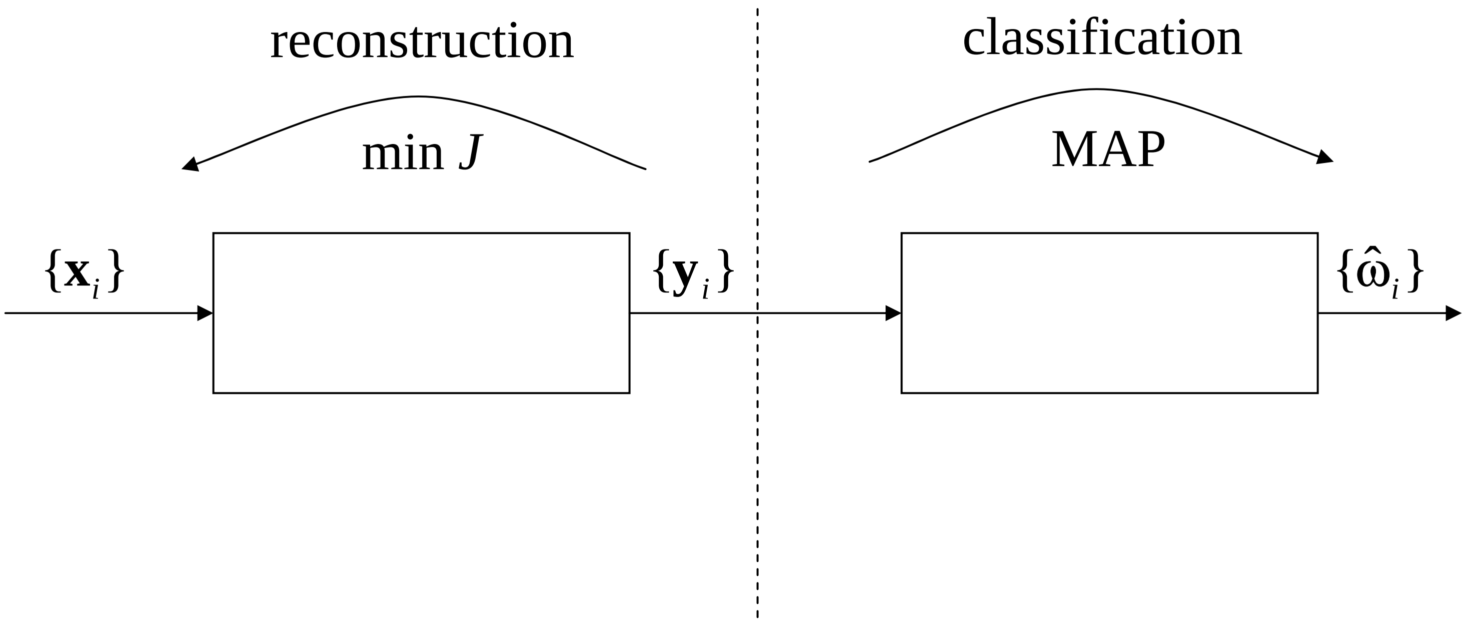
Dividing the process of classification into a *feature selection* (approximation problem) and a *classification in the subspace*



Note: Each class has generally its own class specific distribution density. For optimal feature selection the distribution density over all classes has to be chosen!

