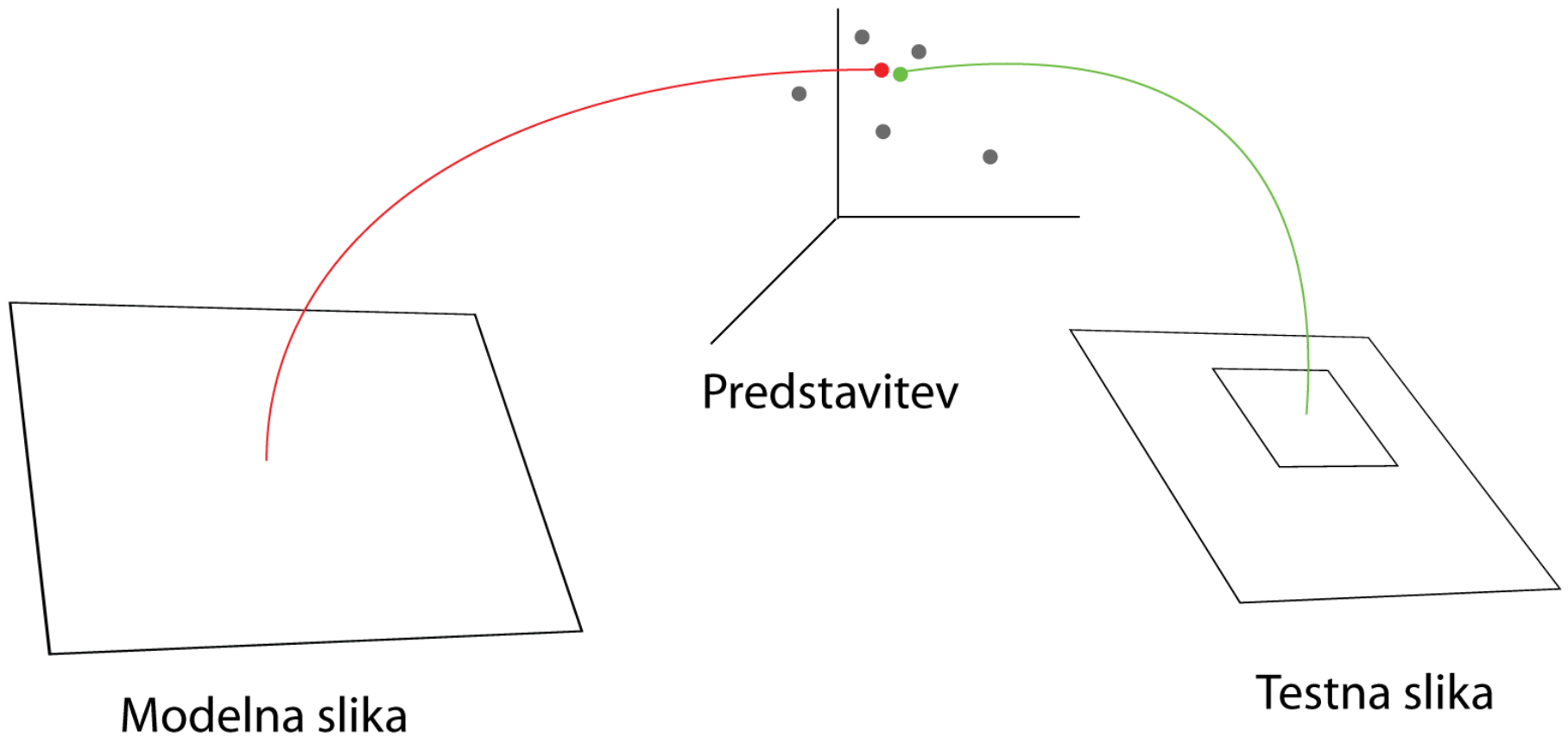
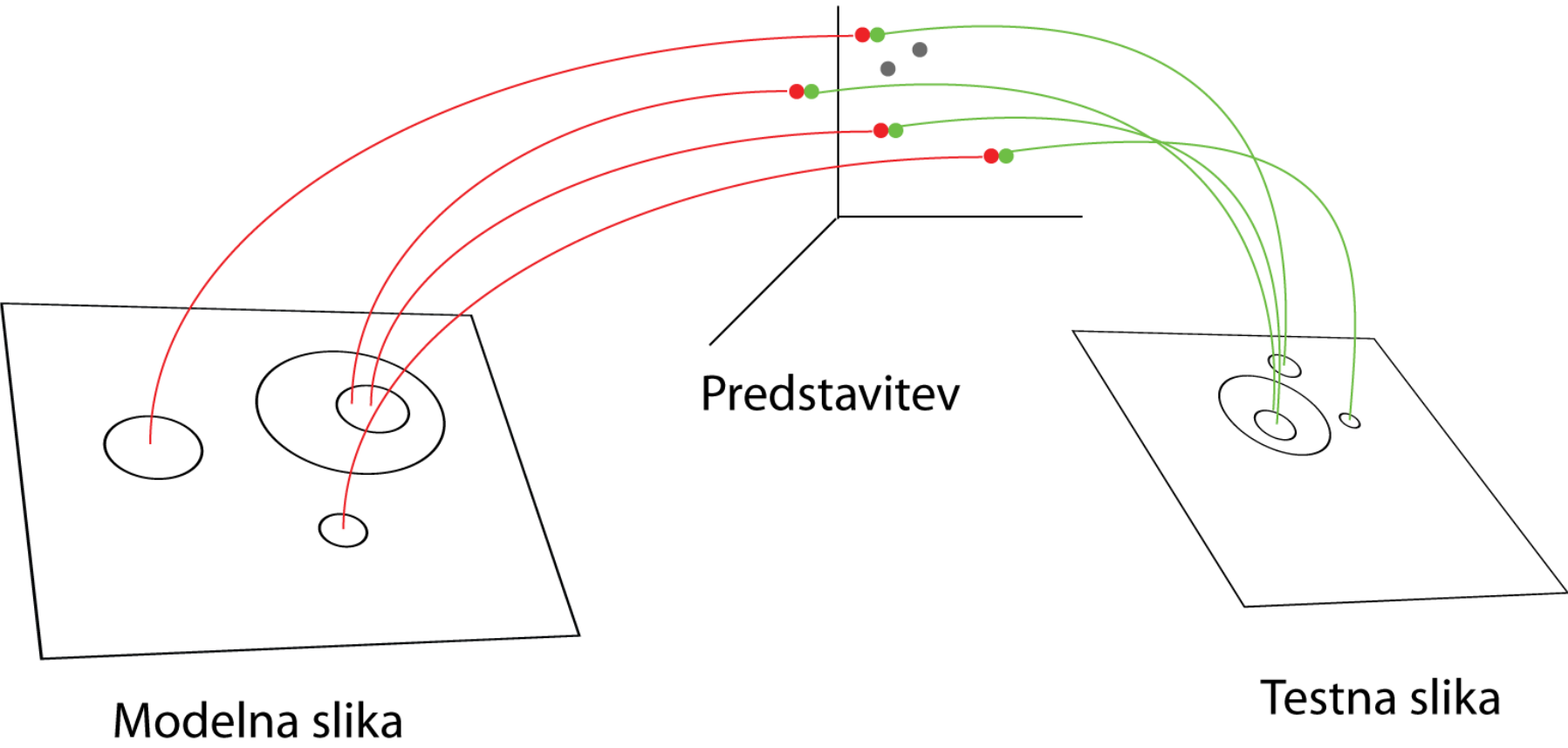


