Képfrekvencia

03

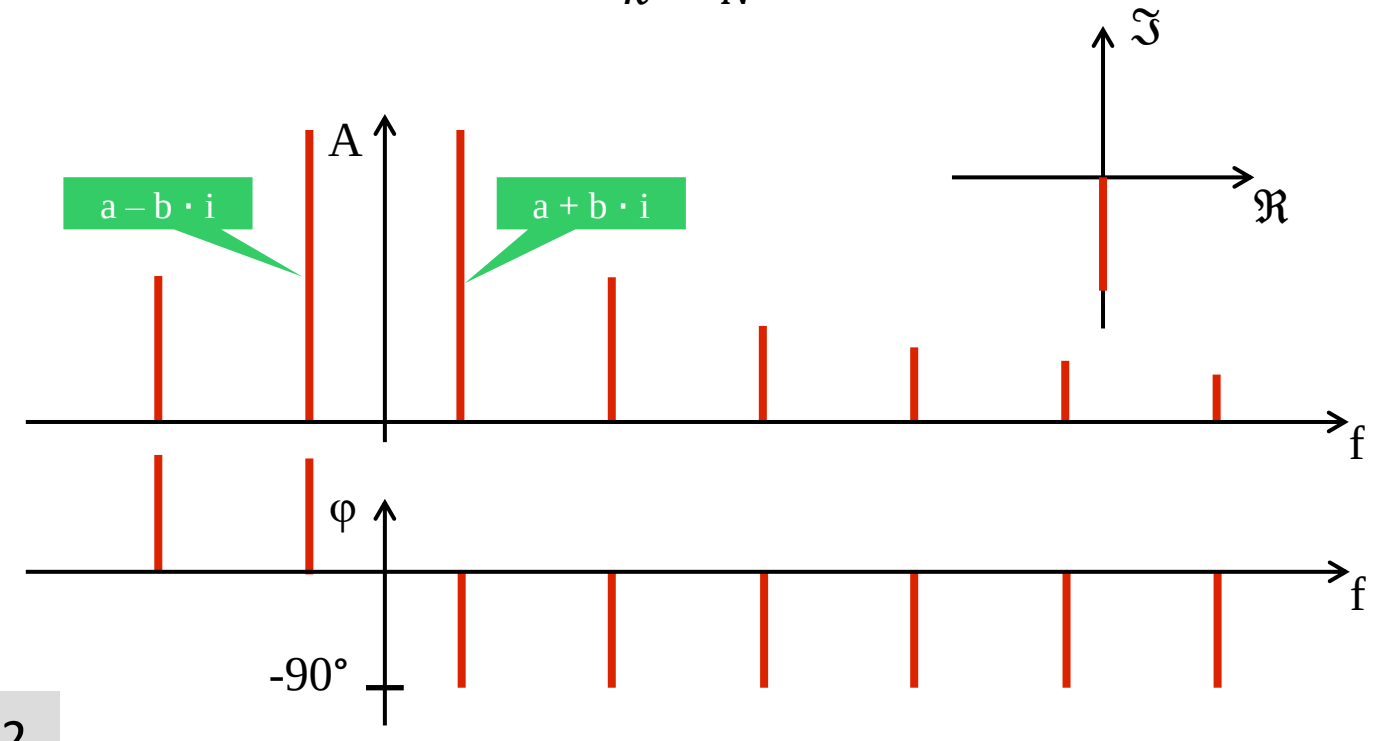
Számítógépes látórendszerek

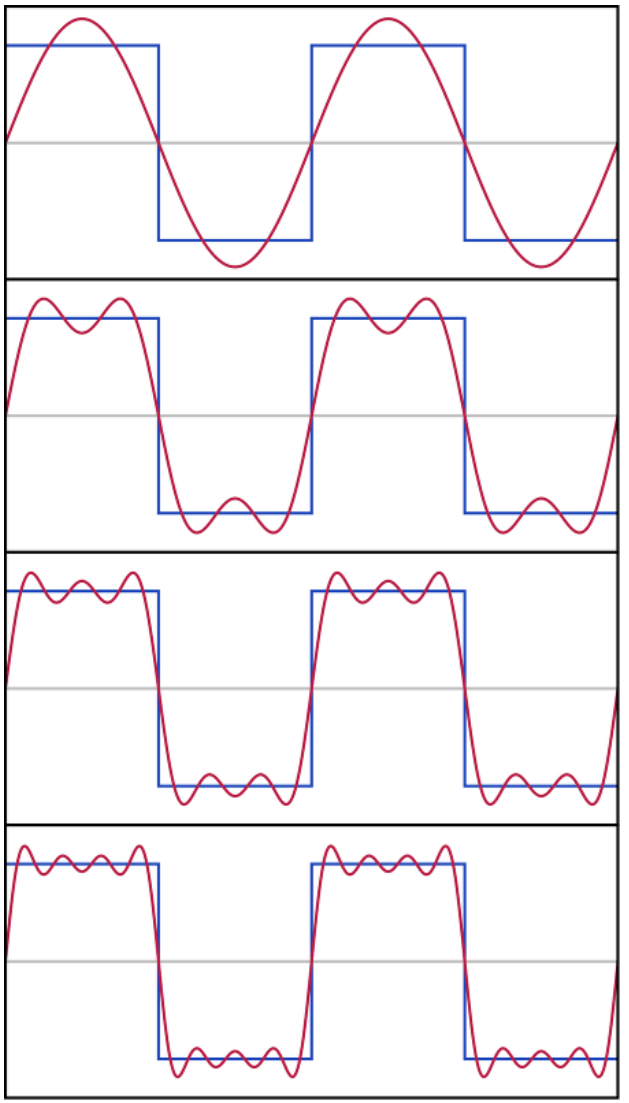
Dr. Szemenyei Márton
Adjunktus
2022

Fourier tér

$$f(t) = a_0 + \sum_{k=1}^{N} a_k \cdot \sin(k\omega_0 \cdot t + \phi_k)$$

$$f(t) = \hat{f}_0 + \sum_{k=-N}^{N} \hat{f}_k \cdot \mathrm{e}^{i \cdot k\omega_0 \cdot t}$$





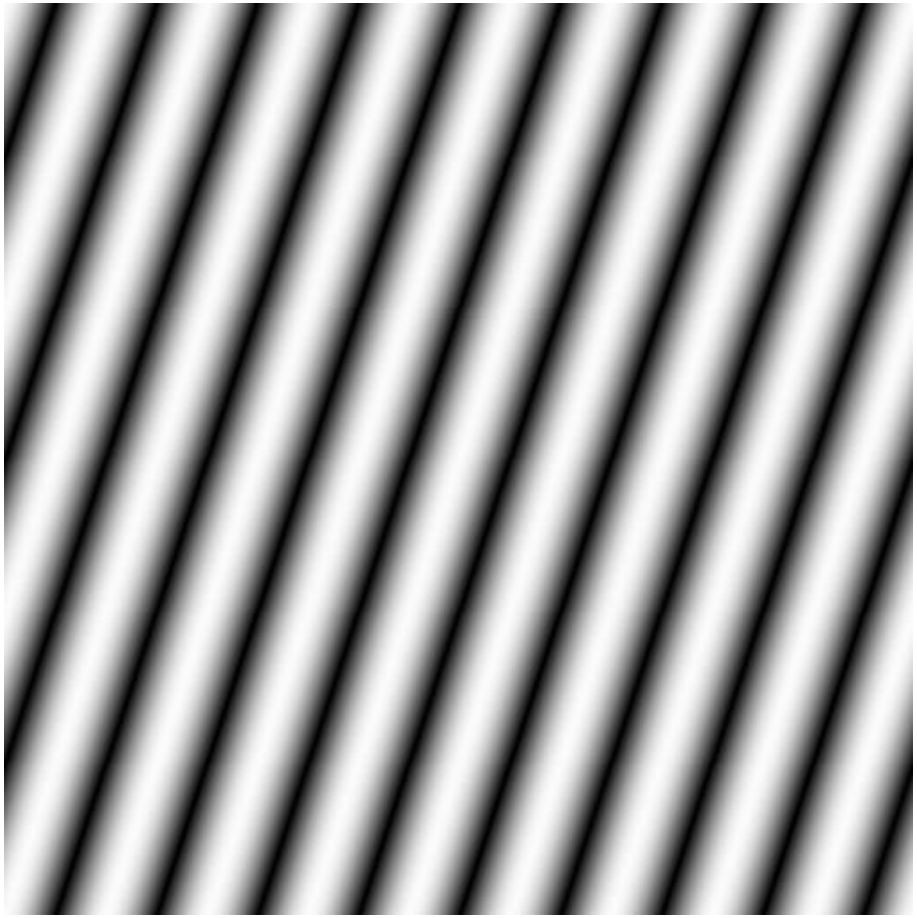
Fourier transzformáció

$$F(k,l) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f\,(x,y) \cdot \mathrm{e}^{-i\left(kx\frac{2\pi}{M} + ly\frac{2\pi}{N}\right)}$$

$$f(x,y) = \frac{1}{MN} \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} F\,(k,l) \cdot \mathrm{e}^{i\left(kx\frac{2\pi}{M} + ly\frac{2\pi}{N}\right)}$$

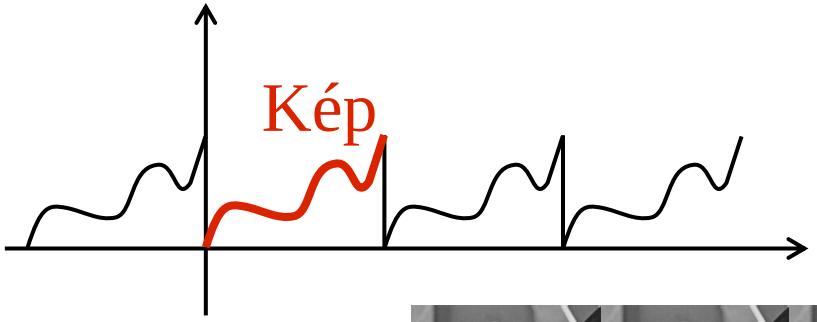
Függvény	**Spektrum**
Periodikus	Diszkrét
Diszkrét	Periodikus
Valós	Szimmetrikus
Szimmetrikus	Valós

Képfrekvencia

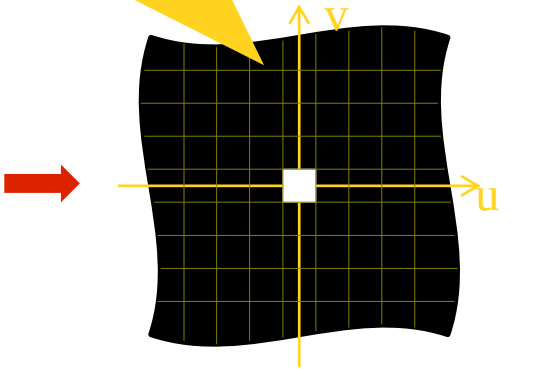


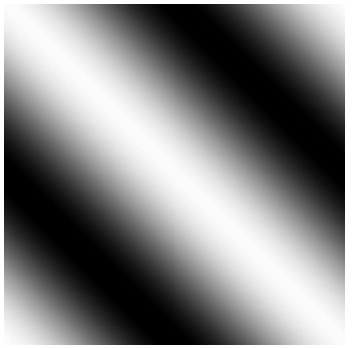
Fourier tér

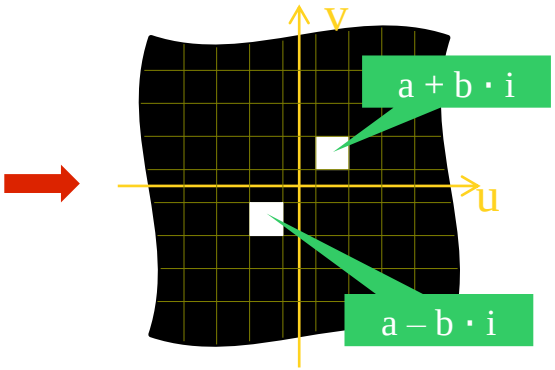
$$f(x,y) = \sum_{m=-M}^{M} \sum_{n=-N}^{N} \hat{f}_{m,n}\, e^{imx} e^{iny}$$

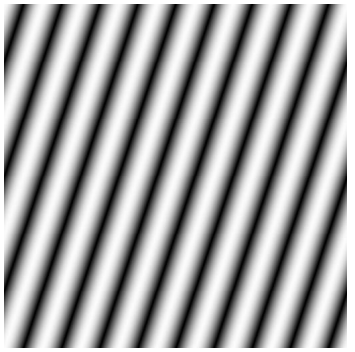


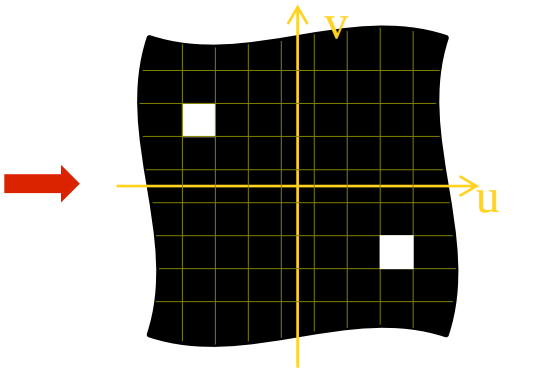
Komplex frekvenciakép részlete







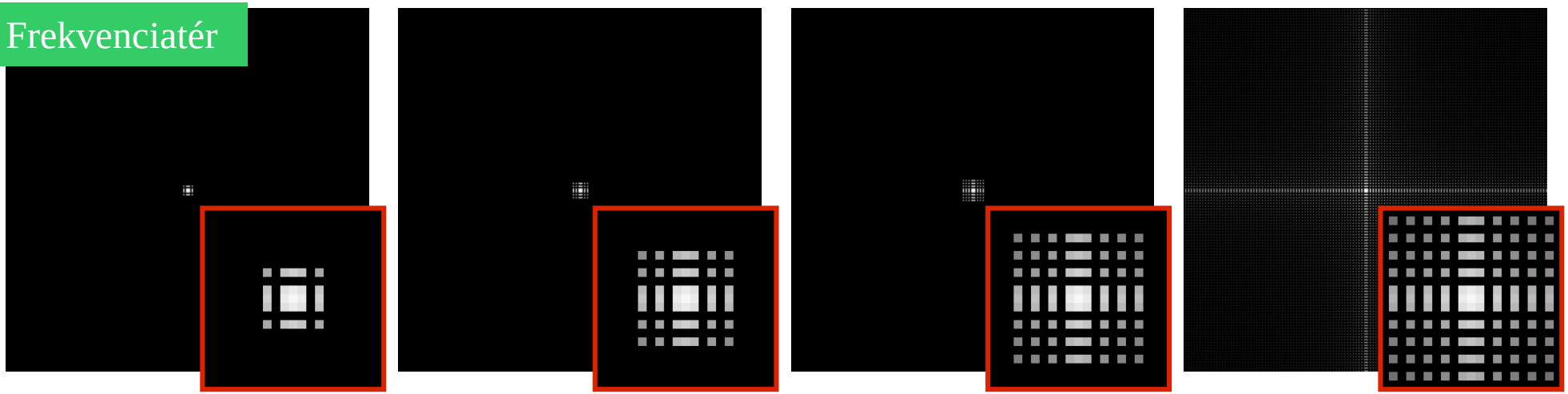




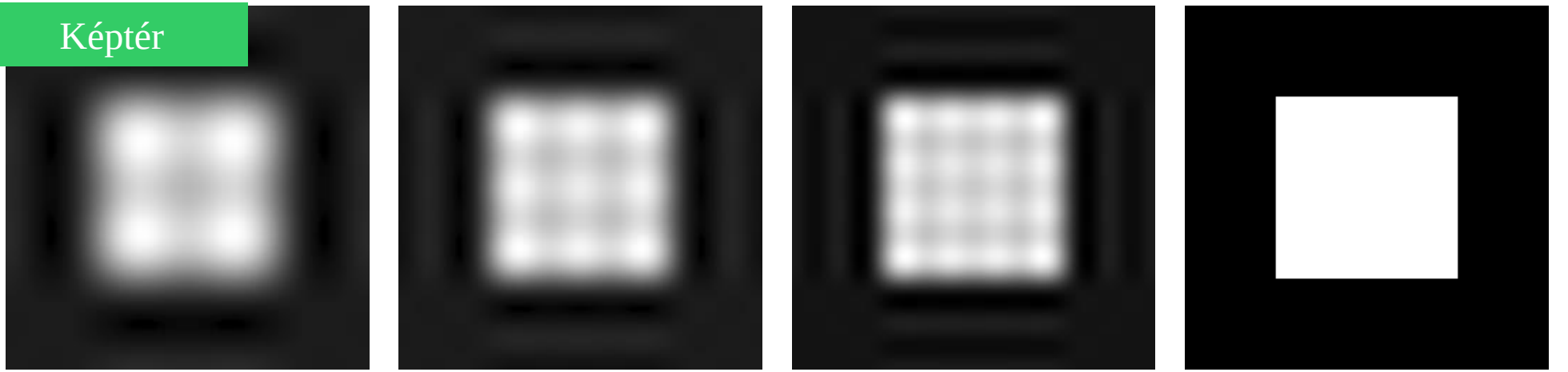
Minden elem komplex!