Example

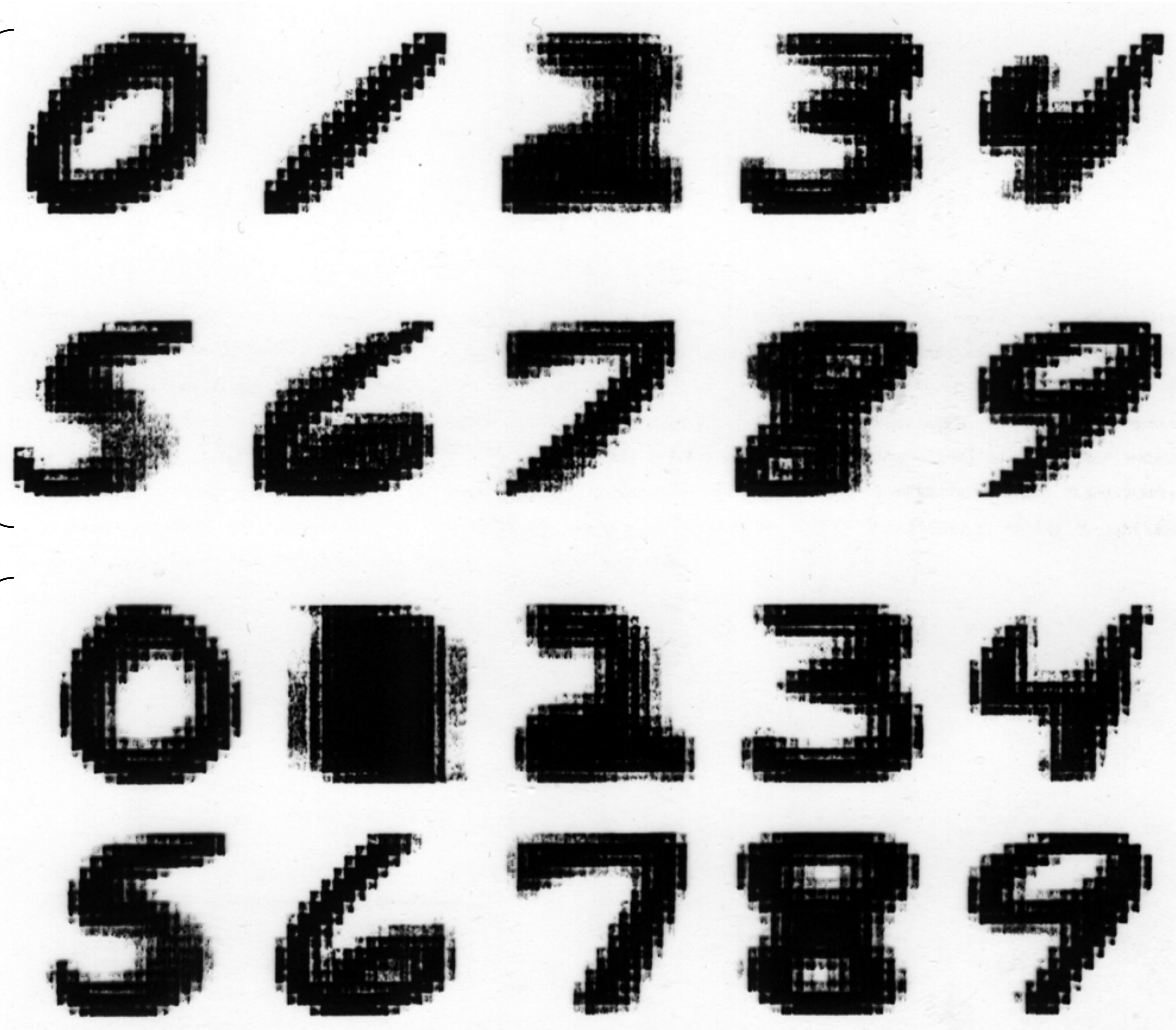
Recognition of handwritten digits and visualization of Eigenvalue decomposition

(taken from J. Schürmann: „Pattern Classification“, John Wiley 1996)

Visualization of class specific *expected values* $\{\mu_k\}$ of handwritten digits

normalization of location and size (bounding box)

