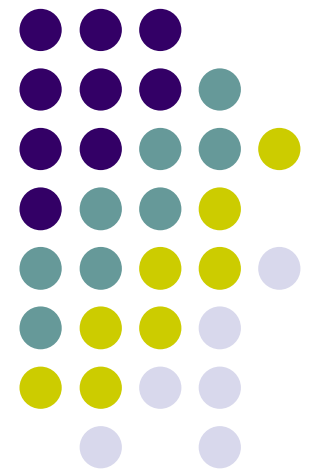


# Procesamiento Digital de Imágenes

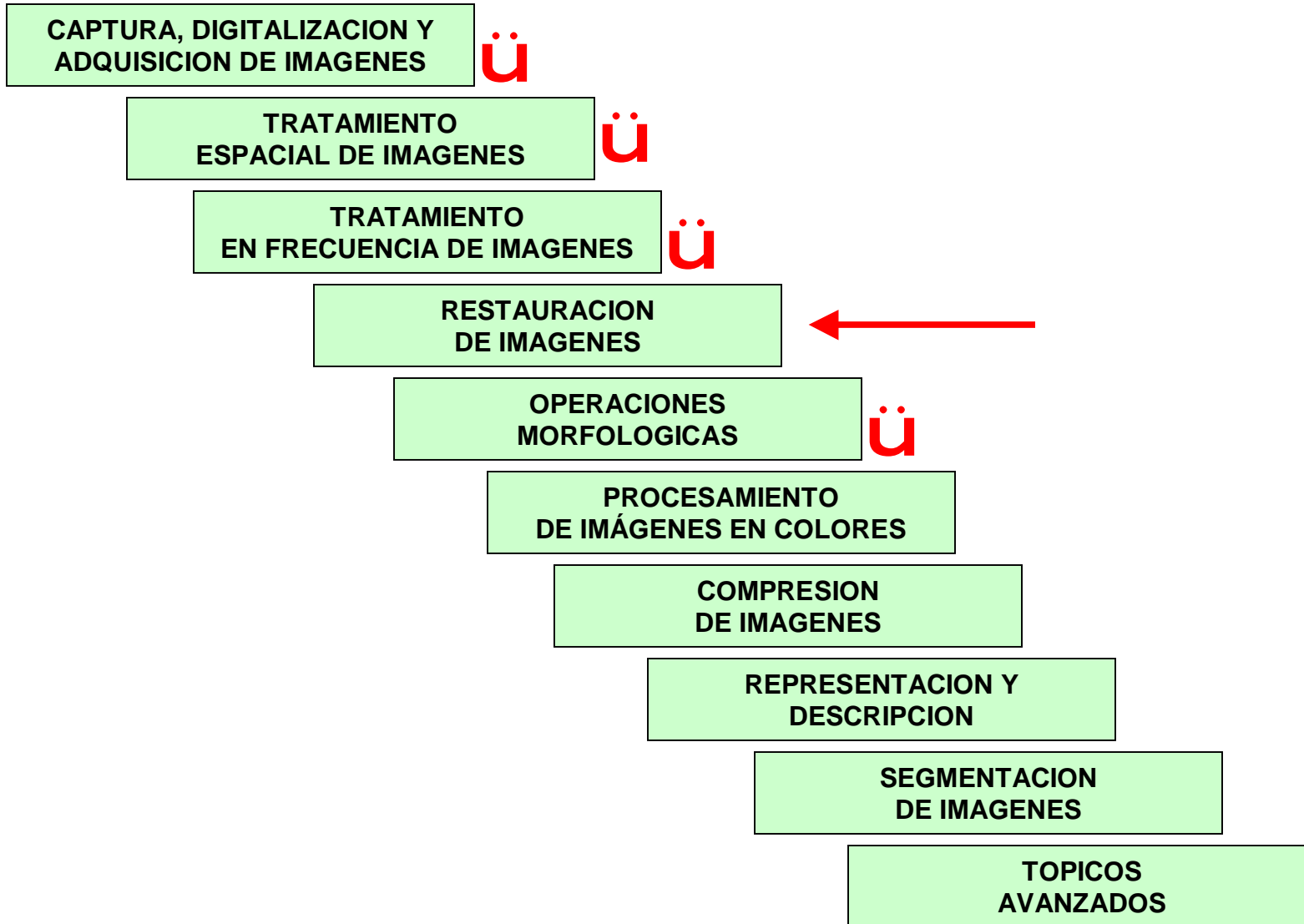
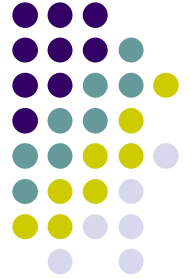
---

Pablo Roncagliolo B.

Nº 10



# Orden de las clases...

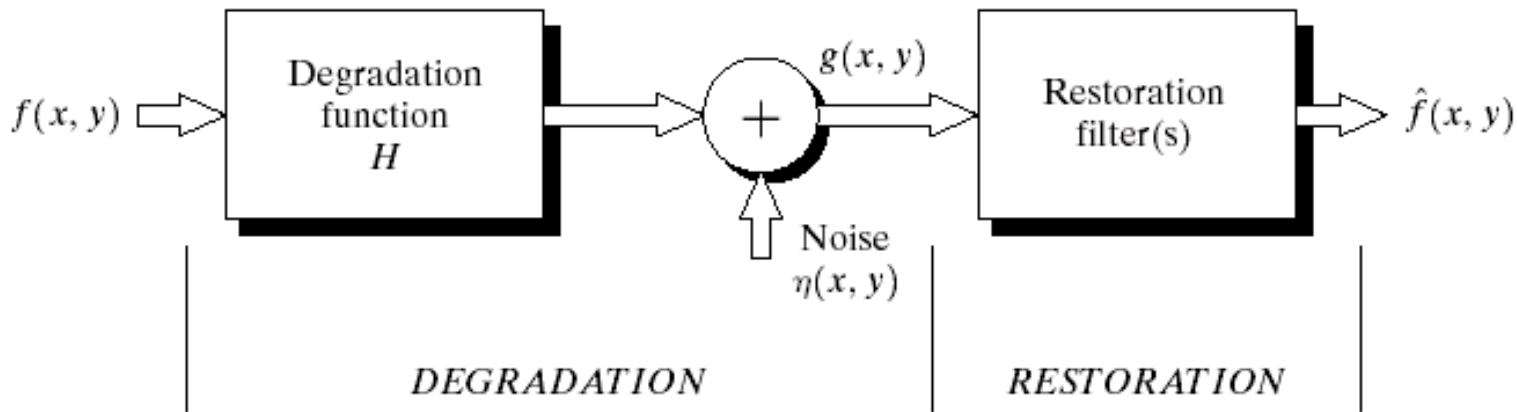




# RESTAURACION DE IMAGENES

## DEGRADACION (Alteraciones y Ruido)

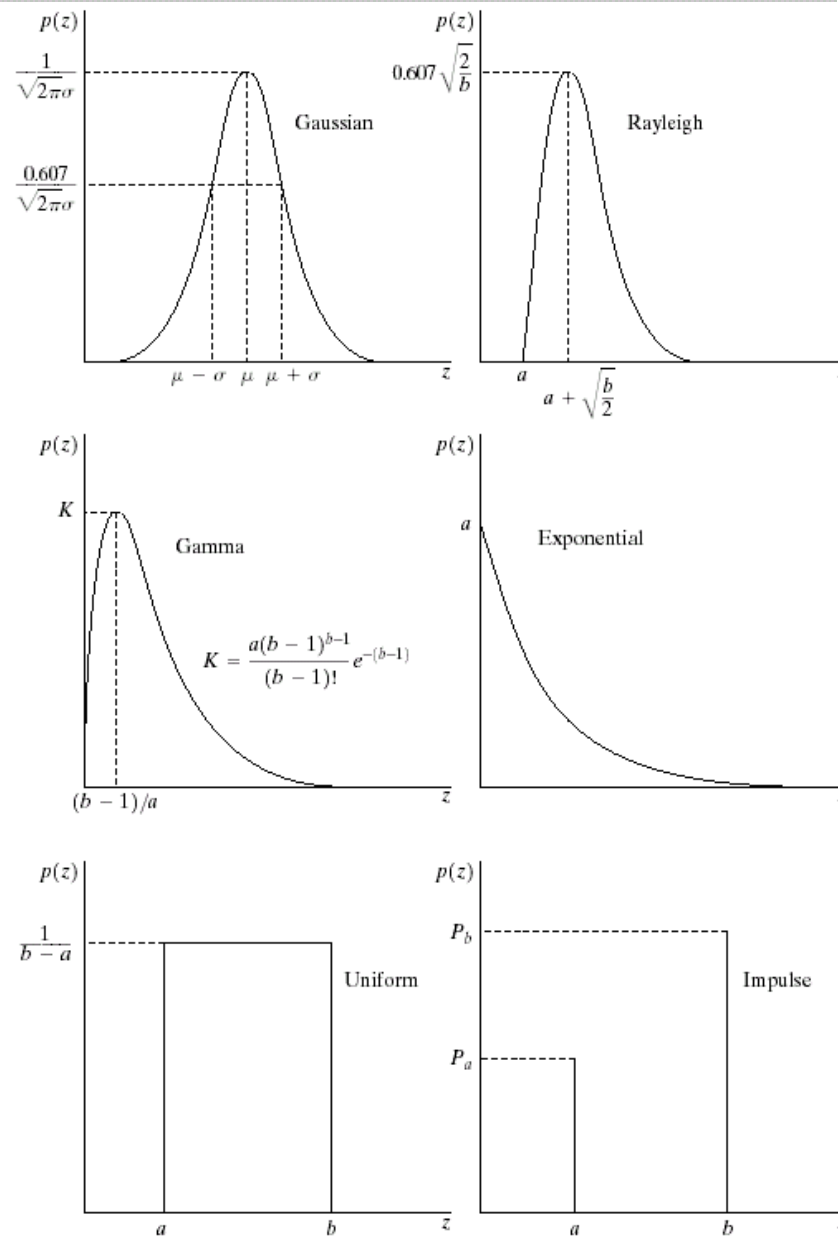
# Proceso Degradación / Restauración



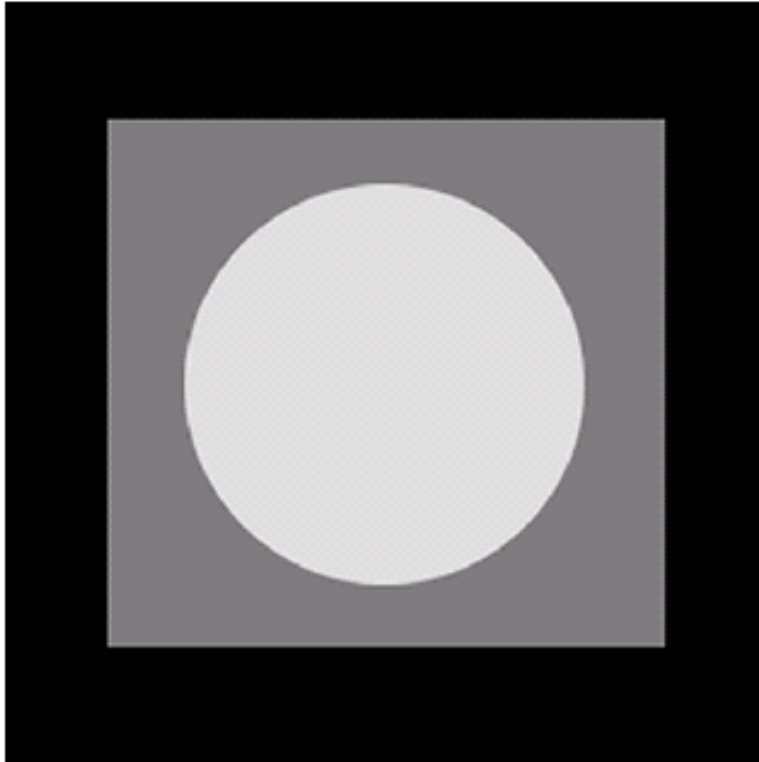
**FIGURE 5.1** A model of the image degradation/restoration process.

# Degradación por adición de ruido

FIGURE 5.2 Some important probability density functions.