VIZUALNO RAZPOZNAVANJE

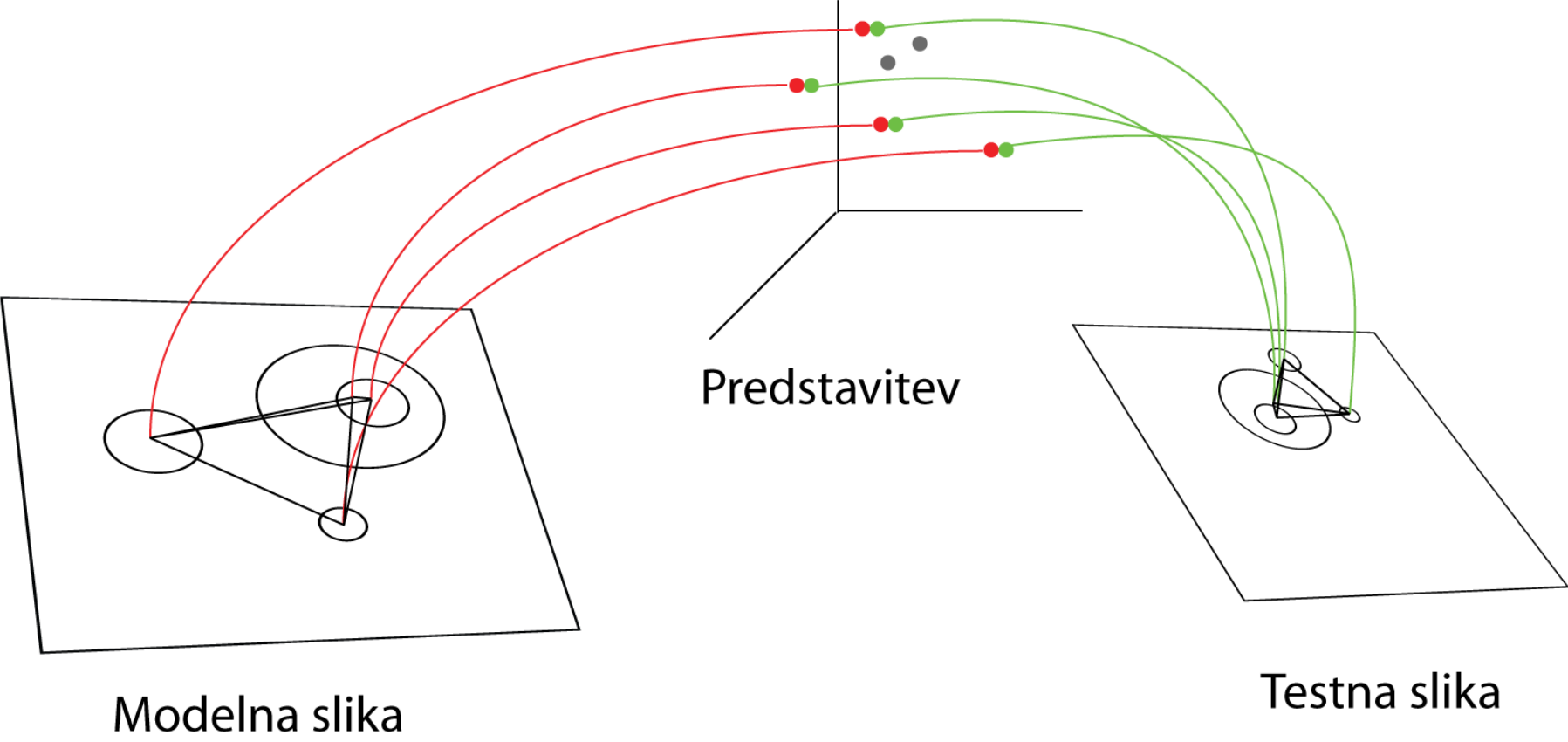
Predstavitve v prostoru značilk – globalne značilke



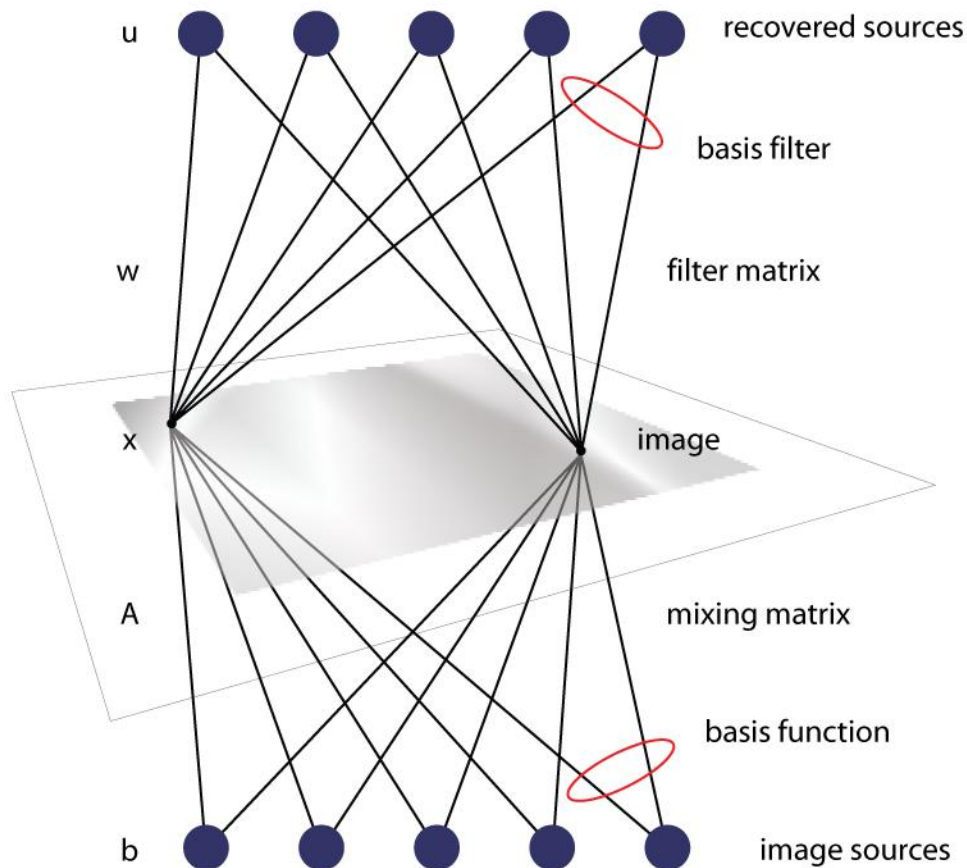
Predstavitve v prostoru značilk – lokalne značilke



Predstavitve v prostoru značilk – lokalne značilke + geometrijske relacije



Slika kot superpozicija virov



Blind linear image synthesis model
(Olshausen & Field, 1996)

Viri \mathbf{u} so parametri slike

\mathbf{u} :

dekorelirani in ortonormirani:
analiza glavnih komponent
(Principal Component Analysis, **PCA**)

dekorelirani in statistično neodvisni:
analiza neodvisnih komponent
(Independent Component Analysis, **ICA**)

