

Immagini digitali

Fondamenti Elaborazione dei Segnali e Immagini
(FESI)

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Immagini pittoriche (foto) a livelli di grigio

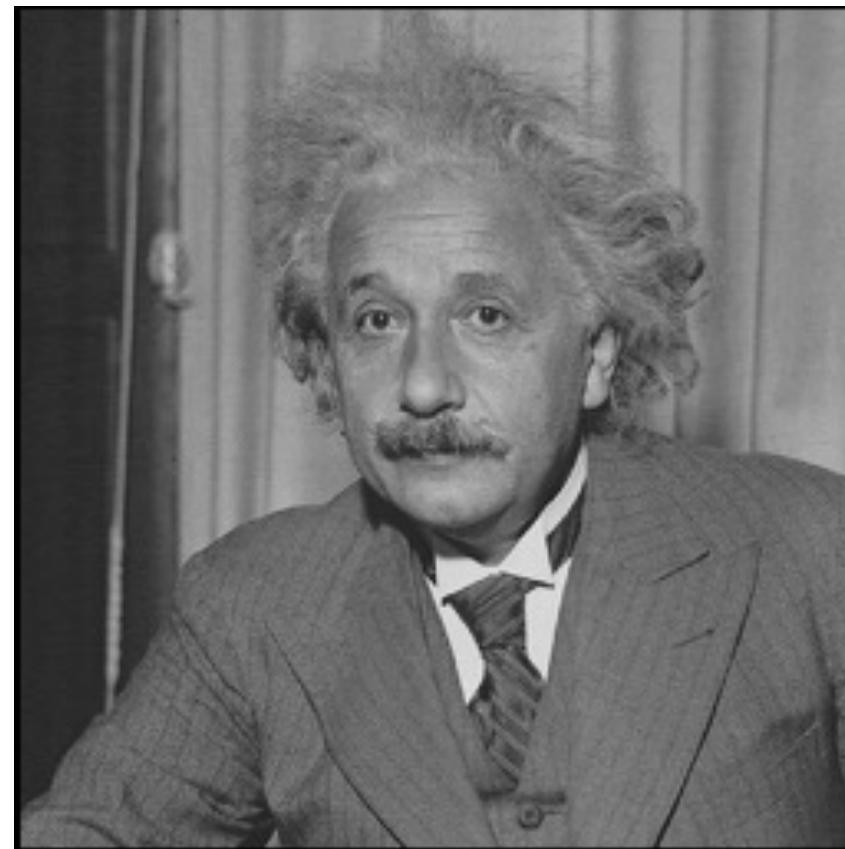


Immagine digitale

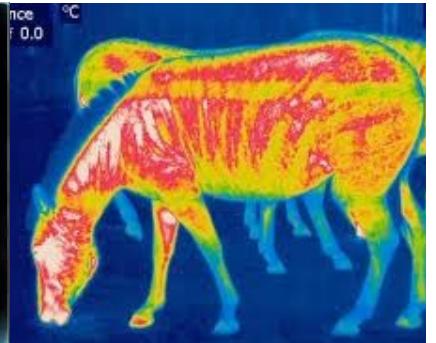
Dimensione dell'immagine = numero di pixel
Convenzione: righe x colonne

Matrice di numeri

98	103	102	110	118	118	119	119	118	118	109	88	
98	105	101	110	118	118	119	118	116	113	105	84	
92	98	96	109	116	121	130	130	142	141	151	145	
95	98	98	104	110	112	124	127	148	147	157	159	
95	98	98	104	110	112	124	127	148	147	157	159	
103	104	107	111	116	121	128	128	137	135	146	169	
101	106	106	110	116	119	128	128	134	133	145	166	
99	109	106	118	127	131	143	145	154	153	155	168	
102	110	110	121	131	136	148	148	157	157	160	169	
RIGA	102	110	111	124	136	140	153	154	164	165	167	174
	105	113	112	124	130	135	147	147	159	159	167	175
	104	113	112	125	134	137	144	147	161	161	169	177
	102	110	108	122	131	131	140	140	149	150	157	168
	103	109	109	121	128	131	139	140	149	148	156	167
	101	106	103	116	127	133	144	143	148	148	149	159
	84	94	91	103	113	118	132	134	145	146	146	149
	85	92	91	103	114	119	134	135	146	145	146	149
	70	82	81	91	97	100	112	115	131	130	139	142
	70	82	81	91	97	100	114	115	131	132	139	142
	77	76	76	82	89	89	100	101	115	113	127	135
	111	85	84	79	81	81	90	90	102	100	111	125
	107	86	88	79	79	79	88	88	100	101	110	126

Il contenuto dei pixel

- Pictorial digital images (photos): Intensity (“black & white”), color
- Range images: Depth information
- Medical images: Radiations absorbance level
- Thermal images: Heat
-

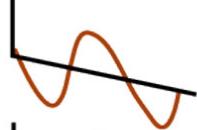


Fourier in 2D

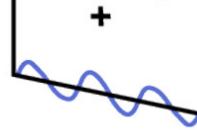
1D Fourier Projection



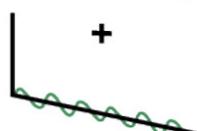
equals



+

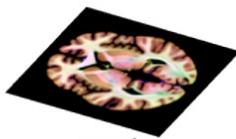


+



etc.