# Degradación por adición de ruido



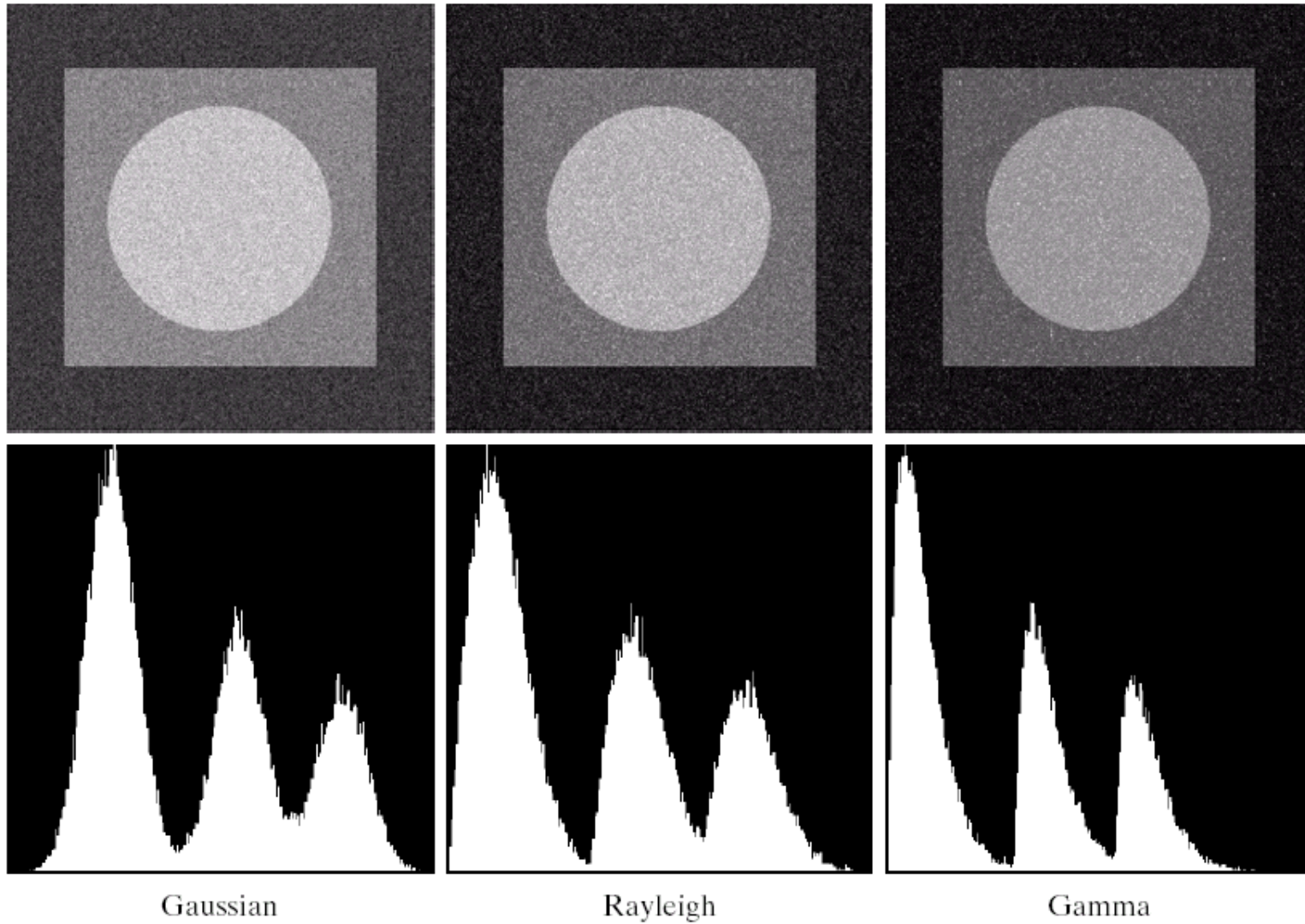
**FIGURE 5.3** Test pattern used to illustrate the characteristics of the noise PDFs shown in Fig. 5.2.

**% Ej. Agregar ruido**

```
IM2=imnoise(IM,'gaussian',mean,var)
```

```
IM2=imnoise(IM,'salt & pepper', percent)
```

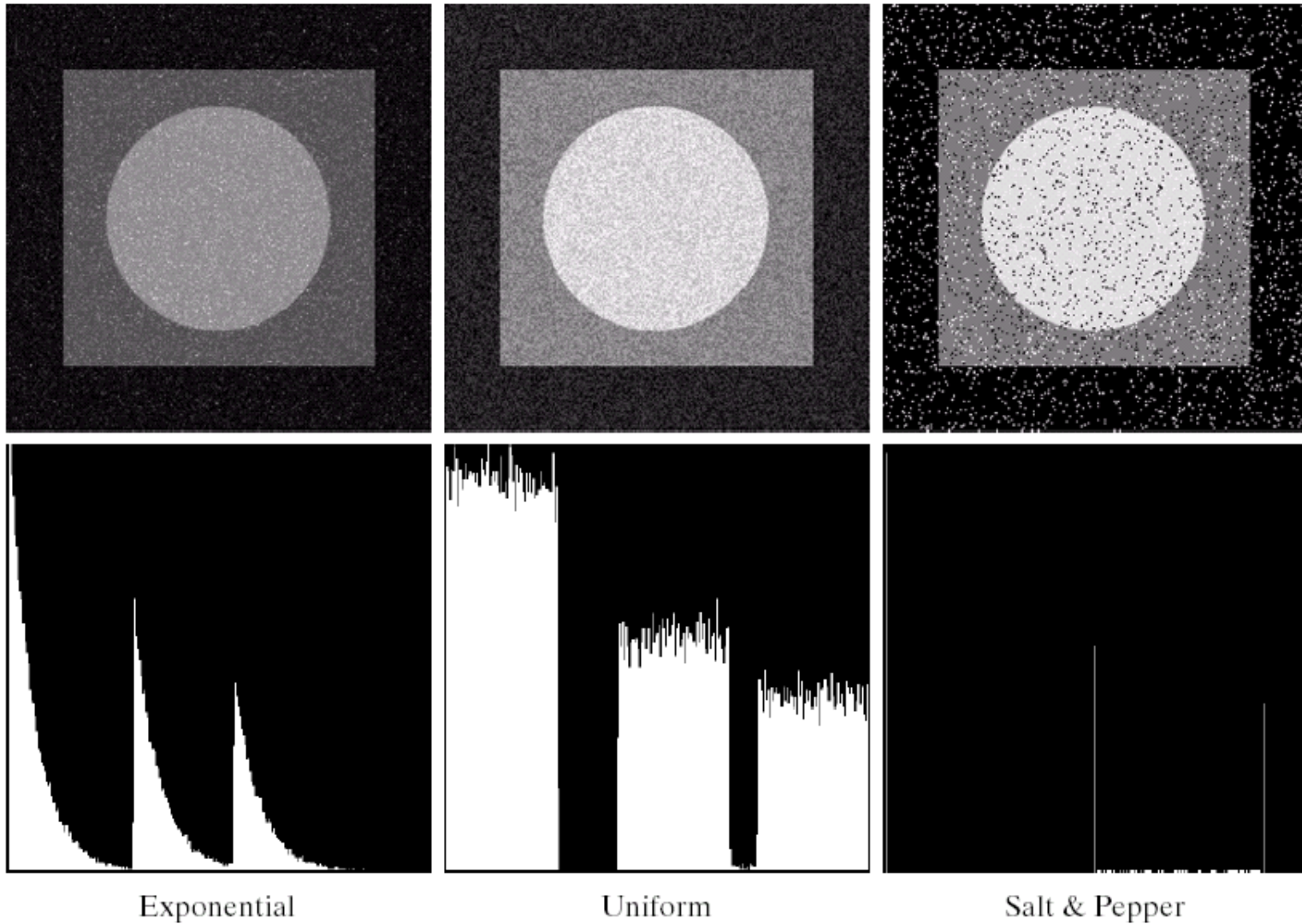
# Degradación por adición de ruido



a	b	c
d	e	f

**FIGURE 5.4** Images and histograms resulting from adding Gaussian, Rayleigh, and gamma noise to the image in Fig. 5.3.

# Degradación por adición de ruido



g	h	i
j	k	l

**FIGURE 5.4** (Continued) Images and histograms resulting from adding exponential, uniform, and impulse noise to the image in Fig. 5.3.



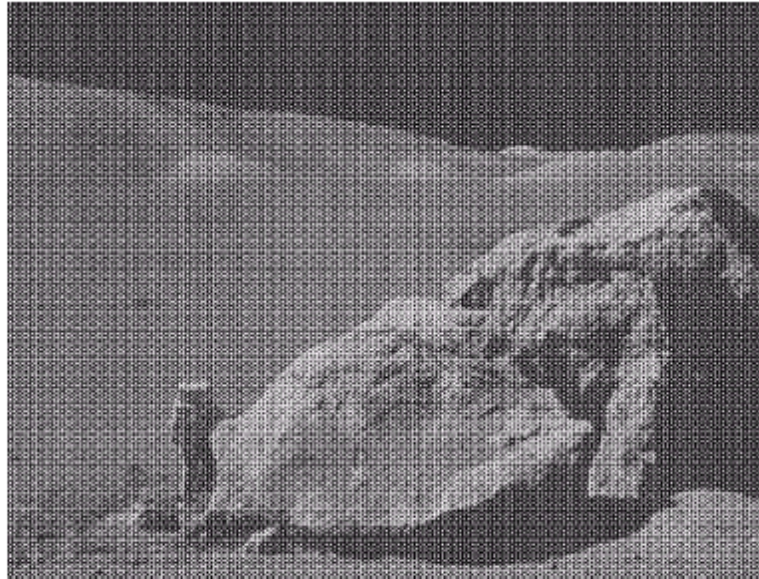
# Degradación por adición de ruido



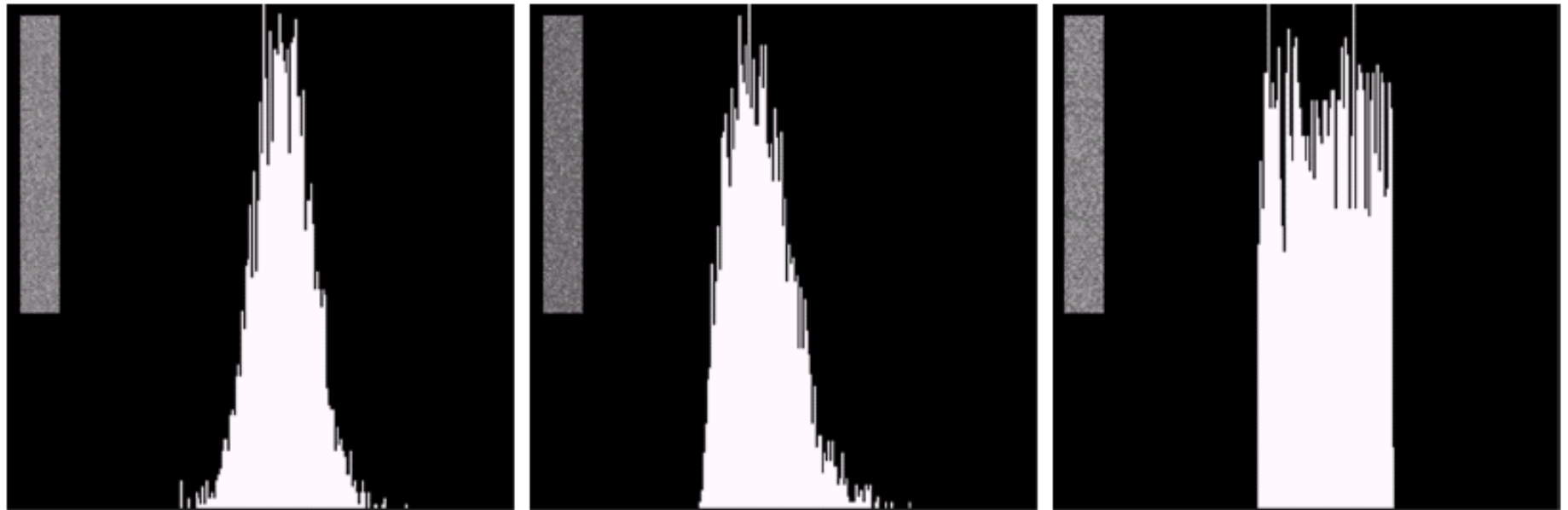
a  
b

**FIGURE 5.5**

(a) Image corrupted by sinusoidal noise.  
(b) Spectrum (each pair of conjugate impulses corresponds to one sine wave).  
(Original image courtesy of NASA.)