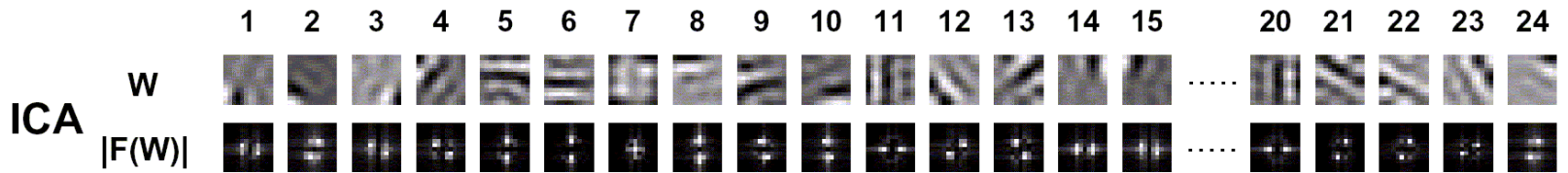
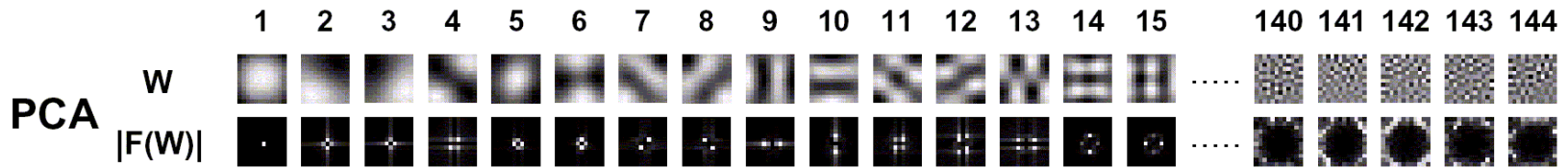
$$x_i = \sum_{j=1}^N a_{ij} b_j$$

Slika kot superpozicija virov

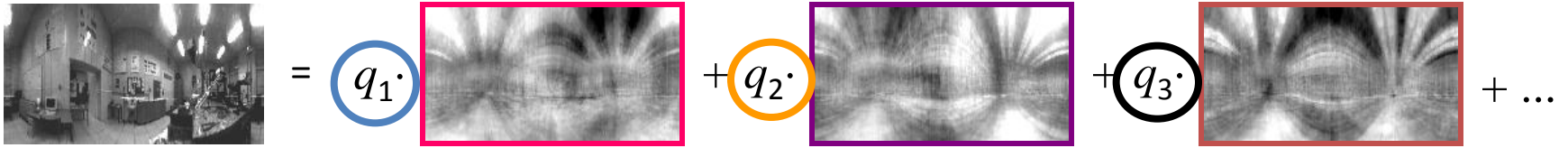
Analiza glavnih komponent, PCA



The image shows the decomposition of a grayscale photograph of a room into its principal components. The original image is on the left. It is equal to the sum of three principal components, each multiplied by a scalar coefficient: q_1 (circled in blue), q_2 (circled in orange), and q_3 (circled in black). The components are shown in colored boxes: pink for q_1 , purple for q_2 , and red for q_3 . The equation ends with "+ ...", indicating further components.

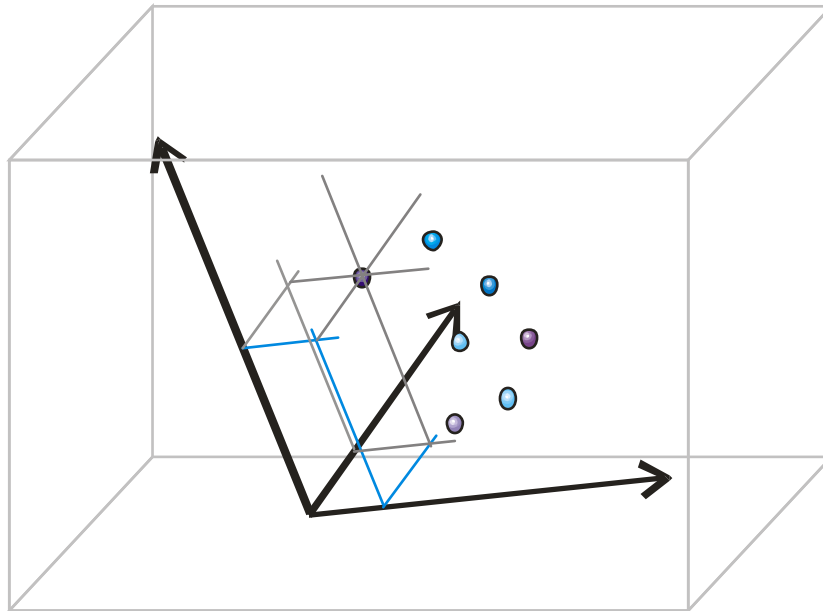


Analiza glavnih komponent, PCA

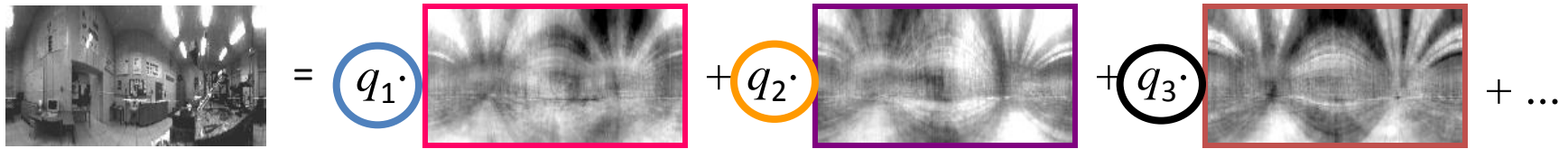


$$X = [\mathbf{x}_0 \quad \mathbf{x}_1 \quad \dots \quad \mathbf{x}_{n-1}] ; X \in \mathbb{R}^{m \times n}$$

$$U = [\mathbf{u}_0 \quad \mathbf{u}_1 \quad \dots \quad \mathbf{u}_k] ; k \ll n$$



Analiza glavnih komponent, PCA



PCA kot dekoreliranje podatkov: \mathbf{q} dekorelirani

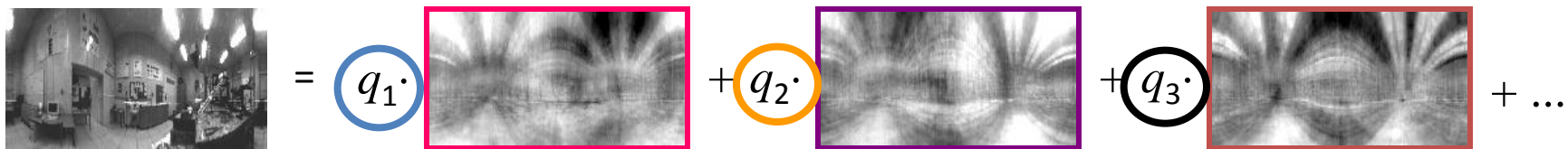
PCA kot projekcija v optimalen podprostor (glede na rekonstrukcijo) $\sum_{i=0}^{n-1} \left\| \mathbf{x}_i - \sum_{j=0}^k q_j(\mathbf{x}_i) \mathbf{u}_j \right\|^2 \rightarrow \min$