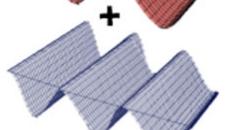
2D Fourier Projection



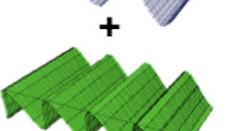
equals



planar waves
+ at multiple
other angles

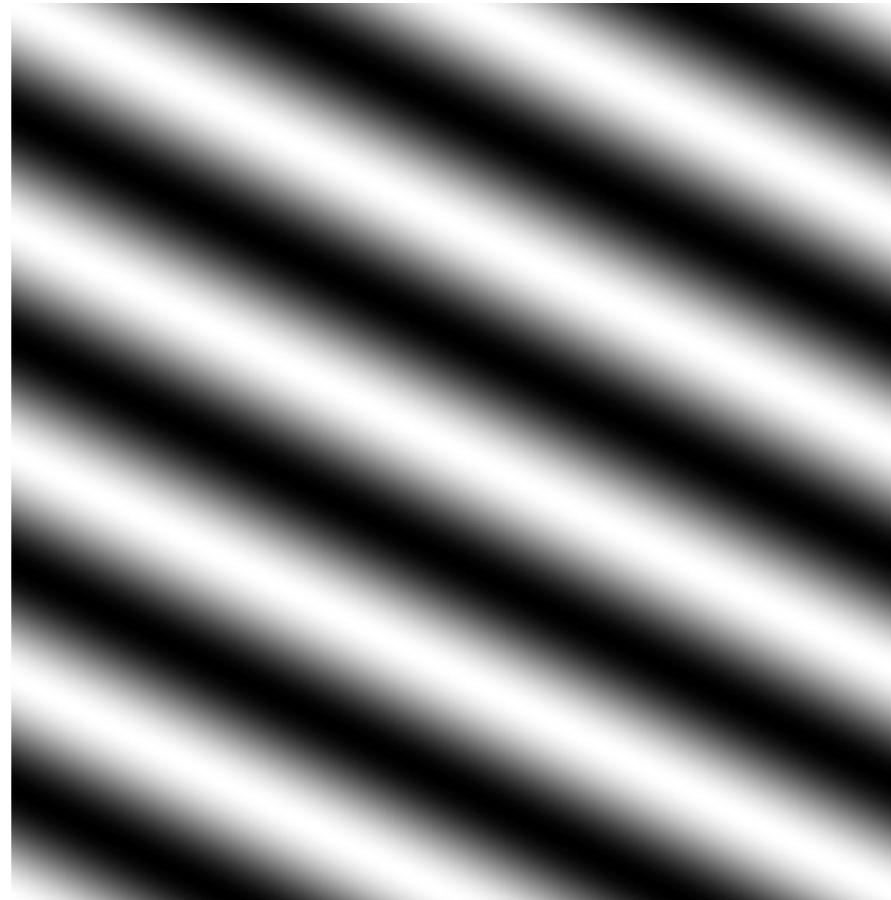


+
etc.



$$F(u, v) = \sum_{m=-\infty}^{\infty} \sum_{n=-\infty}^{\infty} f[m, n] e^{-j2\pi(um+vn)}$$

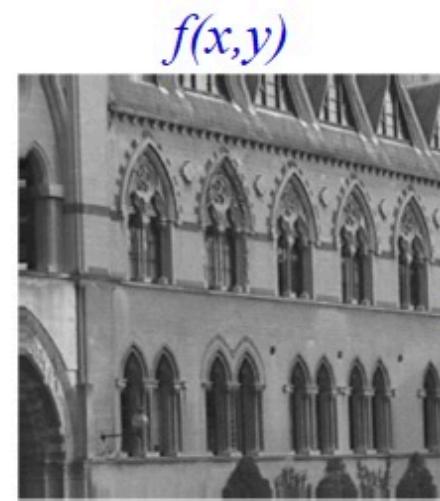
	v	$e^{-\pi i(ux+vy)}$
	•	u
$e^{\pi i(ux+vy)}$	•	



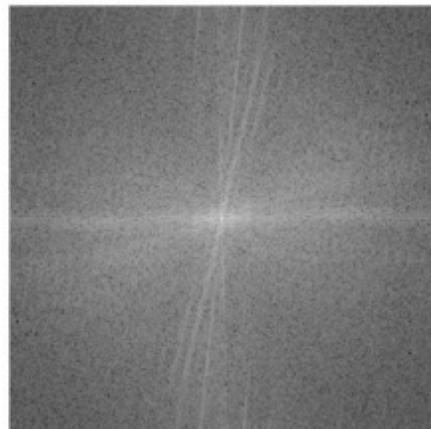
$$\begin{array}{|c|c|} \hline & v \\ e^{-\pi i(ux+vy)} & \bullet \\ \hline u & e^{\pi i(ux+vy)} \\ \hline \end{array}$$