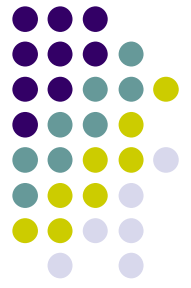
# Degradación por adición de ruido



a b c

**FIGURE 5.6** Histograms computed using small strips (shown as inserts) from (a) the Gaussian, (b) the Rayleigh, and (c) the uniform noisy images in Fig. 5.4.

# Degradación por adición de ruido



Filtro de media aritmética:

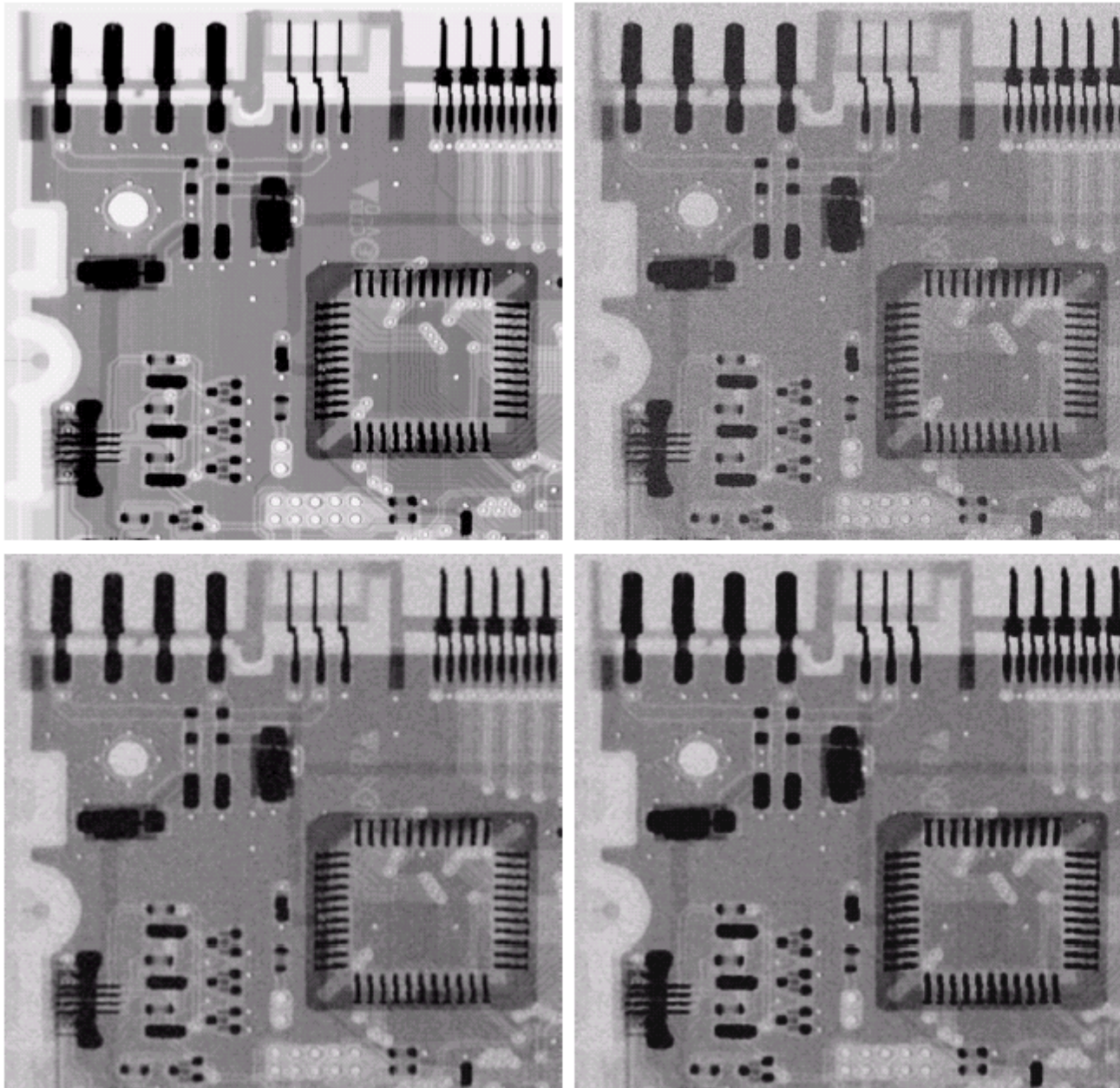
$$f(x, y) = \frac{1}{mn} \sum g(s, t) \quad \text{con } (s, t) \in \text{vecindad de } (x, y)$$

Filtro de media geométrica:

$$f(x, y) = \left[ \prod g(s, t) \right]^{\frac{1}{mn}}$$

*Logra un proceso de filtrado simple, pero mantiene detalles*

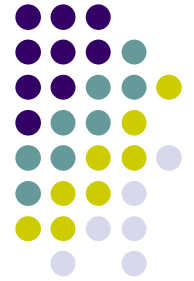
# Degradación por adición de ruido



a	b
c	d

**FIGURE 5.7** (a) X-ray image. (b) Image corrupted by additive Gaussian noise. (c) Result of filtering with an arithmetic mean filter of size  $3 \times 3$ . (d) Result of filtering with a geometric mean filter of the same size. (Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.)

# Degradación por adición de ruido



Filtro de media *Contra*harmonic :

$$f(x, y) = \frac{\sum g(s, t)^{Q+1}}{\sum g(s, t)^Q}$$

*Se utiliza para filtrar ruidos tipo sal y pimienta. El parámetro Q corresponde al orden del filtro. Con Q positivo se puede eliminar el ruido 'pimienta'. Con Q negativo se puede eliminar el ruido 'sal'.*

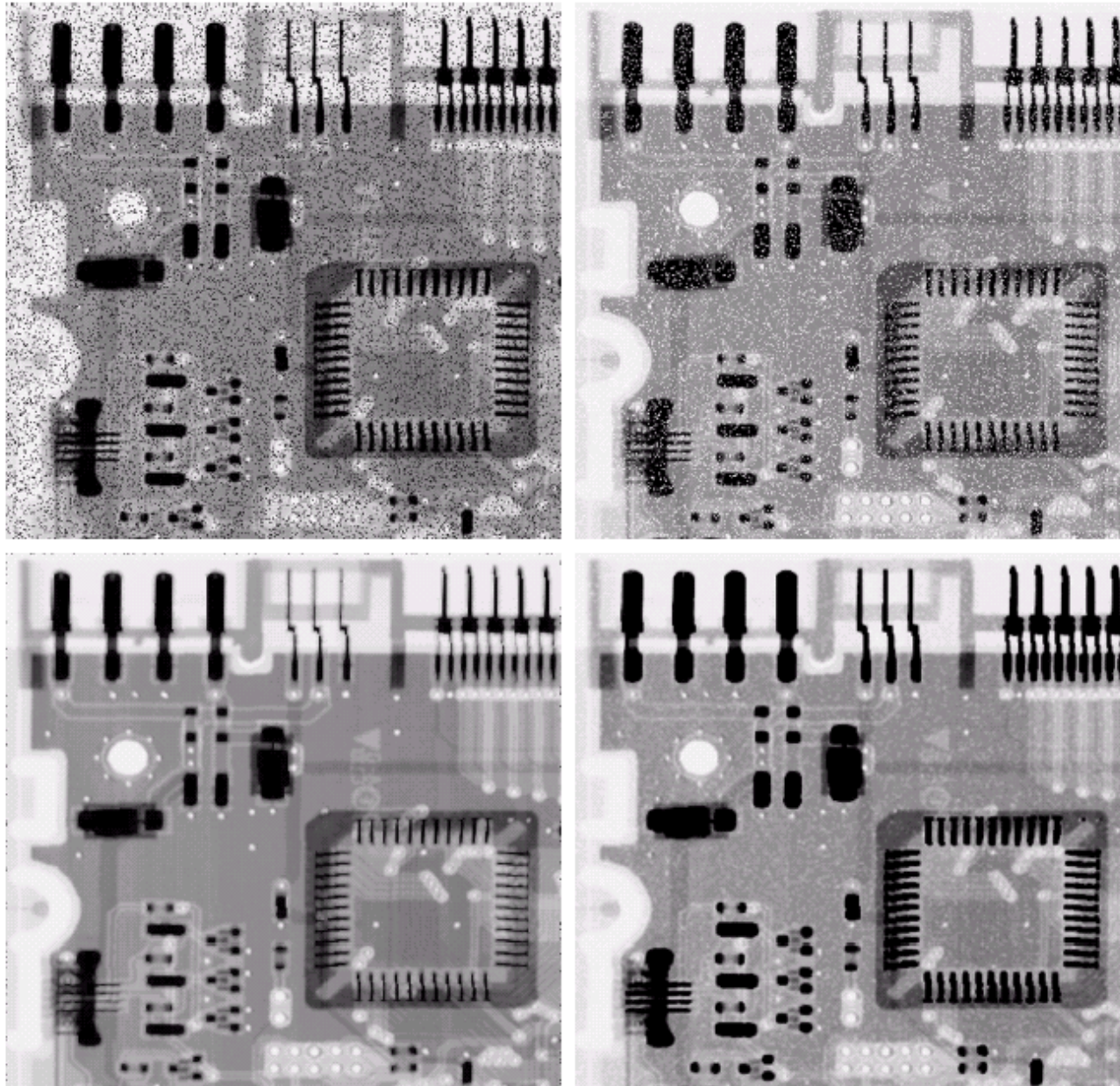
# Degradación por adición de ruido



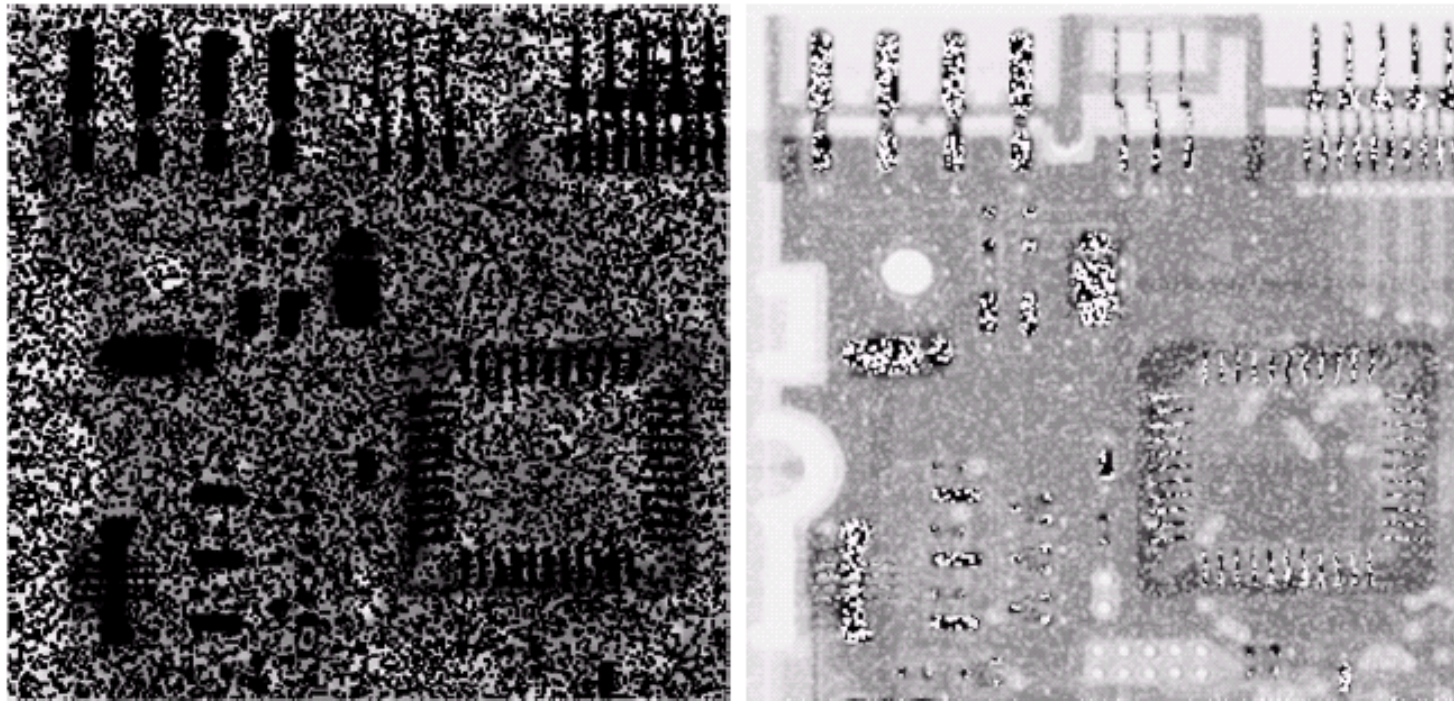
a b  
c d

**FIGURE 5.8**

(a) Image corrupted by pepper noise with a probability of 0.1. (b) Image corrupted by salt noise with the same probability. (c) Result of filtering (a) with a  $3 \times 3$  contraharmonic filter of order 1.5. (d) Result of filtering (b) with  $Q = -1.5$ .