additional normalization of shear

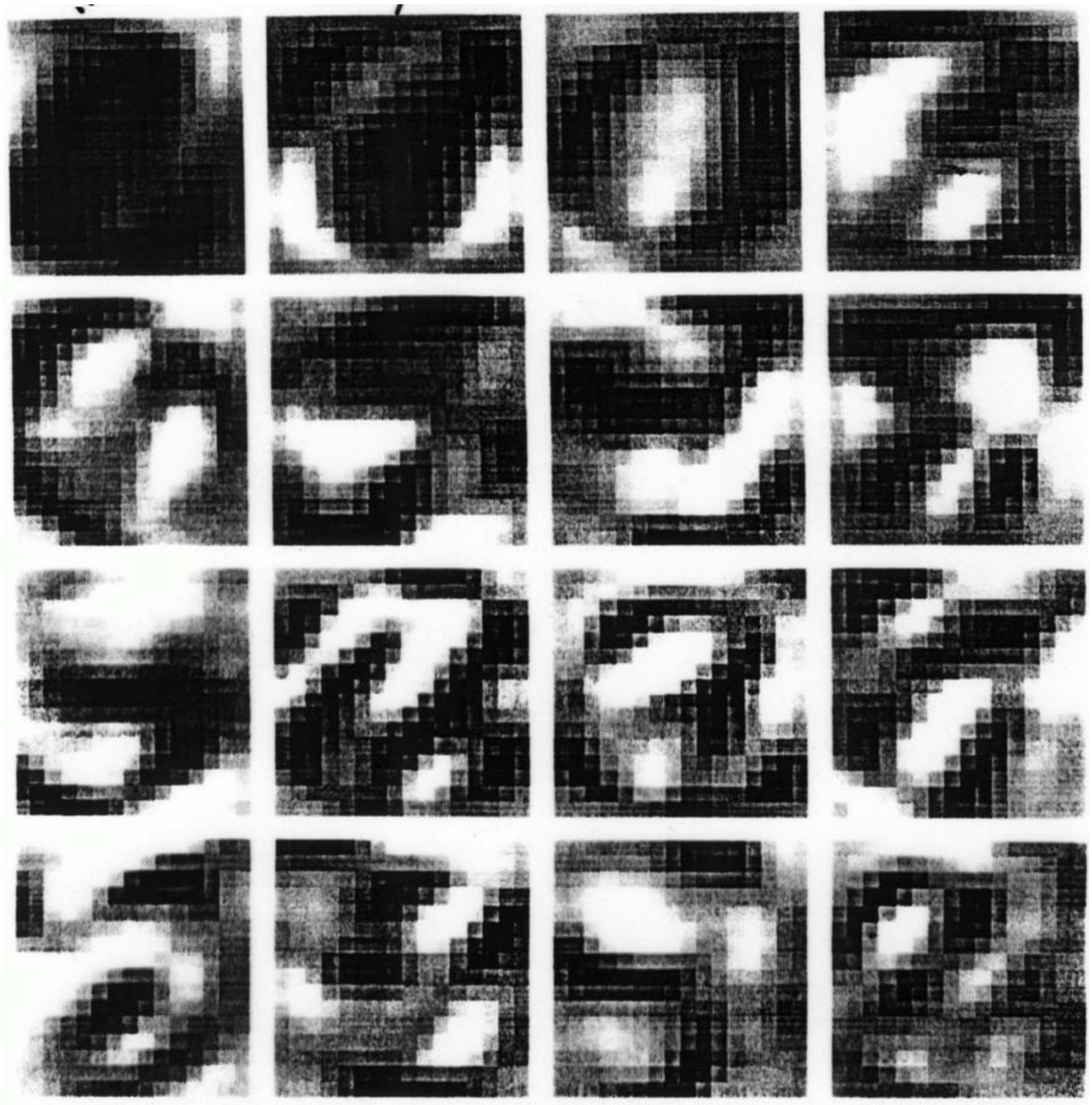


the original samples $\{\mathbf{x}_i\}$ are black and white, pixel grid: 16×16, the expected values reach general grey values, the gray values clarify the statistical spread

Representation of the first M=16 Eigenvectors in the feature space $\{\mathbf{y}_i\}$