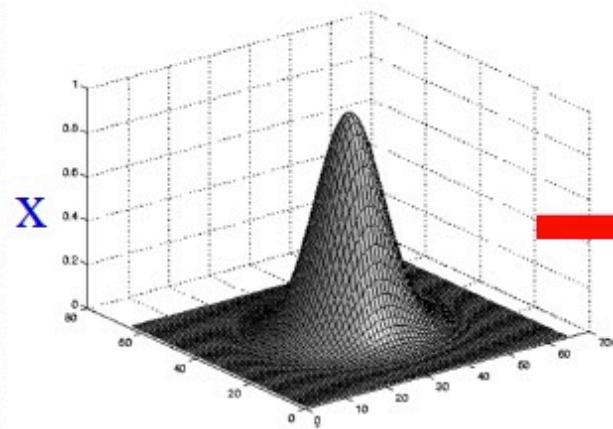
Filtraggio in Fourier



Fourier transform



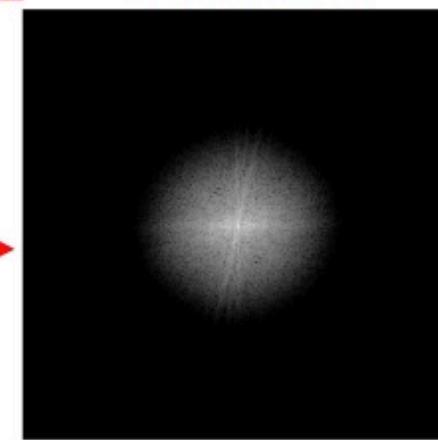
$$|F(u,v)|$$



$$g(x,y)$$



Inverse Fourier transform



$$|G(u,v)|$$



La pipeline in 2D

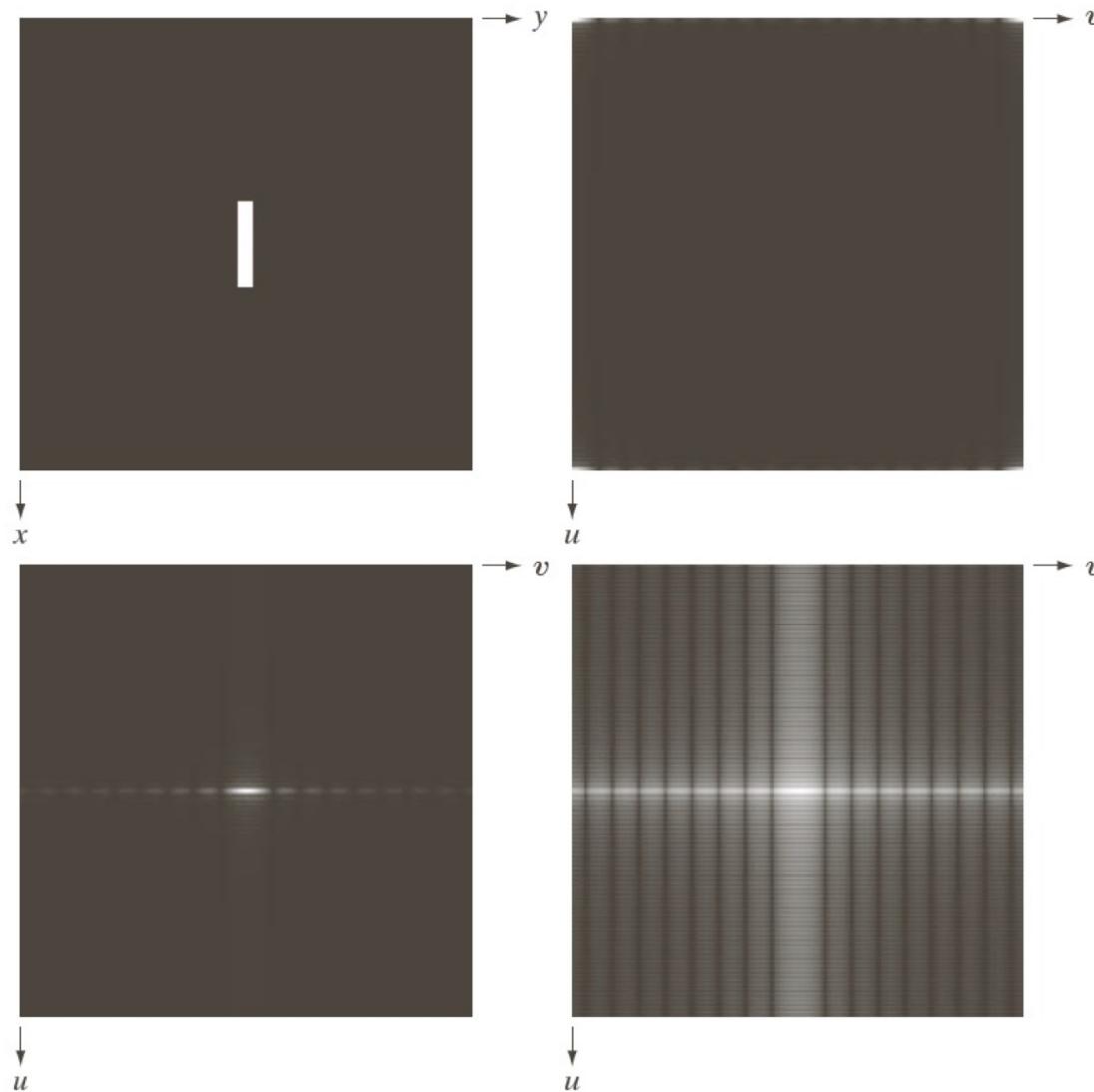
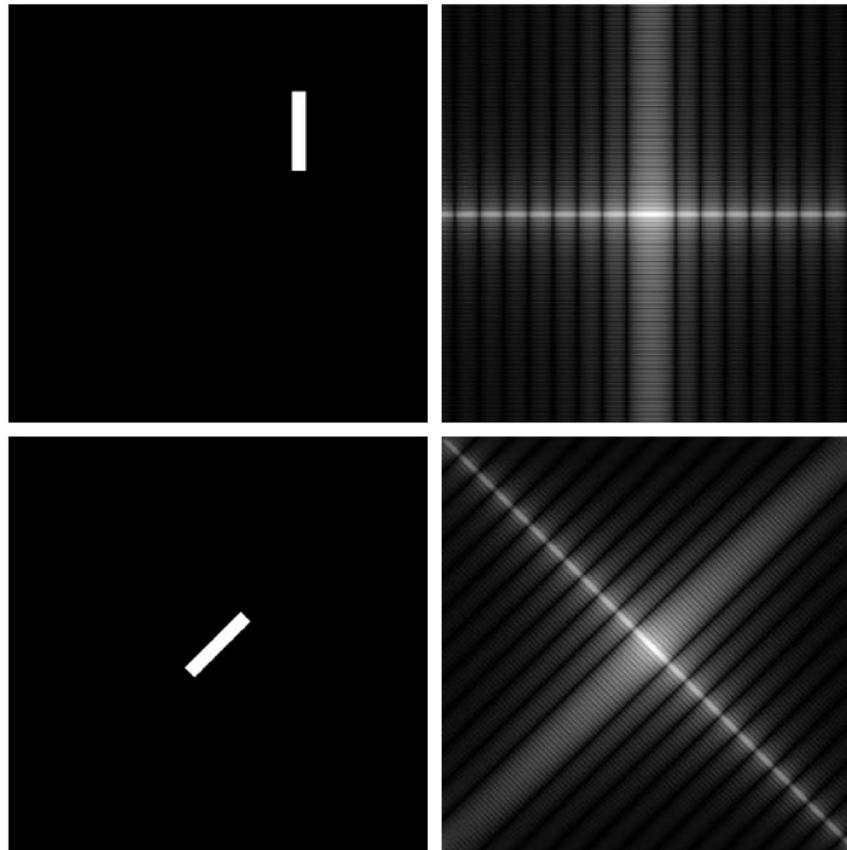


FIGURE 4.24

(a) Image.
(b) Spectrum
showing bright spots
in the four corners.
(c) Centered
spectrum. (d) Result
showing increased
detail after a log
transformation. The
zero crossings of the
spectrum are closer in
the vertical direction
because the rectangle
in (a) is longer in that
direction. The
coordinate
convention used
throughout the book
places the origin of
the spatial and
frequency domains at
the top left.