PCA kot analiza kovariančne matrike

$$C = X X^T = \begin{bmatrix} \mathbf{x}_0 & \mathbf{x}_1 & \dots & \mathbf{x}_{n-1} \end{bmatrix} \begin{bmatrix} \mathbf{x}_0^\top \\ \mathbf{x}_1^\top \\ \dots \\ \mathbf{x}_{n-1}^\top \end{bmatrix}$$

$$C \mathbf{u}_i = \lambda_i \mathbf{u}_i$$

Računanje PCA



Dekompozicija kovariančne matrice C

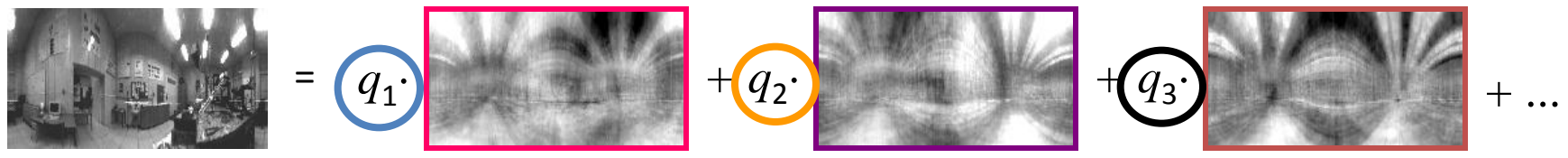
$$C = XX^T = \begin{bmatrix} \mathbf{x}_0 & \mathbf{x}_1 & \dots & \mathbf{x}_{n-1} \end{bmatrix} \begin{bmatrix} \mathbf{x}_0^\top \\ \mathbf{x}_1^\top \\ \dots \\ \mathbf{x}_{n-1}^\top \end{bmatrix}$$

$$C = ULU^T$$

$$U = [\mathbf{u}_1 \mathbf{u}_2 \dots \mathbf{u}_n]$$

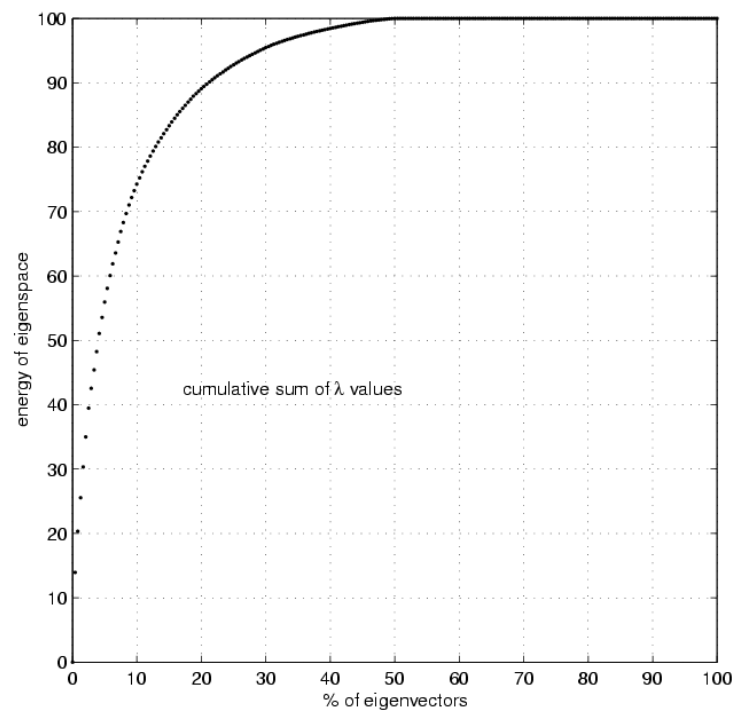
$$L = \begin{bmatrix} \lambda_1 & 0 & \dots & 0 \\ 0 & \lambda_2 & & \\ \dots & & \dots & \\ 0 & \dots & & \lambda_n \end{bmatrix}$$

Predstavitev v PCA podprostoru



Ohranimo samo k dimenzij, $k \ll n$

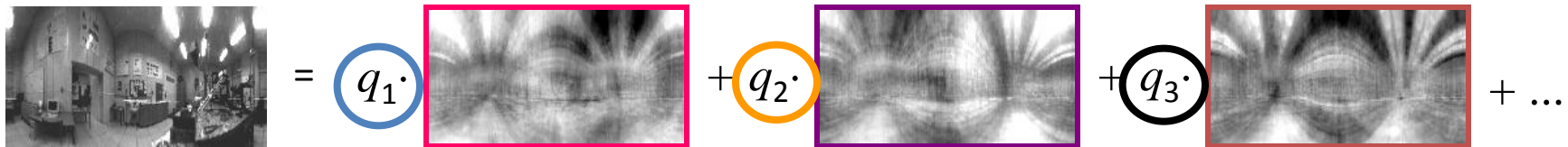
$$U = [\mathbf{u}_0 \quad \mathbf{u}_1 \quad \dots \quad \mathbf{u}_k]; \quad k \ll n$$



Ocena energije lastnega podprostora:
normalizirana kumulativna vsota lastnih vrednosti

$$\lambda_j^S = \frac{\sum_{i=1}^j \lambda_i}{\sum_{i=1}^n \lambda_i}$$

Projekcija slike v lastni prostor



$$\mathbf{x} = q_1 \mathbf{e}_1 + q_2 \mathbf{e}_2 + q_3 \mathbf{e}_3 + \dots$$

$$\mathbf{x} \mathbf{e}_1 = q_1 \mathbf{e}_1 \mathbf{e}_1 + q_2 \mathbf{e}_2 \mathbf{e}_1 + q_3 \mathbf{e}_3 \mathbf{e}_1 + \dots$$