$\mathbf{e}'_1$ $\mathbf{e}'_2$ $\mathbf{e}'_3$ $\mathbf{e}'_4$

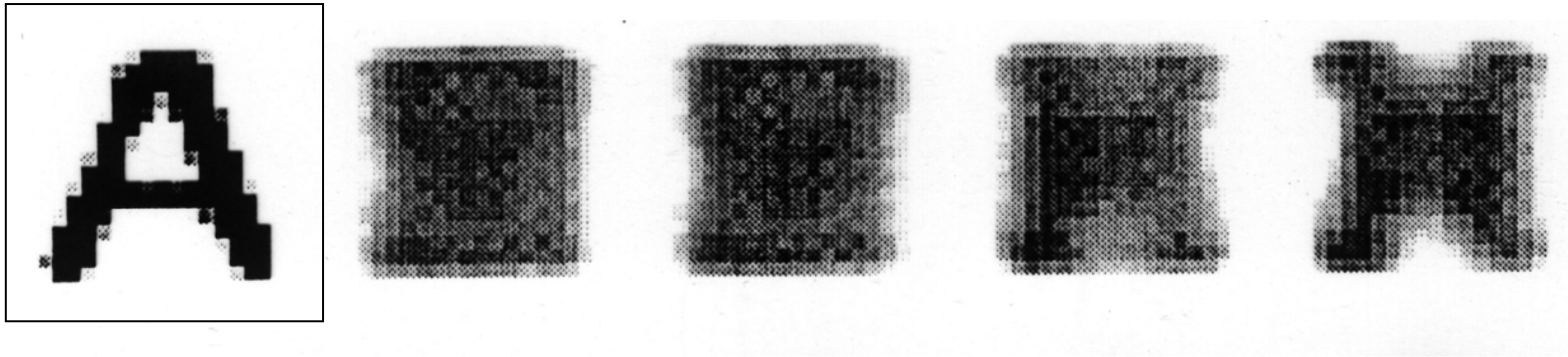
$\mathbf{e}'_5$



The low Eigenvectors contribute to the rough structures, the higher Eigenvalues to the finer details