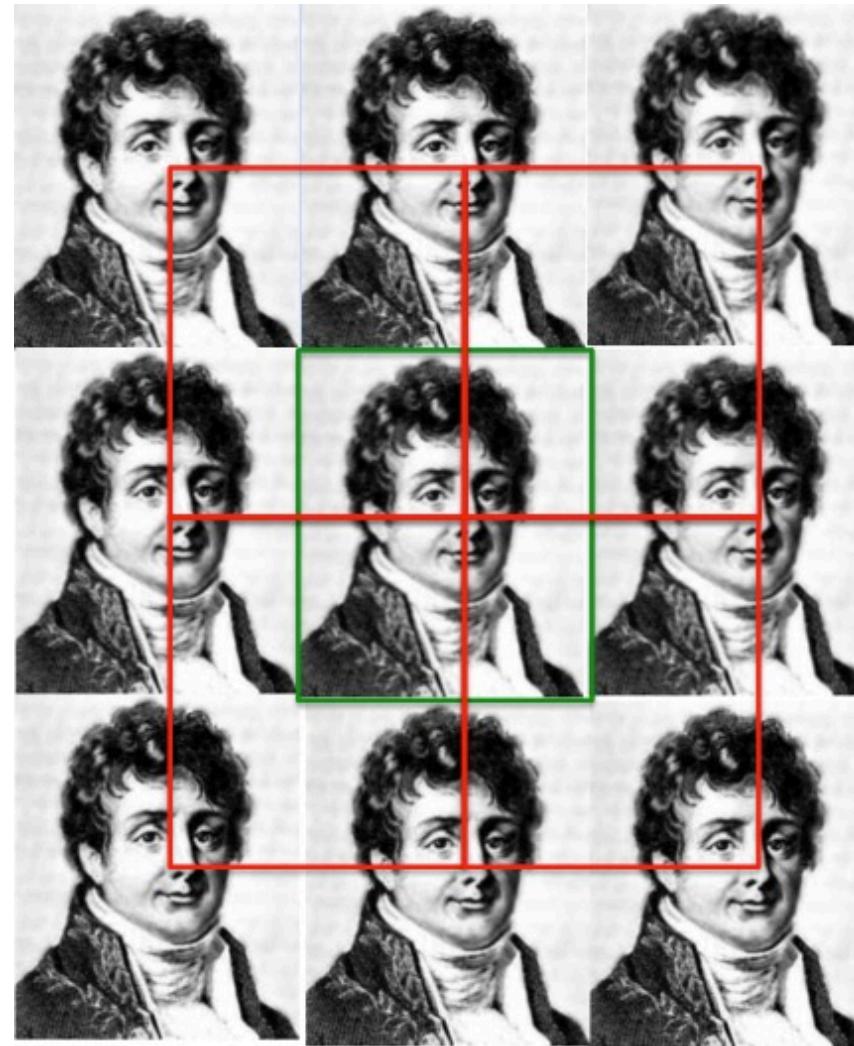
Invarianze in Fourier



a	b
c	d

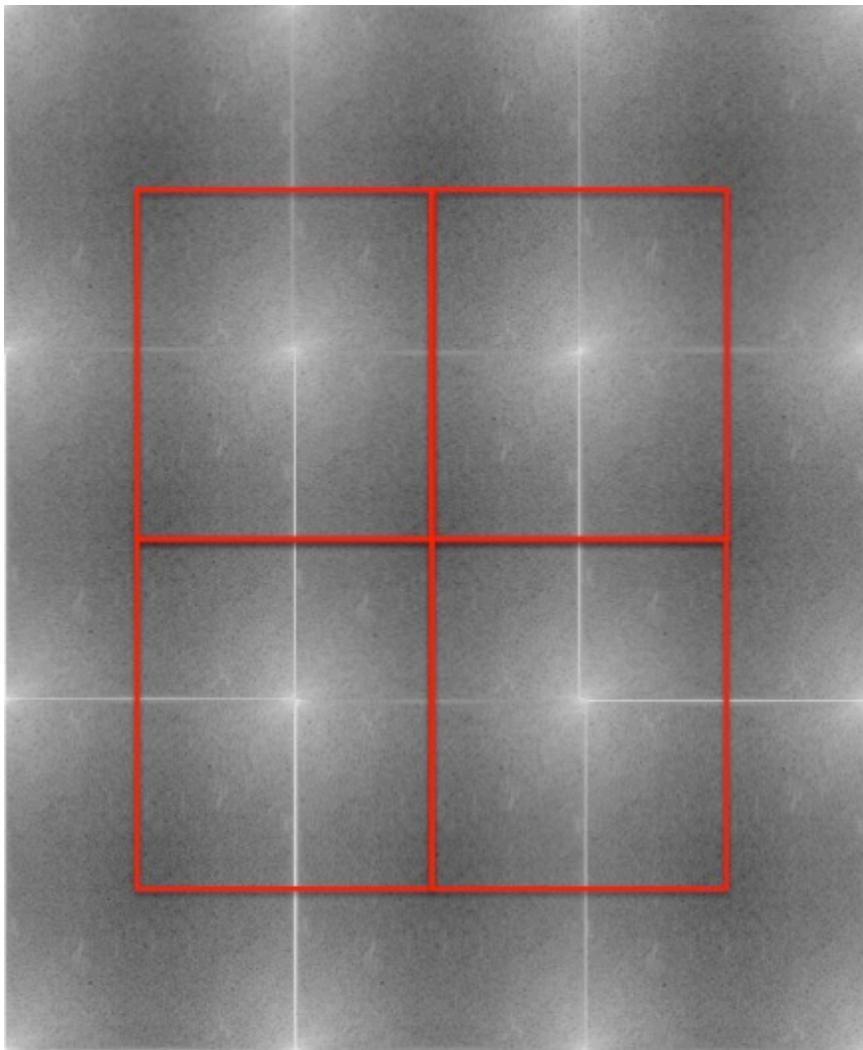
FIGURE 4.25
(a) The rectangle
in Fig. 4.24(a)
translated,
and (b) the
corresponding
spectrum.
(c) Rotated
rectangle,
and (d) the
corresponding
spectrum.
The spectrum
corresponding to
the translated
rectangle is
identical to the
spectrum
corresponding to
the original image
in Fig. 4.24(a).