$$\mathbf{x} \mathbf{e}_1 = q_1$$

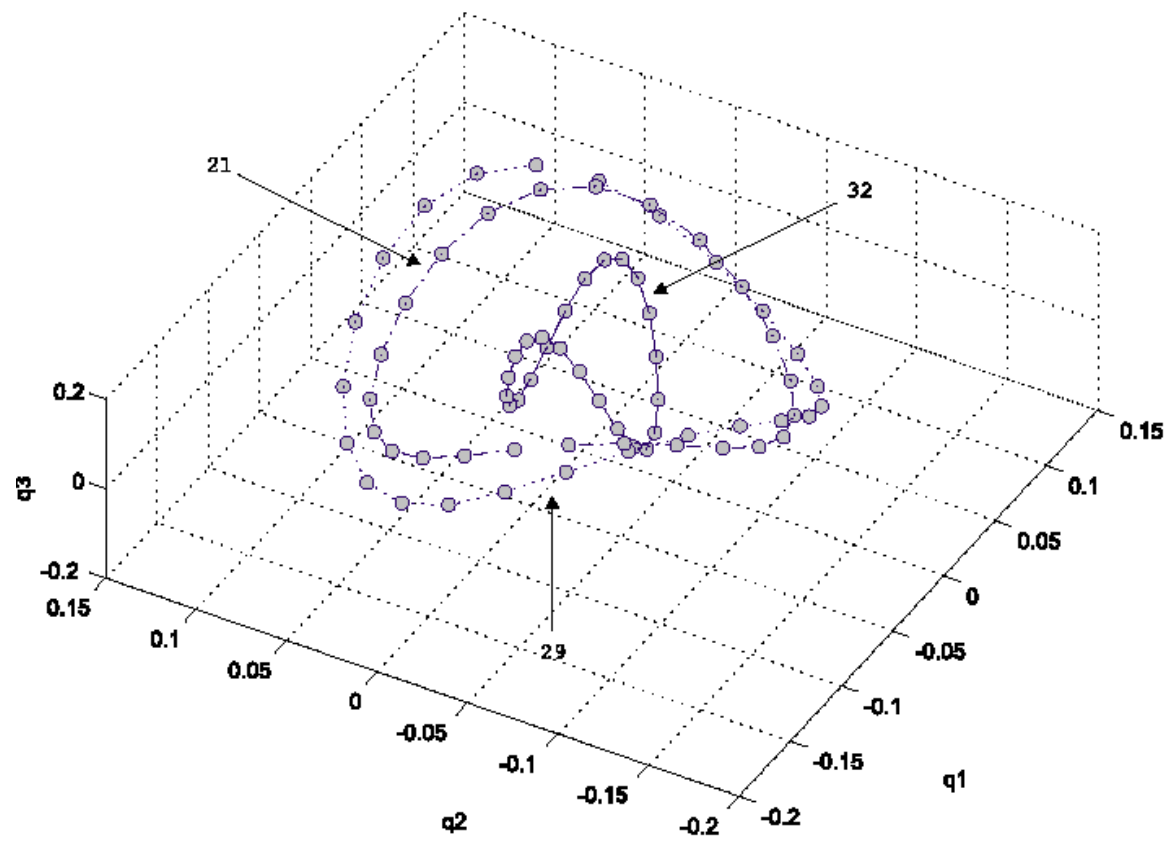
$$\mathbf{x} \mathbf{e}_2 = q_2$$

...

