Computer Image Processing

Lecture 6

Segmentation

Binarization

Image segmentation

The main goal of image segmentation is dividing it into sub-areas corresponding to objects visible on it.

This operation is often accompanied by indexing of objects (labelling), which means assigning labels to them that indicate the belonging of pixels.

Segmentation allows separating fragments that fulfill a certain homogeneity criterion (eg. color, brightness, texture).

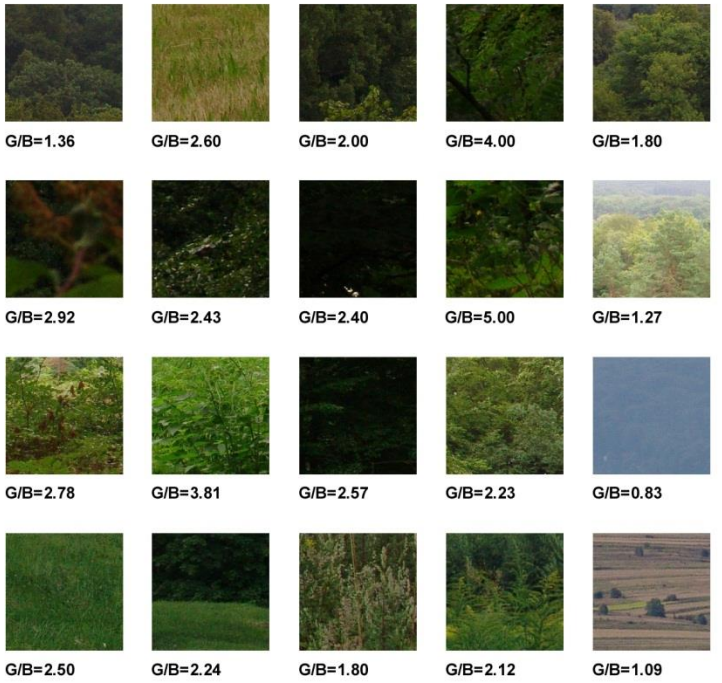
Segmentation is the initial stage for recognizing objects, detecting their features and geometry, and assessing the spatial relationships between them.

Image segmentation

Image segmentation

Background detection

Image segmentation



Greenery detection

Image segmentation

The other elements are buildings and infrastructure (well, almost …)

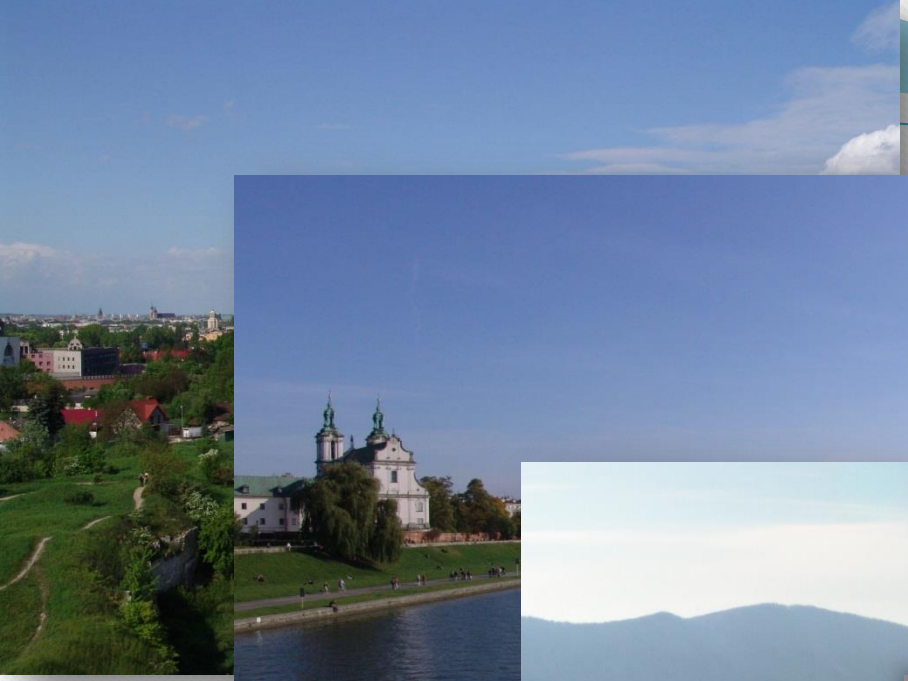


Image segmentation

- region splitting, clustering
- region growing
- thresholding
- edge detection
- histogram-based methods
- watershed
- graph partitioning methods
- trainable segmentation
- etc…