Attenzione agli shift

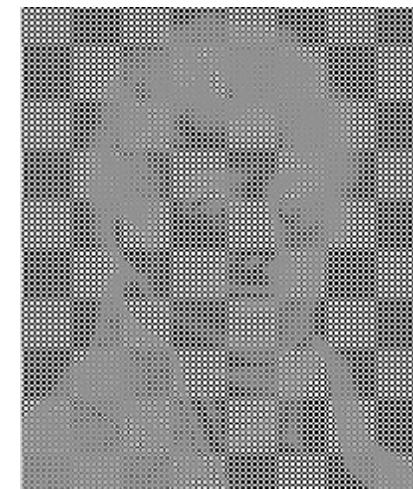


REPLICHE E SHIFTING

Attenzione agli shift

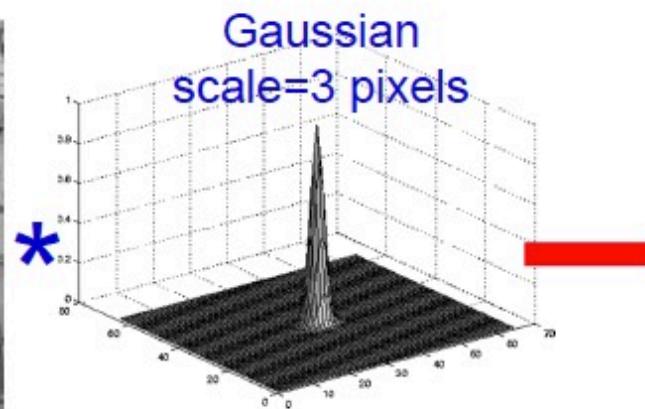
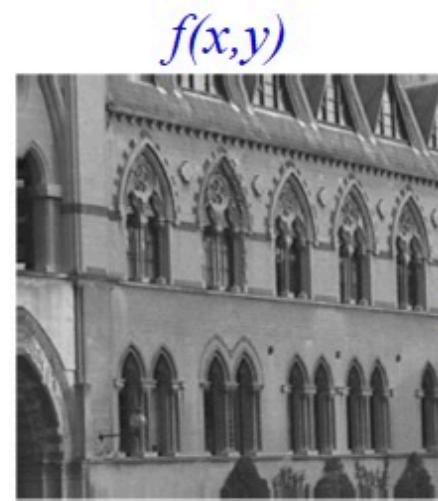


REPLICHE IN FOURIER E PIASTRELLATURA

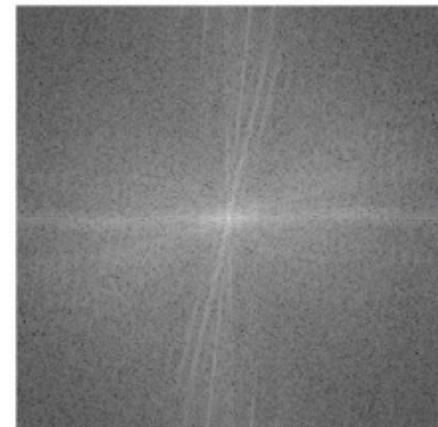


INVERSA (SENZA SHIFTING BACK)

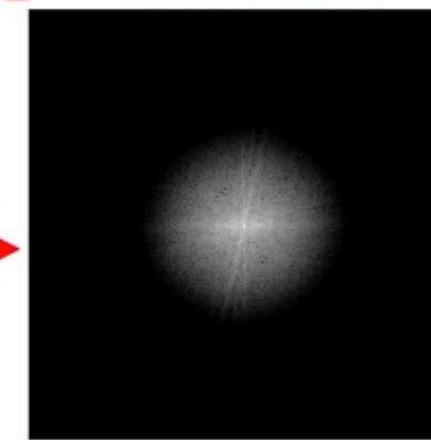
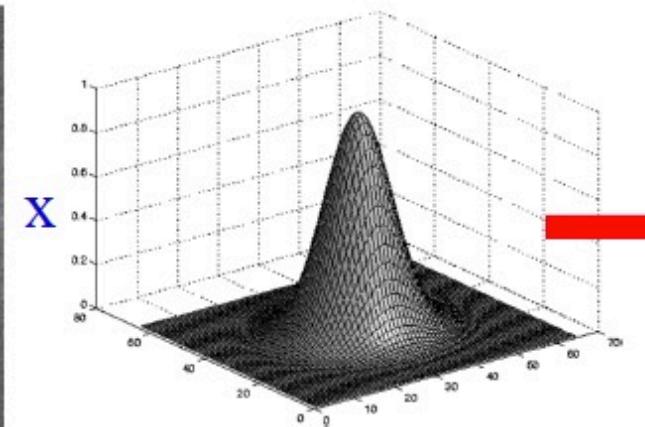
Filtraggio nello spazio e in Fourier