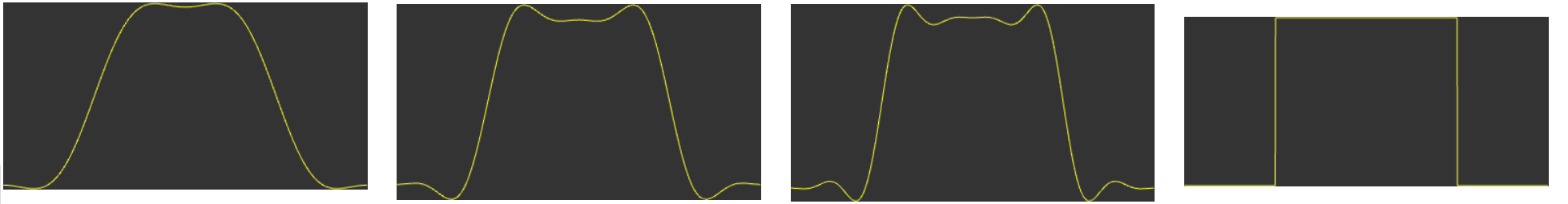
„Négyszögjel”

Frekvenciatér

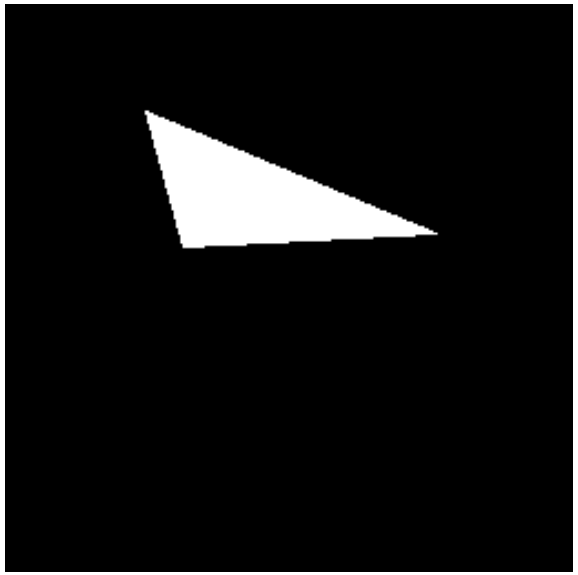
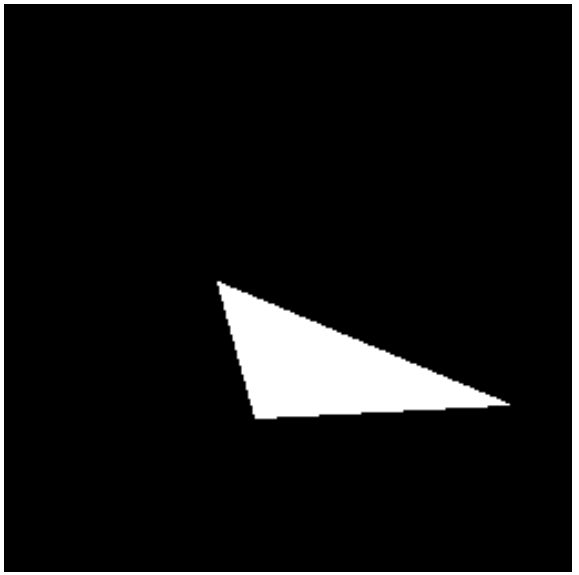
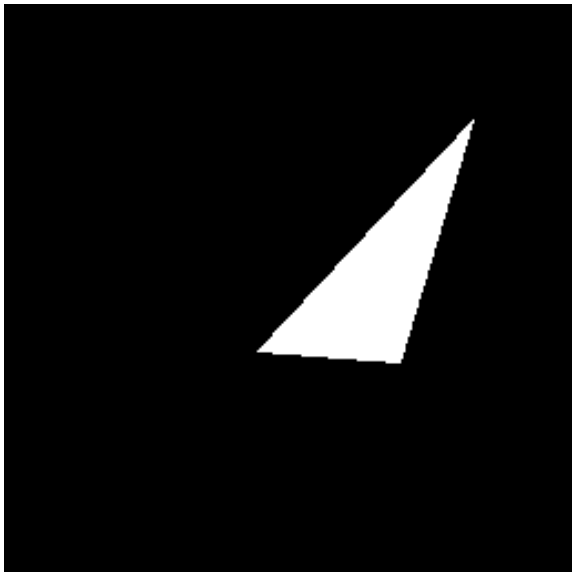
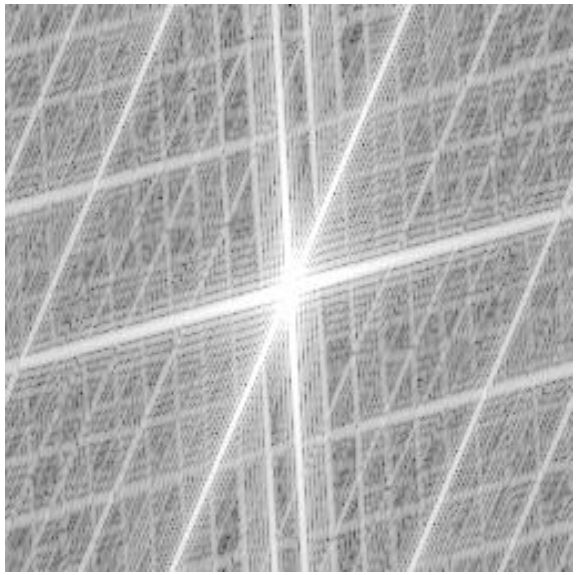
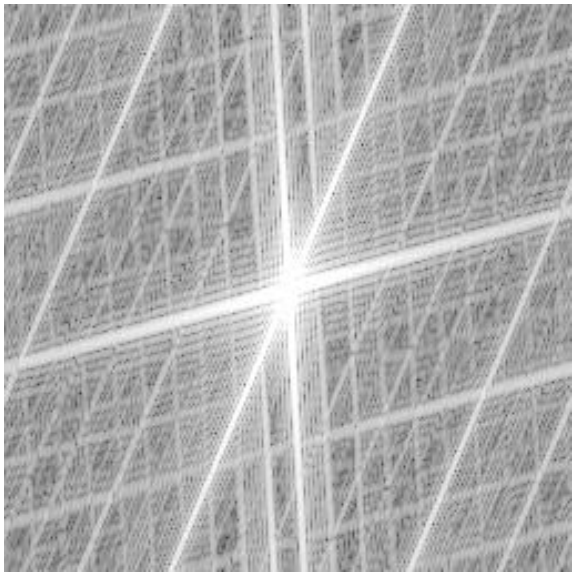
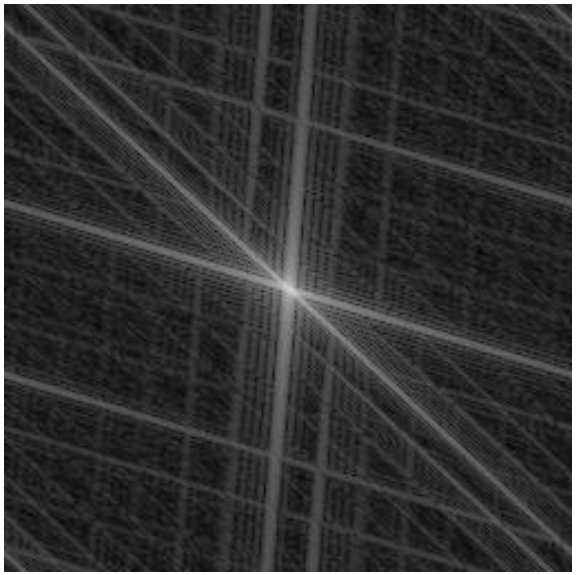