Image segmentation

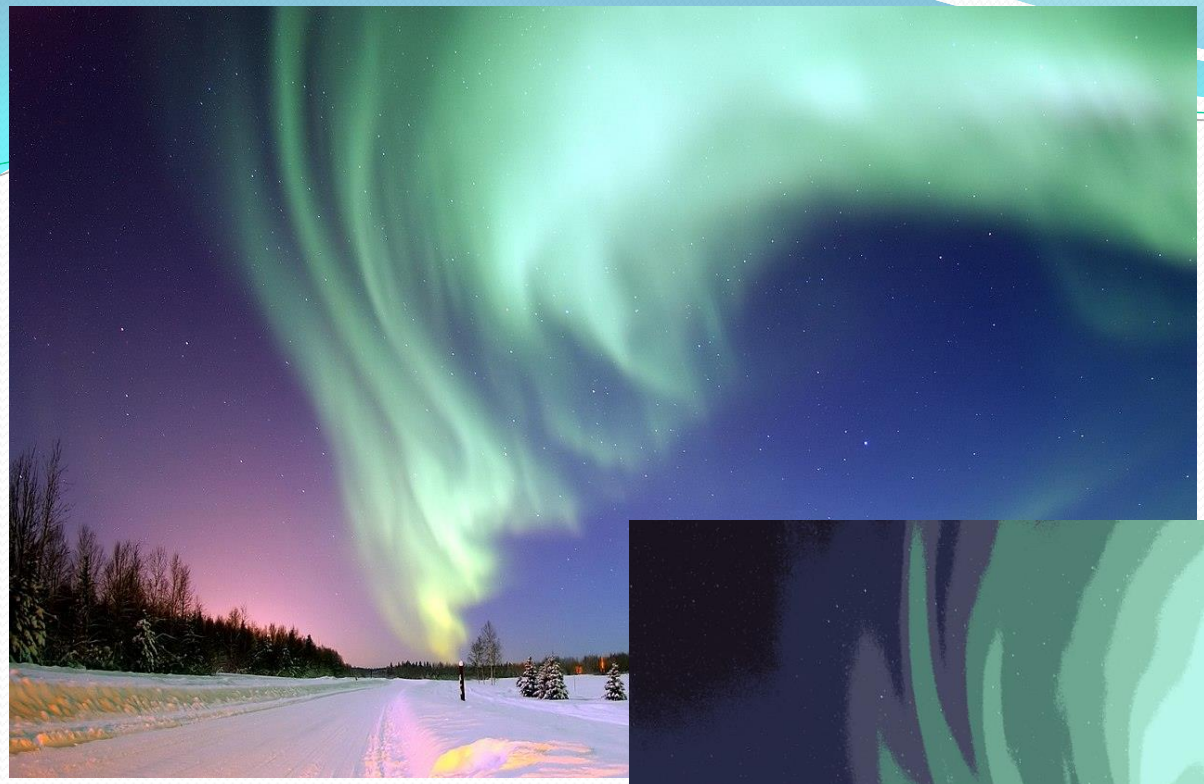
Two main approaches to image segmentation:

1. Pixels belonging to different classes have different characteristics (eg. they differ in color, brightness or texture characteristics). Search for differences that indicate the boundaries of areas of the classes.
2. Pixels belonging to same class have similar characteristics (fulfilling the given homogenity criterion). Search for similar pixels and join them into area of one class.

Image segmentation

Example of clustering method (K-means algorithm).