Fourier transform

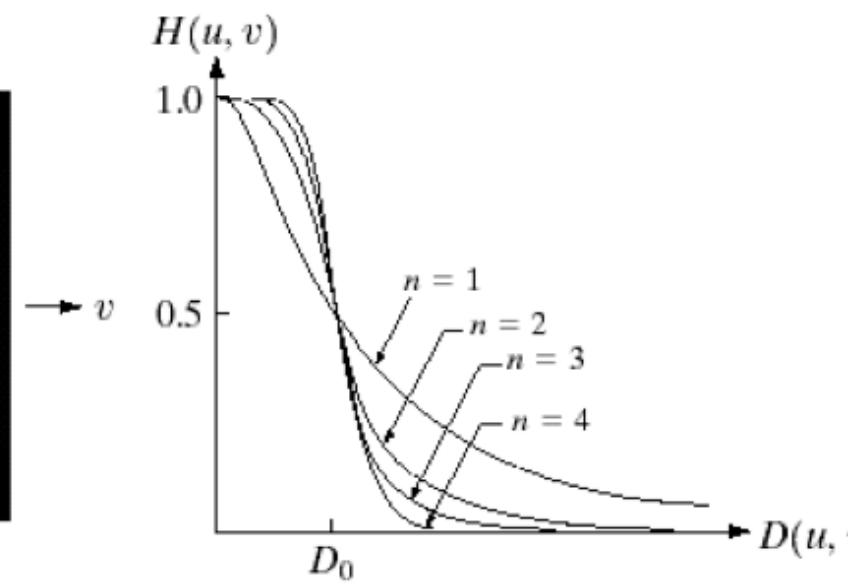
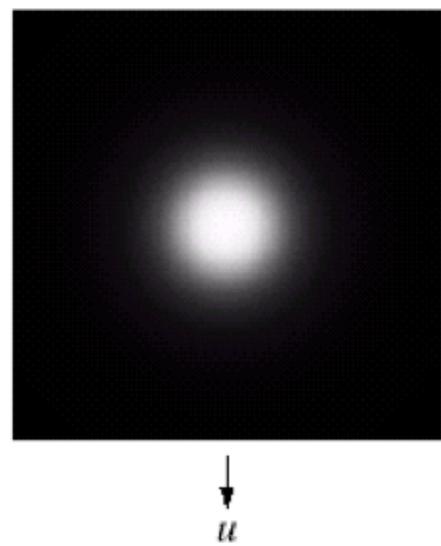
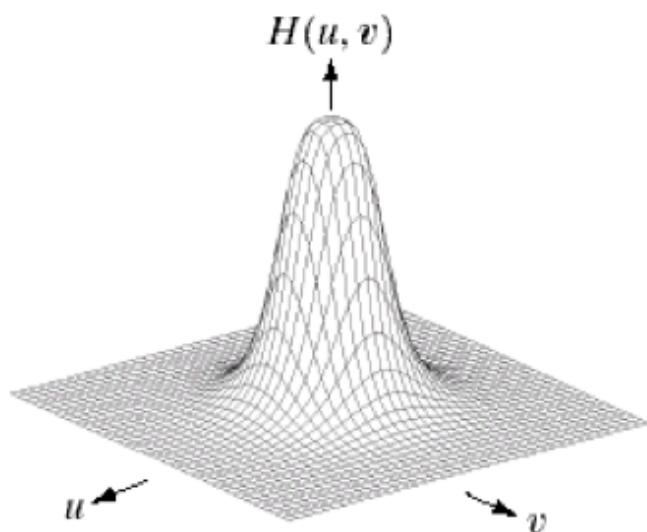
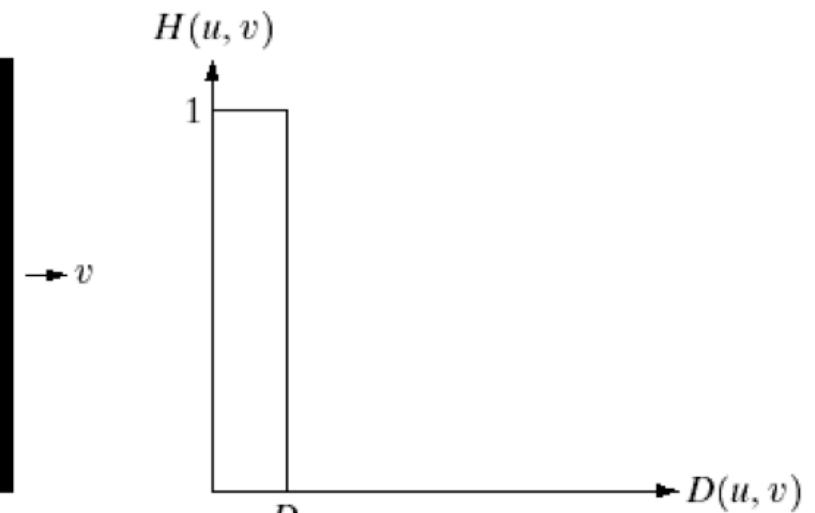
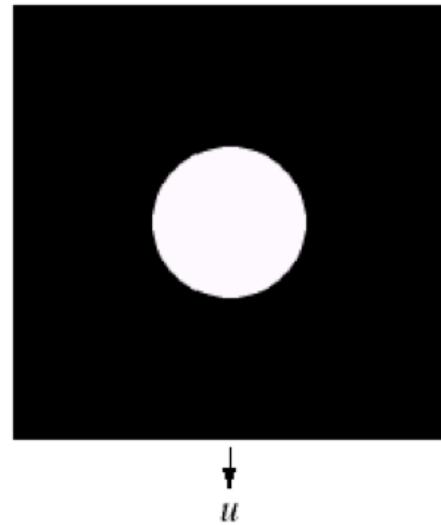
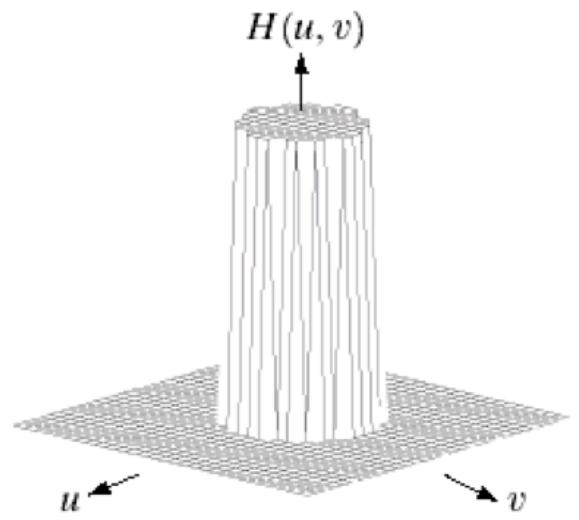


