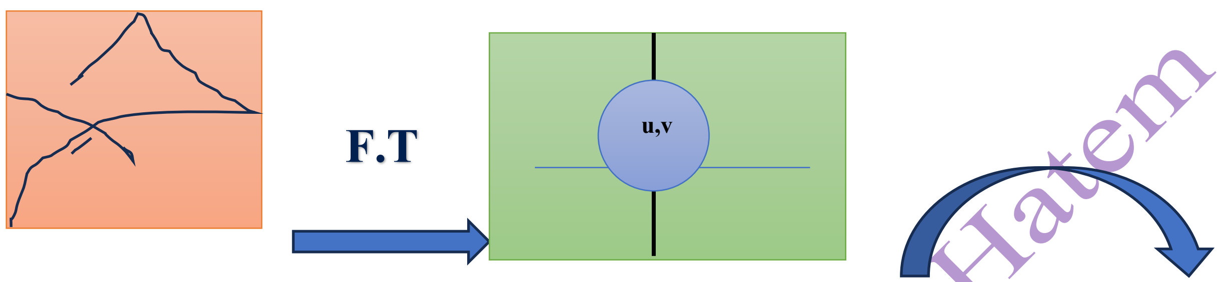
3-A band-pass filter allows signals within a specified range of frequencies to pass while blocking higher and lower frequencies outside that range.

4-Band Stop attenuates signals within the specified band or band and allows higher and lower frequencies to pass outside the band.

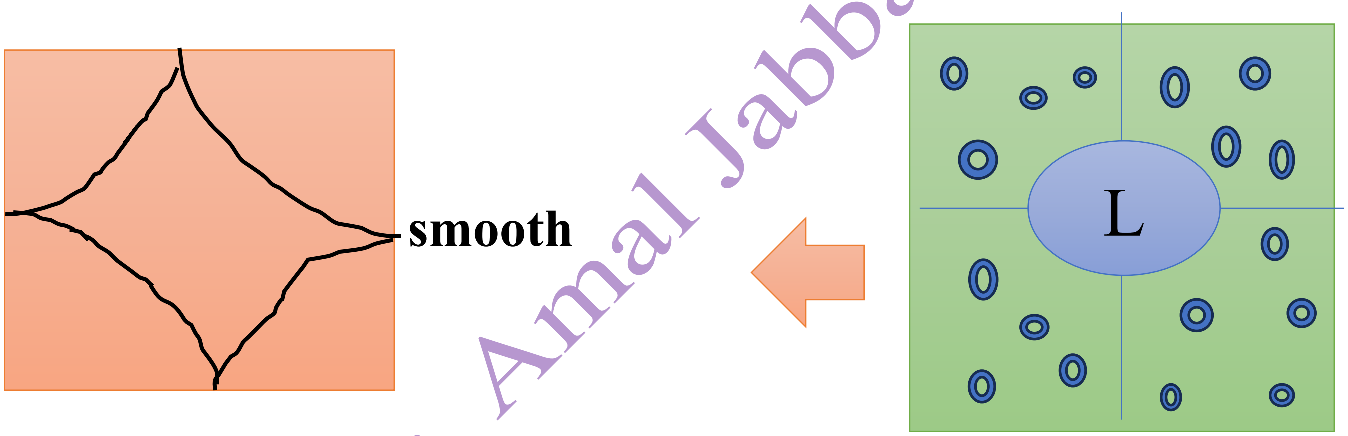


A_F
Low Pass Filter
Pass
Stop
f_L
f_H
A_F
High Pass Filter
Stop
Pass
0
f_L
f_H
A_F
Band Pass Filter
Stop
Pass
Stop
0
f_L
f_H
A_F
Band Stop Filter
Pass
Stop
Pass
0
f_L
f_H

(4-2-2-1) Low-pass Filter

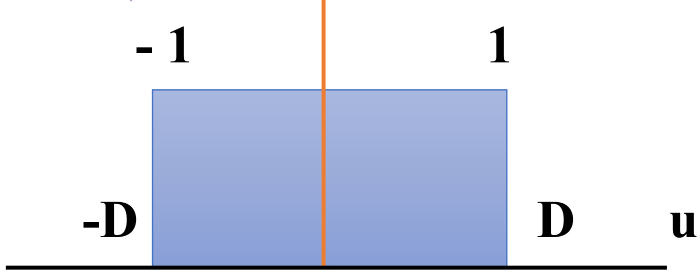


f (x, y) **f(u,v)**



In the frequency range, a low-pass filter is used to soften the image because high frequencies include image details such as edges, and to process these edges, a low-pass filters are used to give us a smooth image.

