

Περιγραφή υφής

Περιγραφείς στατιστικής

Φασματικοί περιγραφείς

Ανάλυση χώρου / κλίμακας



(a)



(b)



(c)



(d)



(e)



(f)

Απλοί περιγραφείς υφής

Εμπειρική πυκνότητα πιθανότητας $p(i), \quad i=0, \dots, L-1, \quad \sum_{i=0}^{L-1} p(i)=1$

Μέση τιμή $\mu = \sum_{i=0}^{L-1} i p(i)$

Ροπές $m_k = \sum_{i=0}^{L-1} (i - \mu)^k p(i)$

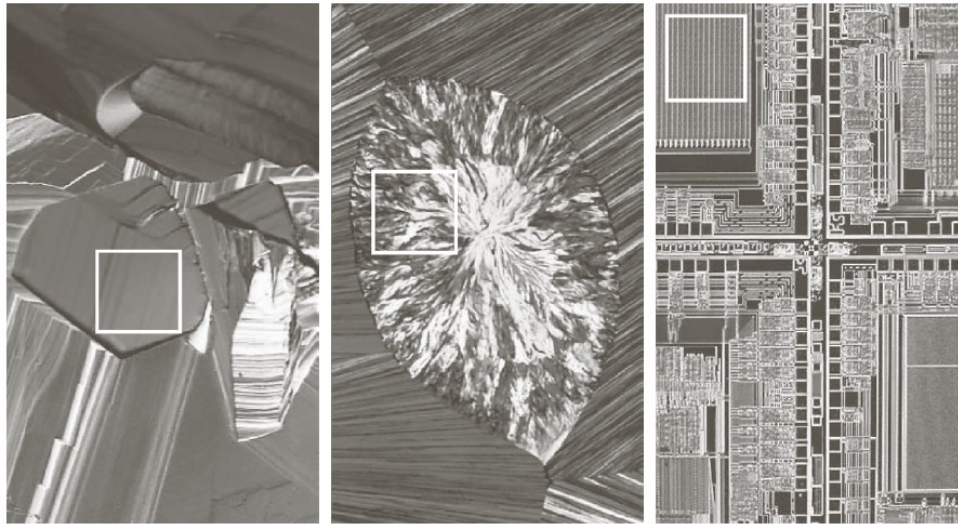
Τυπική απόκλιση
(κανονικοποίηση) $\sigma = \frac{\sqrt{m_2}}{L-1}$

Βαθμός διασποράς
(κανονικοποίηση) $R = 1 - \frac{1}{1 + \sigma^2}$

Ομοιομορφία $U = \sum_{i=0}^{L-1} p^2(i)$

Εντροπία $H = - \sum_{i=0}^{L-1} p(i) \log_2 p(i)$

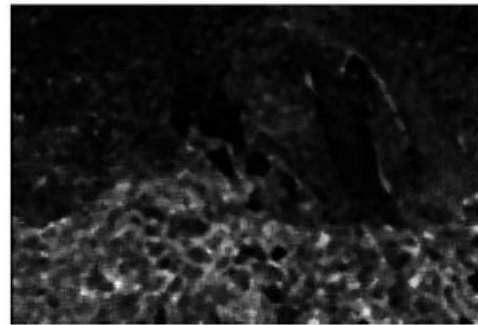
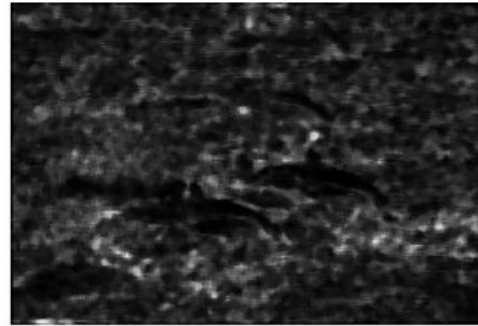
Απλοί περιγραφείς υφής



Texture	Mean	Standard deviation	R (normalized)	Third moment	Uniformity	Entropy
Smooth	82.64	11.79	0.002	-0.105	0.026	5.434
Coarse	143.56	74.63	0.079	-0.151	0.005	7.783
Regular	99.72	33.73	0.017	0.750	0.013	6.674

Gonzalez & Woods, Digital Image Processing

Απλοί περιγραφείς υφής



Τοπική απόκλιση με μεσαία τιμή

$$\sqrt{\text{Mean} \{ (x - \text{Med} \{ x \})^2 \}}$$

Αναλλοίωτες ροπές

$$m_{pq} = \sum_{x=1}^M \sum_{y=1}^N x^p y^q f(x, y)$$

$$\bar{x} = \frac{m_{10}}{m_{00}}, \quad \bar{y} = \frac{m_{01}}{m_{00}}$$

$$\mu_{pq} = \sum_{x=1}^M \sum_{y=1}^N (x - \bar{x})^p (y - \bar{y})^q f(x, y)$$

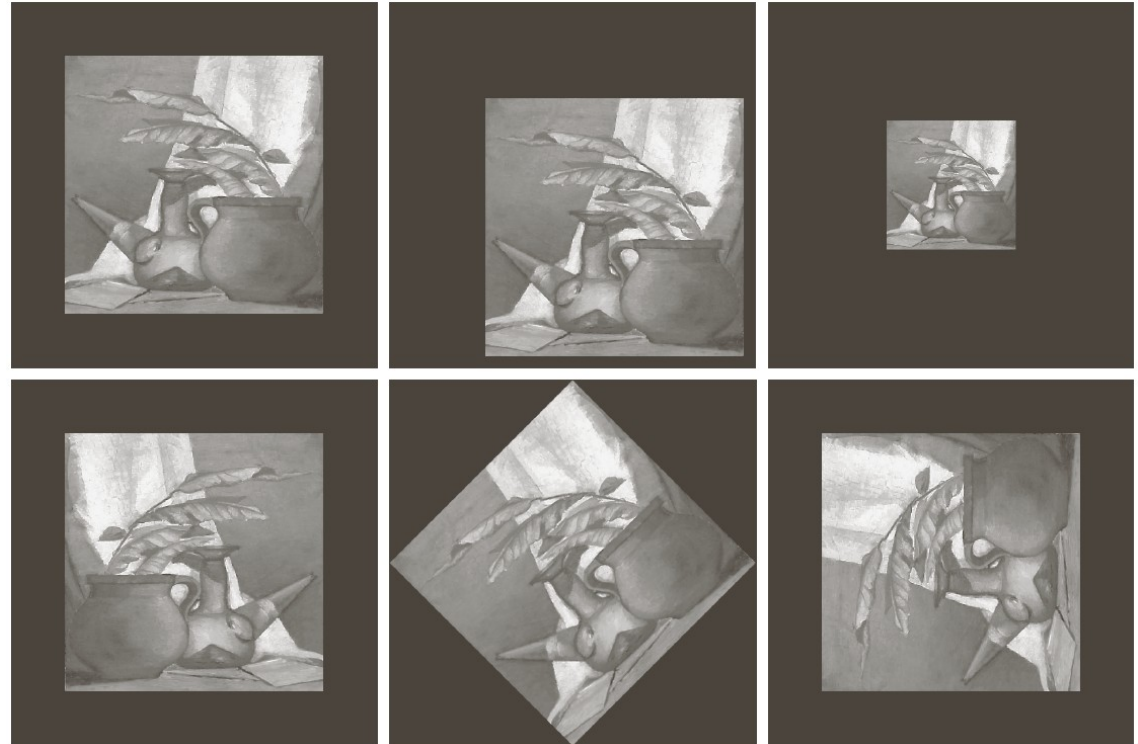
$$\eta_{pq} = \frac{\mu_{pq}}{(\mu_{00})^{\gamma}}, \quad \gamma = \frac{p+q}{2} + 1$$

$$\varphi_1 = \eta_{20} + \eta_{02}$$

$$\varphi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$

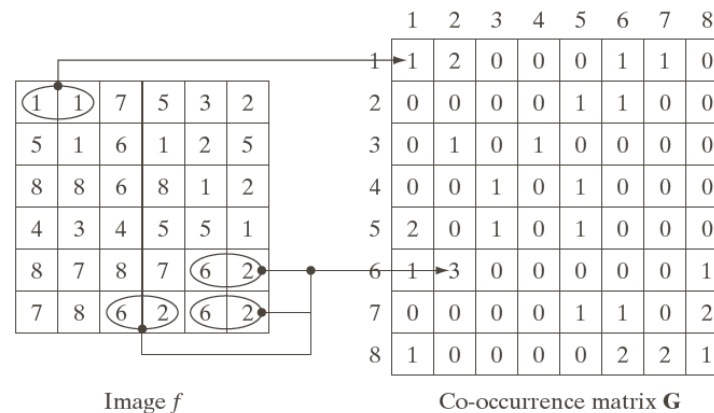
$$\varphi_3 = (\eta_{30} - 3\eta_{12})^2 + (\eta_{03} - 3\eta_{21})^2$$

$$\varphi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{03} + \eta_{21})^2$$



Moment Invariant	Original Image	Translated	Half Size	Mirrored	Rotated 45°	Rotated 90°
ϕ_1	2.8662	2.8662	2.8664	2.8662	2.8661	2.8662
ϕ_2	7.1265	7.1265	7.1257	7.1265	7.1266	7.1265
ϕ_3	10.4109	10.4109	10.4047	10.4109	10.4115	10.4109
ϕ_4	10.3742	10.3742	10.3719	10.3742	10.3742	10.3742
ϕ_5	21.3674	21.3674	21.3924	21.3674	21.3663	21.3674
ϕ_6	13.9417	13.9417	13.9383	13.9417	13.9417	13.9417
ϕ_7	-20.7809	-20.7809	-20.7724	20.7809	-20.7813	-20.7809

Πίνακας συνύπαρξης



Gonzalez & Woods, Digital Image Processing

Μέγιστη πιθανότητα

$$\max_{i,j} p_{ij}$$

Συσχέτιση

$$\frac{1}{\sigma^2} \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} (i-\mu)(j-\mu) p_{ij}$$