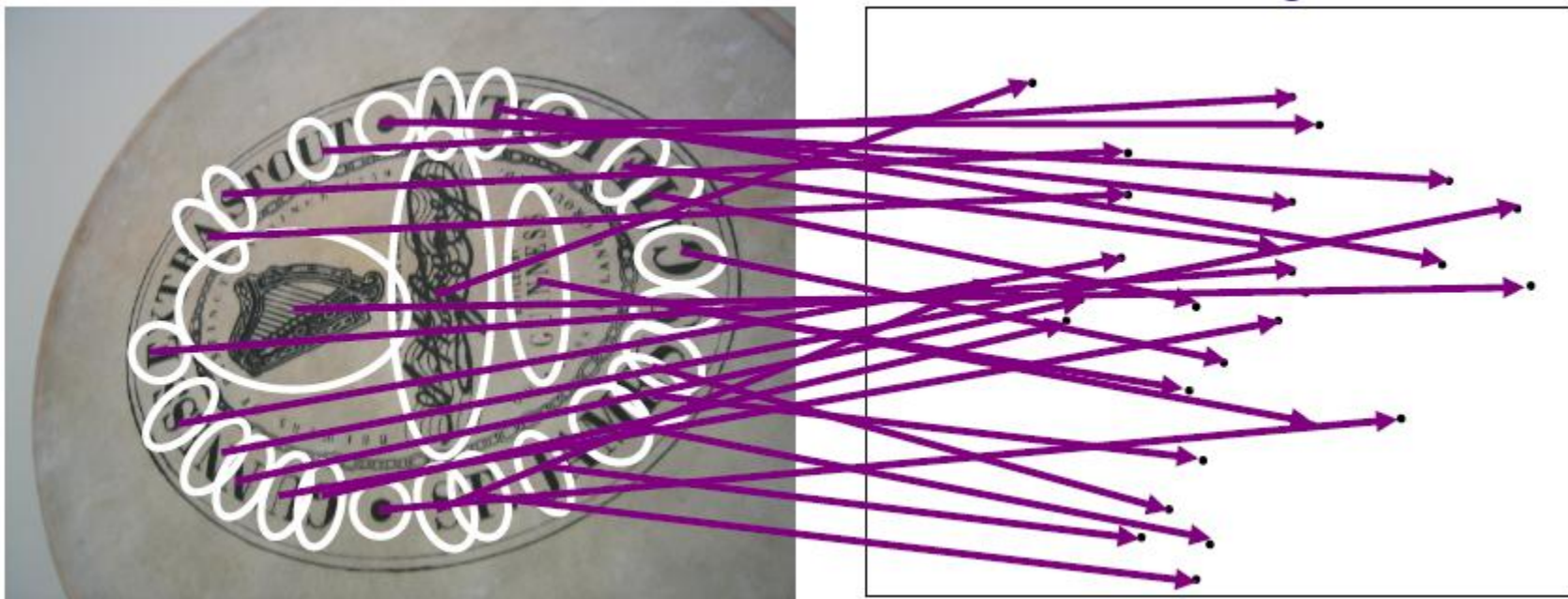
$$\mathbf{q} = U^T \mathbf{x}$$

$$Q = U^T X$$

Preslikave v lastni prostor

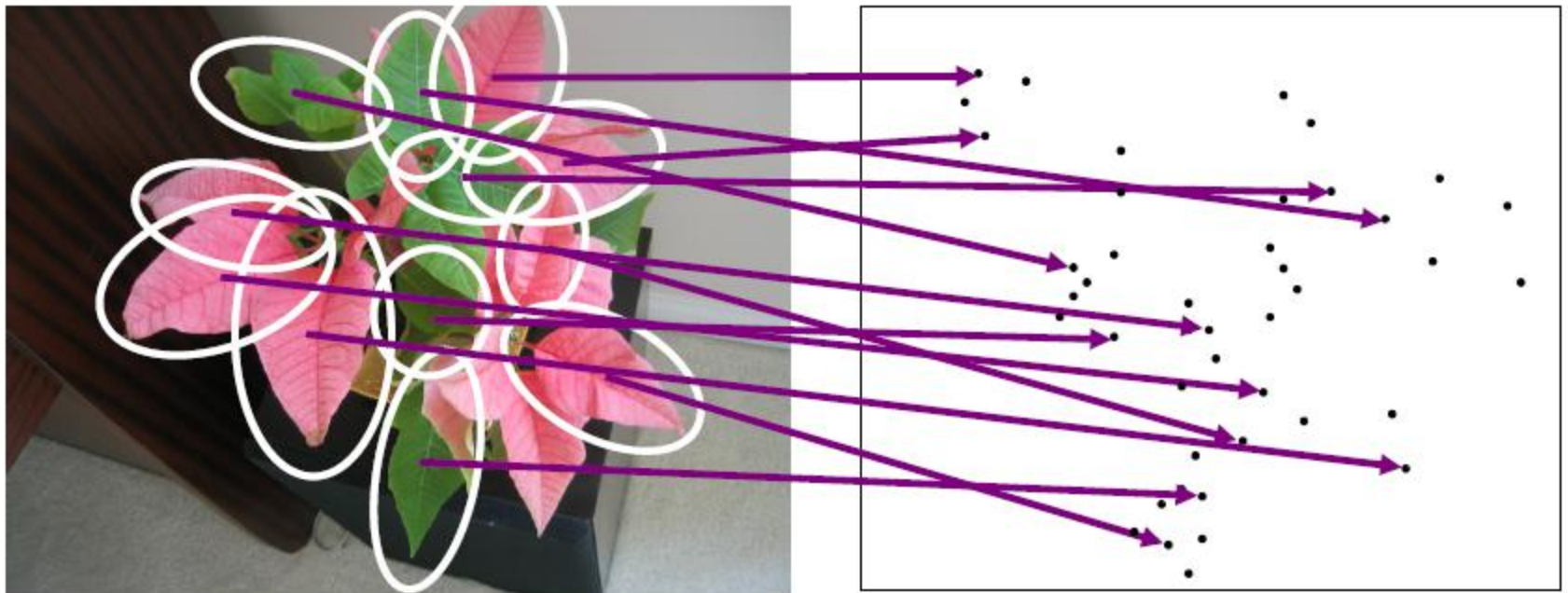


Prostori lokalnih značilk



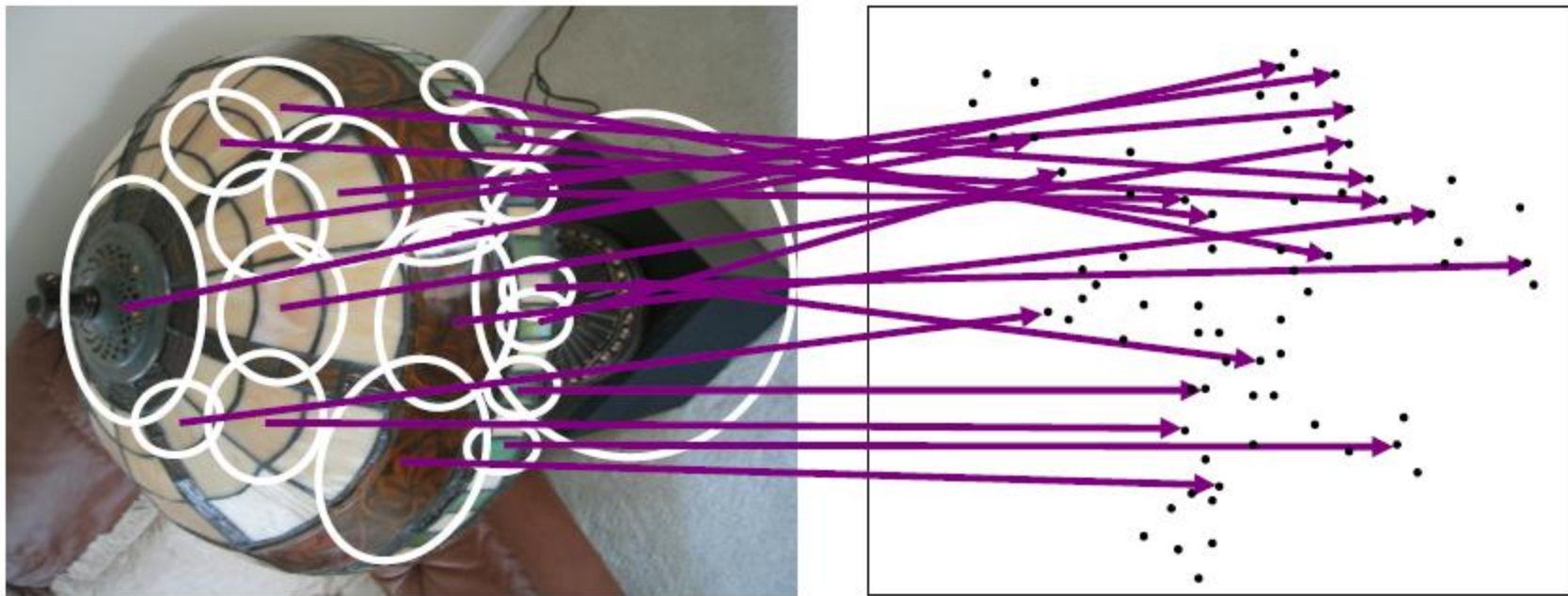
Prostor značilk (PCA, SIFT ...)

Prostori lokalnih značilk



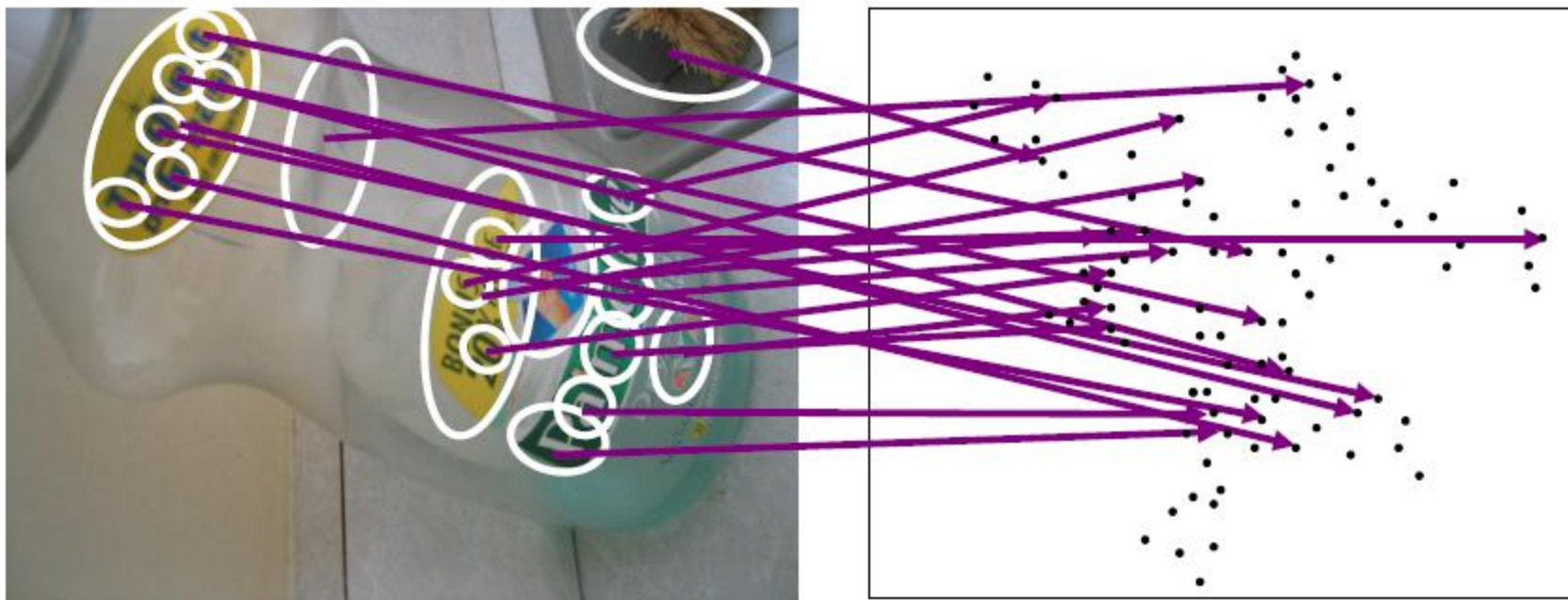
Prostor značilk (PCA, SIFT ...)