✓ **D يعمل على تنعيم عالي للصورة وتشوه عالي للحافات.**

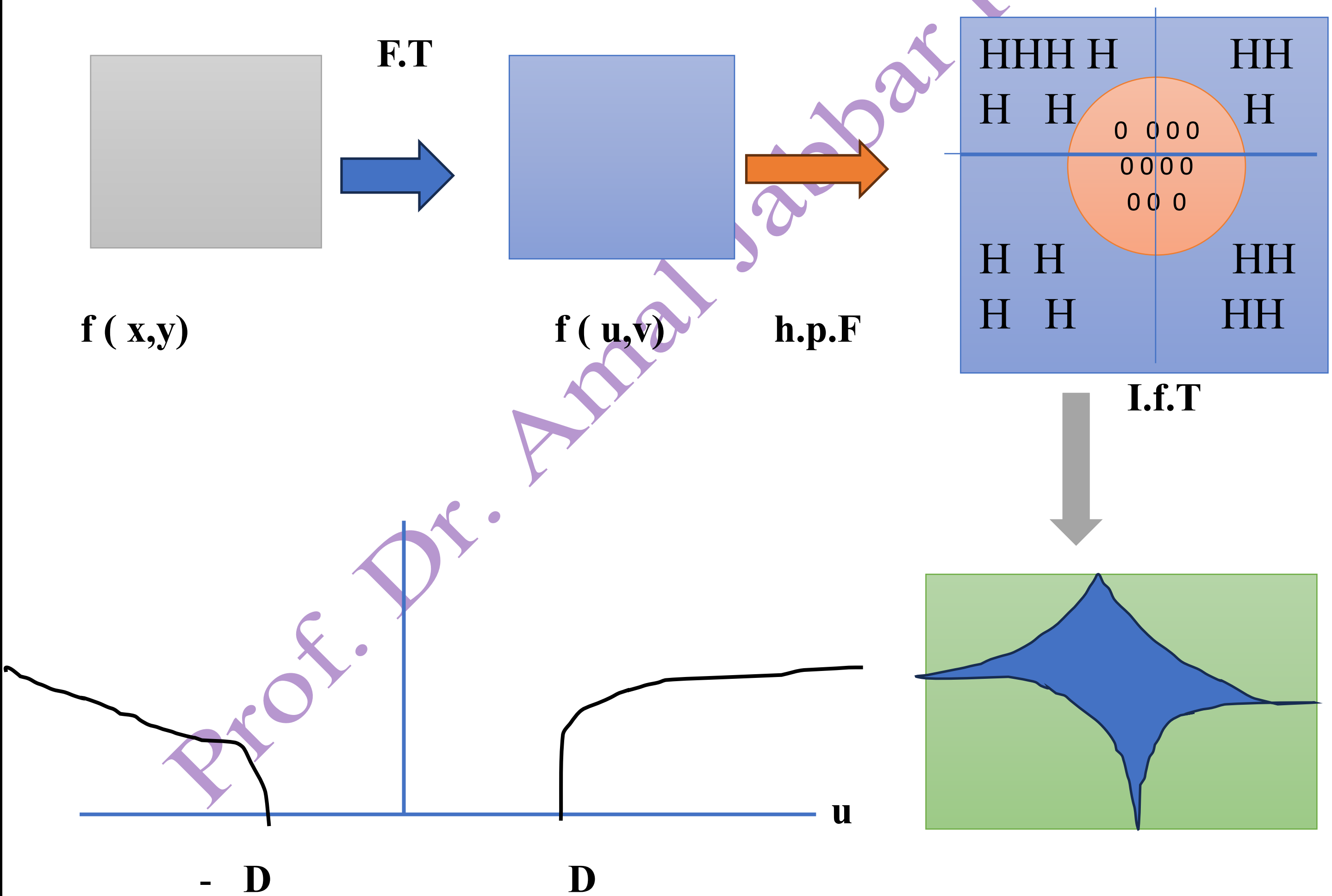


				f(x) u>1
?	**?**	**0**	**0**	**f(u) = 0**

(4-2-2-2) High pass Filter

A filter that converts the image from spatial coordinates to frequency coordinates using the Fourier transform.

This filter passes high frequencies and cuts low frequencies in the frequency cutoff region.



0	0	?	?

u≤ 1

عندما يقل فان سمك الحافة يزداد D

(4-3) Fourier transforms

The Fourier transform is a mathematical process used to convert mathematical functions from the time domain to the frequency domain. It is useful for analyzing signals and knowing the frequencies they contain.

There are two formulas for Fourier transformations: - one is for the forward transformation from spatial coordinates to frequency coordinates, and the other is for the inverse transformation from frequency coordinates to spatial coordinates.

The first formula is called the forward Fourier formula

$$F(u) = \frac{1}{\sqrt{N}} \sum_{x=0}^{N-1} f(x)\ e^{\frac{-2\pi iux}{N}} \quad \ldots\ldots(4\text{-}12)$$

The Second formula is called the inverse Fourier formula

$$F(x) = \frac{1}{\sqrt{N}} \sum_{u=0}^{N-1} f(u)\ e^{\frac{+2\pi iux}{N}} \quad \ldots\ldots(4\text{-}13)$$