Αντίθεση

$$\sum_{i=0}^{L-1} \sum_{j=0}^{L-1} (i-j)^2 p_{ij}$$

Ομοιομορφία

$$\sum_{i=0}^{L-1} \sum_{j=0}^{L-1} p_{ij}^2$$

Ομοιογένεια

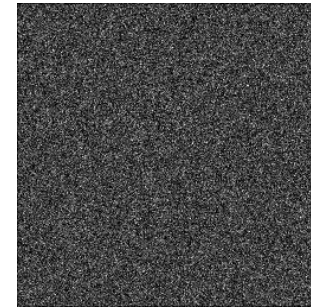
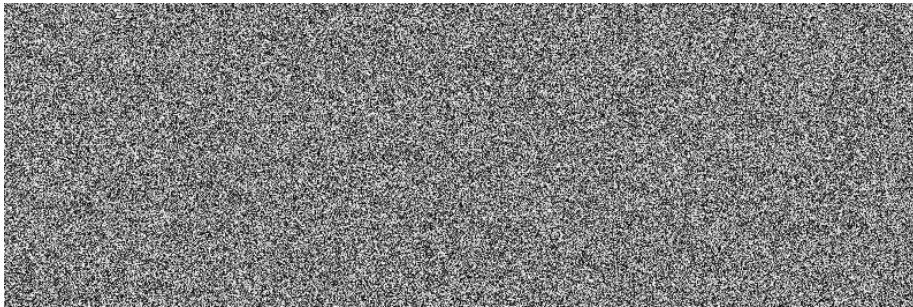
$$\sum_{i=0}^{L-1} \sum_{j=0}^{L-1} \frac{p_{ij}}{1+|i-j|}$$

Εντροπία

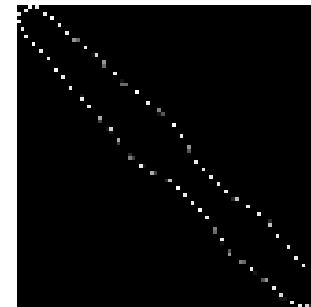
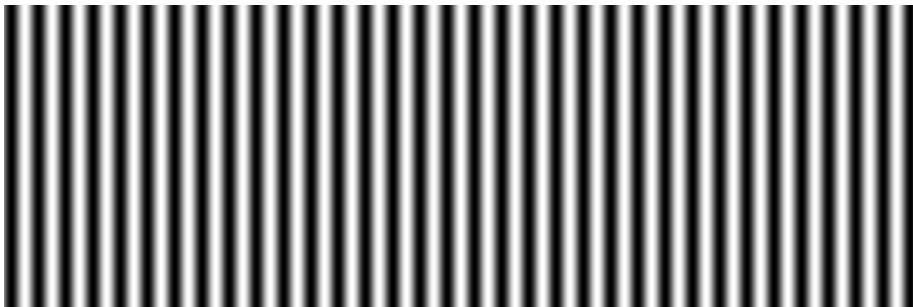
$$-\sum_{i=0}^{L-1} \sum_{j=0}^{L-1} p_{i,j} \log_2 p_{i,j}$$

Πίνακας συνύπαρξης

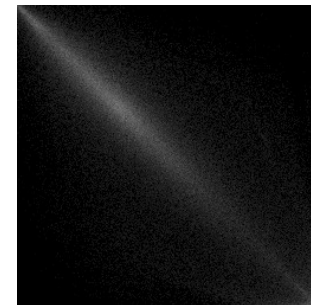
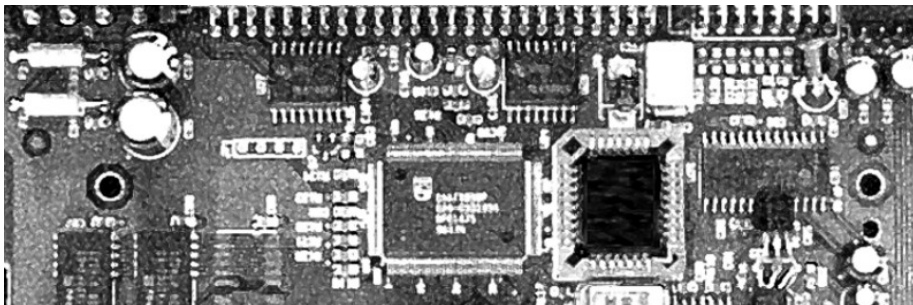
G_1



G_2



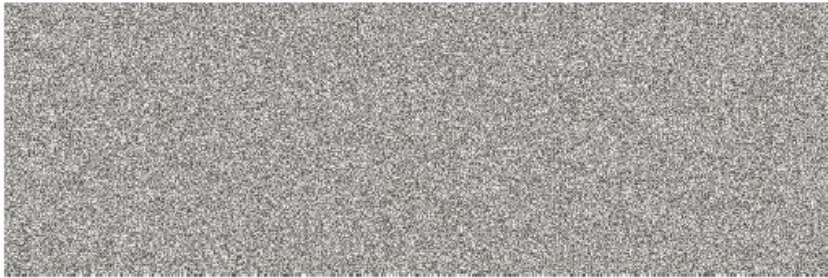
G_3



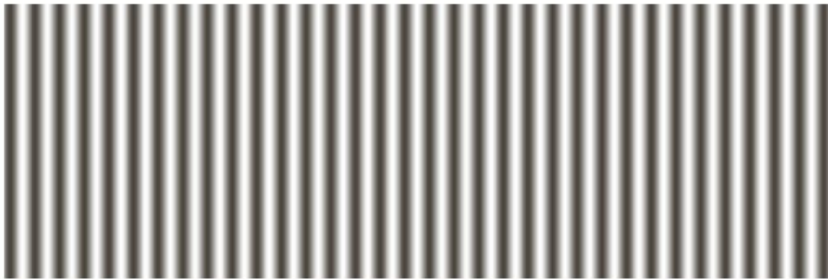
Normalized Co-occurrence Matrix	Descriptor					
	Max Probability	Correlation	Contrast	Uniformity	Homogeneity	Entropy
G_1/n_1	0.00006	-0.0005	10838	0.00002	0.0366	15.75
G_2/n_2	0.01500	0.9650	570	0.01230	0.0824	6.43
G_3/n_3	0.06860	0.8798	1356	0.00480	0.2048	13.58

Συντελεστής συσχέτισης

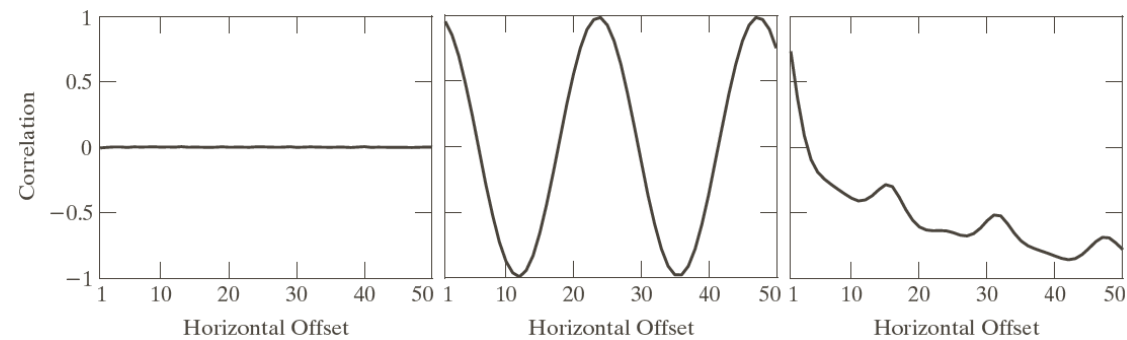
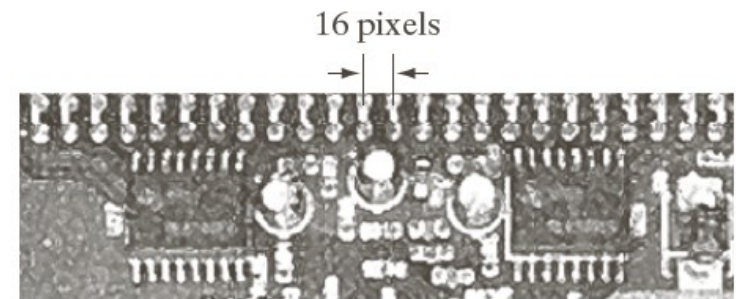
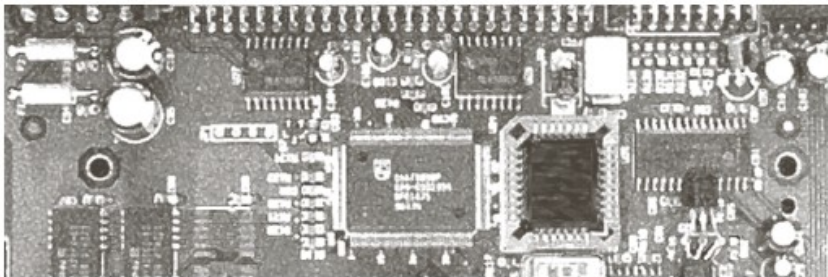
G_1