# Degradación por adición de ruido



a b

**FIGURE 5.9** Results of selecting the wrong sign in contraharmonic filtering. (a) Result of filtering Fig. 5.8(a) with a contraharmonic filter of size  $3 \times 3$  and  $Q = -1.5$ . (b) Result of filtering 5.8(b) with  $Q = 1.5$ .

*No resulta si el parámetro  $Q$  está cambiando.*

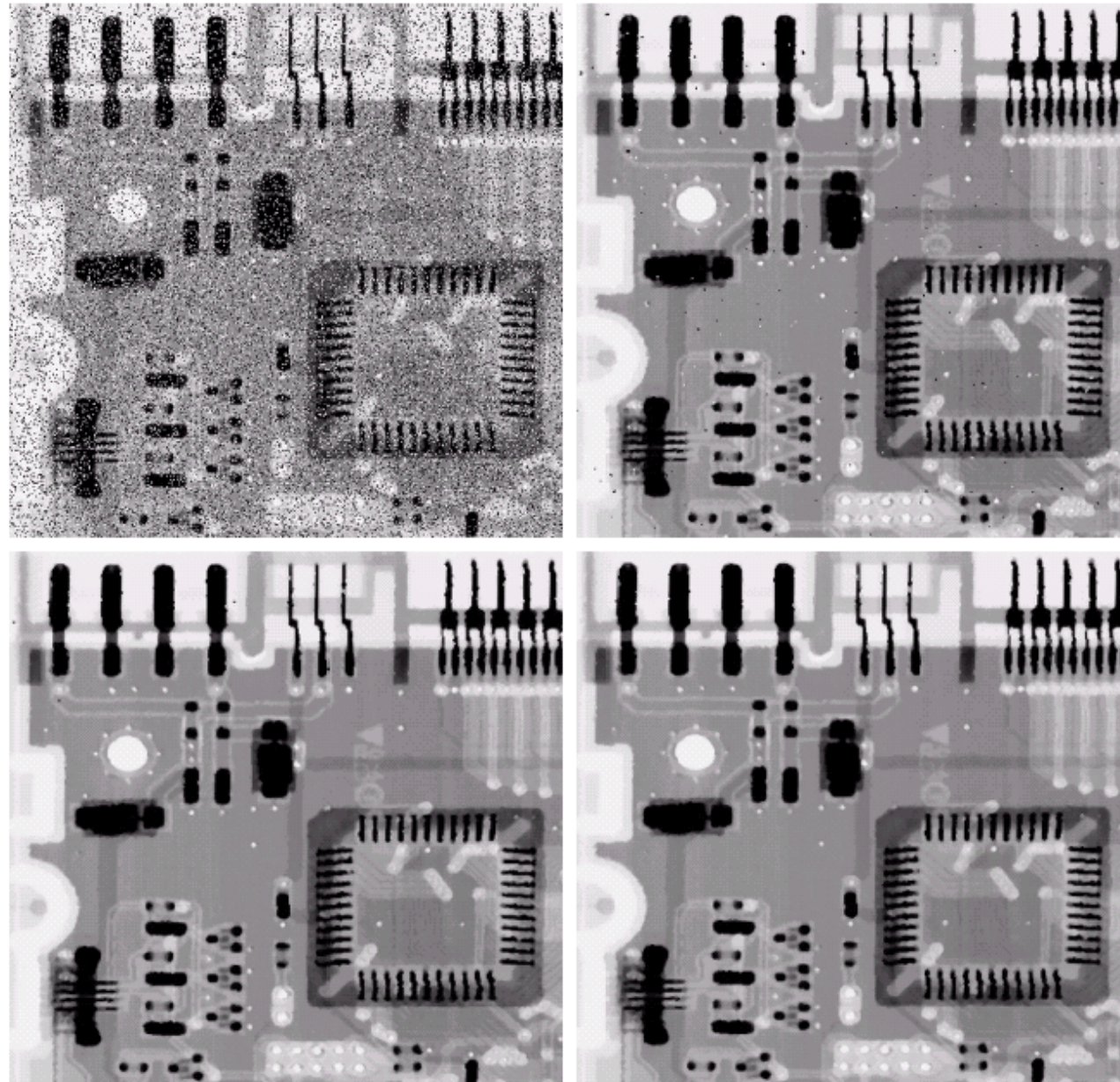
# Degradación por adición de ruido



a b  
c d

**FIGURE 5.10**

(a) Image corrupted by salt-and-pepper noise with probabilities  $P_a = P_b = 0.1$ .  
(b) Result of one pass with a median filter of size  $3 \times 3$ .  
(c) Result of processing (b) with this filter.  
(d) Result of processing (c) with the same filter.



*Aplicación  
recursiva de filtro  
de “mediana”*



# Degradación por adición de ruido



Filtro de máxima:

$$f(x, y) = \text{median}\{g(s, t)\}$$

$$f(x, y) = \max\{g(s, t)\}$$

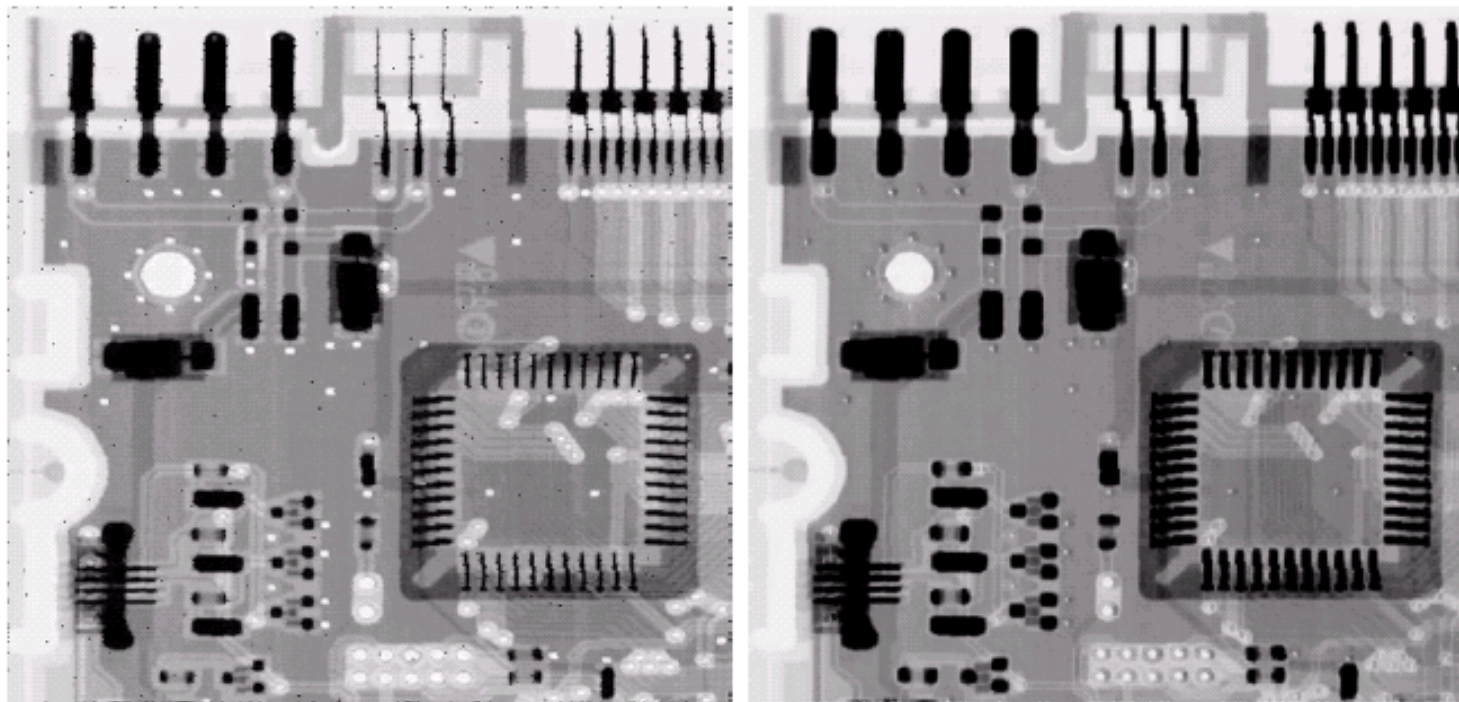
$$f(x, y) = \min\{g(s, t)\}$$

Filtro de punto medio:

$$f(x, y) = \frac{1}{2} [\max\{g(s, t)\} + \min\{g(s, t)\}]$$

*Filtros estadísticos básicos.*

# Degradación por adición de ruido



a b

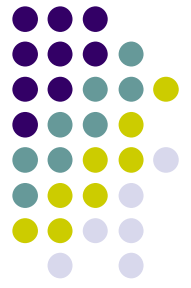
**FIGURE 5.11**

(a) Result of filtering Fig. 5.8(a) with a max filter of size  $3 \times 3$ . (b) Result of filtering 5.8(b) with a min filter of the same size.

*Filtro “max” para ruido “pimienta”*

*Filtro “min” para ruido “sal”*

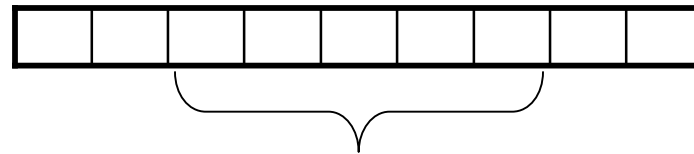
# Degradación por adición de ruido



Filtro de media de sección (*Alpha-trimmed mean filter*):