Fast convergence in the Eigenvectorspace

original

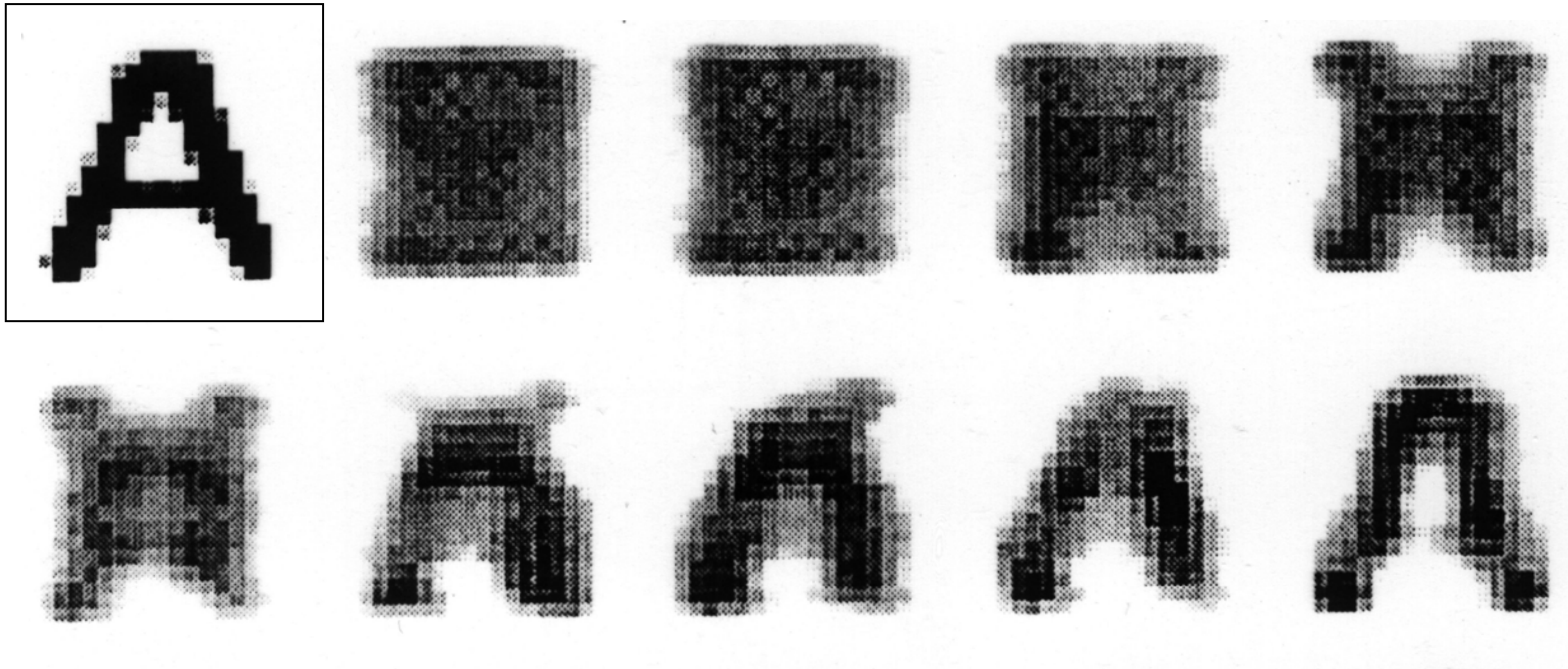


Respresentation with: top: 1,2,3,4 center: 5,6,8,10,15 bottom: 20,25,30,35,40

The original images have dimension N=16×16=256. With feature vector of dimension 40 a very good respresentation can be found.