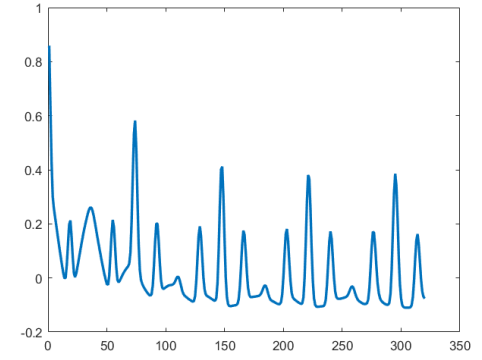
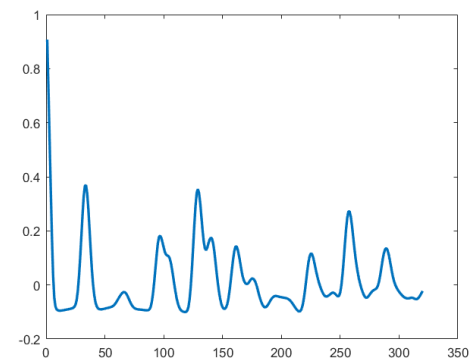
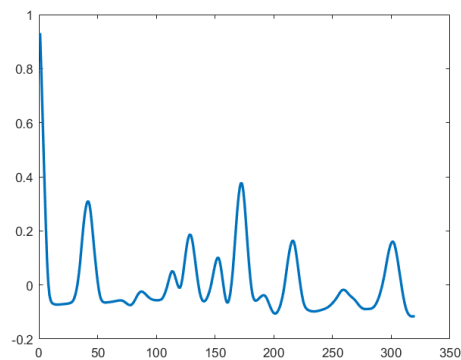
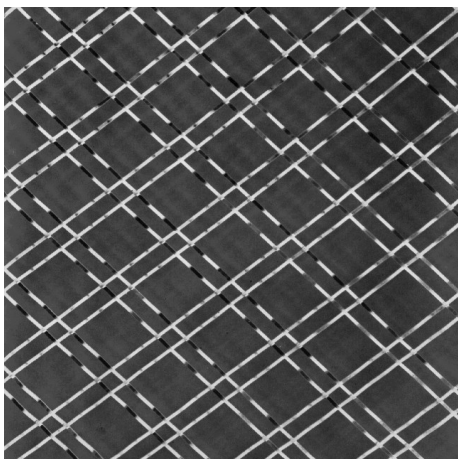
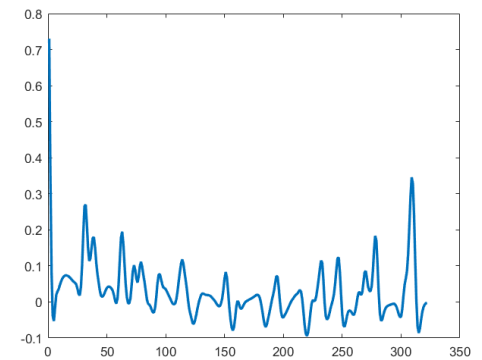
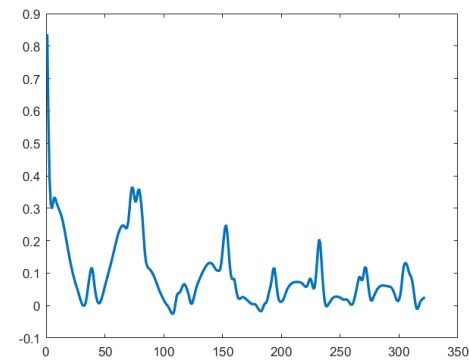
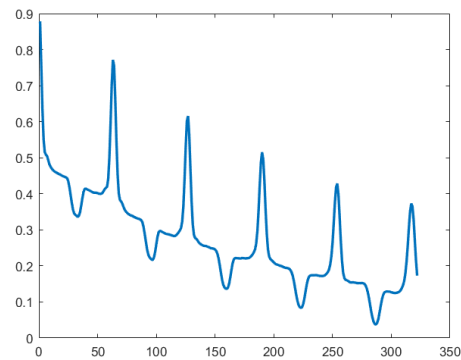
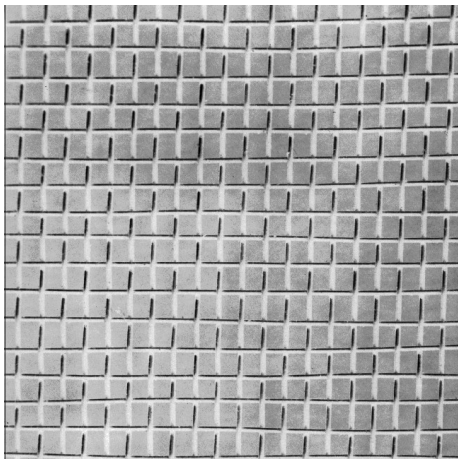
G_2



G_3



Συντελεστής συσχέτισης

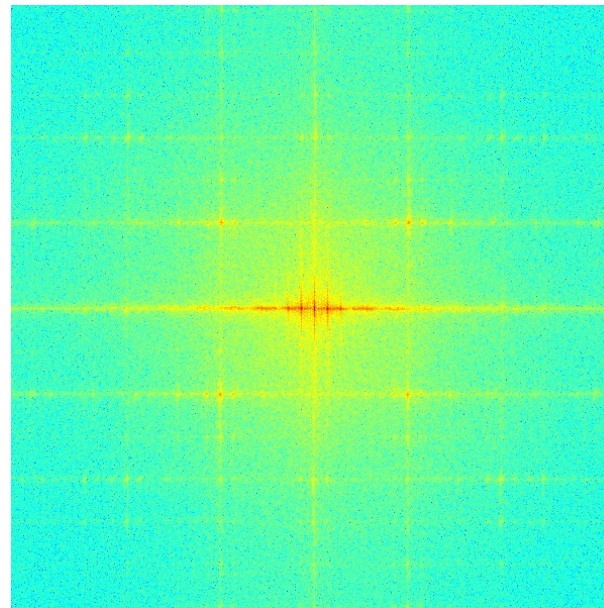
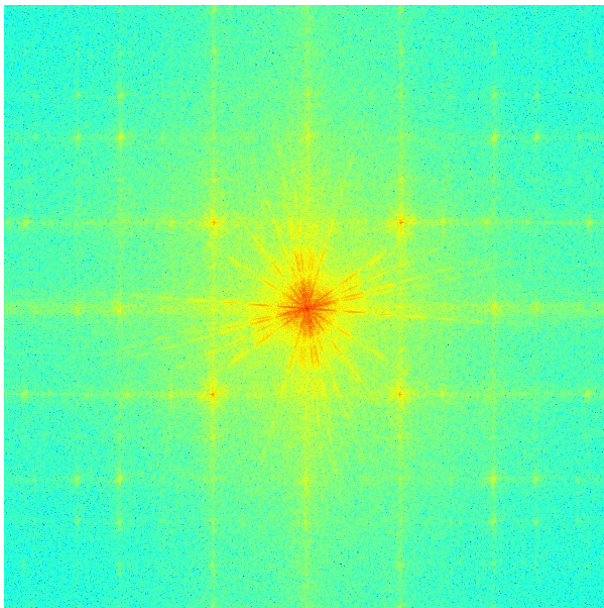
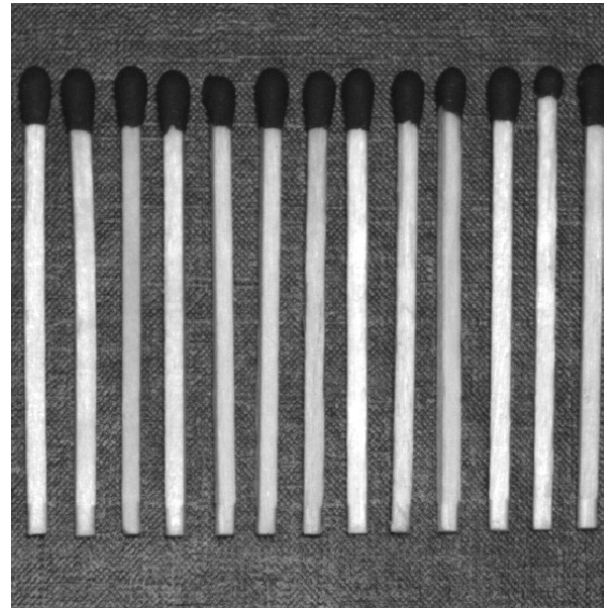
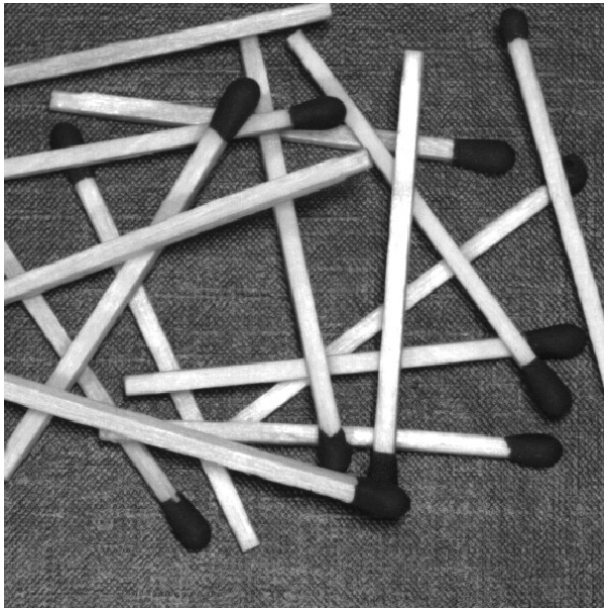