$$|F(u,v)|$$

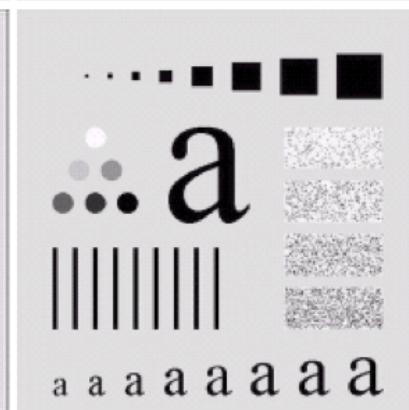
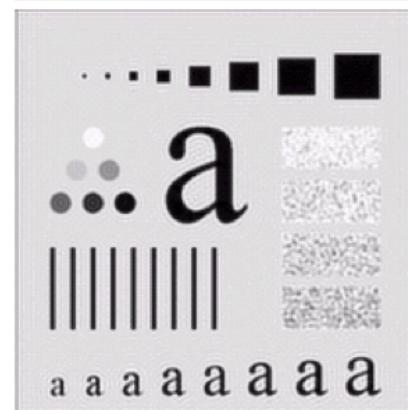
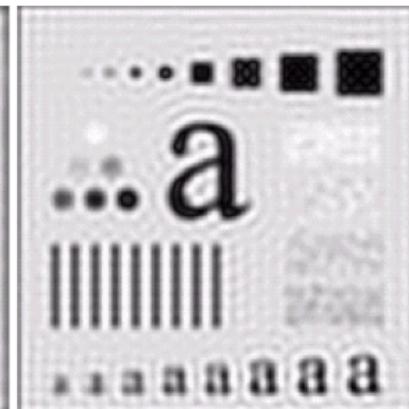
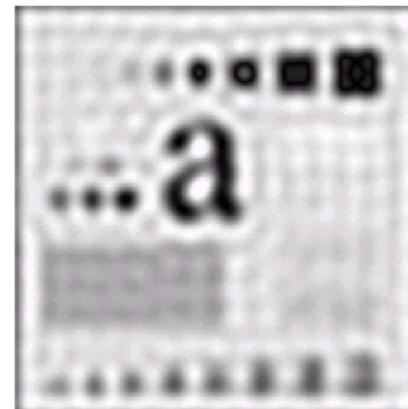
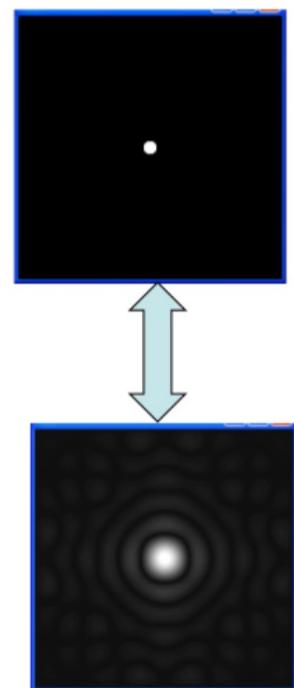
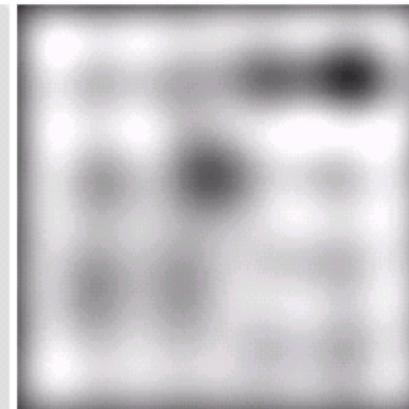
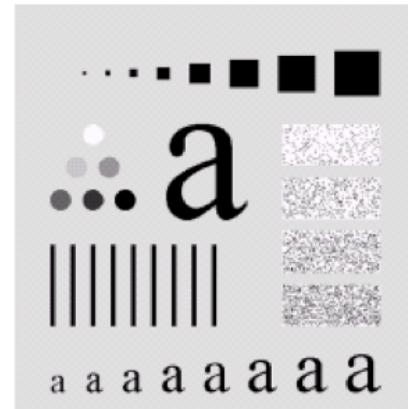
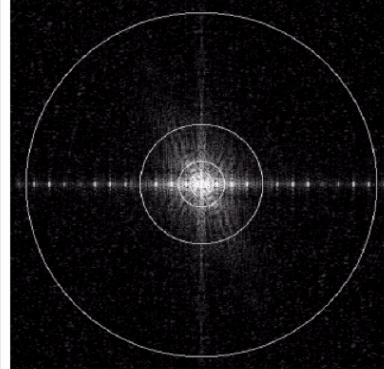
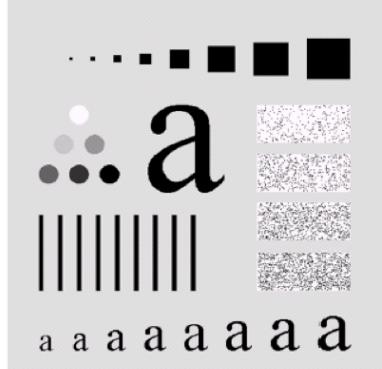