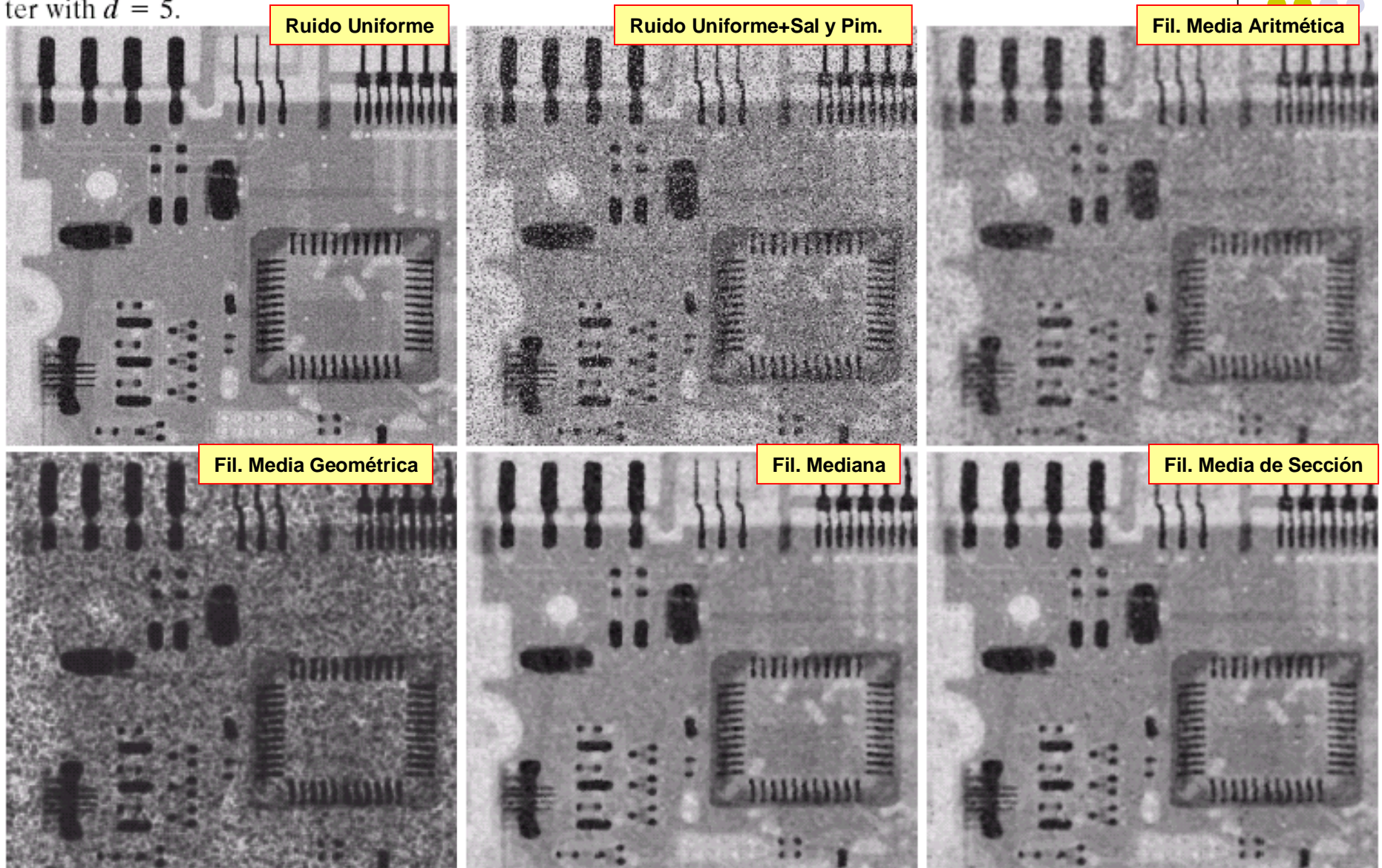
$$f(x, y) = \frac{1}{mn - d} \sum g_r(s, t)$$

*Se eliminan los  $d/2$  menores y los  $d/2$  mayores niveles de gris de la vecindad de  $x, y$ . Por lo tanto el nuevo tamaño de la vecindad es  $mn - d$ . La función sumatoria de  $g_r$  corresponde a la suma de los píxeles remanentes.*

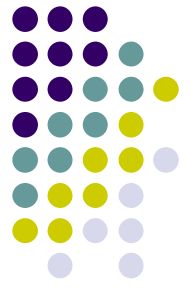


# Degradación por adición de ruido

**FIGURE 5.12** (a) Image corrupted by additive uniform noise. (b) Image additionally corrupted by additive salt-and-pepper noise. Image in (b) filtered with a  $5 \times 5$ : (c) arithmetic mean filter; (d) geometric mean filter; (e) median filter; and (f) alpha-trimmed mean filter with  $d = 5$ .



# Degradación por adición de ruido



Filtro de media adaptivo:

```
Vmax=tamaño ventana máxima  
Zmin=min en Vecindad  
Zmax=max en Vecindad  
Zmed=mediana en Vecindad  
Zxy=valor (x,y)
```

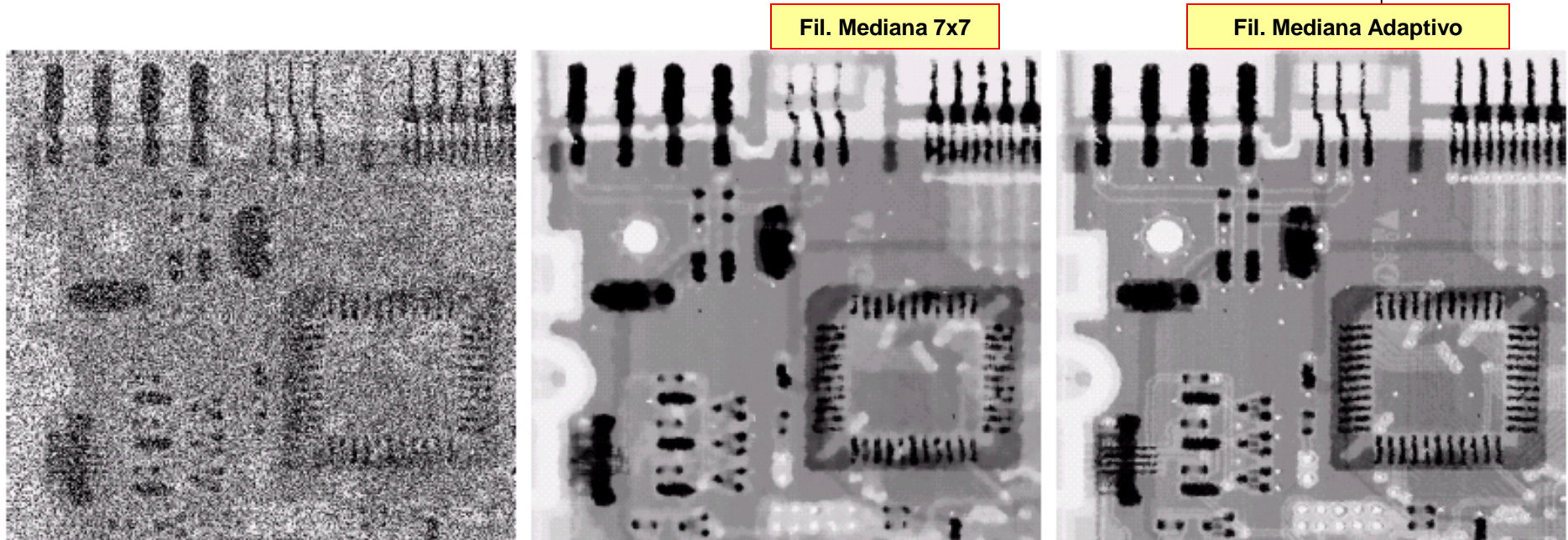
**Level A:**

```
If Zmin < Zmed < Zmax, goto B  
Else aumenta el tamaño de ventana  
If tamaño ventana < Vmax, repeat A  
Else output Zmed
```

**Level B:**

```
If Zmin < Zxy < Zmax, output Zxy  
Else output Zmed
```

# Degradación por adición de ruido



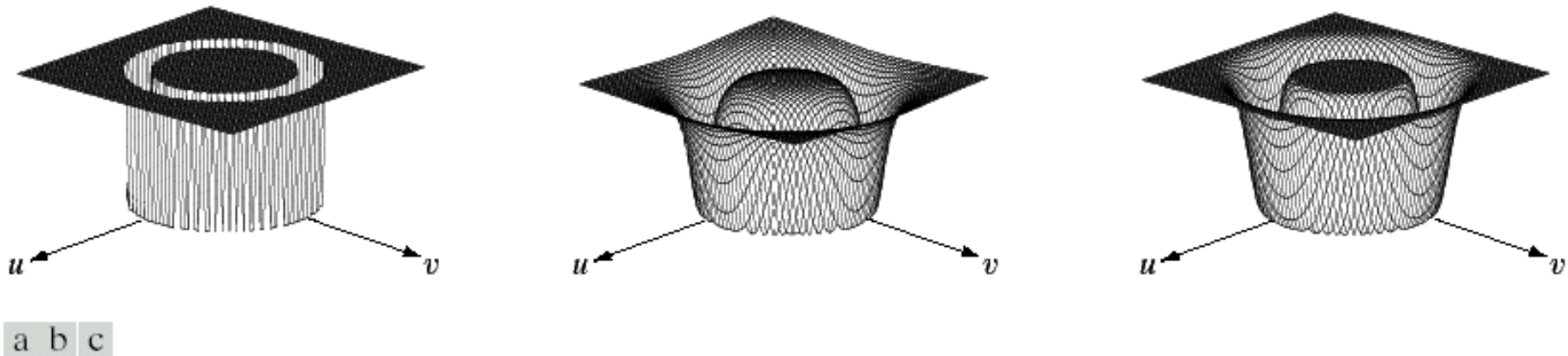
a b c

**FIGURE 5.14** (a) Image corrupted by salt-and-pepper noise with probabilities  $P_a = P_b = 0.25$ . (b) Result of filtering with a  $7 \times 7$  median filter. (c) Result of adaptive median filtering with  $S_{\max} = 7$ .

% Filtro adaptivo  
 $F = \text{admedian}(g, 7)$

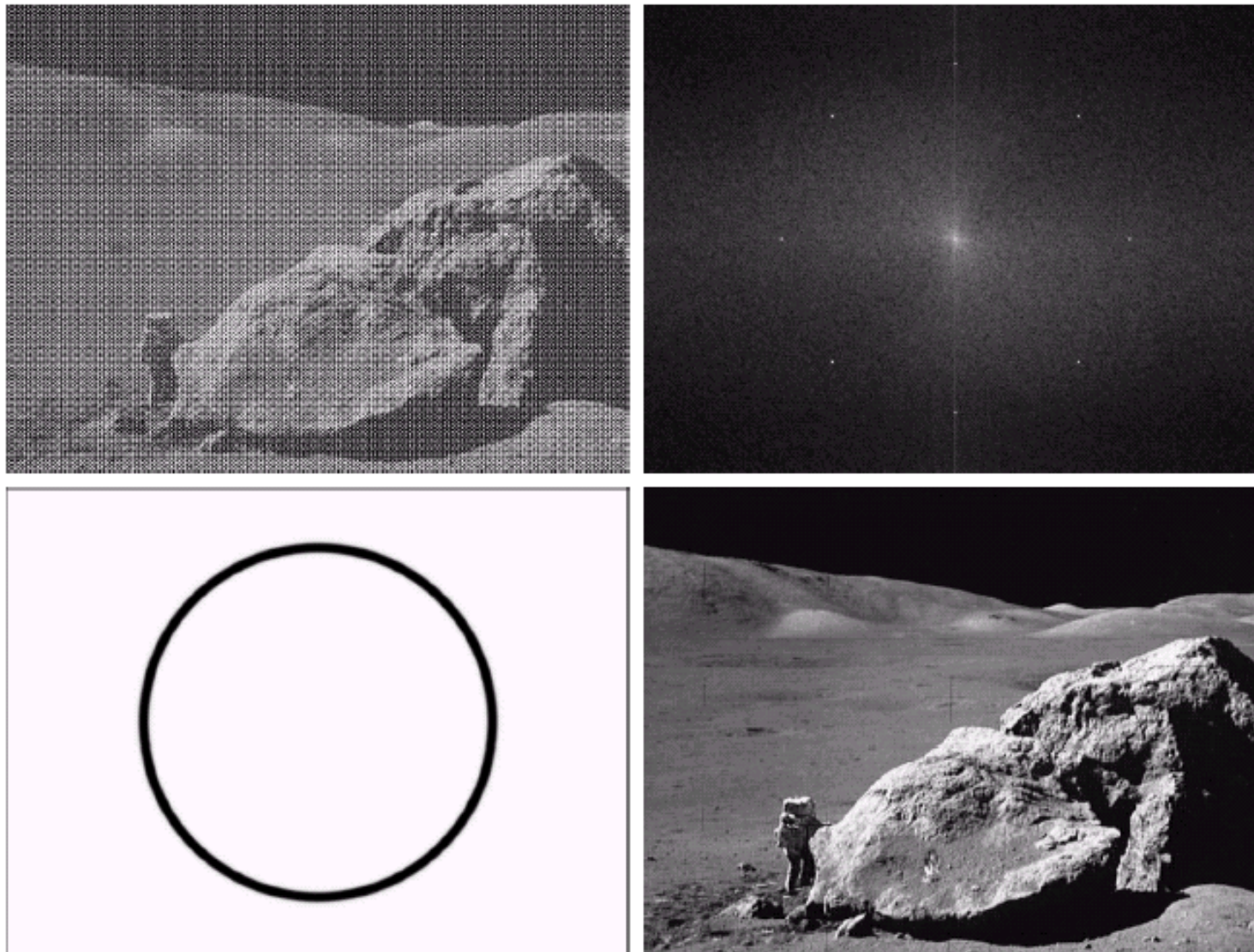
# Degradación por adición de ruido

Otra técnica consiste en aplicar filtros elimina banda, para eliminar ruidos cuyo espectro es conocido è por ej, texturas...