Οριζόντια

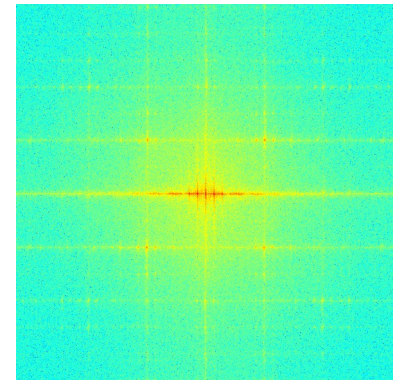
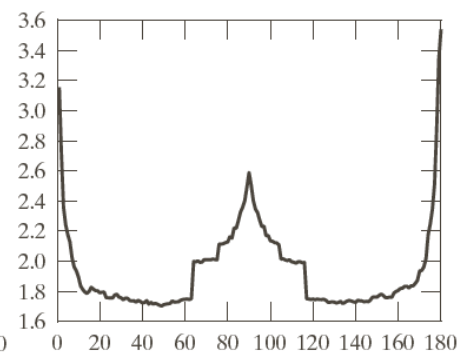
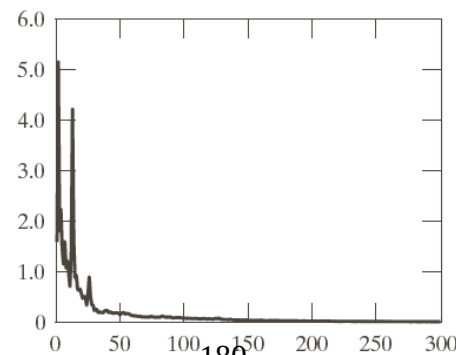
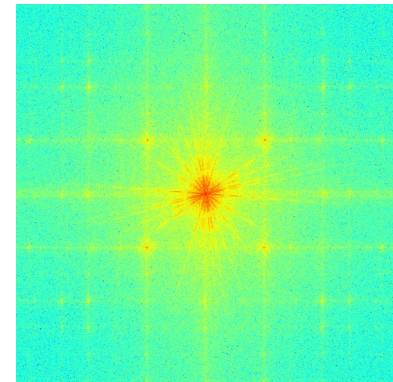
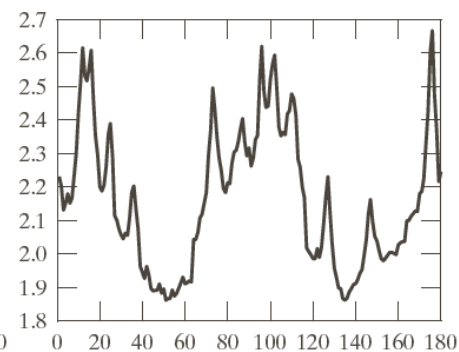
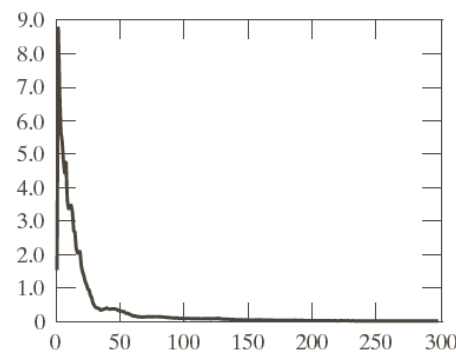
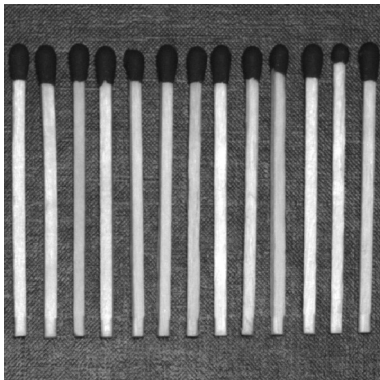
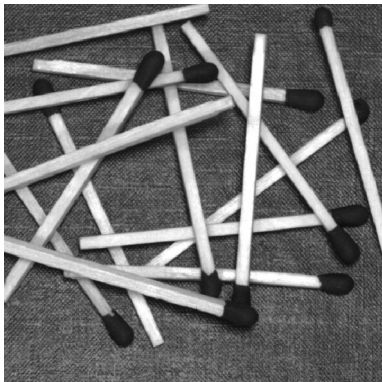
Κατακόρυφα

Διαγώνια

Φασματικές προσεγγίσεις

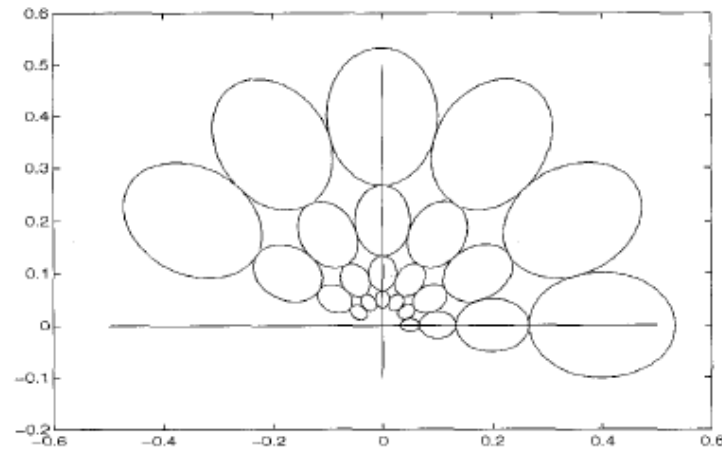


Φασματικές προσεγγίσεις



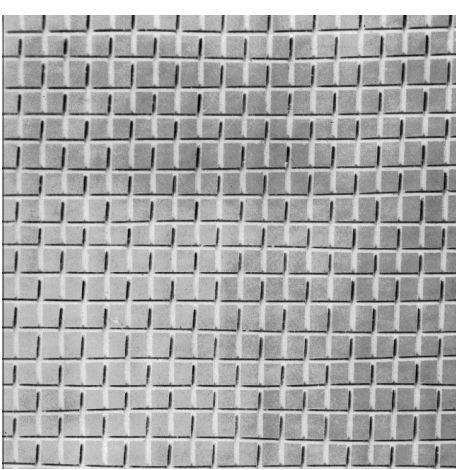
$$S(r) = \sum_{\theta=0}^{180} S(r, \theta) \quad S(\theta) = \sum_r S(r, \theta)$$

Ανάλυση Gabor



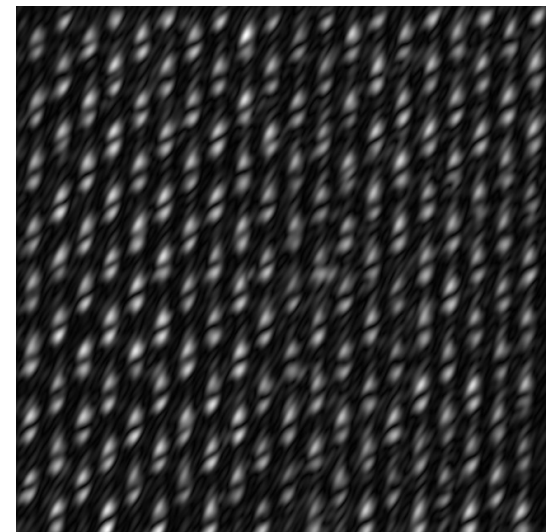
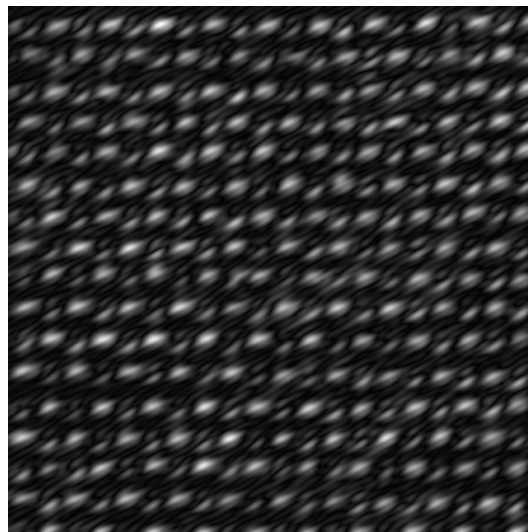
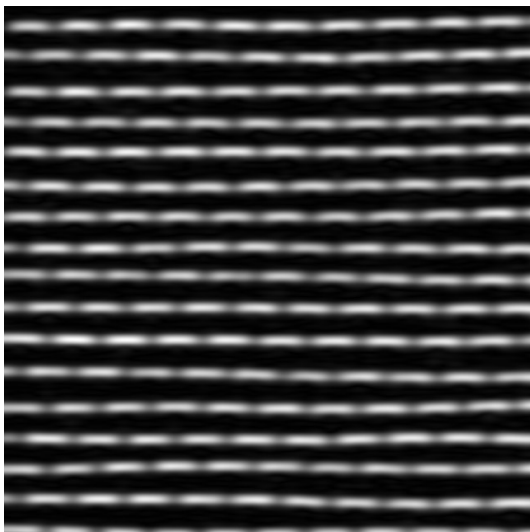
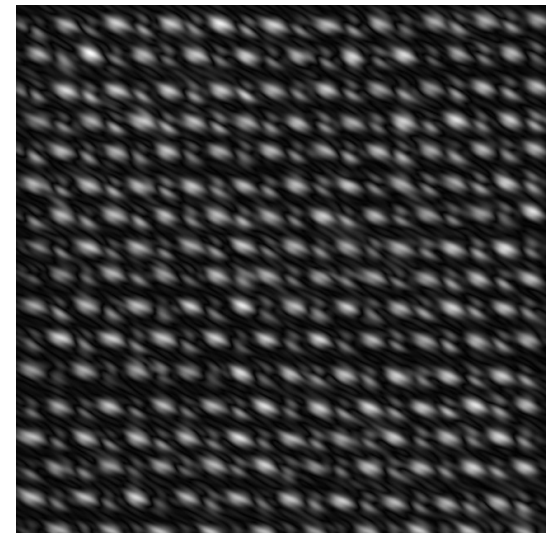
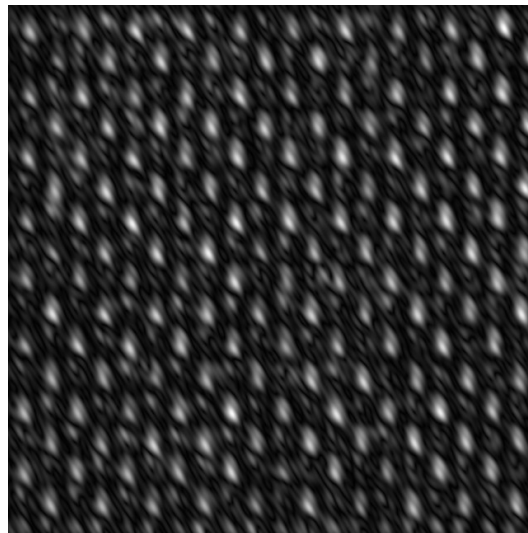
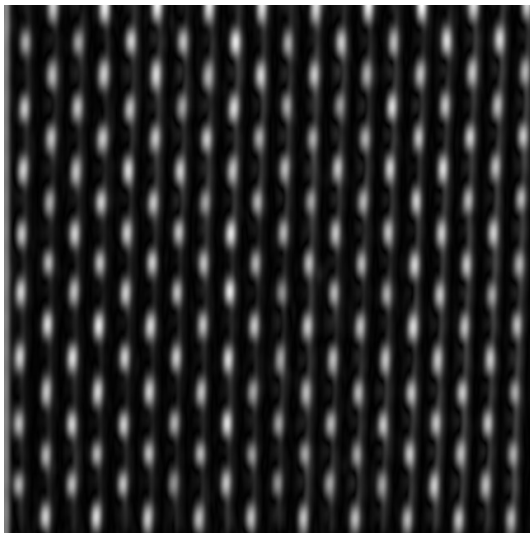
$$g(x, y) = s(x, y) h_G(x, y)$$