Képtér

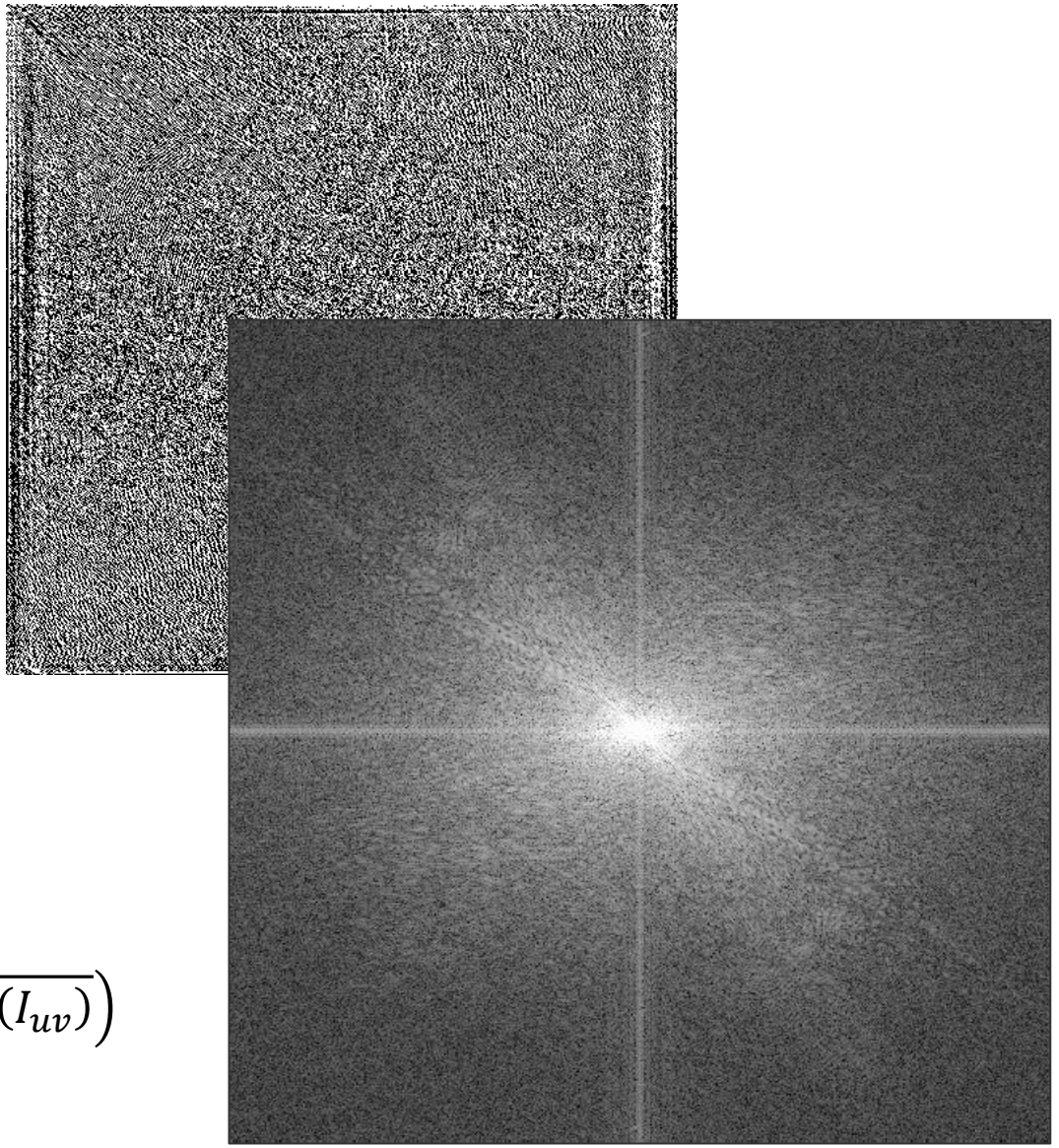




Pozíció, orientáció

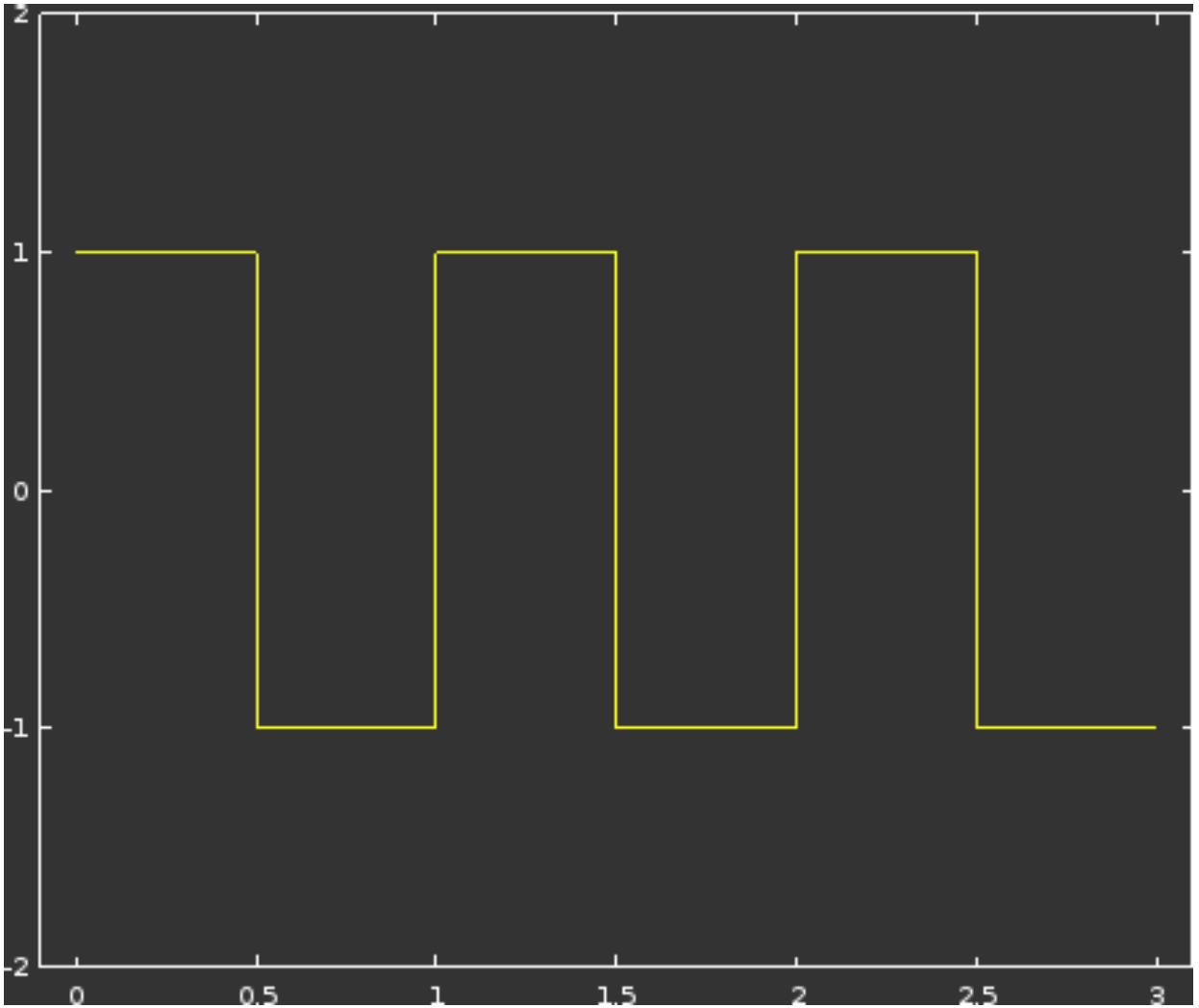
Fourier transzformáció



$$0.1 \cdot \log\left(1 + \sqrt{\Re^2(I_{uv}) + \Im^2(I_{uv})}\right)$$

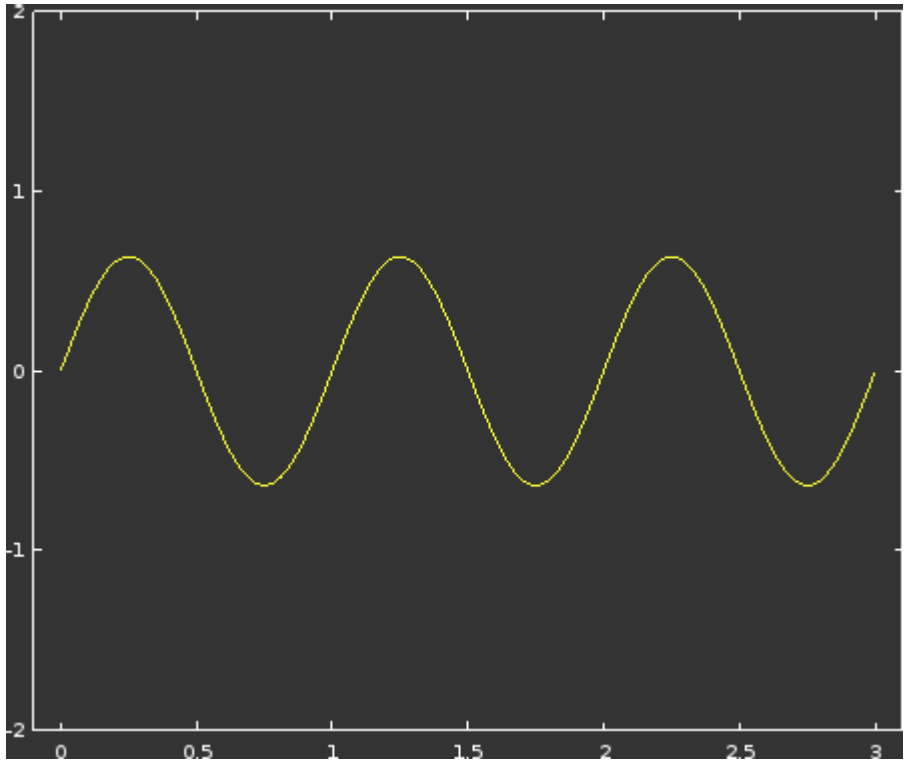
Fázistorzítás

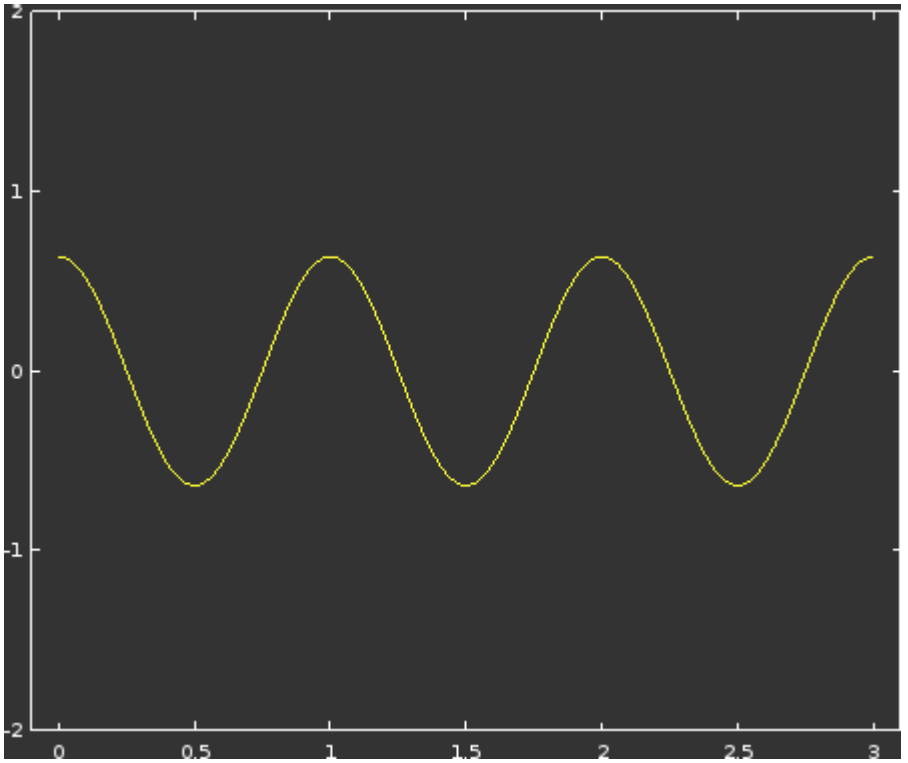
Kiinduló jel



Fázistorzítás

1 felharmonikus

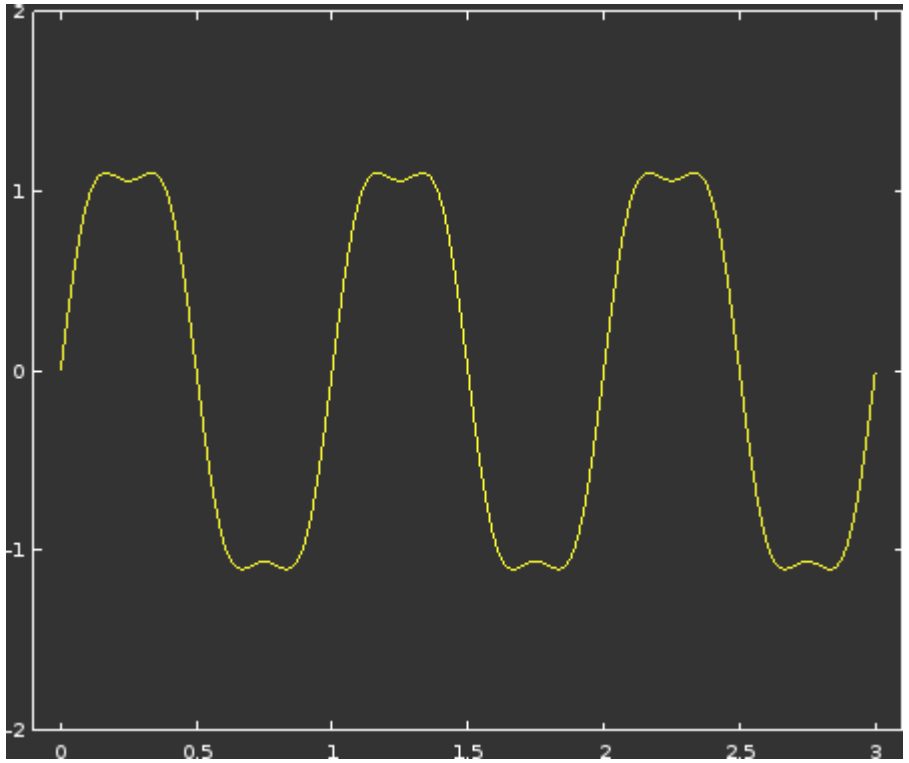


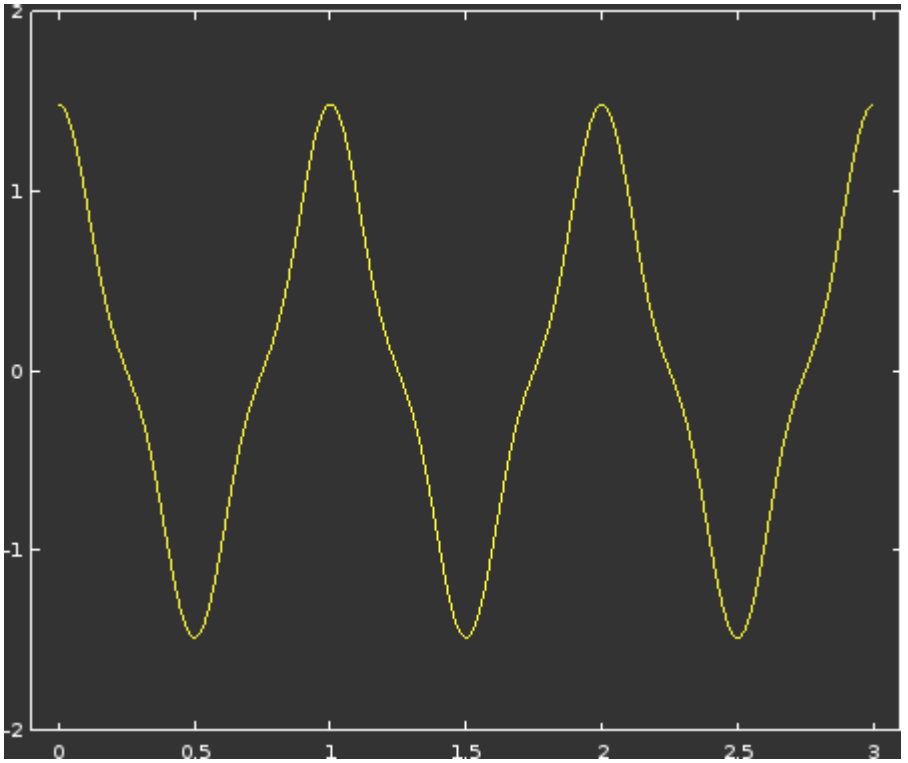


-90° fázis 0°

Fázistorzítás

2 felharmonikus

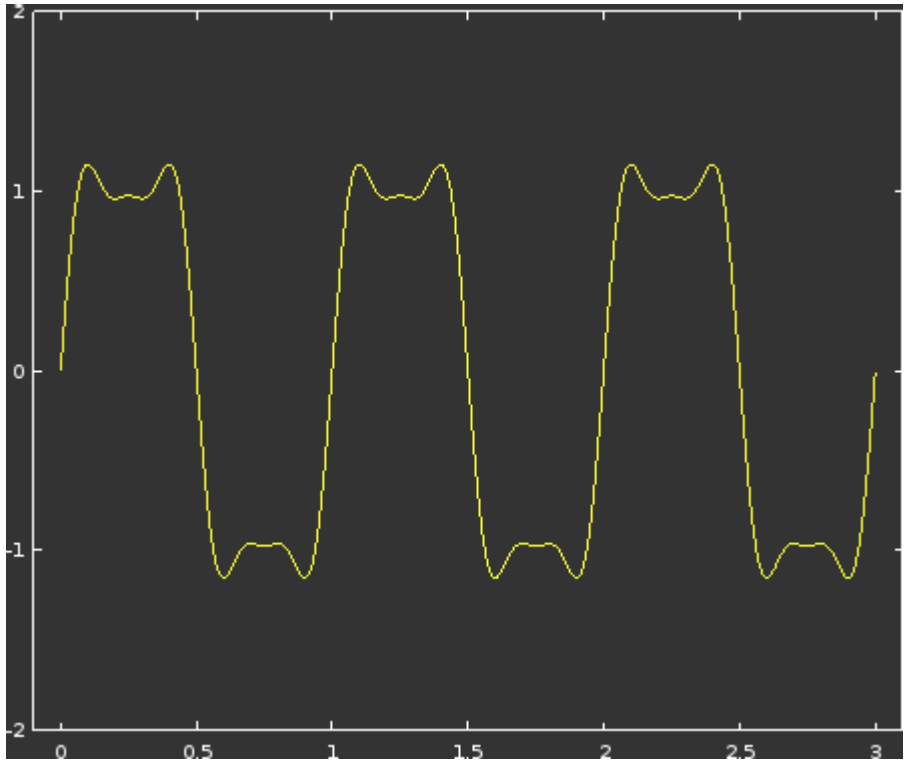


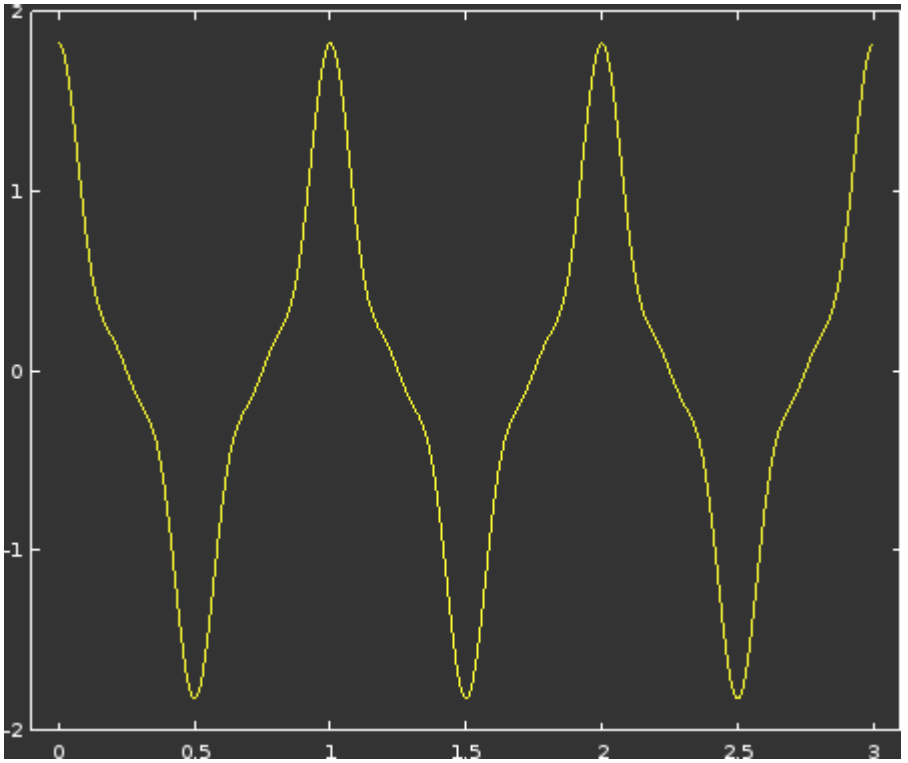