Prostori lokalnih značilk



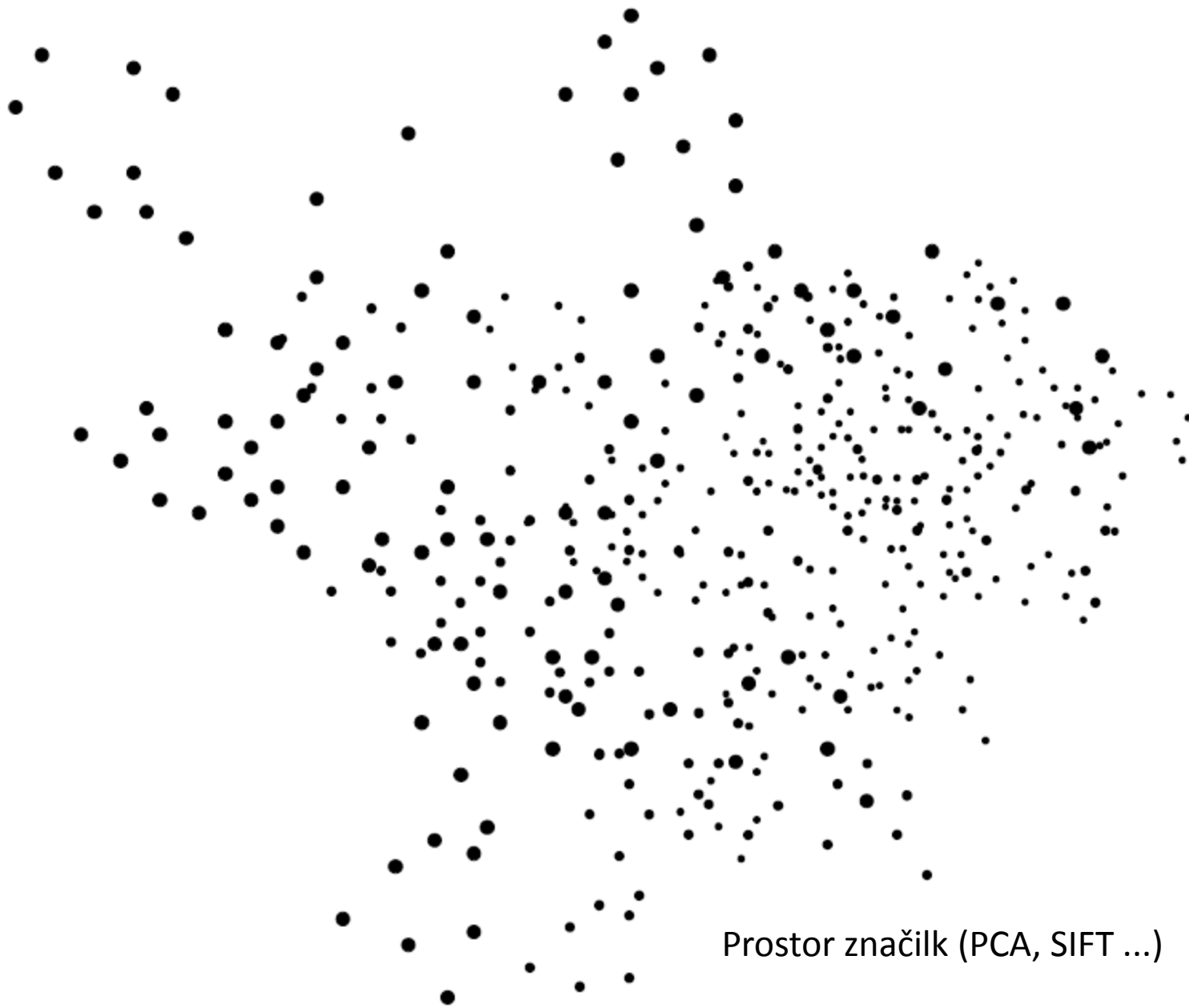
Prostor značilk (PCA, SIFT ...)

Prostori lokalnih značilk

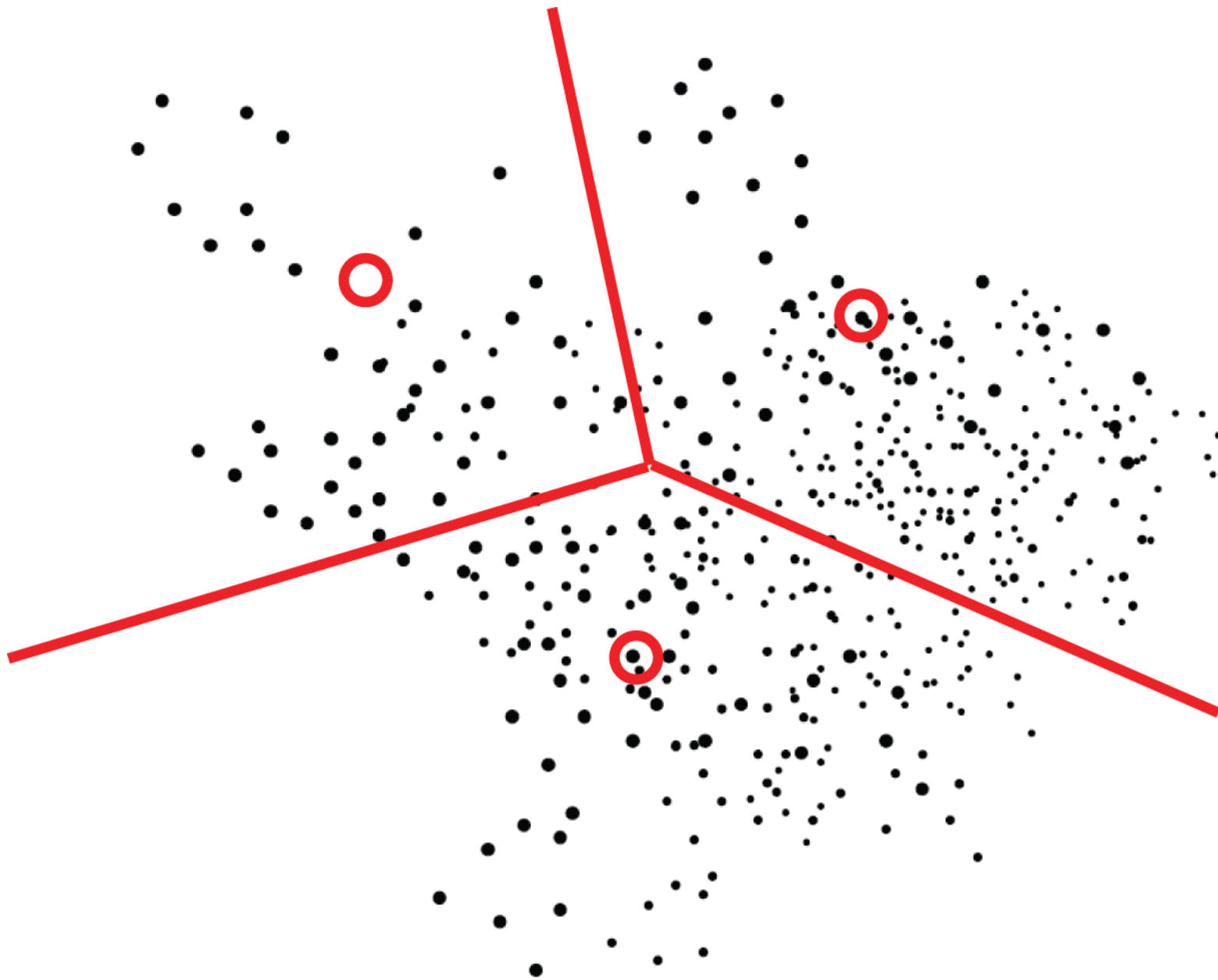


Prostor značilk (PCA, SIFT ...)