Ζώνες στο χώρο των συχνοτήτων
Κλίμακα και κατεύθυνση



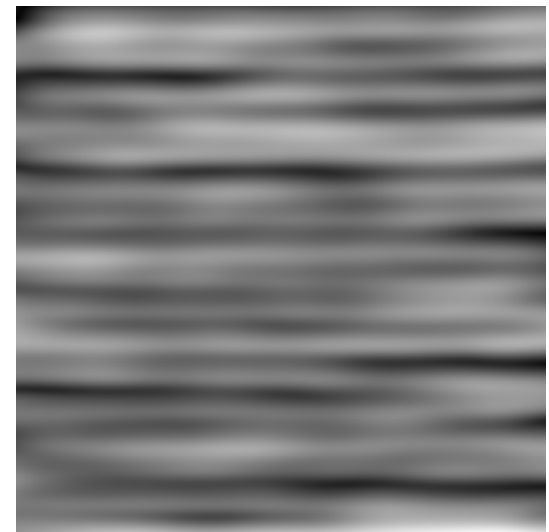
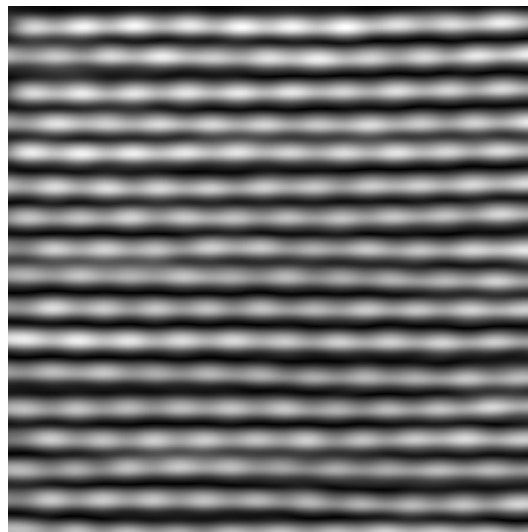
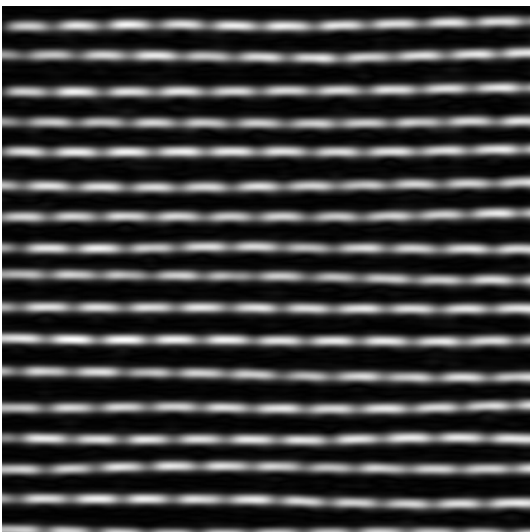
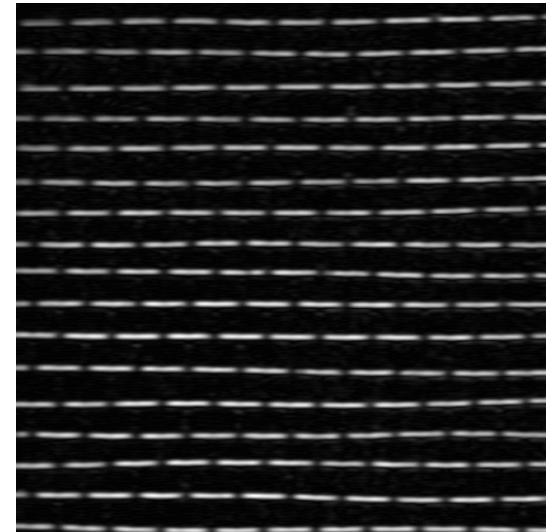
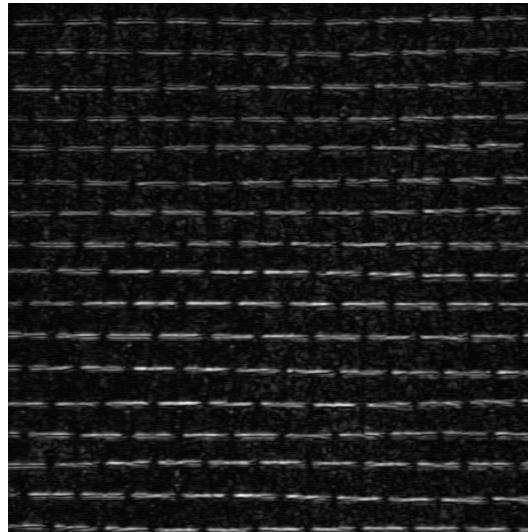
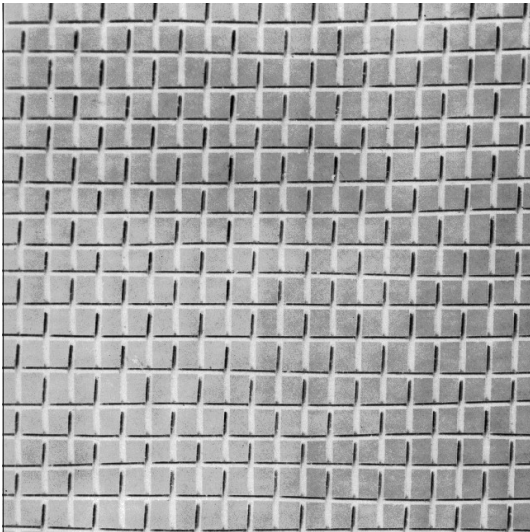
Ανάλυση Gabor

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Ισχύς : 1216 337 394 1941 356 358



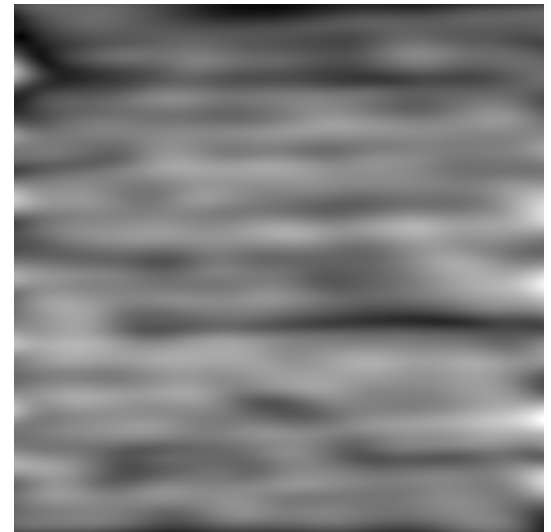
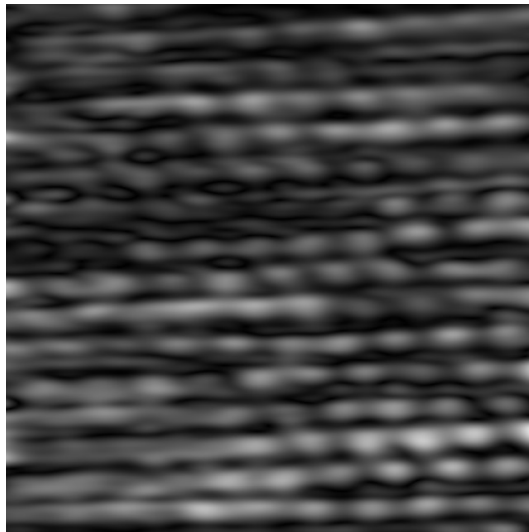
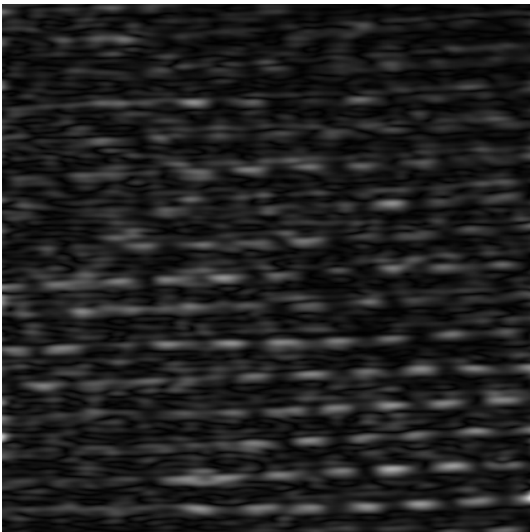
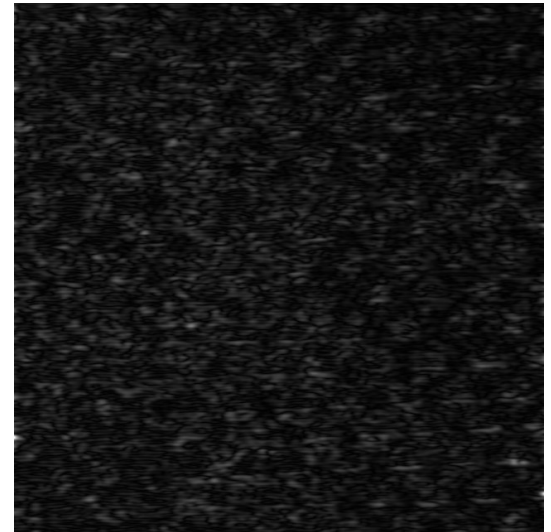
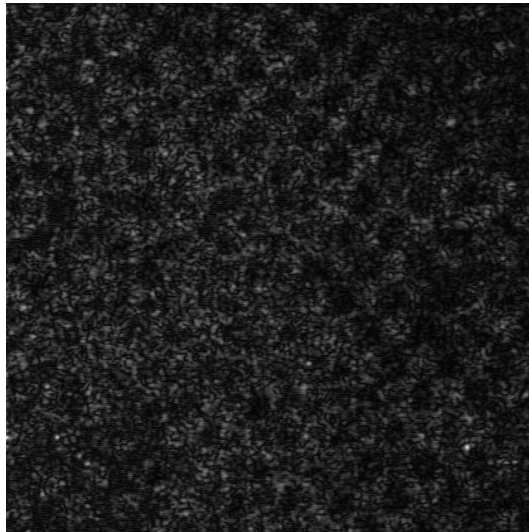
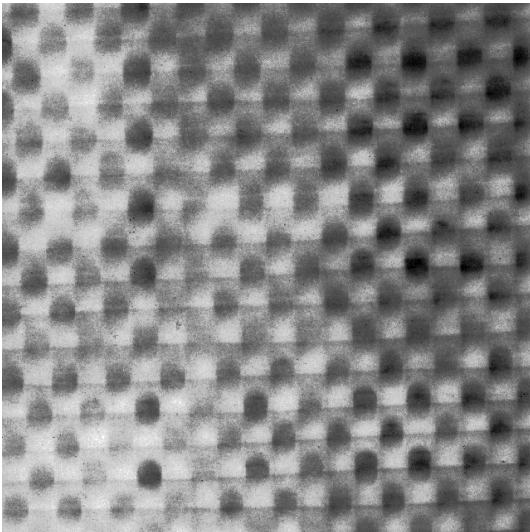
Ανάλυση Gabor