$$|G(u,v)|$$

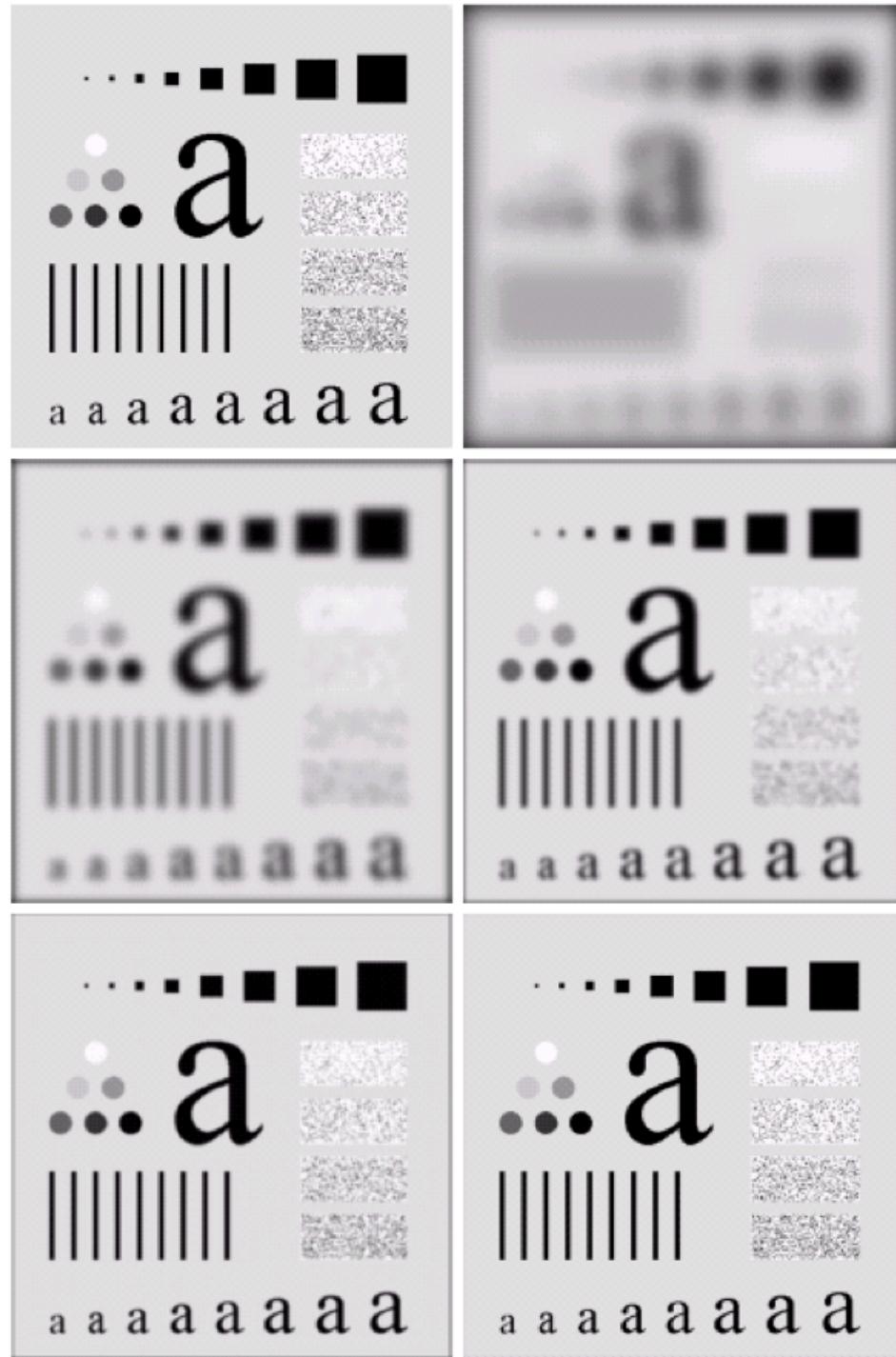
Passa basso: filtri ideali e filtri smooth



Filtri ideali in Fourier ed effetto "ringing"



Filtro Gaussiano



Filtri passa alto e gradiente dell'immagine

Sx

-1	-2	-1
0	0	0
1	2	1

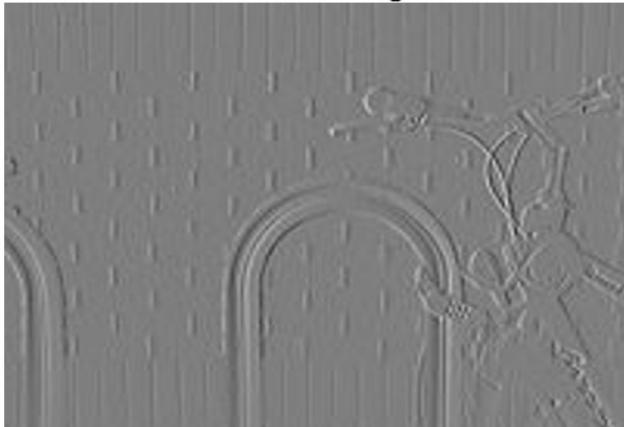
$$g_x = S_x * f$$

$$g_y = S_y * f$$

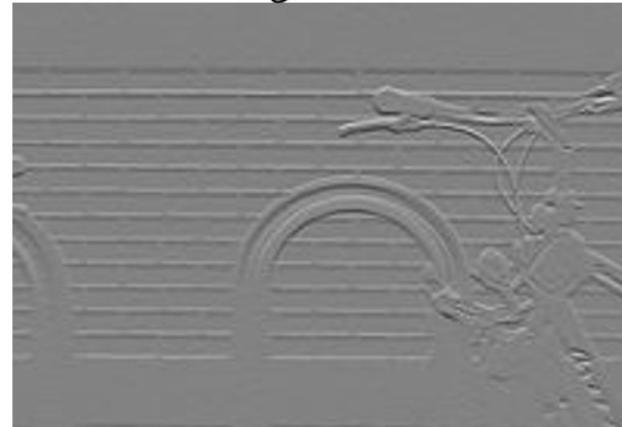
$$S_y = S_x^\top$$



$$S_x * f$$



$$S_y * f$$



$$M$$



Cosa sono gli edge?

- I contorni, o edge, sono cambiamenti significativi e locali all'interno di un'immagine
- Tipicamente si verificano in prossimità dei bordi di diverse regioni dell'immagine
- Non corrispondono necessariamente ai contorni di oggetti reali

Come si calcolano?

- Gli edge sono punti dell'immagine dove si è verificata una alta variazione dei valori di intensità luminosa
- Possono essere messi in evidenza con filtri passa alto

Contorni e ombre



UniGe