-90° fázis 0°

Fázistorzítás

3 felharmonikus

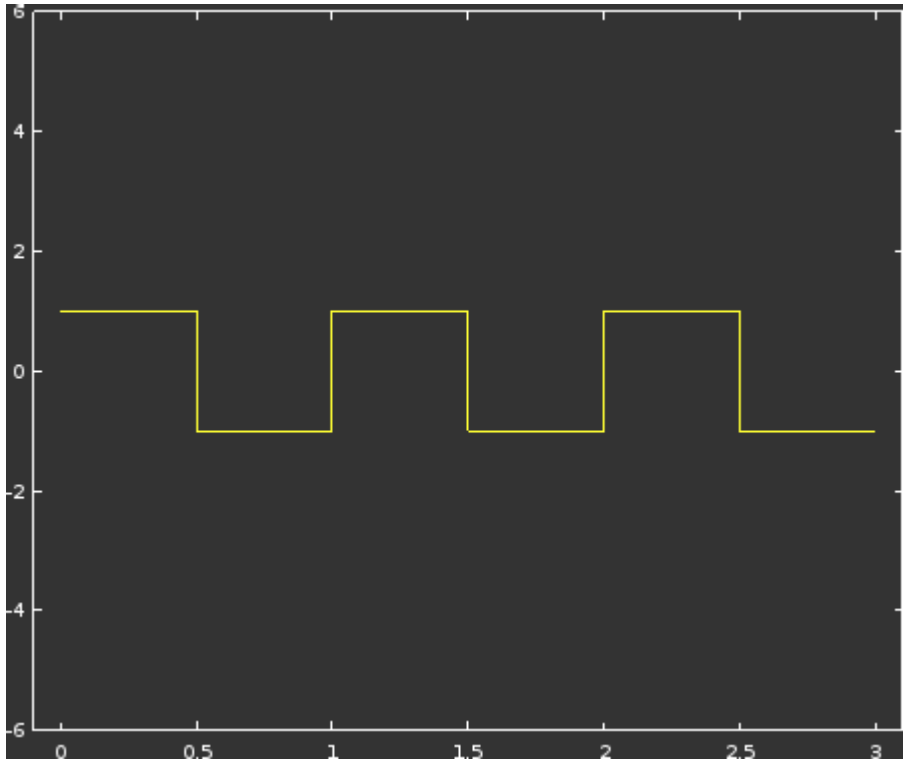


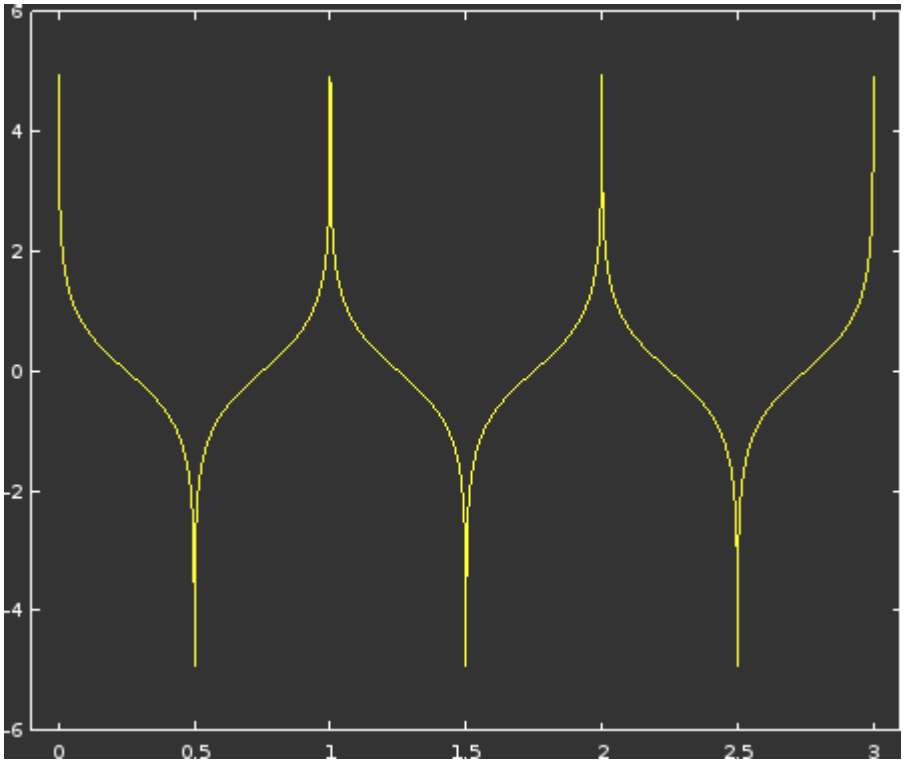


-90° fázis 0°

Fázistorzítás

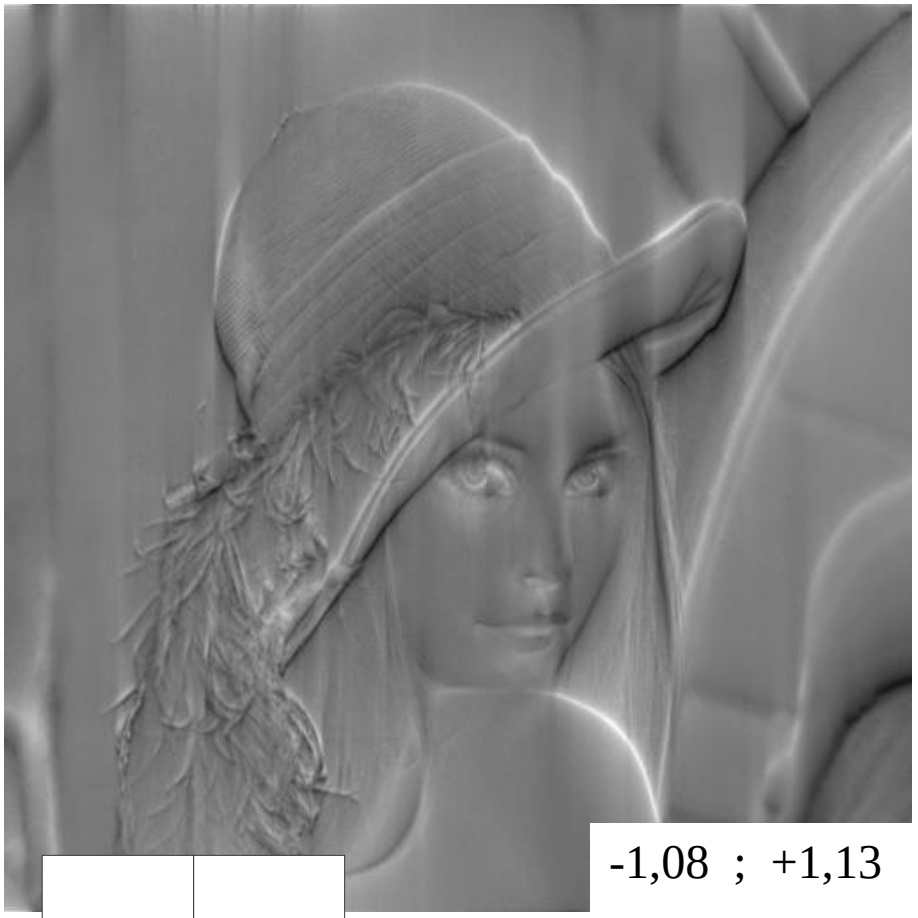
Összes felharmonikus





-90° fázis 0°

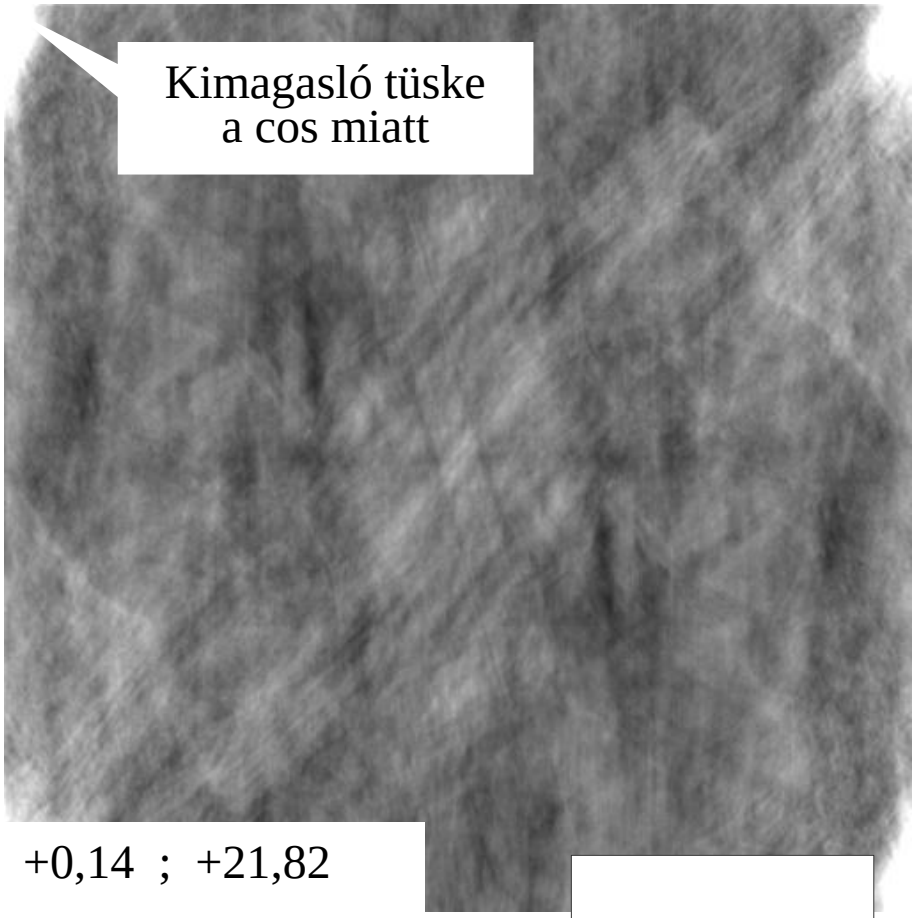
Fázistorzítás



-1,08 ; +1,13

+90°

-90°



+0,14 ; +21,82

0°

(Eredeti kép értéktartománya: 0 ; +1)

FFT

1D FFT

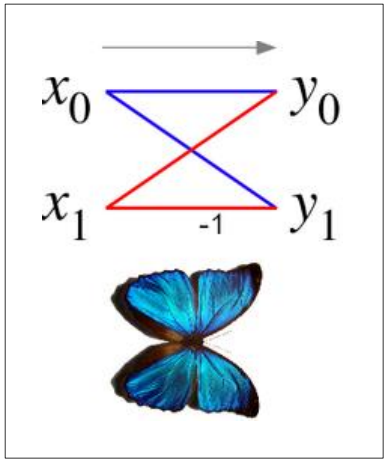
Adatújrarendezés

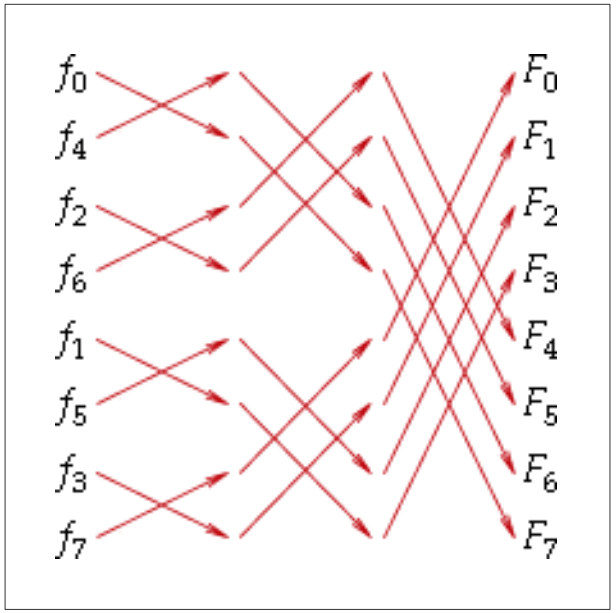
adat[x] ↔ adat[ford(x)] (pl. adat[$0100_{(2)}$] ↔ adat[$0010_{(2)}$])