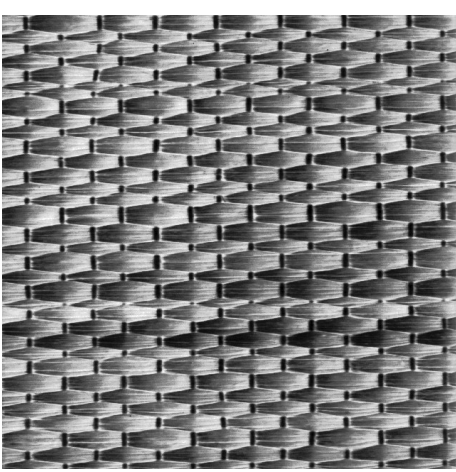
Κλίμακα : 1 2 3 4 5



Ανάλυση Gabor

Κλίμακα : 1 2 3 4 5

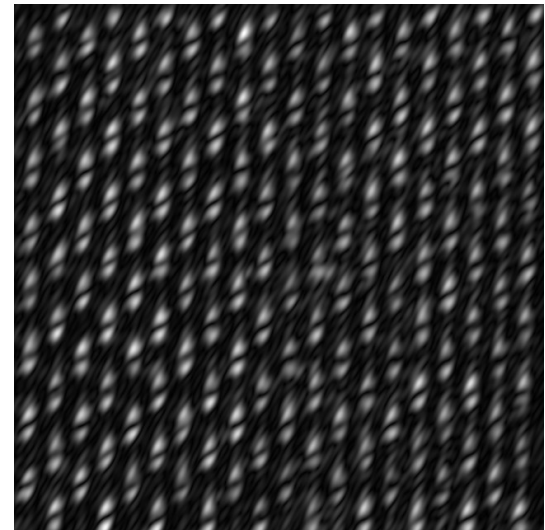
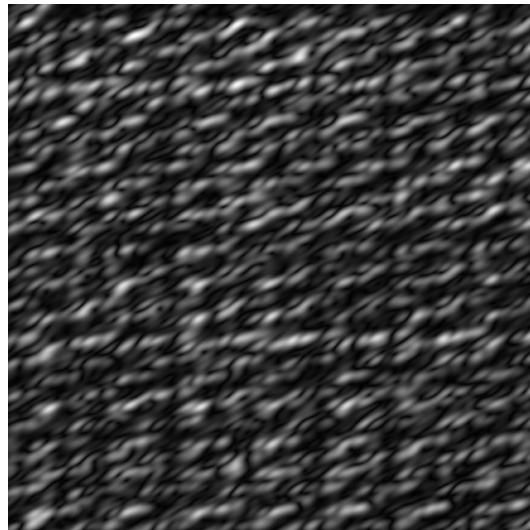
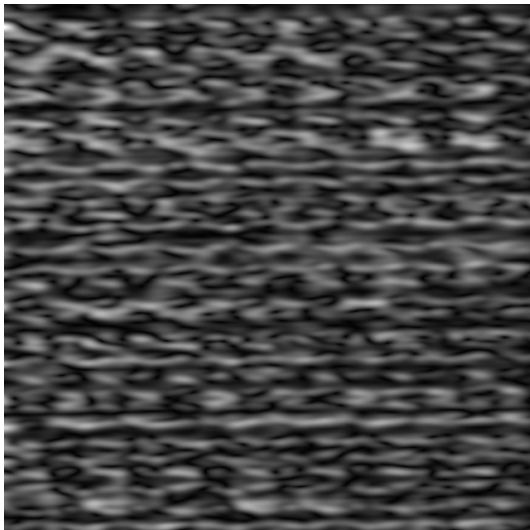
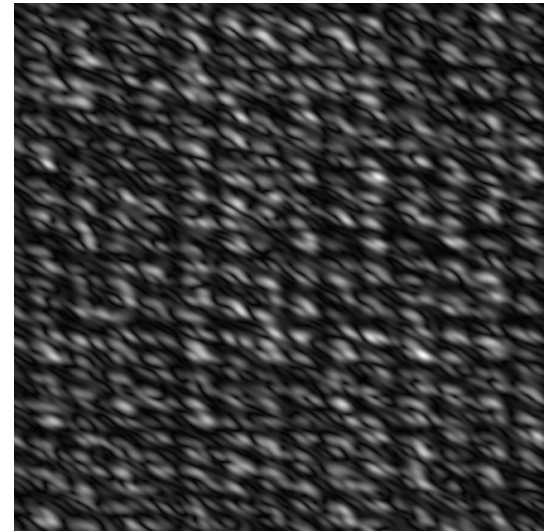
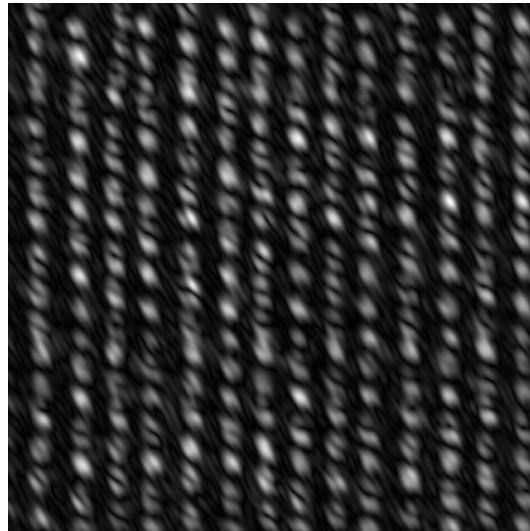
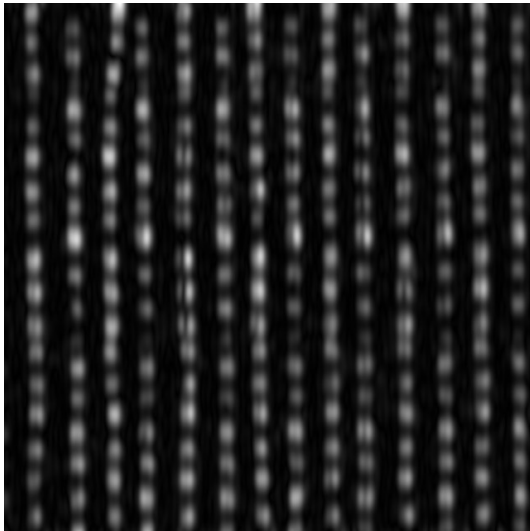




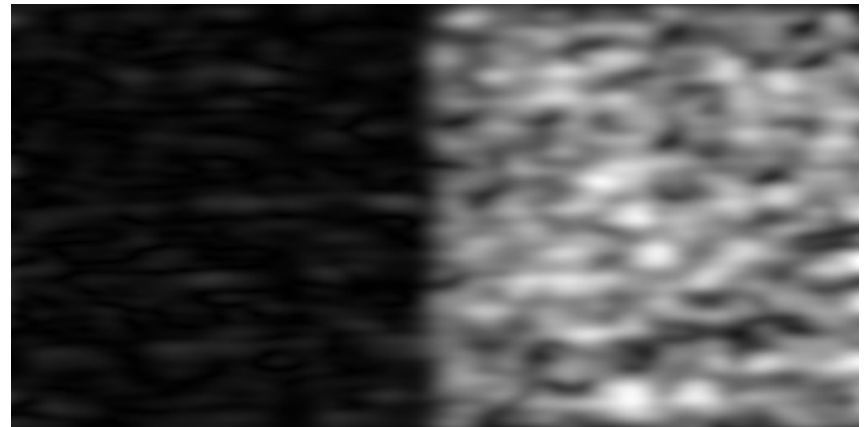
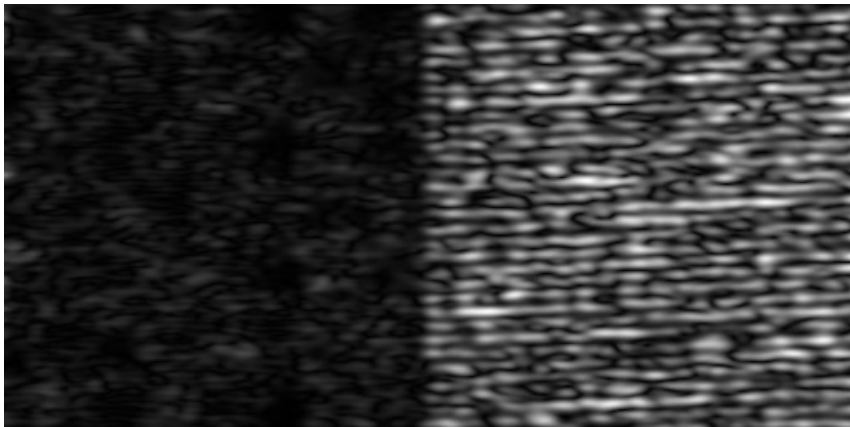
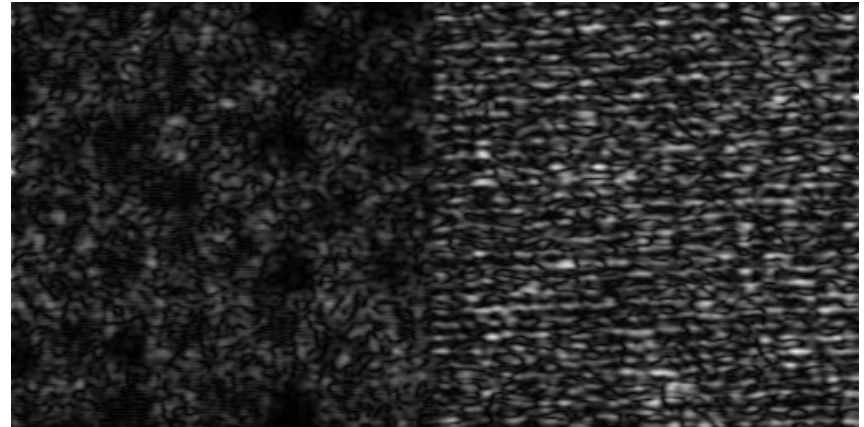
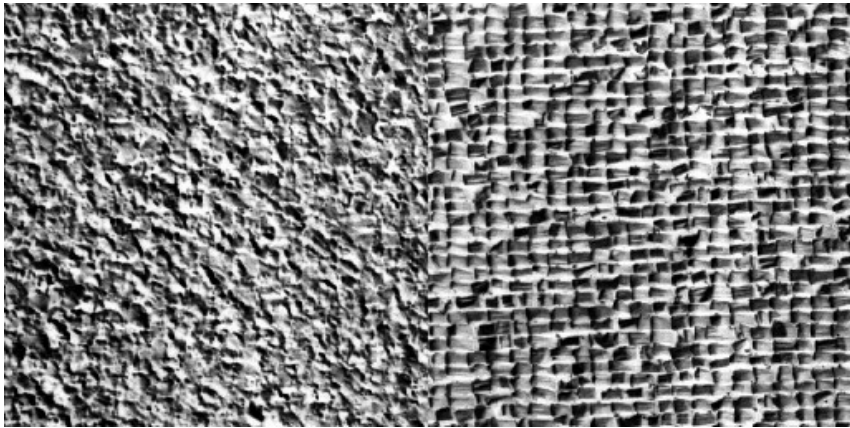
Ανάλυση Gabor