**FIGURE 5.15** From left to right, perspective plots of ideal, Butterworth (of order 1), and Gaussian bandreject filters.

# Degradación por adición de ruido



a	b
c	d

**FIGURE 5.16**

(a) Image corrupted by sinusoidal noise. (b) Spectrum of (a). (c) Butterworth bandreject filter (white represents 1). (d) Result of filtering. (Original image courtesy of NASA.)

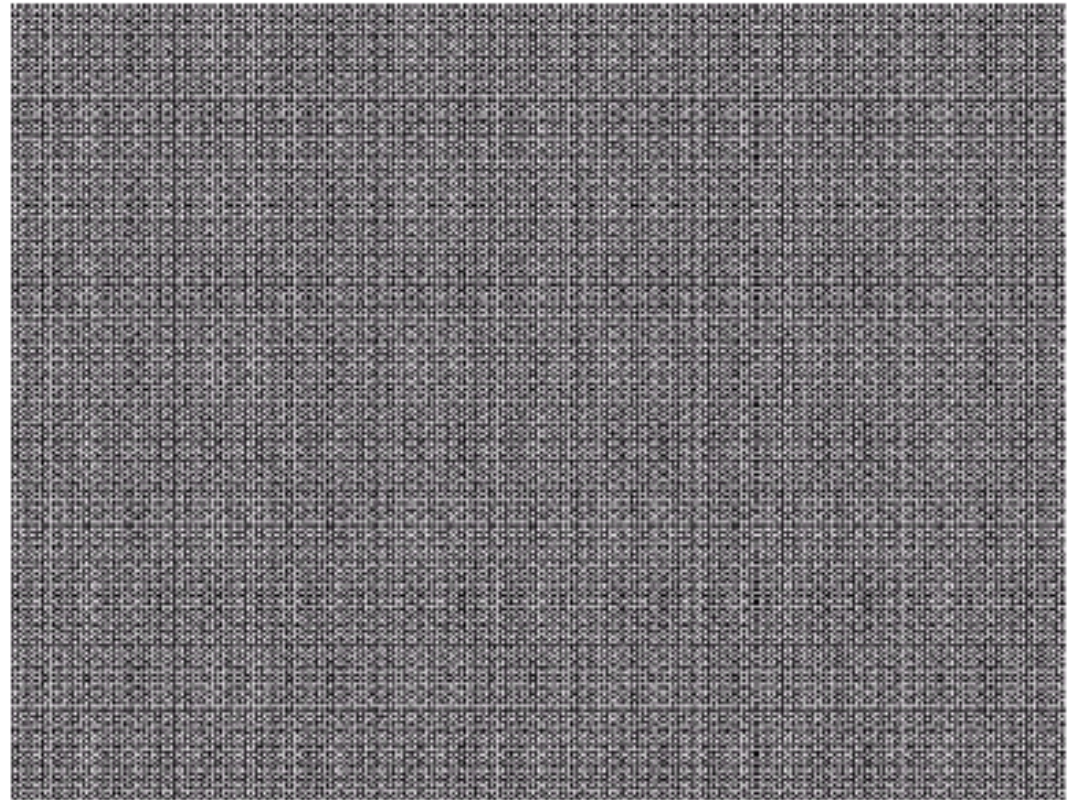


# Degradación por adición de ruido

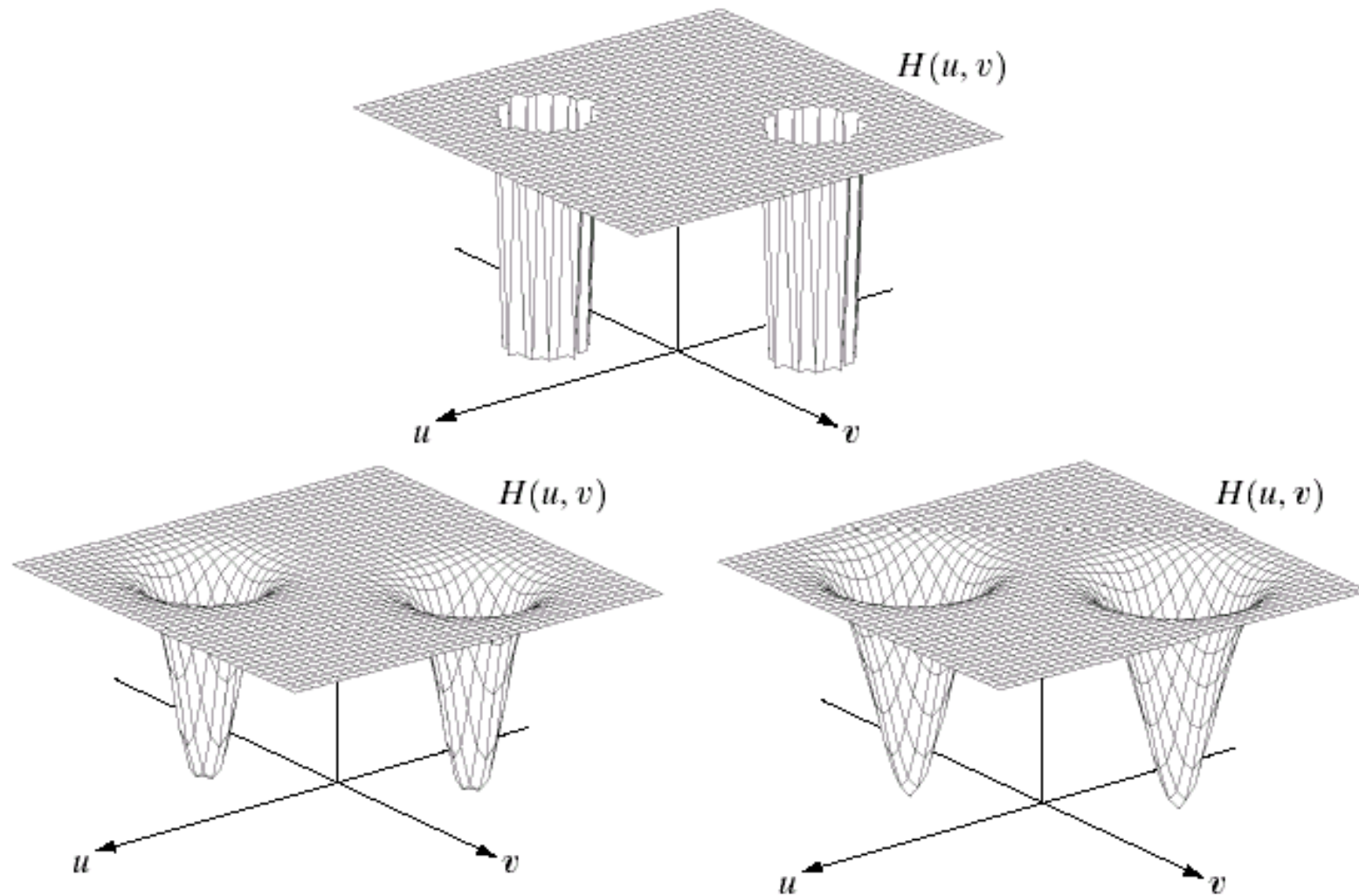


## FIGURE 5.17

Noise pattern of  
the image in  
Fig. 5.16(a)  
obtained by  
bandpass filtering.



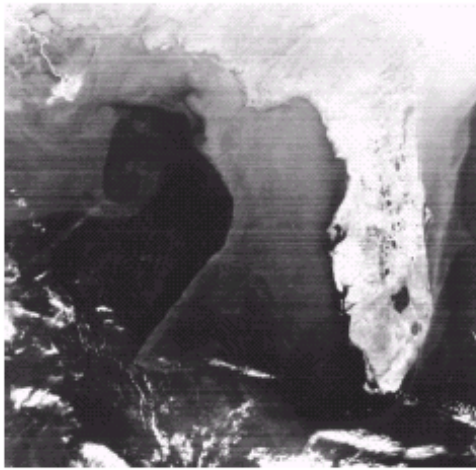
# Degradación por adición de ruido



a  
b c

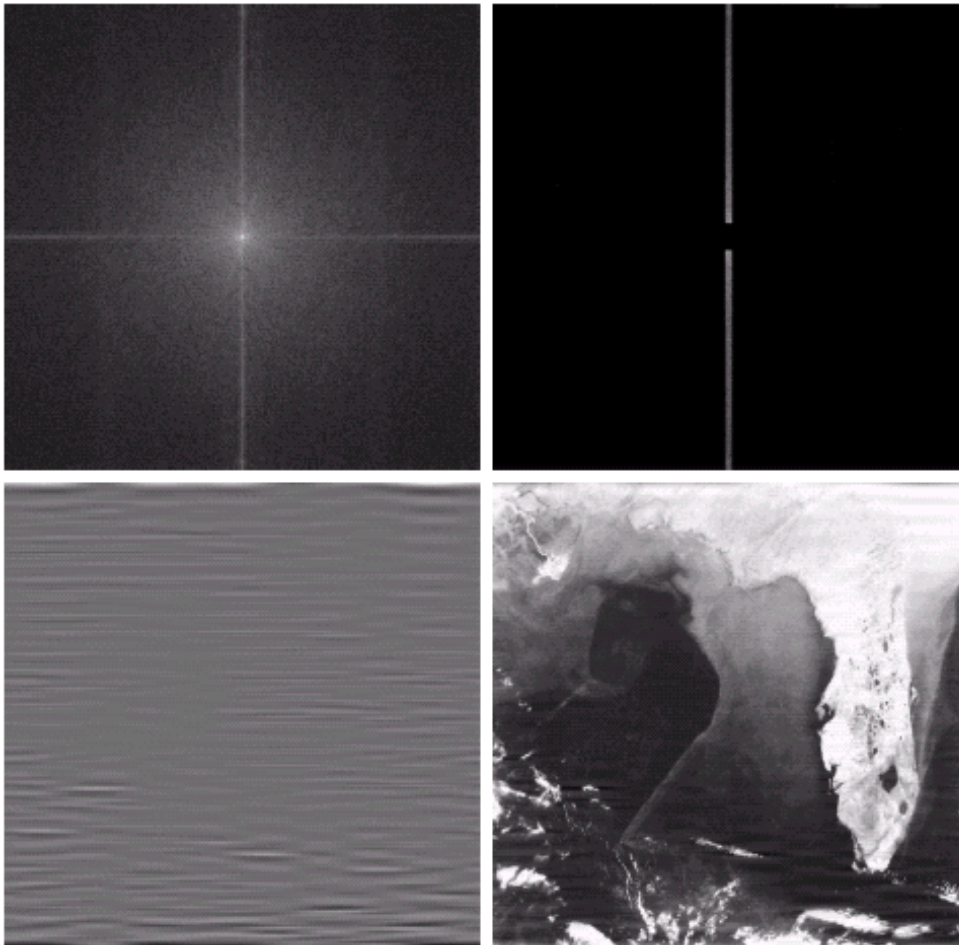
**FIGURE 5.18** Perspective plots of (a) ideal, (b) Butterworth (of order 2), and (c) Gaussian notch (reject) filters.

# Degradación por adición de ruido



a  
b c  
d e

**FIGURE 5.19** (a) Satellite image of Florida and the Gulf of Mexico (note horizontal sensor scan lines). (b) Spectrum of (a). (c) Notch pass filter shown superimposed on (b). (d) Inverse Fourier transform of filtered image, showing noise pattern in the spatial domain. (e) Result of notch reject filtering. (Original image courtesy of NOAA.)