Pillangó műveletek

Log_2N alkalommal

$$y_0 = x_0 + x_1\omega^k$$
$$y_1 = x_0 - x_1\omega^k$$

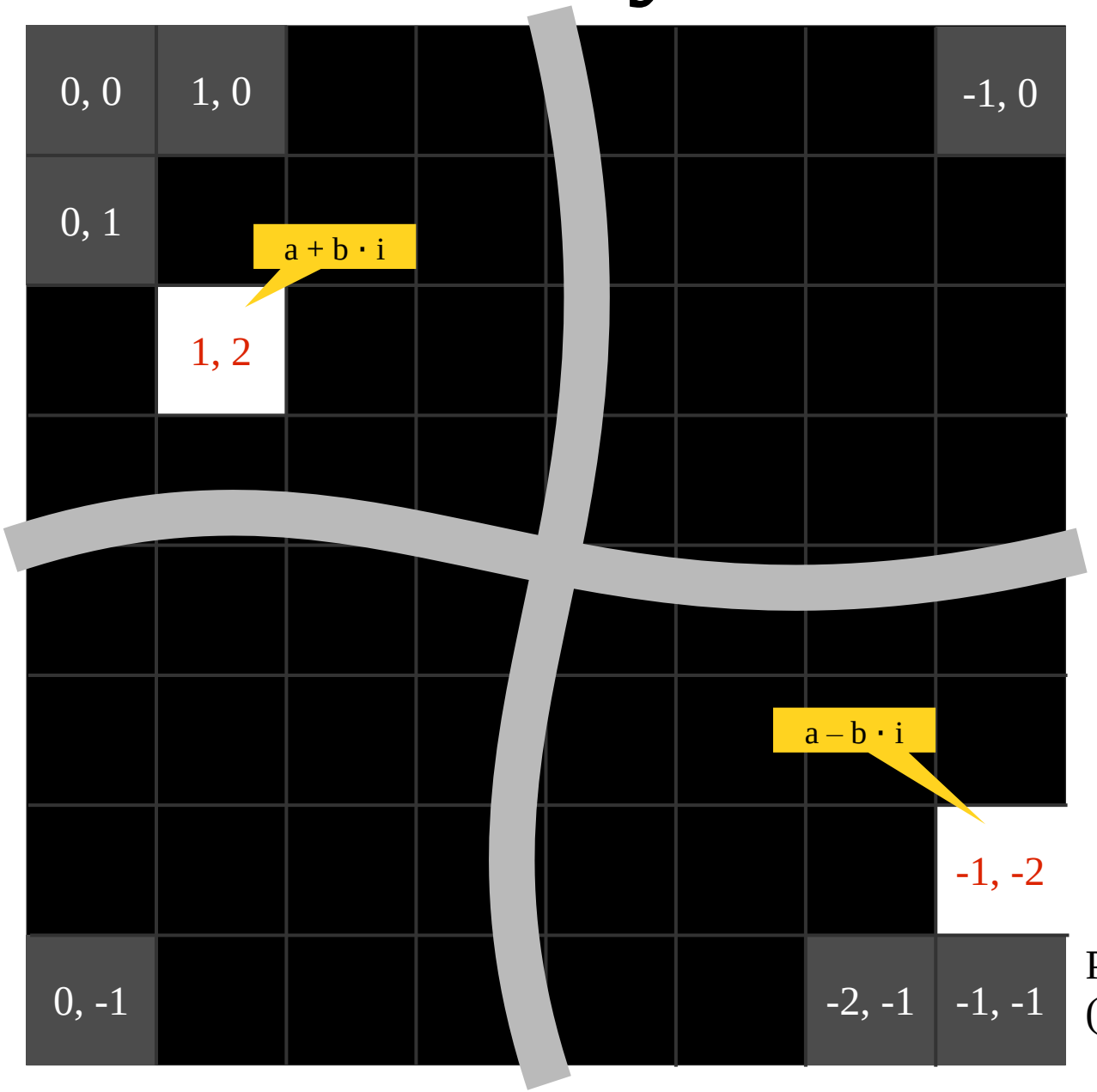




2D FFT

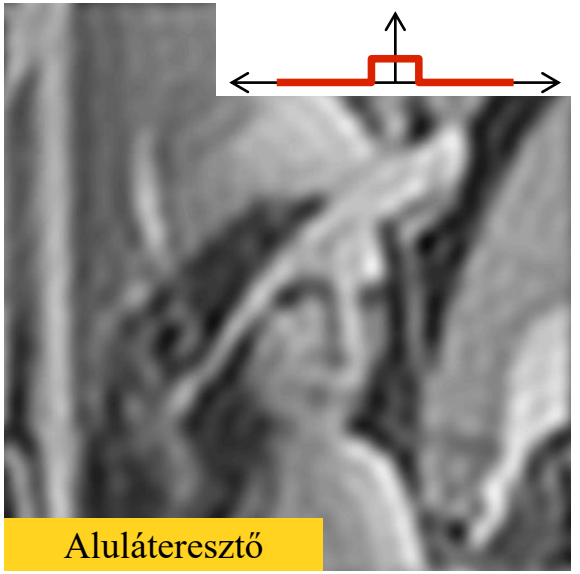
Először vízszintes, majd függőleges irányban...

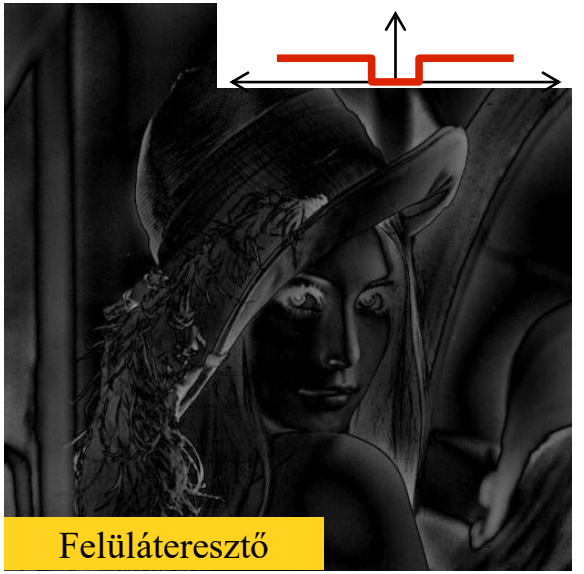
FFT eredménye



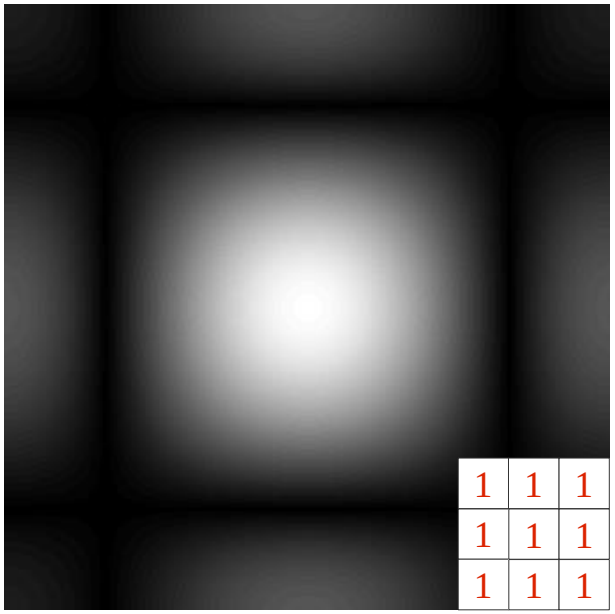
Periodikusság miatt
(N-1, N-1) is lehet

Szűrés

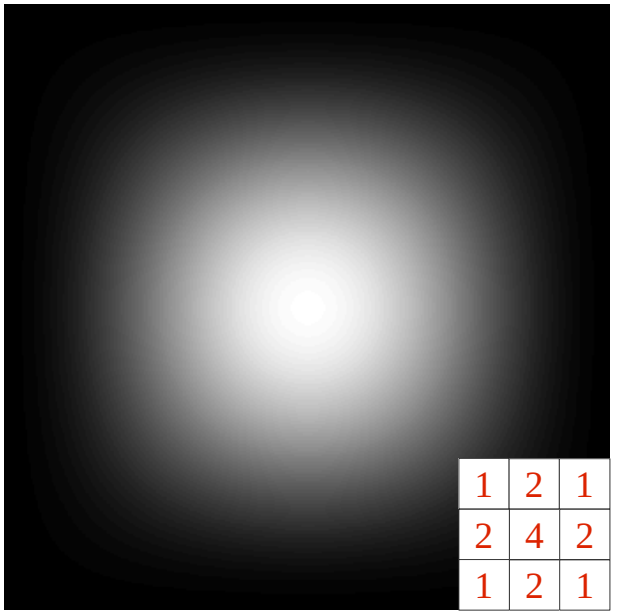




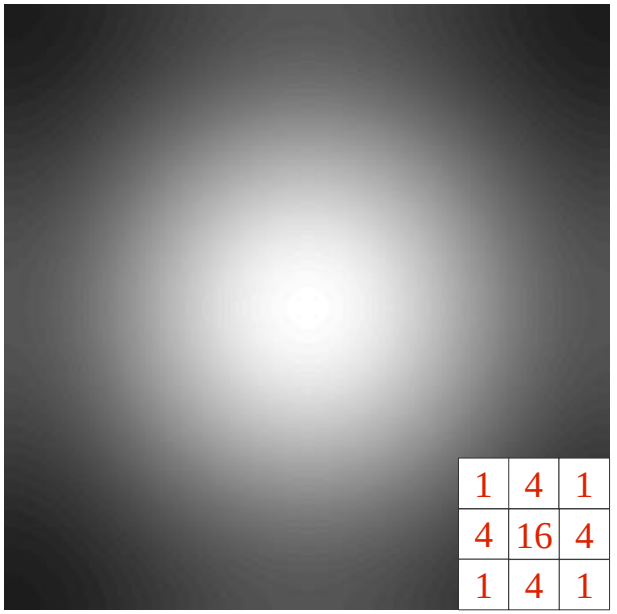
Szűrők frekvenciaképe



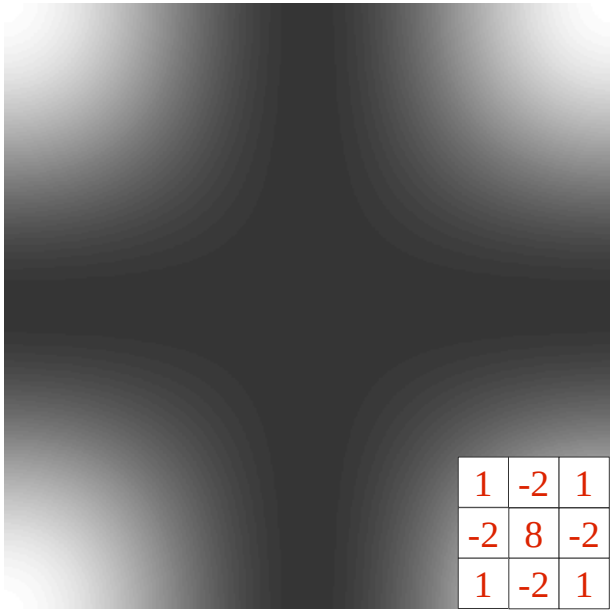
1	1	1
1	1	1
1	1	1



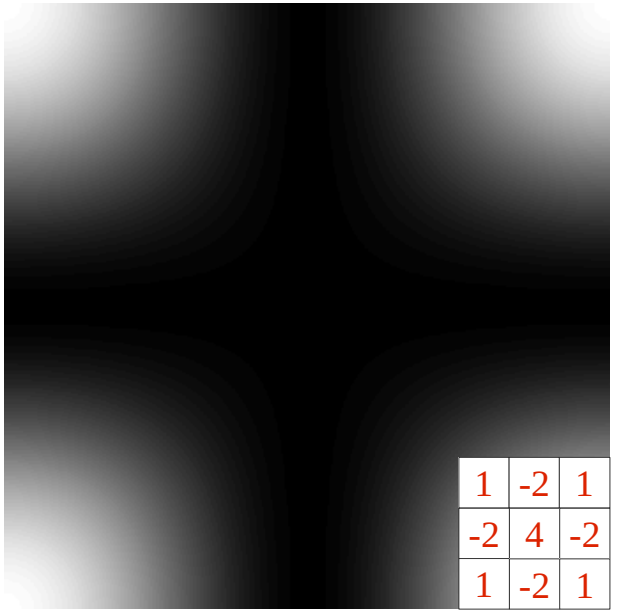
1	2	1
2	4	2
1	2	1



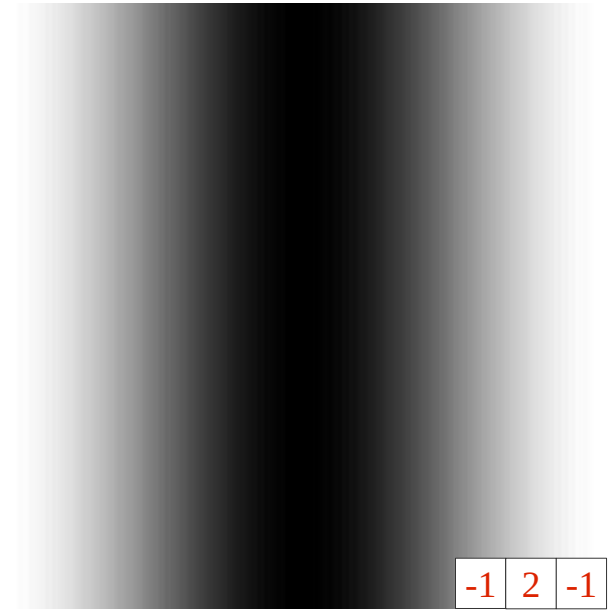
1	4	1
4	16	4
1	4	1



1	-2	1
-2	8	-2
1	-2	1



1	-2	1
-2	4	-2
1	-2	1

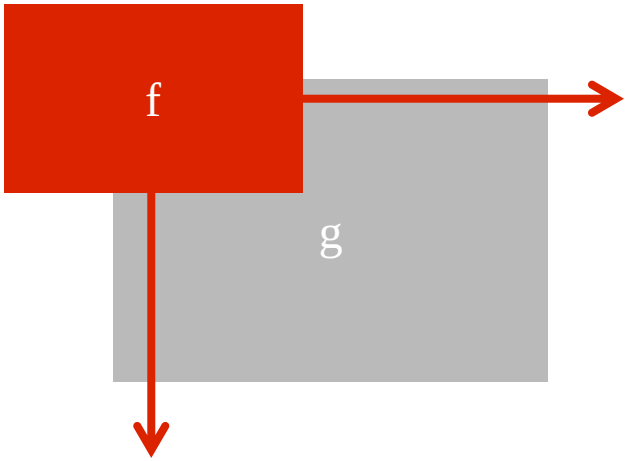


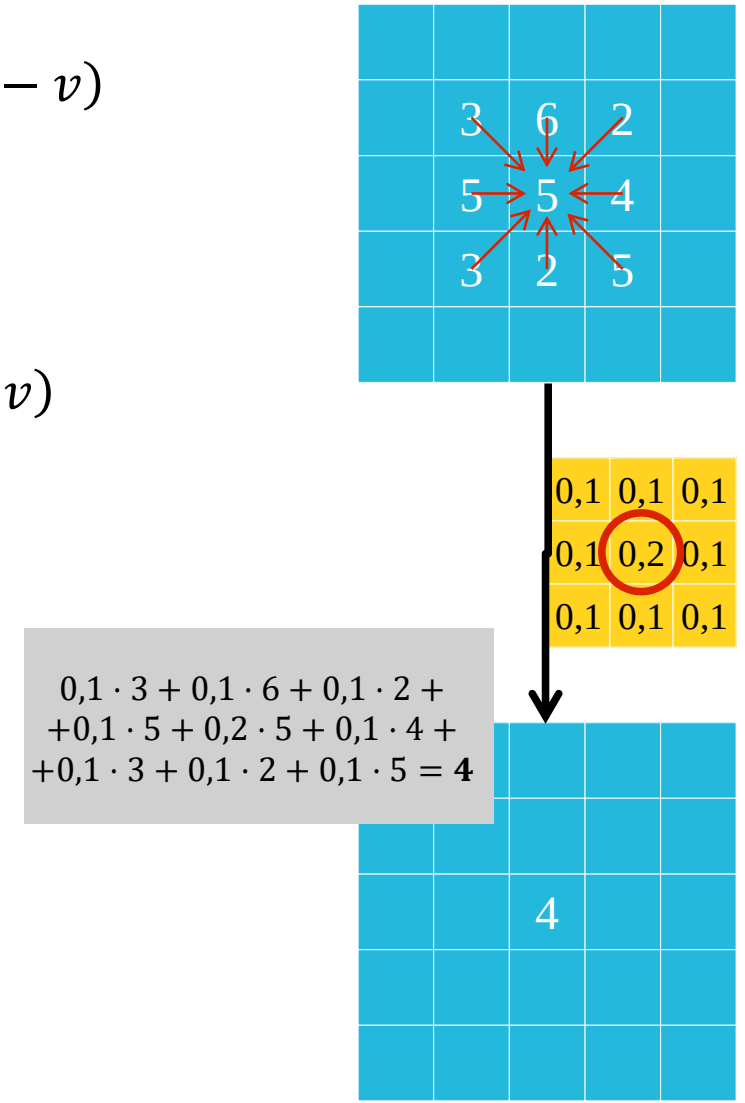
-1	2	-1

Konvolúció

$$(f * g)(x,y) = \sum_{u=-\infty}^{\infty} \sum_{v=-\infty}^{\infty} f\,(u,v) \cdot g(x-u, y-v)$$