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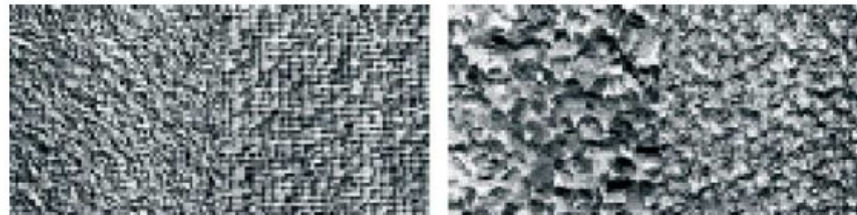
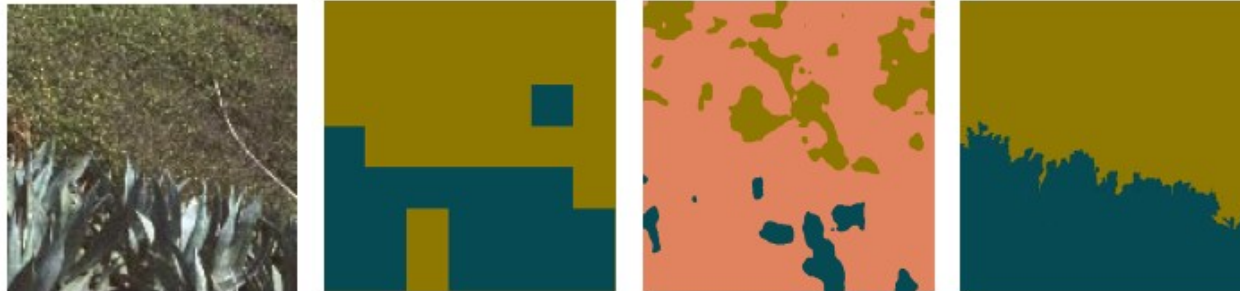
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Ανάλυση Gabor



Τμηματοποίηση με χρήση υφής



(a)

(b)



(c)

(d)

Χαρακτηριστικά υφής : κυματιδιακή ανάλυση
Πιθανότητες κατάταξης στις κλάσεις
Αλγόριθμος γρήγορου βηματισμού

Τμηματοποίηση με χρήση υφής και χρώματος



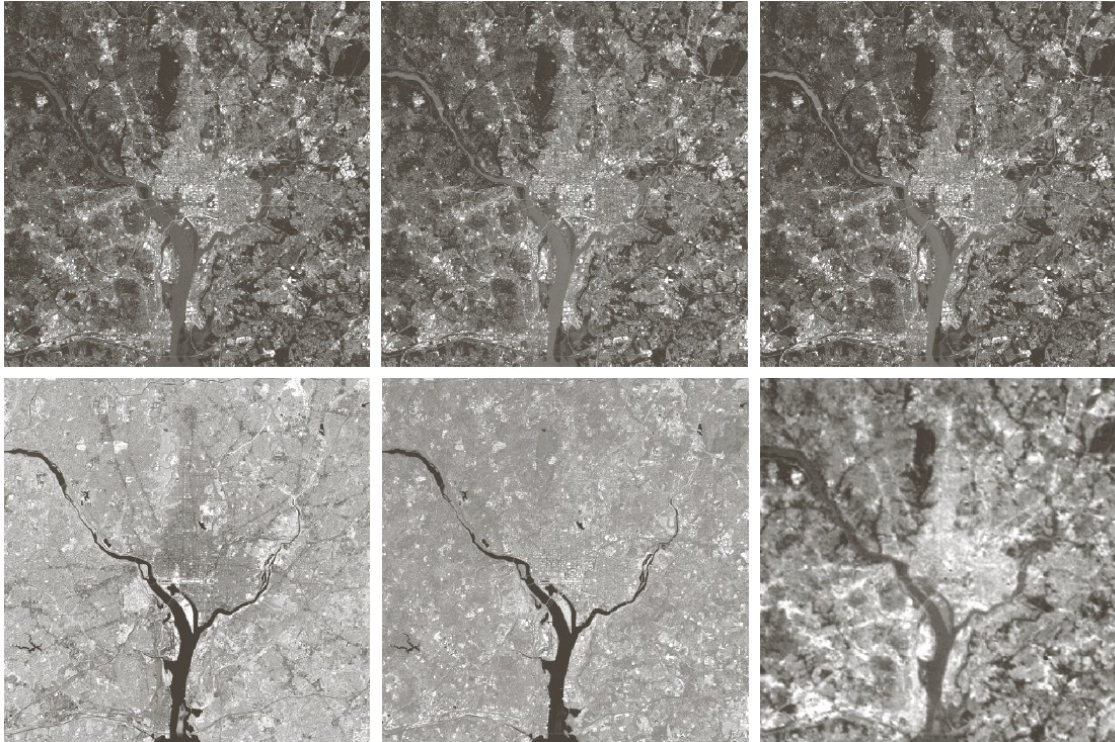
Χαρακτηριστικά υφής : κυματιδιακή ανάλυση
Πιθανότητες κατάταξης στις κλάσεις
Αλγόριθμος γρήγορου βηματισμού

Κύριες συνιστώσες

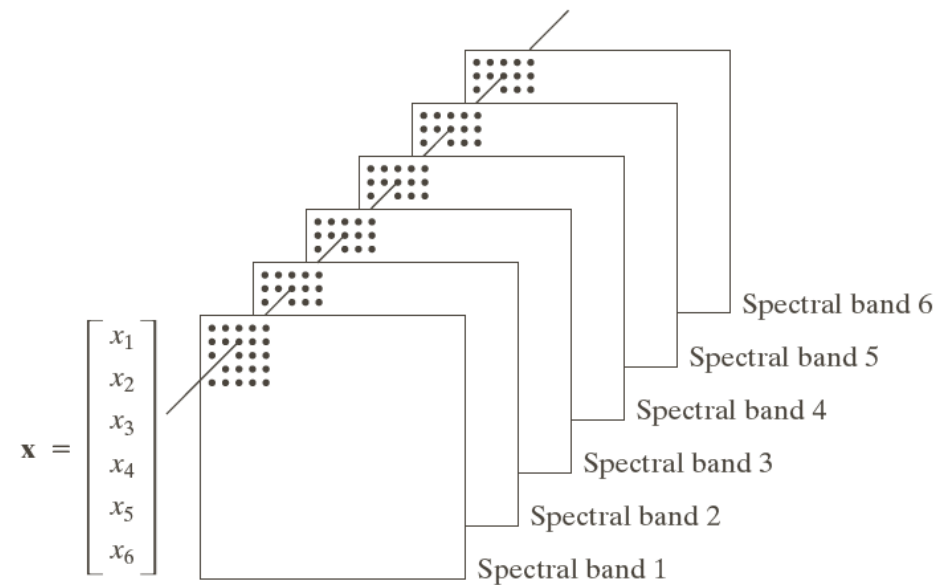
B

G

R



Ζώνες υπερύθρου



Πίνακας συνδιακύμανσης

$$C = \begin{bmatrix} 2624 & 2492 & 2545 & -712 & 1045 & 2126 \\ 2492 & 2524 & 2550 & -586 & 1118 & 1982 \\ 2545 & 2550 & 2657 & -765 & 1060 & 2031 \\ -712 & -586 & -765 & 2155 & 1018 & -726 \\ 1045 & 1118 & 1060 & 1018 & 1673 & 993 \\ 2126 & 1982 & 2031 & -726 & 993 & 3404 \end{bmatrix}$$