# Degradación por adición de ruido



a b

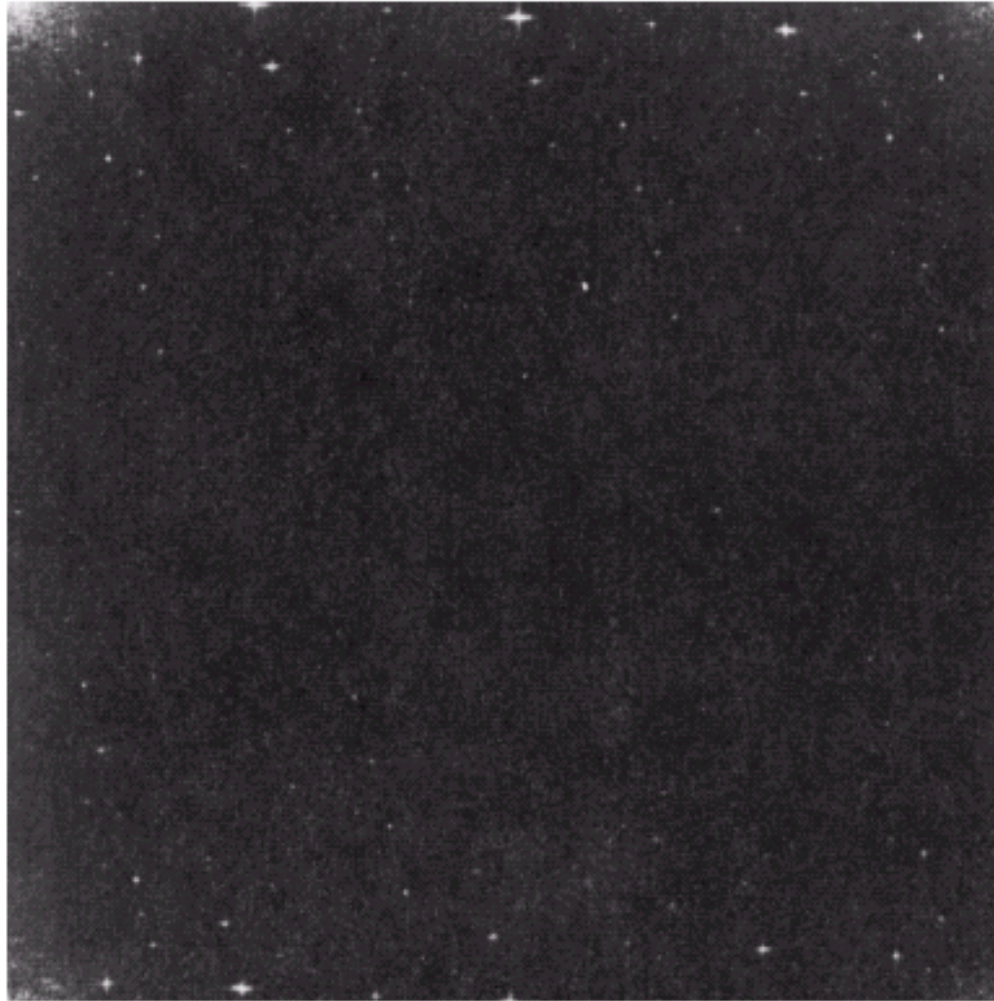
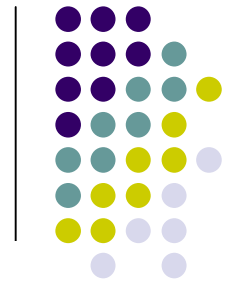
## FIGURE 5.20

(a) Image of the Martian terrain taken by *Mariner 6*.

(b) Fourier spectrum showing periodic interference. (Courtesy of NASA.)

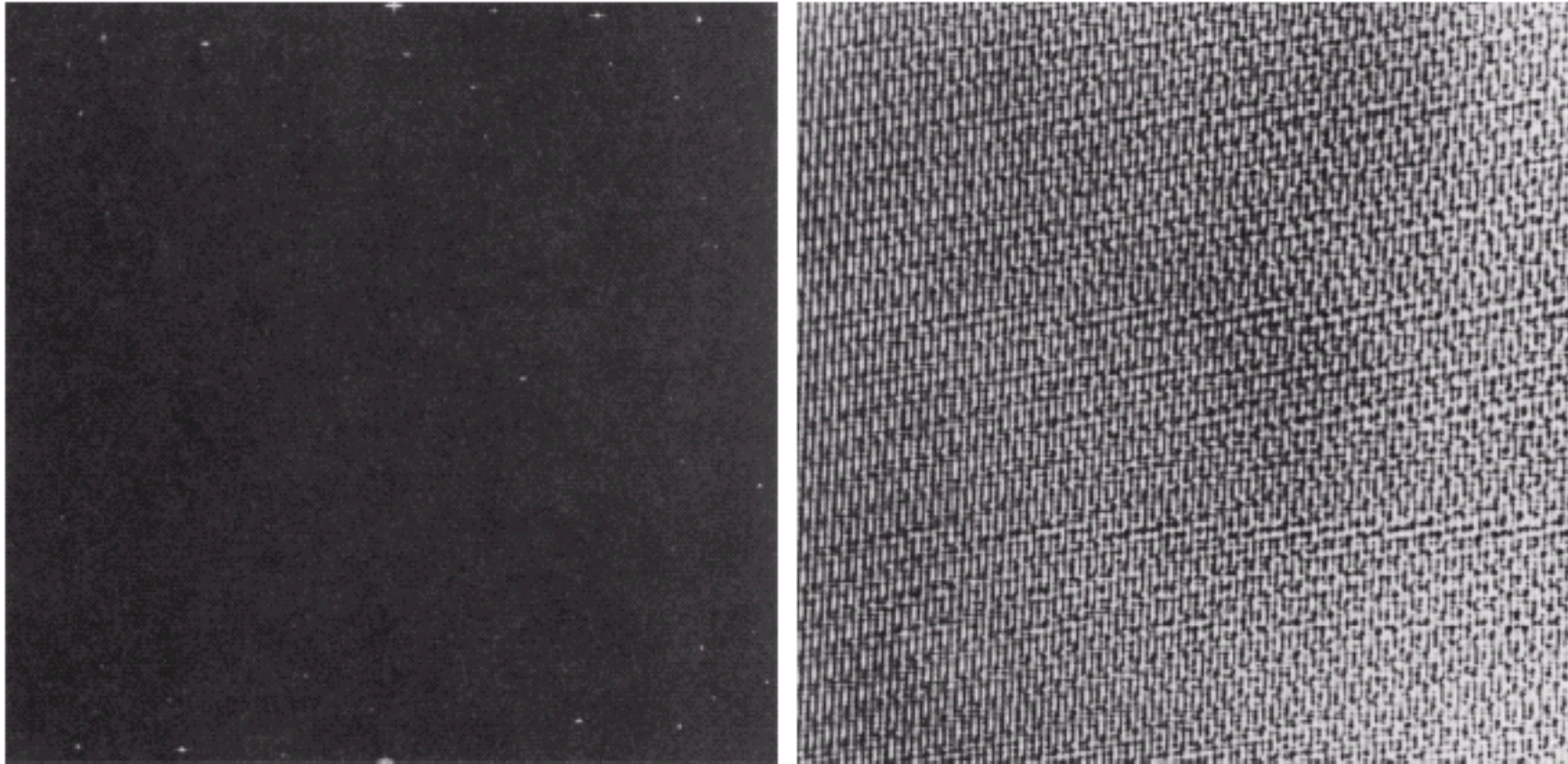


# Degradación por adición de ruido



**FIGURE 5.21** Fourier spectrum (without shifting) of the image shown in Fig. 5.20(a). (Courtesy of NASA.)

# Degradación por adición de ruido

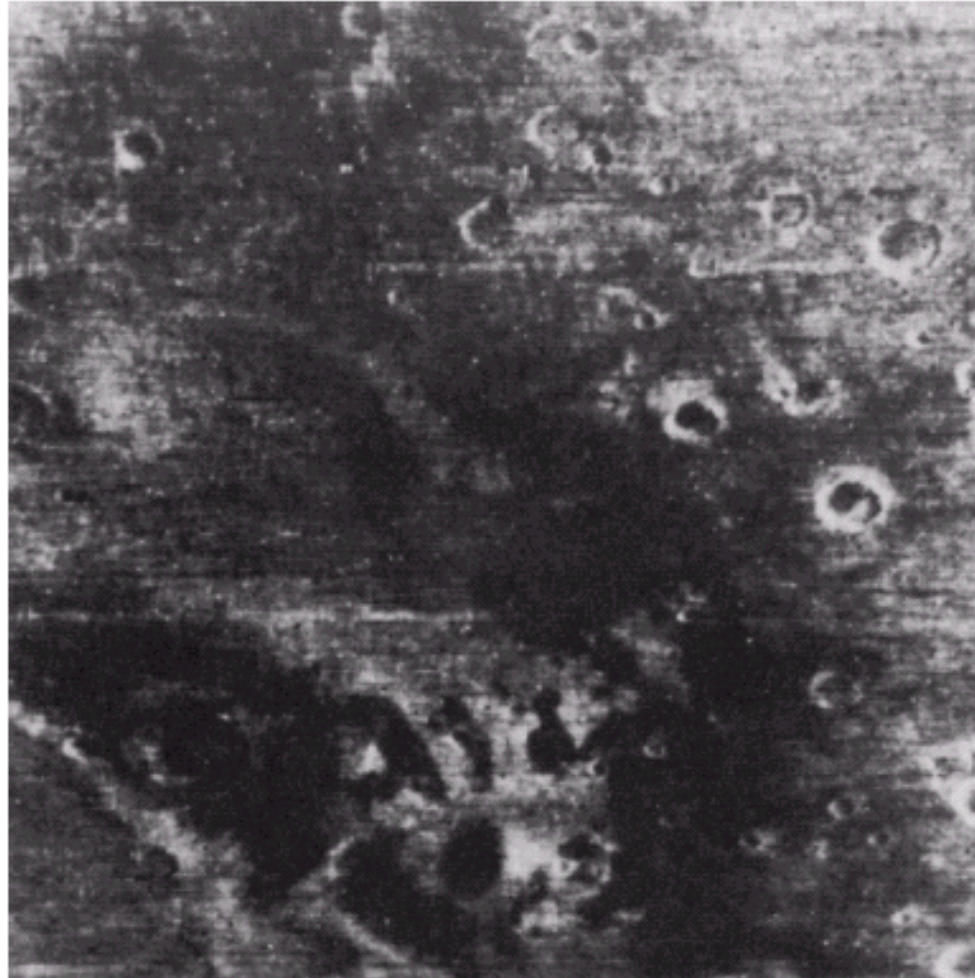


a b

**FIGURE 5.22** (a) Fourier spectrum of  $N(u, v)$ , and (b) corresponding noise interference pattern  $\eta(x, y)$ . (Courtesy of NASA.)