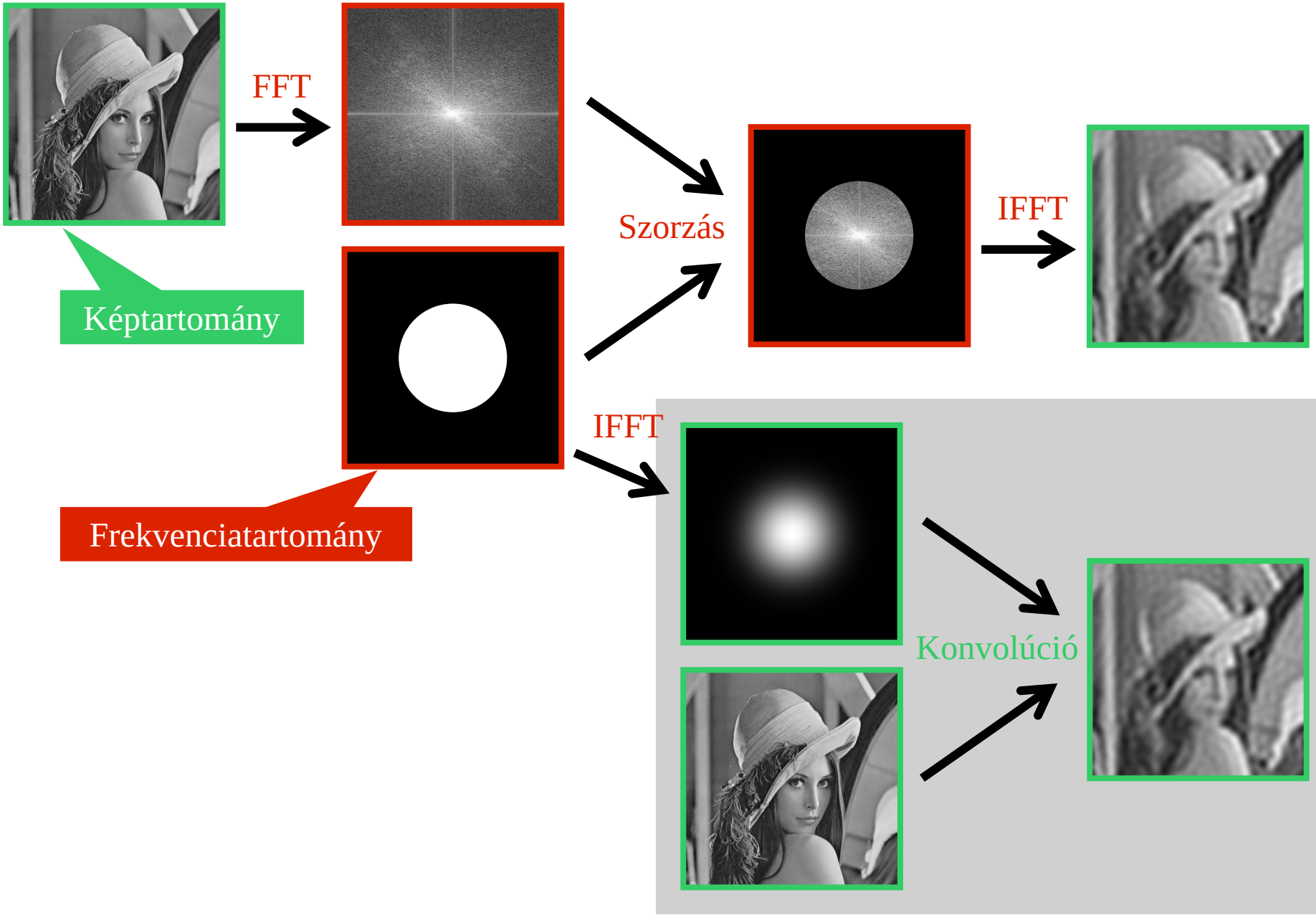
$$(k * I)(x,y) = \sum_{u=-1}^{1} \sum_{v=-1}^{1} k\,(u,v) \cdot I(x-u, y-v)$$



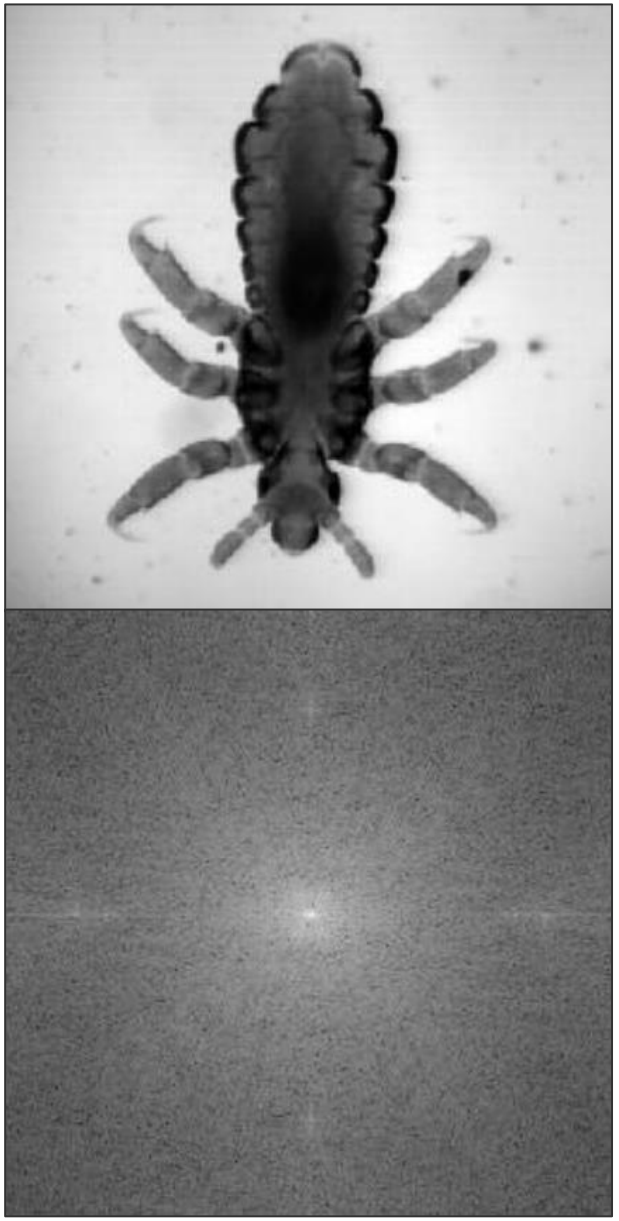


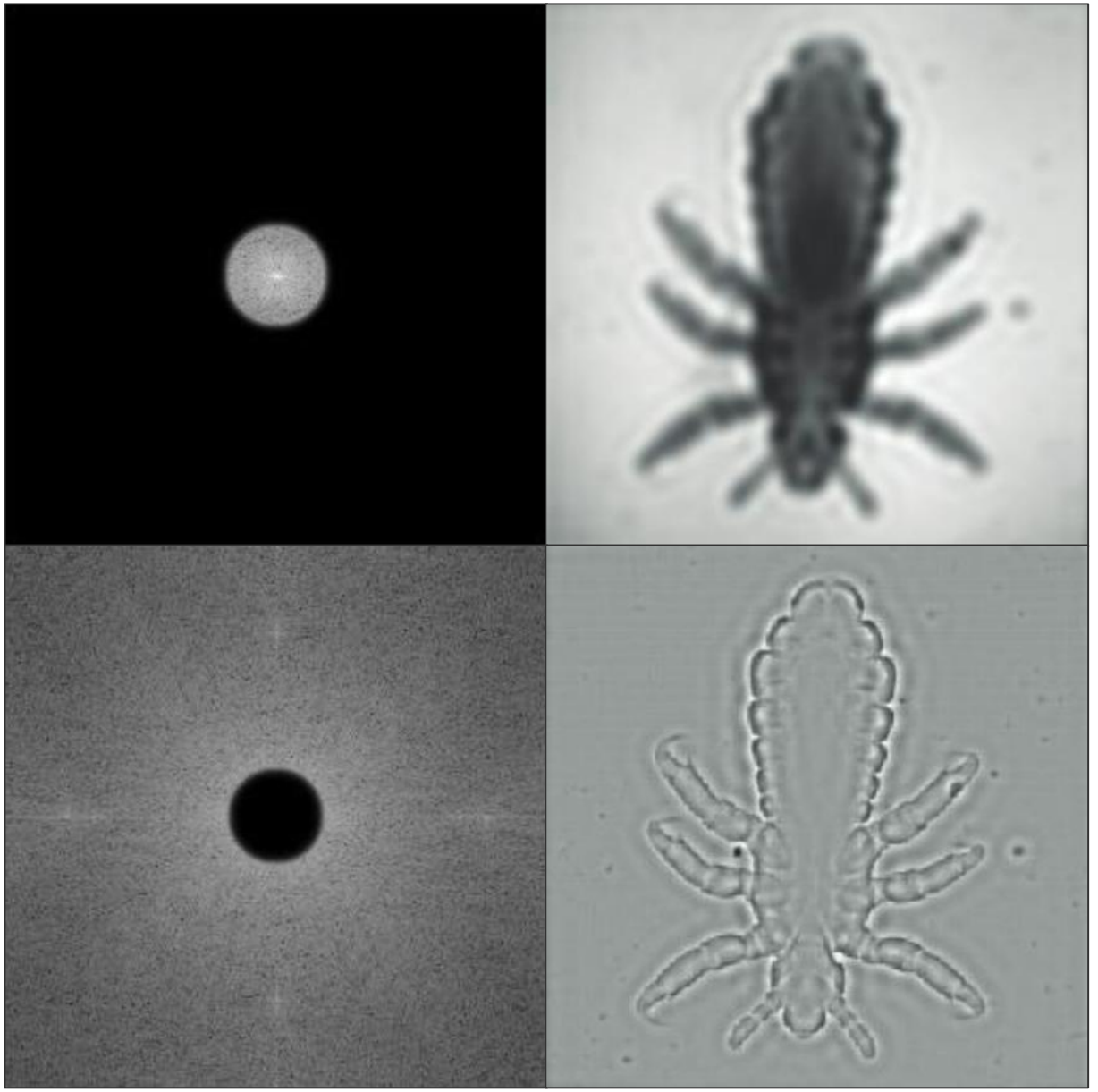
$0{,}1 \cdot 3 + 0{,}1 \cdot 6 + 0{,}1 \cdot 2 +$
$+0{,}1 \cdot 5 + 0{,}2 \cdot 5 + 0{,}1 \cdot 4 +$
$+0{,}1 \cdot 3 + 0{,}1 \cdot 2 + 0{,}1 \cdot 5 = \mathbf{4}$