Fast convergence in the Eigenvectorspace

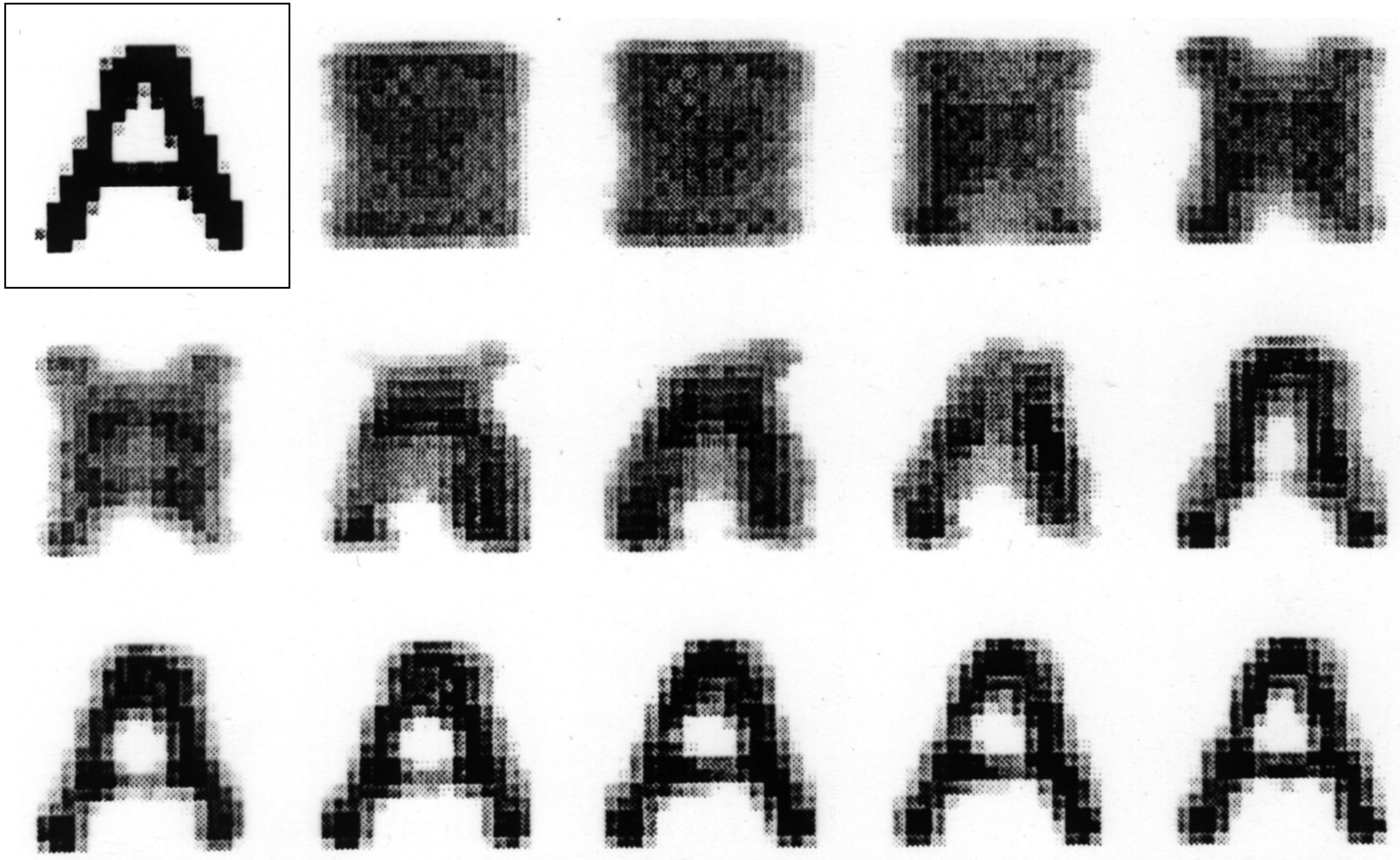
original



Rrespresentation with: top: 1,2,3,4 center: 5,6,8,10,15 bottom: 20,25,30,35,40
The original images have dimension N=16×16=256. With feature vector of dimension 40 a very good rrespresentation can be found.

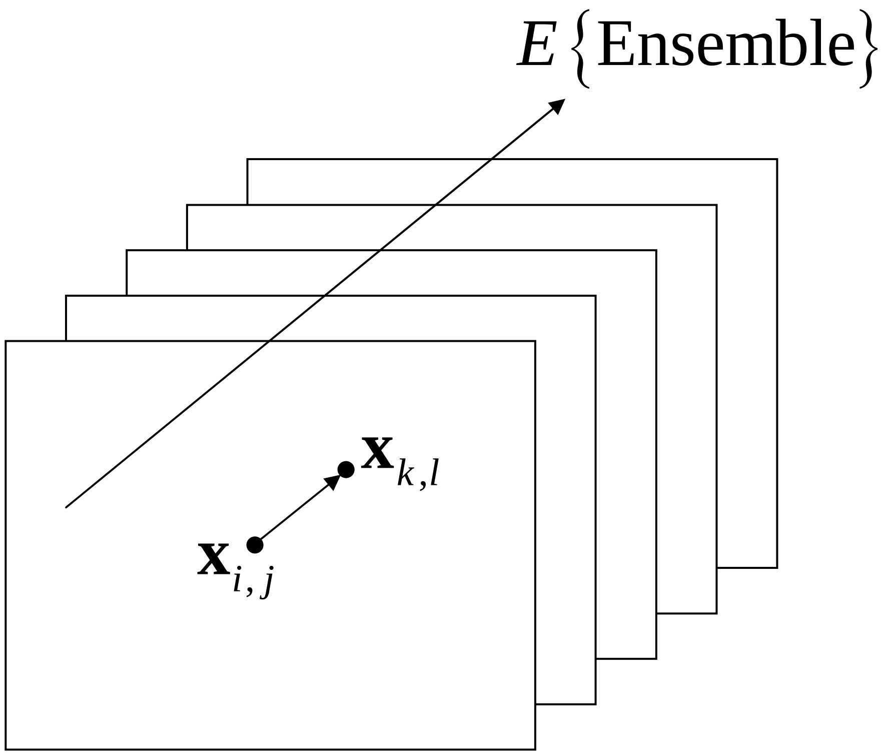
Fast convergence in the Eigenvectorspace

original



Representation with: top: 1,2,3,4 center: 5,6,8,10,15 bottom: 20,25,30,35,40
The original images have dimension N=16×16=256. With feature vector of dimension 40 a very good respresentation can be found.