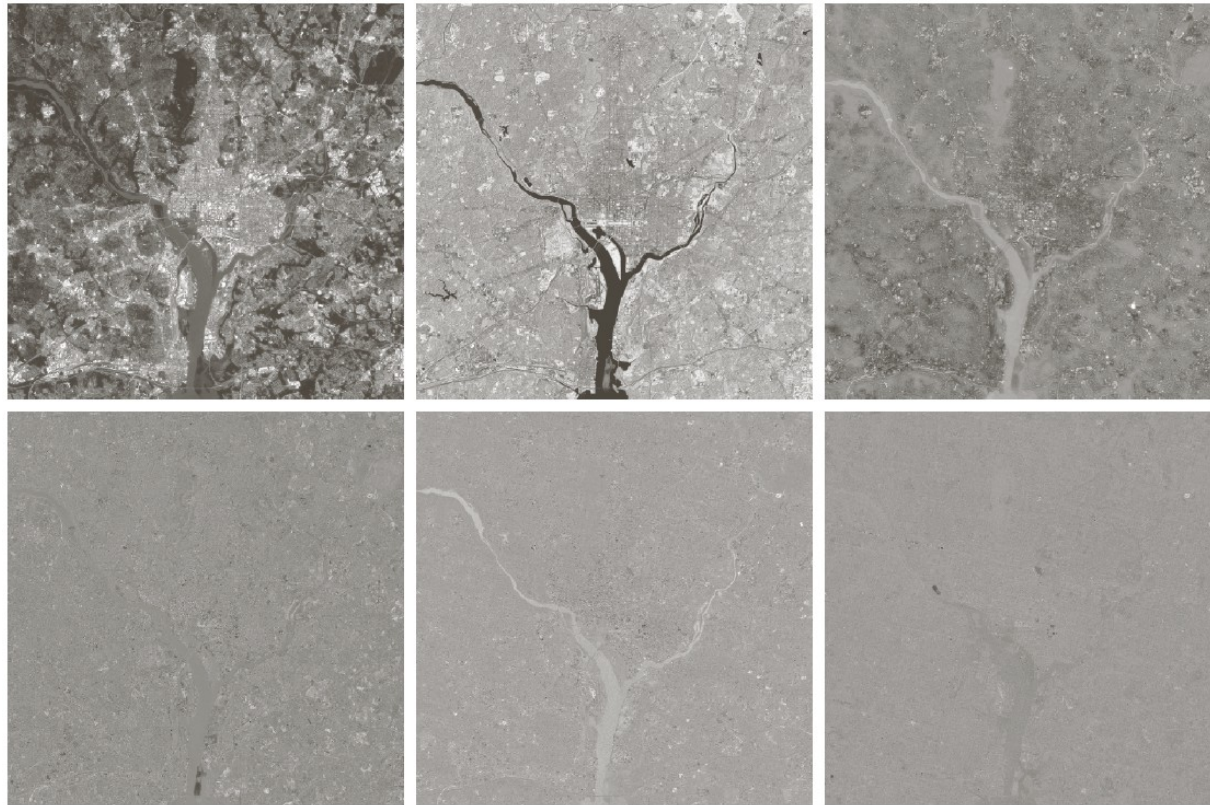
$$R = \begin{bmatrix} 1.0000 & 0.9683 & 0.9638 & -0.2994 & 0.4990 & 0.7113 \\ 0.9683 & 1.0000 & 0.9846 & -0.2514 & 0.5441 & 0.6761 \\ 0.9638 & 0.9846 & 1.0000 & -0.3199 & 0.5028 & 0.6754 \\ -0.2994 & -0.2514 & -0.3199 & 1.0000 & 0.5364 & -0.2681 \\ 0.4990 & 0.5441 & 0.5028 & 0.5364 & 1.0000 & 0.4161 \\ 0.7113 & 0.6761 & 0.6754 & -0.2681 & 0.4161 & 1.0000 \end{bmatrix}$$

Εύρεση ιδιοτιμών και ιδιοδιανυσμάτων του πίνακα συνδιακύμανσης

λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
10344	2966	1401	203	94	31

Κύριες συνιστώσες

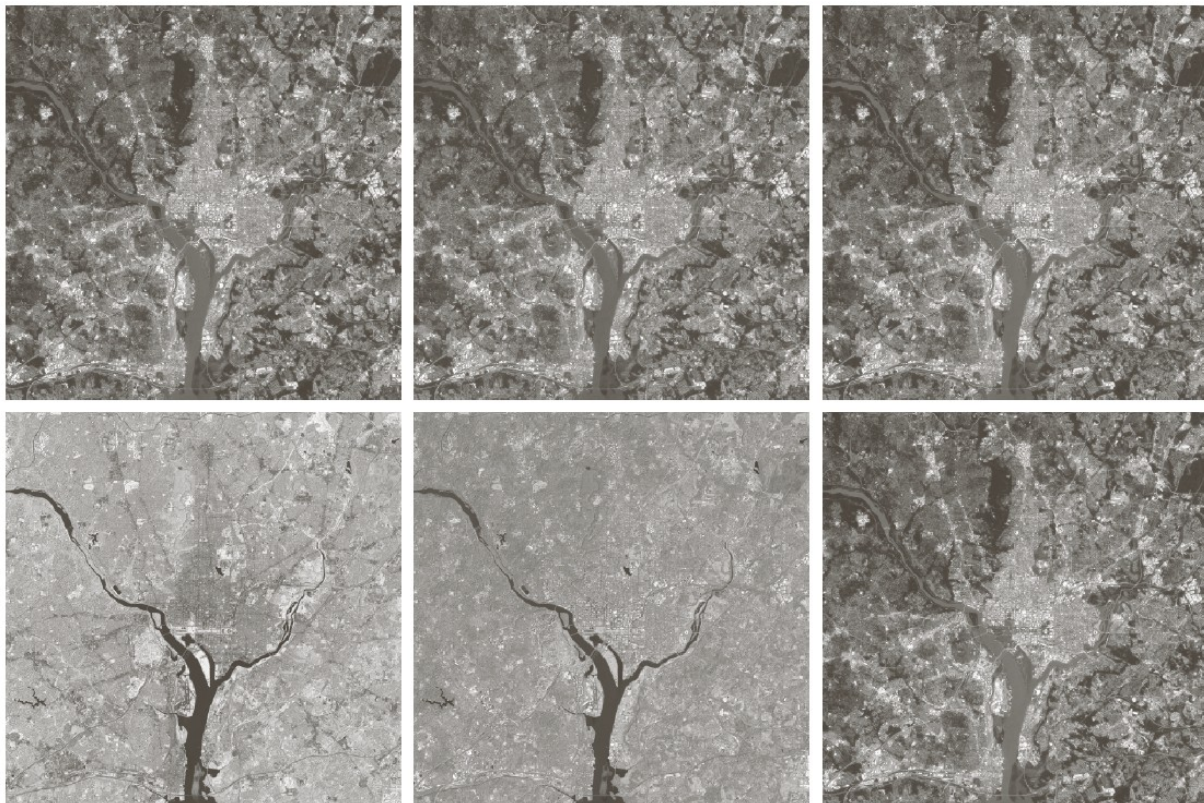
$$Y = (X - m)V$$



$$V = \begin{bmatrix} 0.4890 & -0.0124 & 0.2301 & -0.3066 & -0.7777 & 0.0947 \\ 0.4777 & 0.0394 & 0.3012 & -0.1391 & 0.3547 & -0.7310 \\ 0.4899 & -0.0220 & 0.3150 & 0.0462 & 0.4644 & 0.6652 \\ -0.1375 & 0.7986 & -0.0431 & -0.5624 & 0.1222 & 0.1018 \\ 0.2188 & 0.5981 & -0.0165 & 0.7473 & -0.1788 & -0.0606 \\ 0.4753 & -0.0486 & -0.8689 & -0.0990 & 0.0826 & 0.0090 \end{bmatrix}$$

Κύριες συνιστώσες

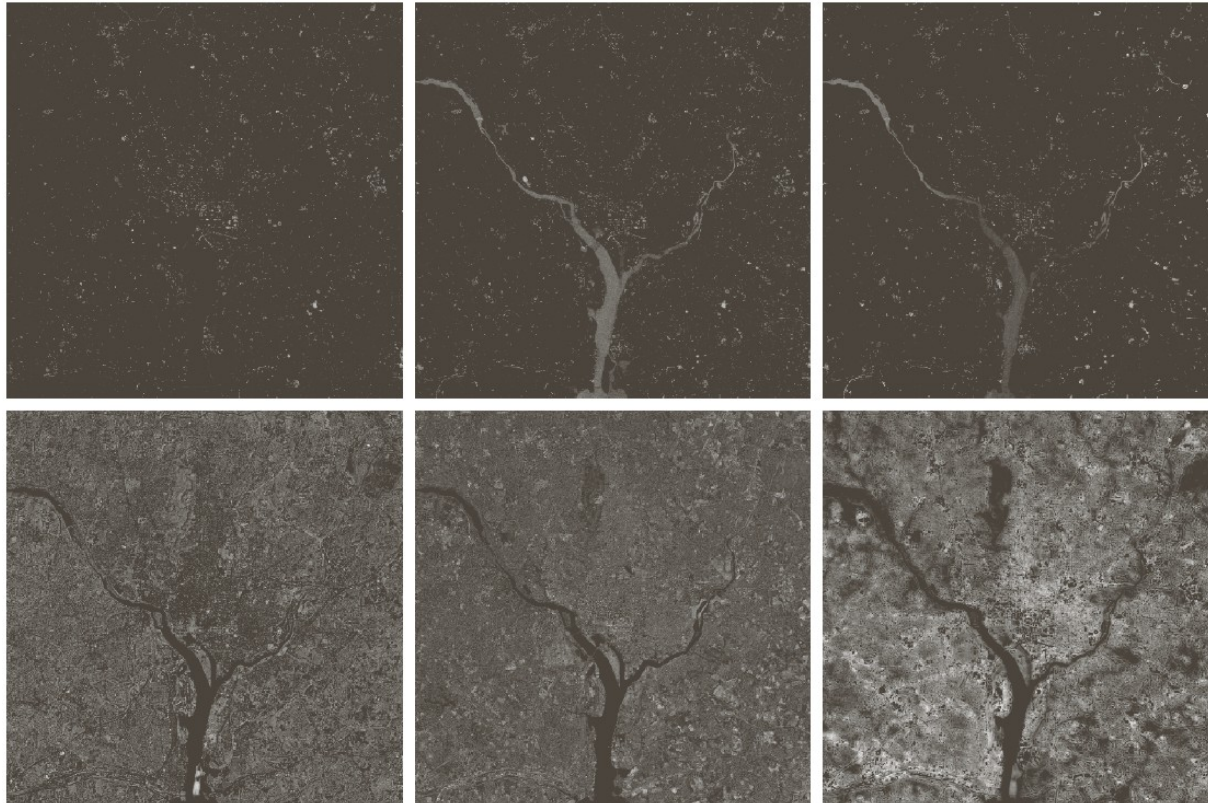
$$\hat{X} = Y \hat{V}^T + m$$



Ανακατασκευή από δύο κύριες συνιστώσες

$$\frac{\lambda_1 + \lambda_2}{\sum_{i=1}^6 \lambda_i} = 0.89$$

Κύριες συνιστώσες



Διαφορές (τονισμένες)