Konvolúció

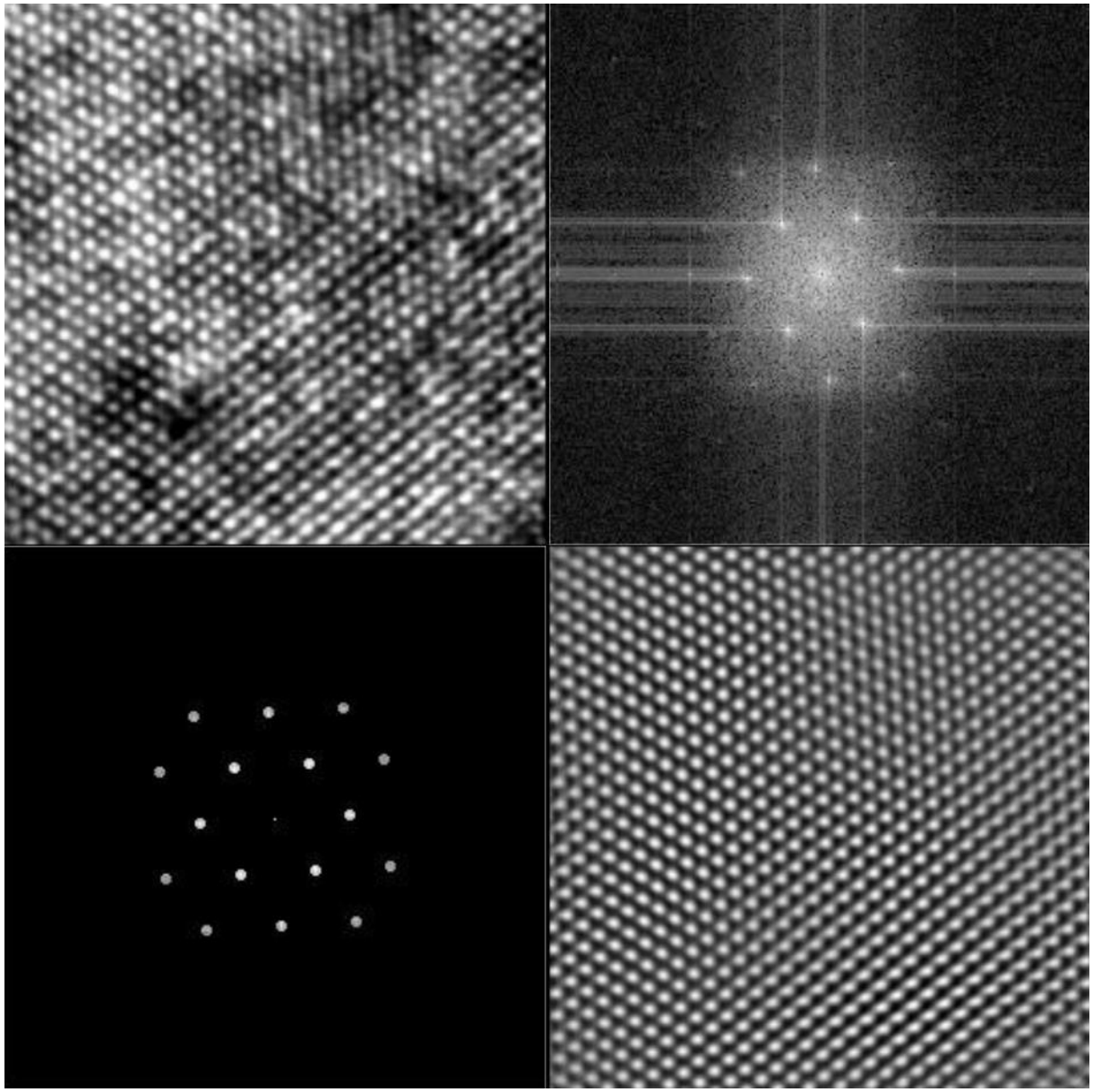

FFT
Szorzás
IFFT
Képtartomány
Frekvenciatartomány
IFFT
Konvolúció

Szűrés

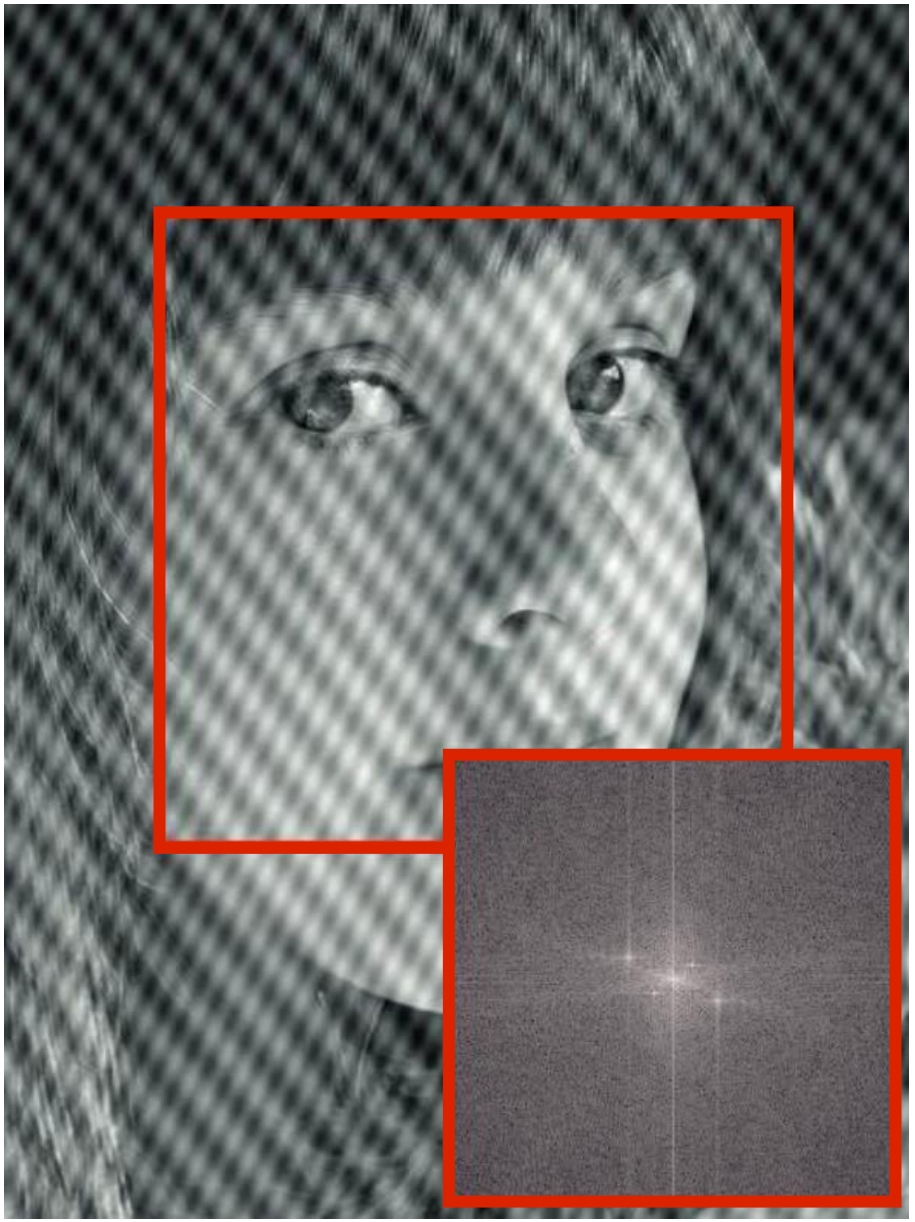


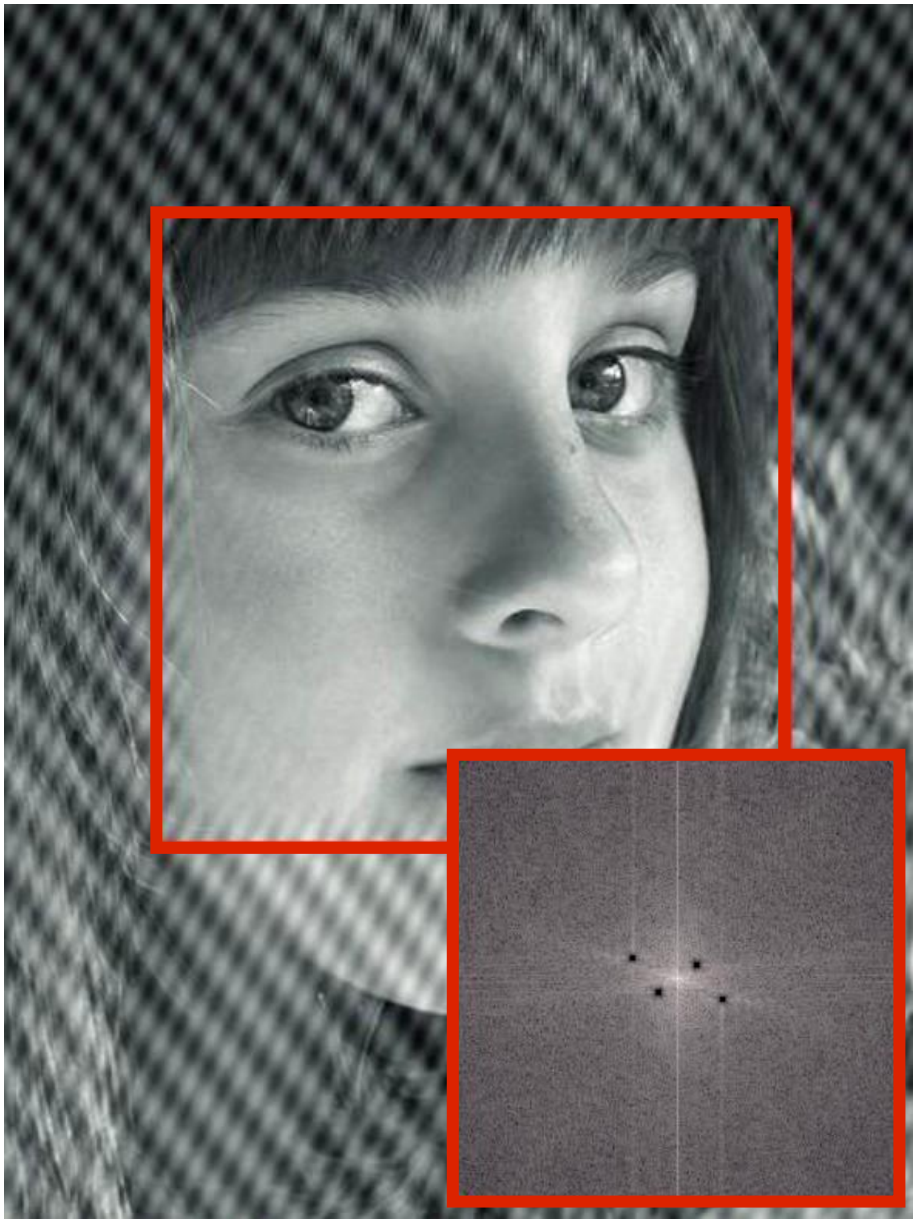


Szűrés

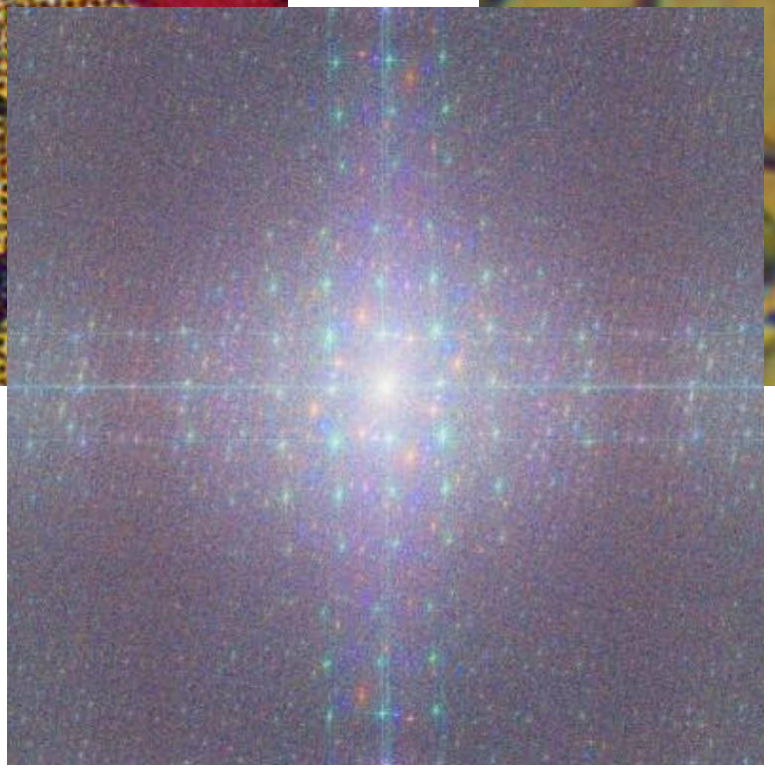


Periodikus zaj

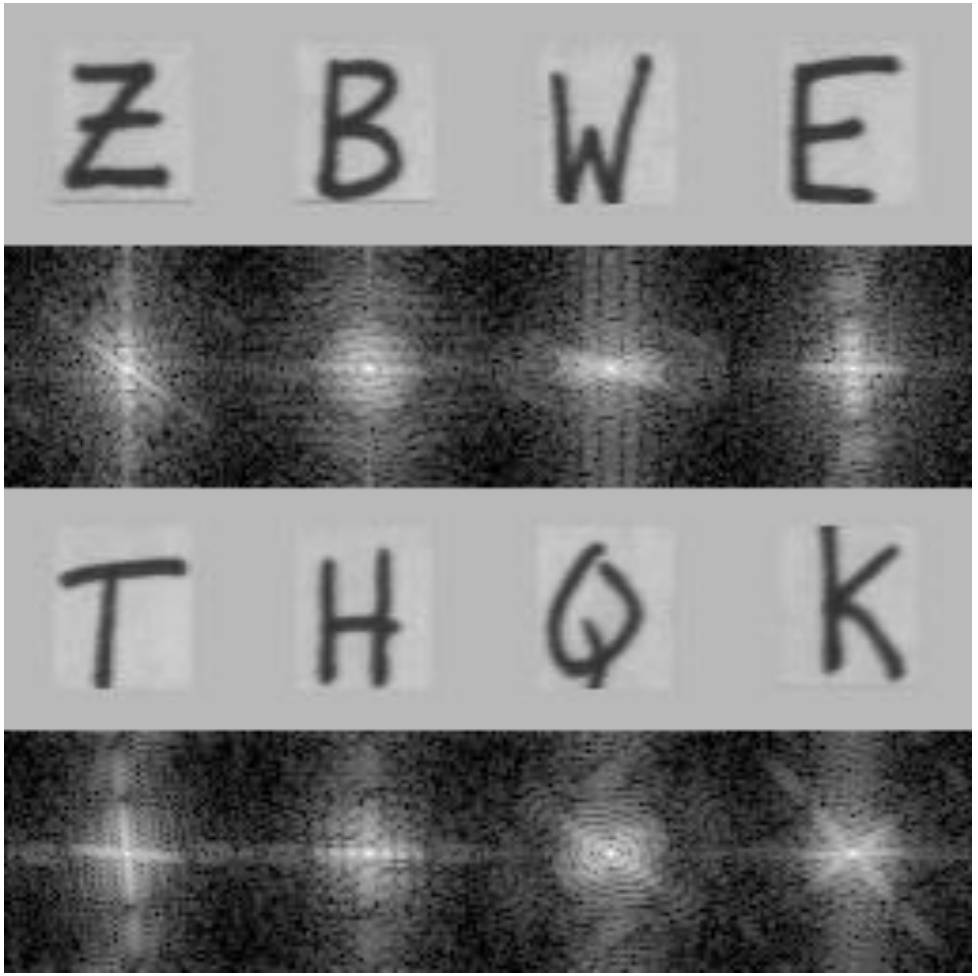




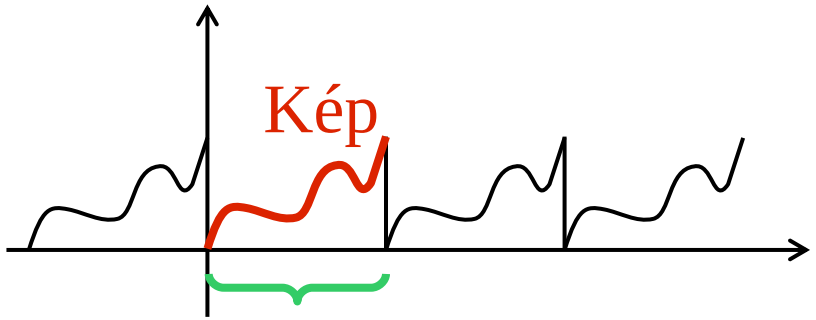
Halftone

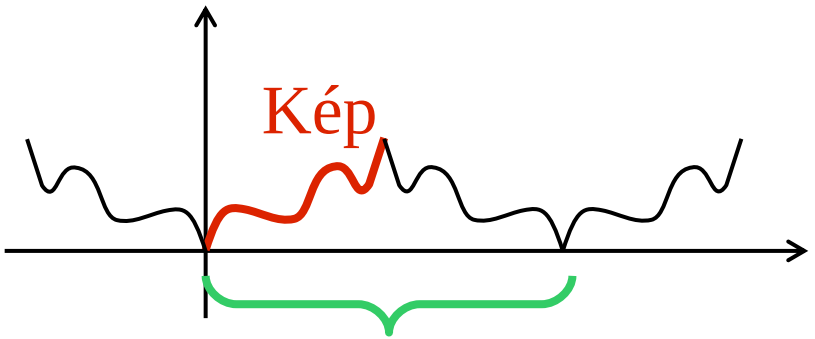


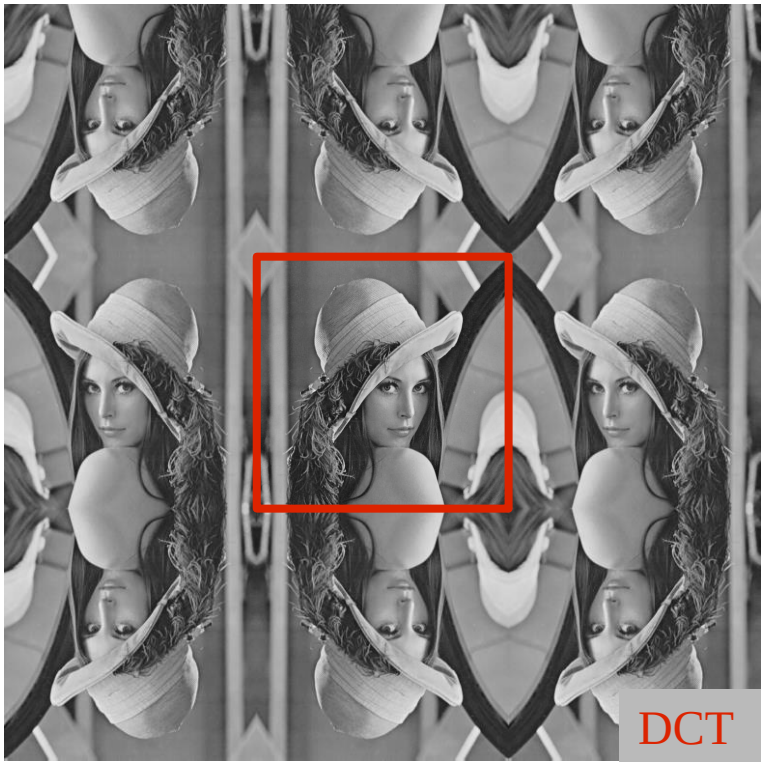
Alakfelismerés



DCT







DCT

Valós értékek

Energiatömörítés

Egyszerűbb

1D

$$C[k] = \sum_{x=0}^{N-1} i\,[x] \cos\left[\frac{\pi}{N}\left(x + \frac{1}{2}\right)k\right]$$