Visualization of the covariance matrix

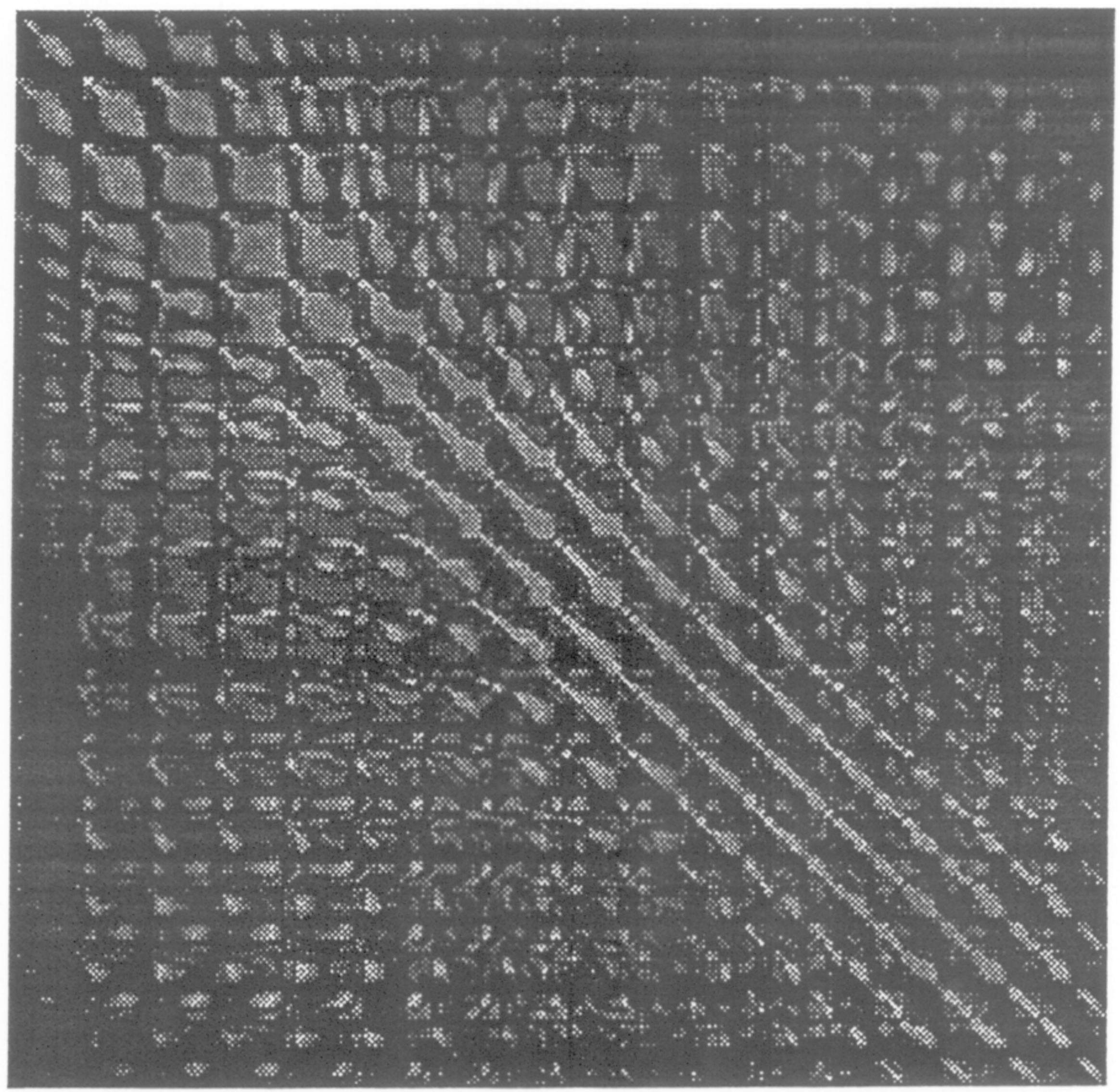


An image of dimension $N\times N$ generates a covariance matrix of dimension $N^2\times N^2$.

covariance: $E\{(\mathbf{x}_{i,j}-\bar{\mathbf{x}}_{i,j})(\mathbf{x}_{k,l}-\bar{\mathbf{x}}_{k,l})\}$