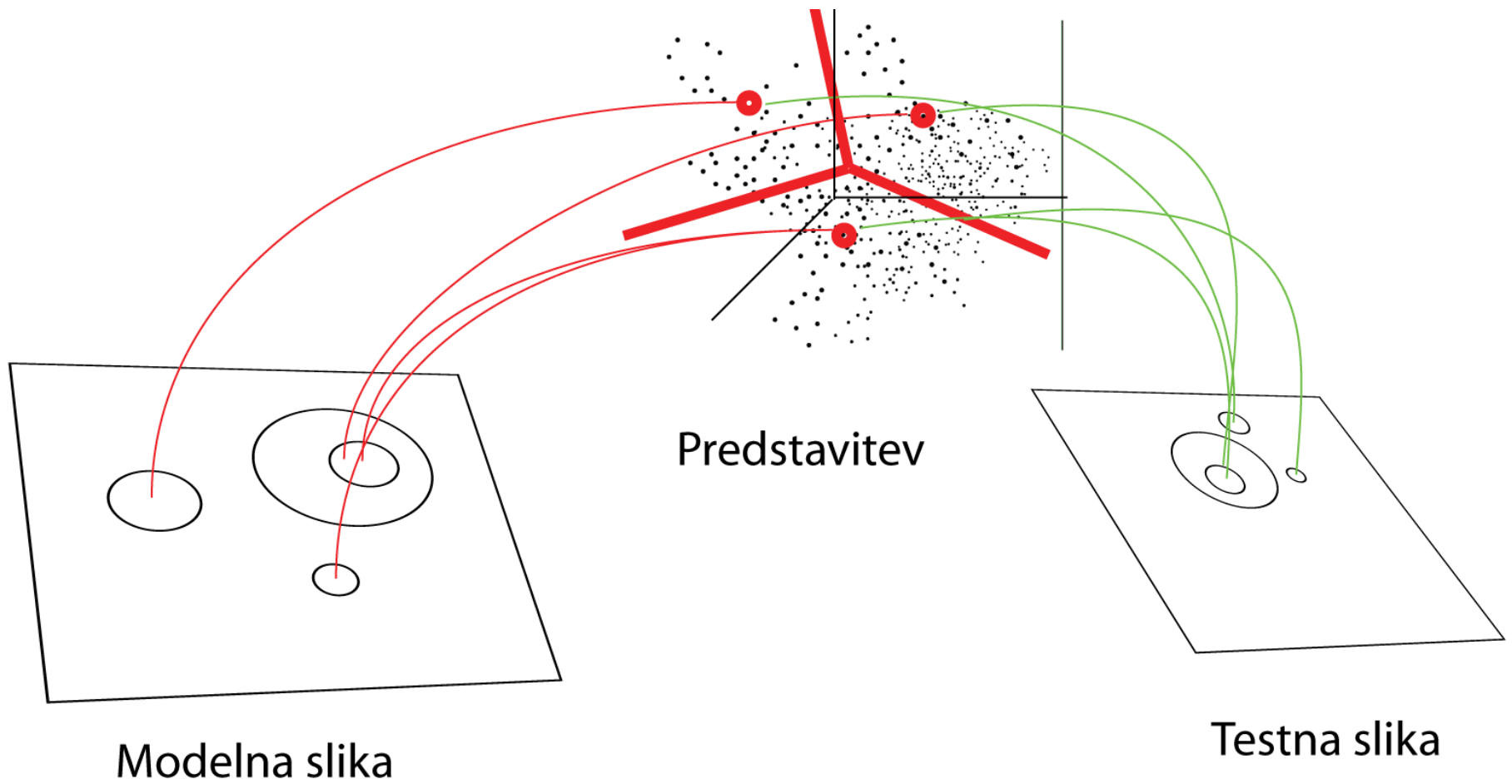
Prostori lokalnih značilk



Prototipi lokalnih značil

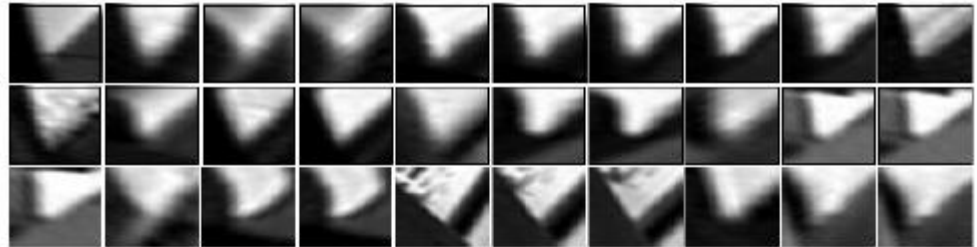
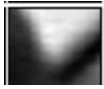


Prototipi lokalnih značilk

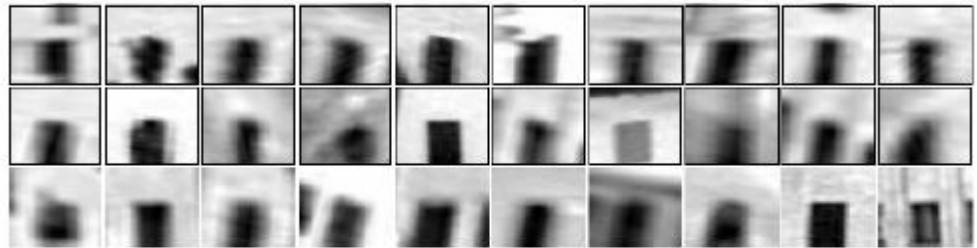


Slovar (codebook)

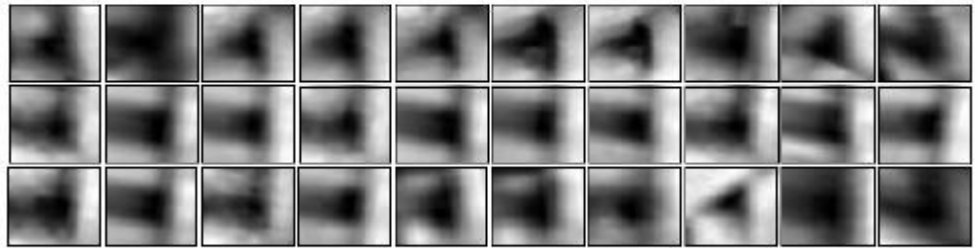
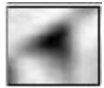
koren 1



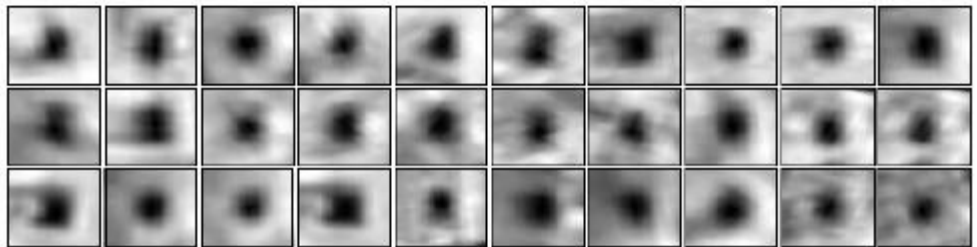
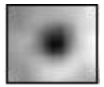
koren 2



koren 3



koren n



Invertirano indeksiranje



frame #5



frame #10

Word number	List of image numbers
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1	→ 5, 10, ...
2	→ 10, ...
...	...