2D

$$C[k,l] = \sum_{x=0}^{N-1}\sum_{y=0}^{M-1} i\,[x,y] \cos\left[\frac{\pi}{N}\left(x + \frac{1}{2}\right)k\right] \cos\left[\frac{\pi}{M}\left(y + \frac{1}{2}\right)l\right]$$

FCT

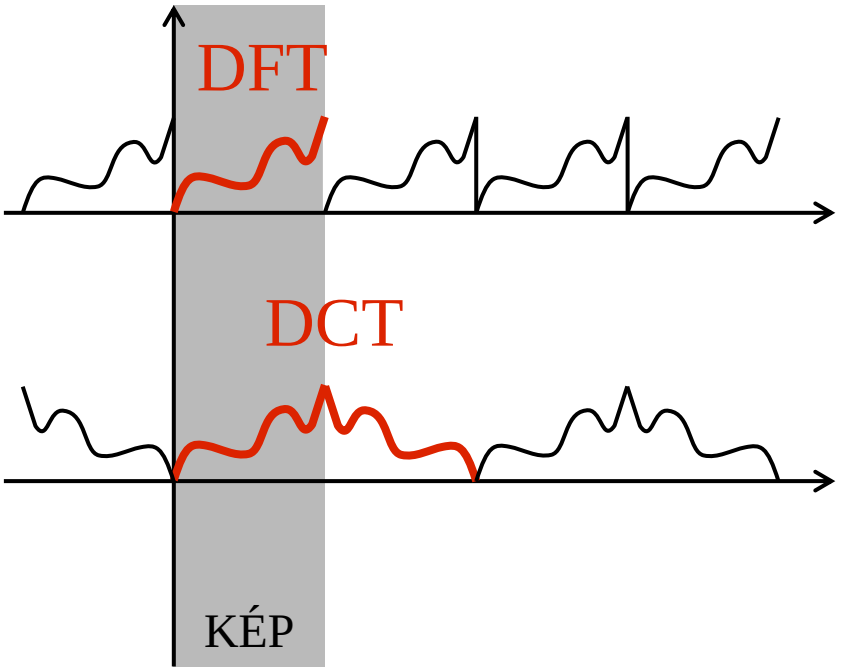
1. Szimmetrikus függvény

$$y[n] = \begin{cases} x[n] & , ha\ 0 \leq n < N \\ x[2N-1-n] & , ha\ N \leq n < 2N \end{cases}$$

2. FFT (2N adaton)

3. Valós rész

$$C[n] = \Re\left(e^{\frac{-i\pi k}{2N}} * Y[n]\right)$$



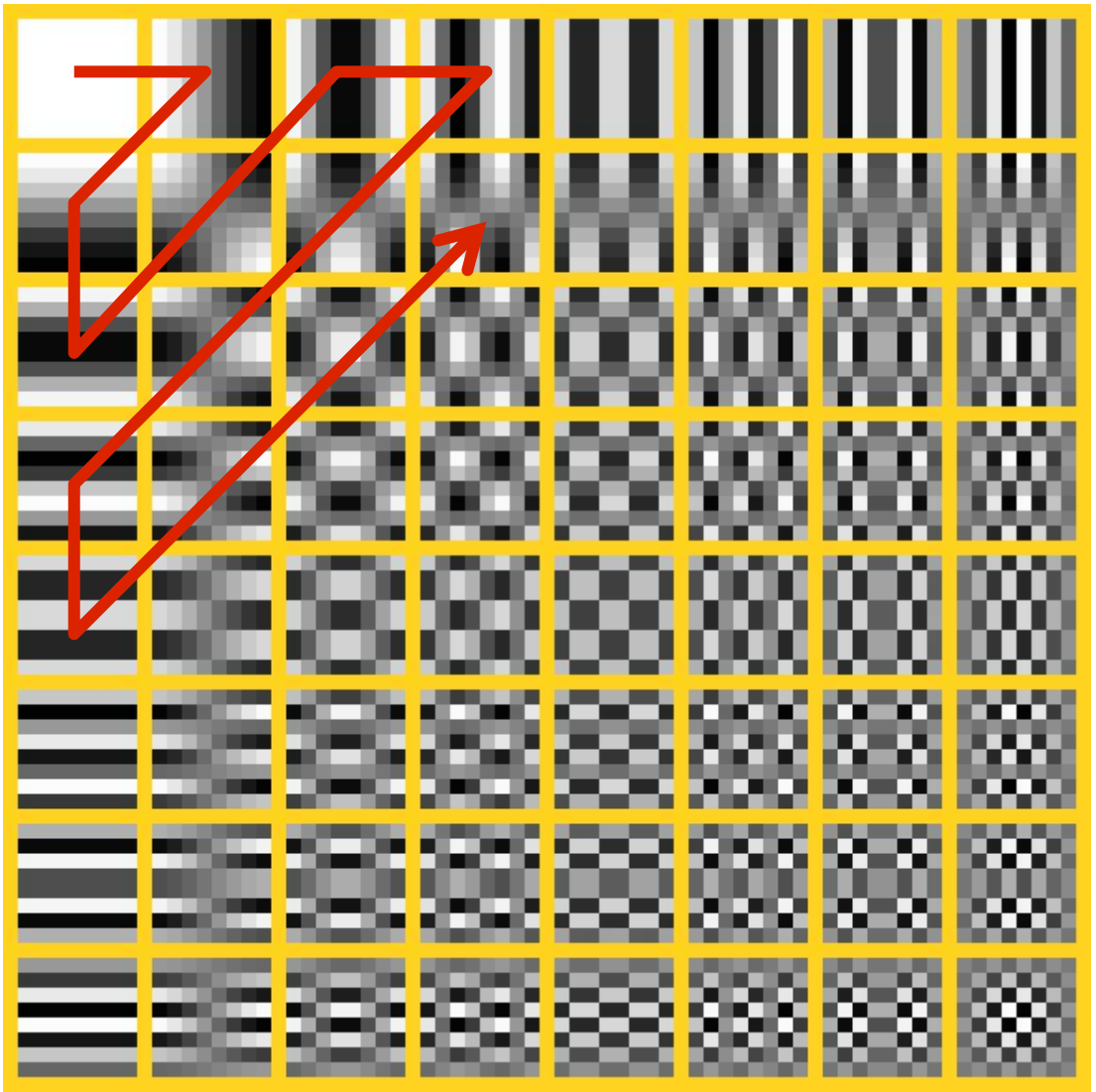
JPEG

DCT-II

8x8 elemek

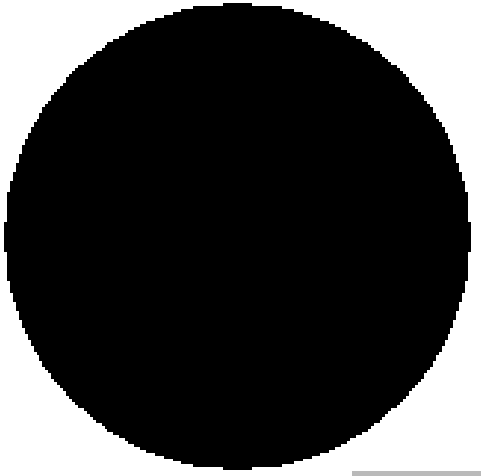
8x8 C-tábla

Csak az első pár elemet tároljuk

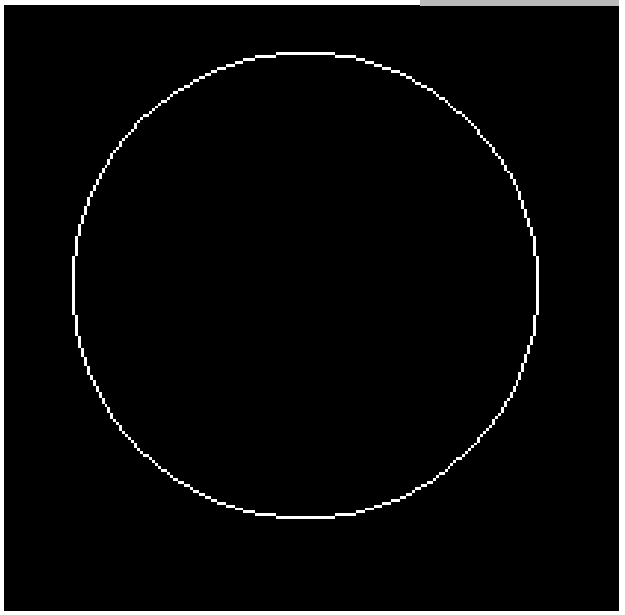


Tömörítés hatása

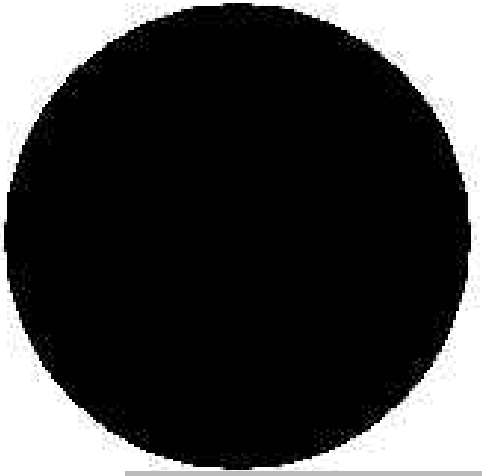
Veszteséges JPEG



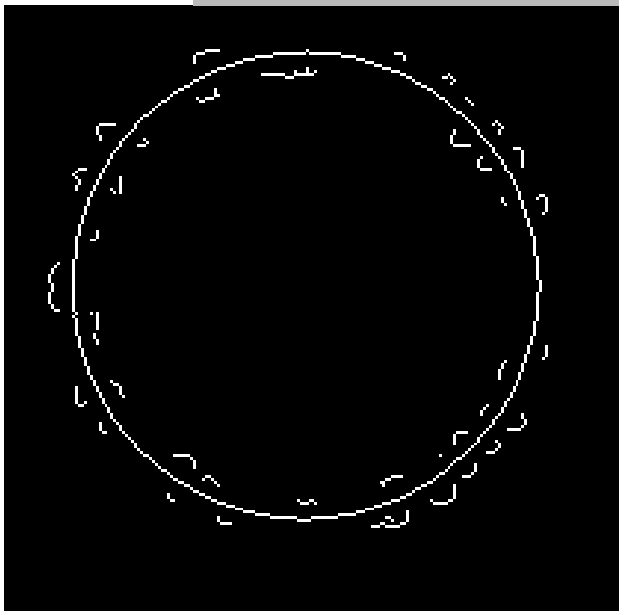
Eredeti



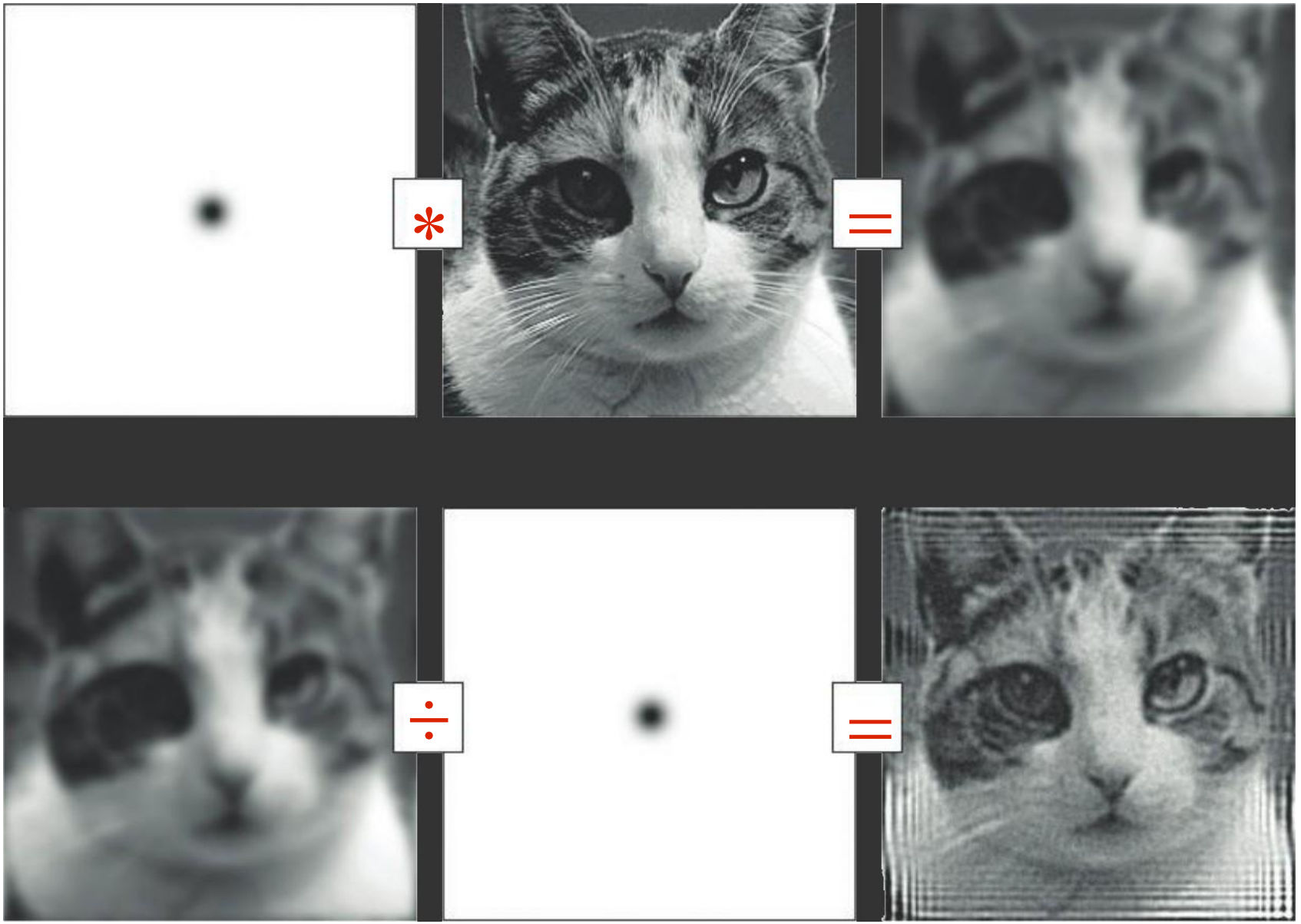
Canny élkereső



Veszteséges JPEG



Dekonvolúció



Egyszerű dekonvolúció

$$g(x,y) = f(x,y) * h(x,y)$$

$$f(x,y) = g(x,y) \div h(x,y)$$

$$F(u,v) = \left[\frac{1}{H(u,v)}\right] \cdot G(u,v)$$

Wiener dekonvolúció

$$g(x,y) = f(x,y) * h(x,y) + \varepsilon$$

$$f(x,y) = g(x,y) \div h(x,y)$$

$$F(u,v) \approx \left[\frac{1}{H(u,v)}\right] \cdot \left[\frac{|H(u,v)|^2}{|H(u,v)|^2 + \frac{1}{SNR(u,v)}}\right] \cdot G(u,v)$$