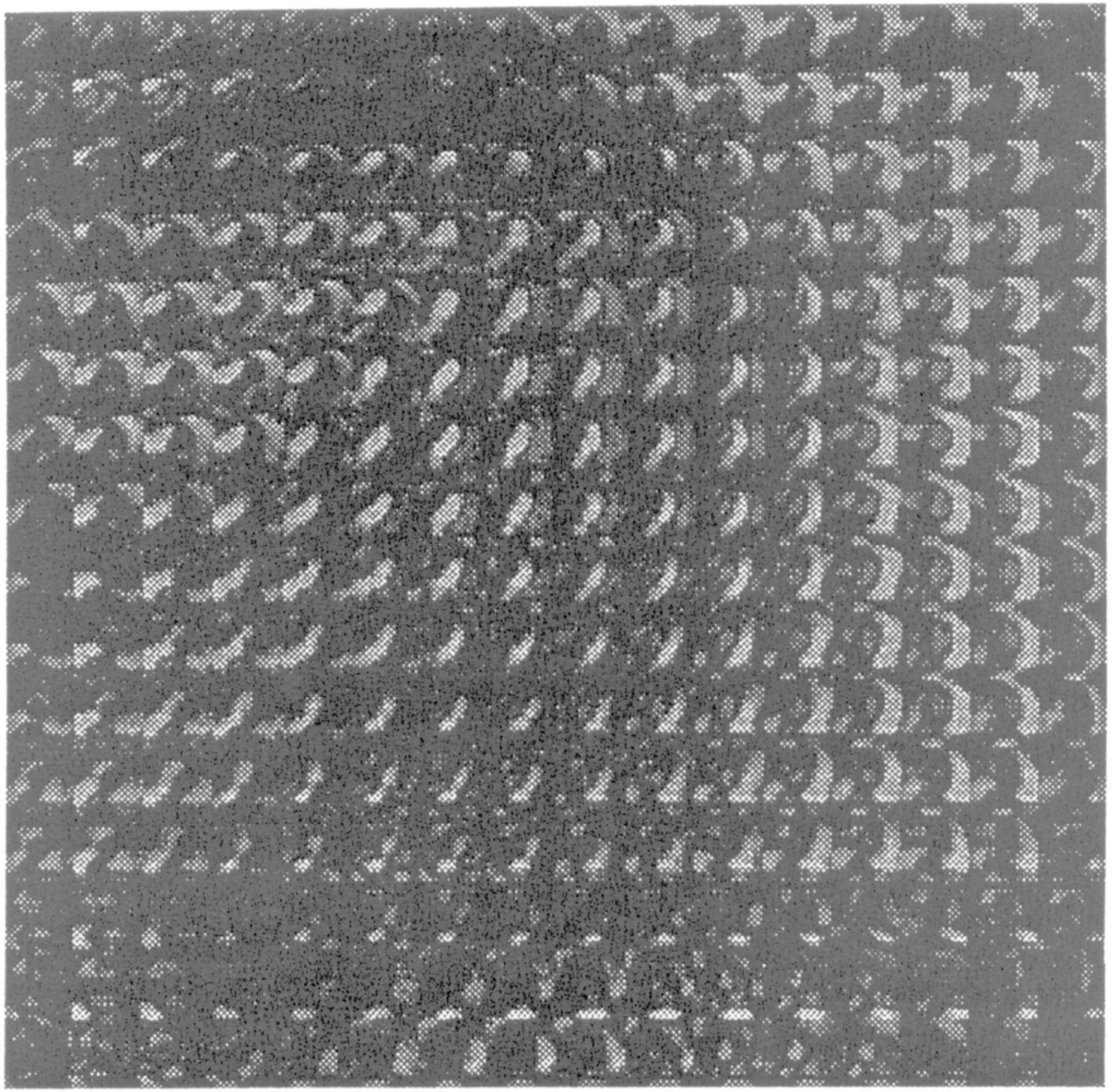
Characterizes the static dependency between pixel and images

Visualization of the covariance matrix of *one* handwritten digit class "2"



Natural arrangement of the covariance matrix (rowwise stacked). The image shows that the process is not a white process (then only gray values along the diagonal could be seen), but the gray value distributions visualize the correlations in the neighbourhood.

Visualization of the covariance matrix of *one* handwritten digit class "2"



Reorganization of the covariance matrix:
The sub matrices, which represent the local correlations, are pushed to the corresponding pixel positions.