---

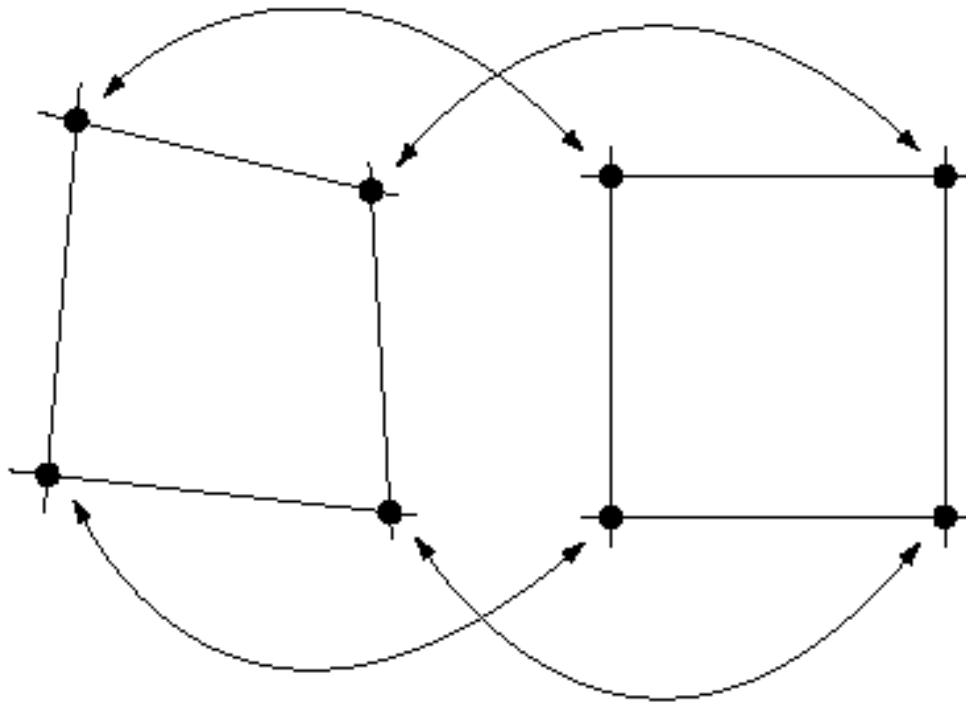
# Degradación por adición de ruido



**FIGURE 5.23** Processed image. (Courtesy of NASA.)

# Degradación por alteraciones en la adquisición

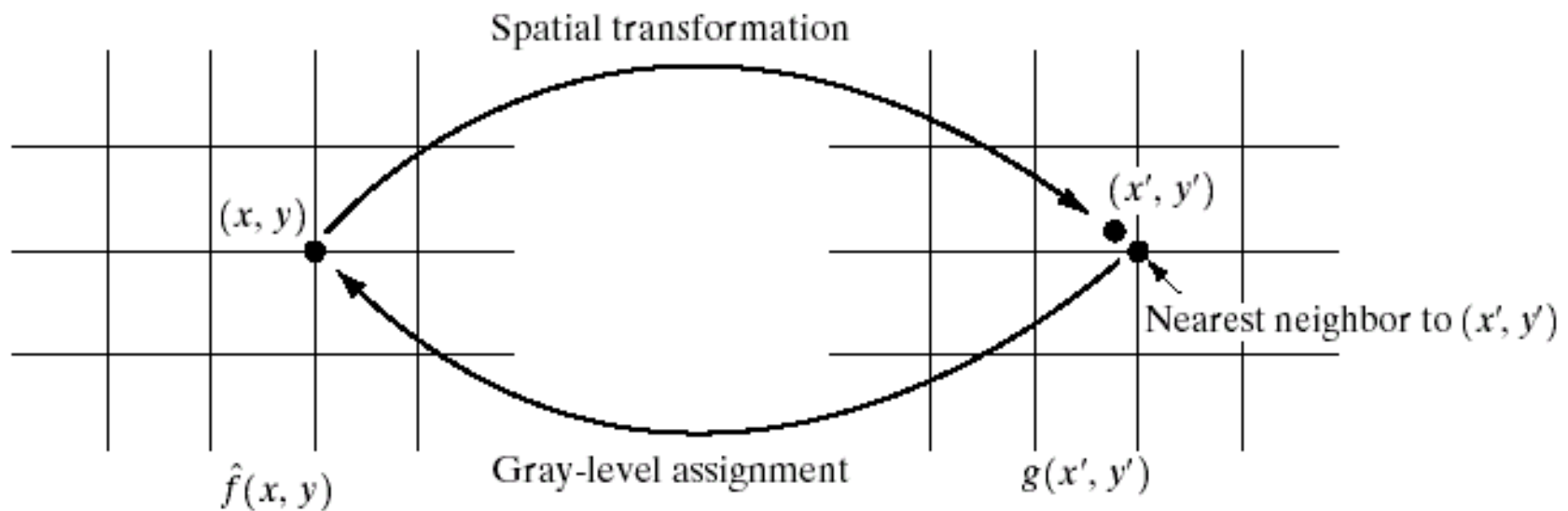
Otra tipo de degradaciones de una imagen  $\Rightarrow$  deformaciones



**FIGURE 5.32**  
Corresponding tiepoints in two image segments.

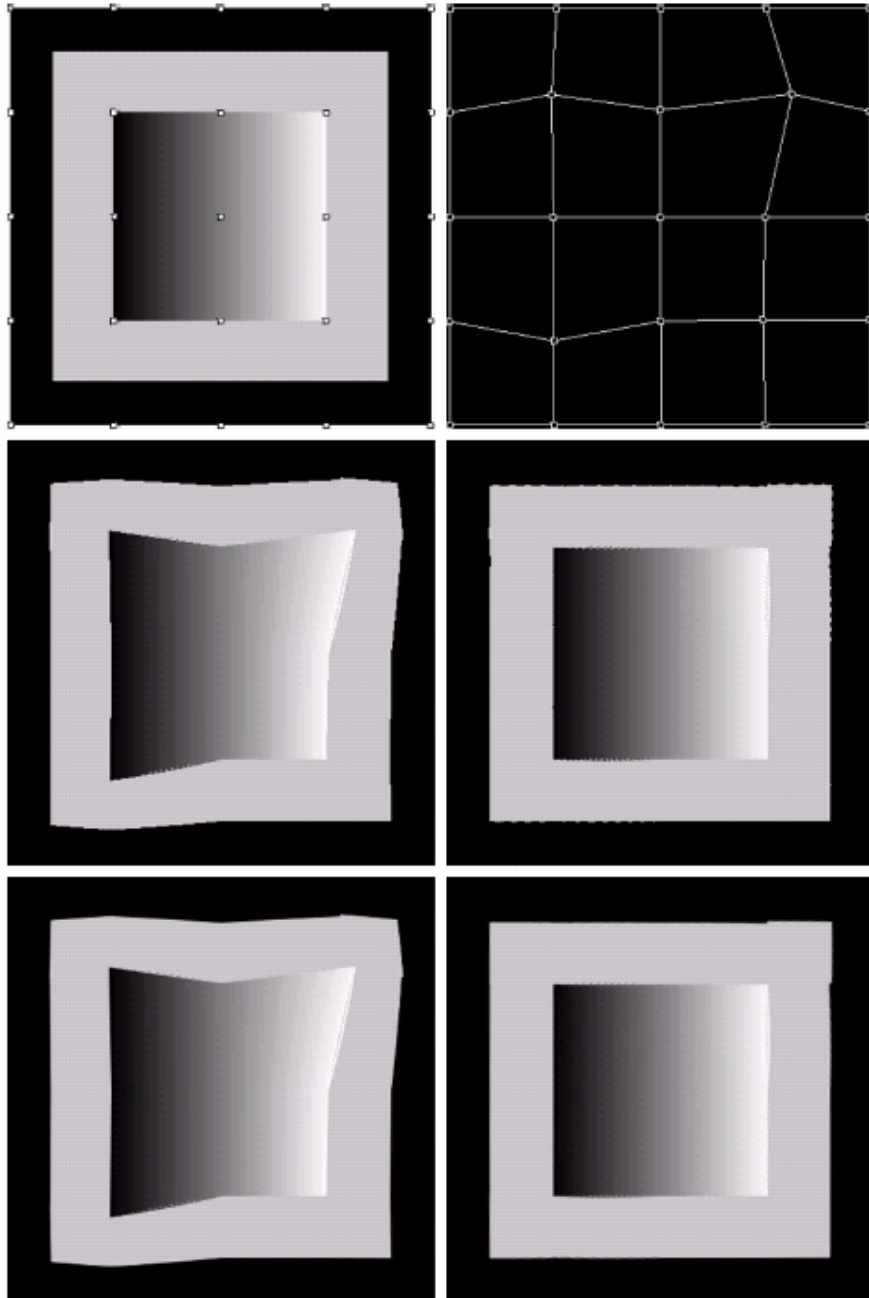


# Degradación por alteraciones en la adquisición



**FIGURE 5.33** Gray-level interpolation based on the nearest neighbor concept.

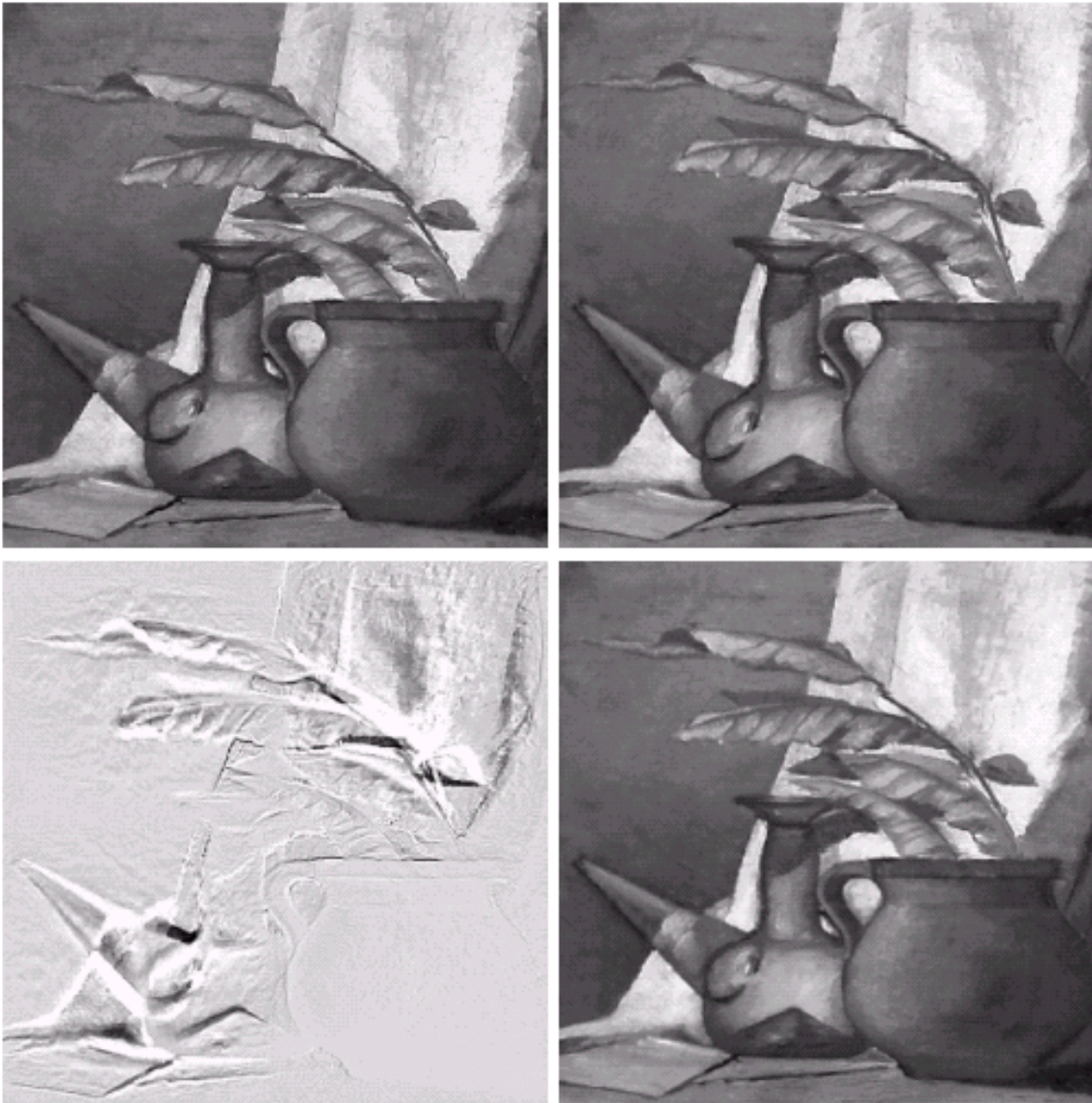
# Degradación por alteraciones en la adquisición



a b  
c d  
e f

**FIGURE 5.34** (a) Image showing tiepoints. (b) Tiepoints after geometric distortion. (c) Geometrically distorted image, using nearest neighbor interpolation. (d) Restored result. (e) Image distorted using bilinear interpolation. (f) Restored image.

## Degradación por alteraciones en la adquisición



a b  
c d

**FIGURE 5.35** (a) An image before geometric distortion. (b) Image geometrically distorted using the same parameters as in Fig. 5.34(e). (c) Difference between (a) and (b). (d) Geometrically restored image.