1. Select *K* cluster centers (randomly or heuristic)
2. Assign each pixel to the cluster by minimizing distance (in term of brightness, color, etc.) between pixel and cluster center.
3. Recalculate pixel centers by averaging values of pixels assigned to the cluster.
4. Repeat steps 2-3 until no pixels change the assignment.



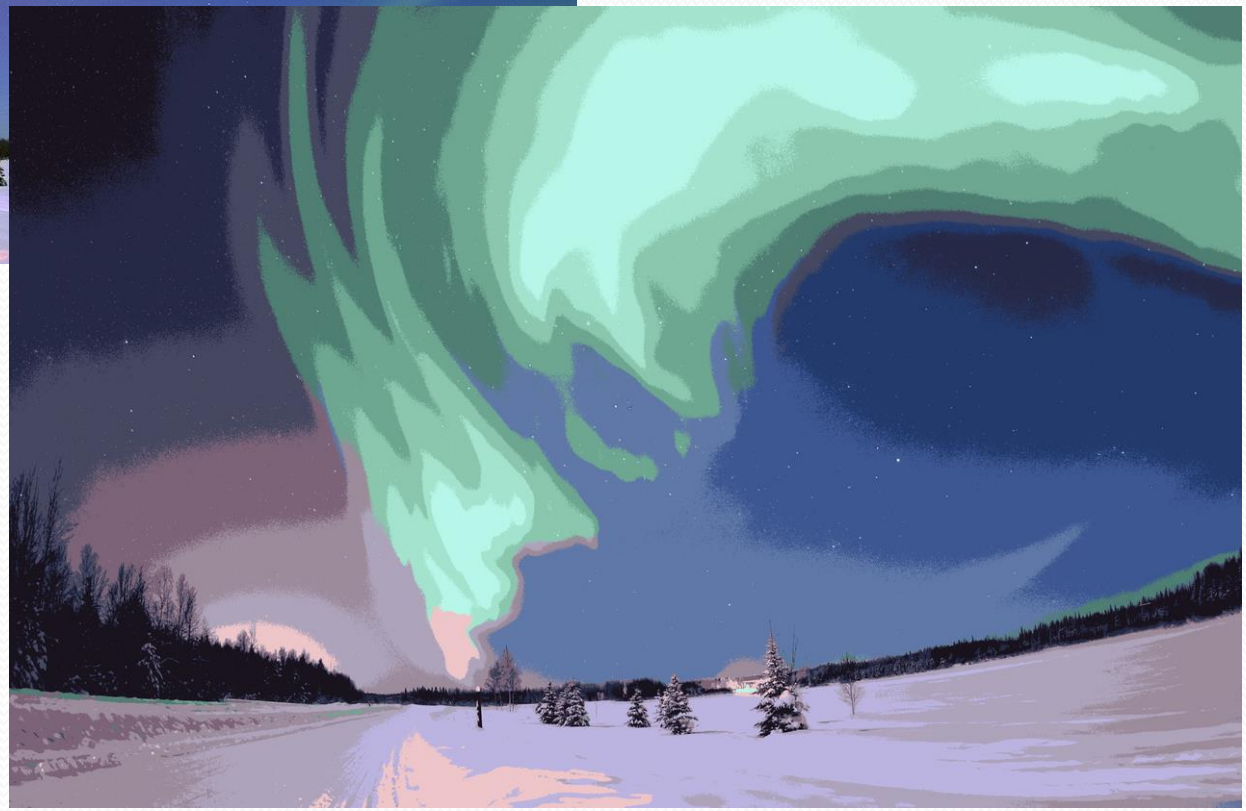


Image segmentation

Example of region growing method .

1. Determine the uniformity test (brightness, color, etc.)
2. Divide the image to areas of the same size.
3. Perform the uniformity test to each region.
4. If the area is homogeneous, it should be joined with its possible neighbour (or neighbours). If not, it should be re-divided (split and merge method)
5. Continue until each area pass the uniformity test.

Image segmentation

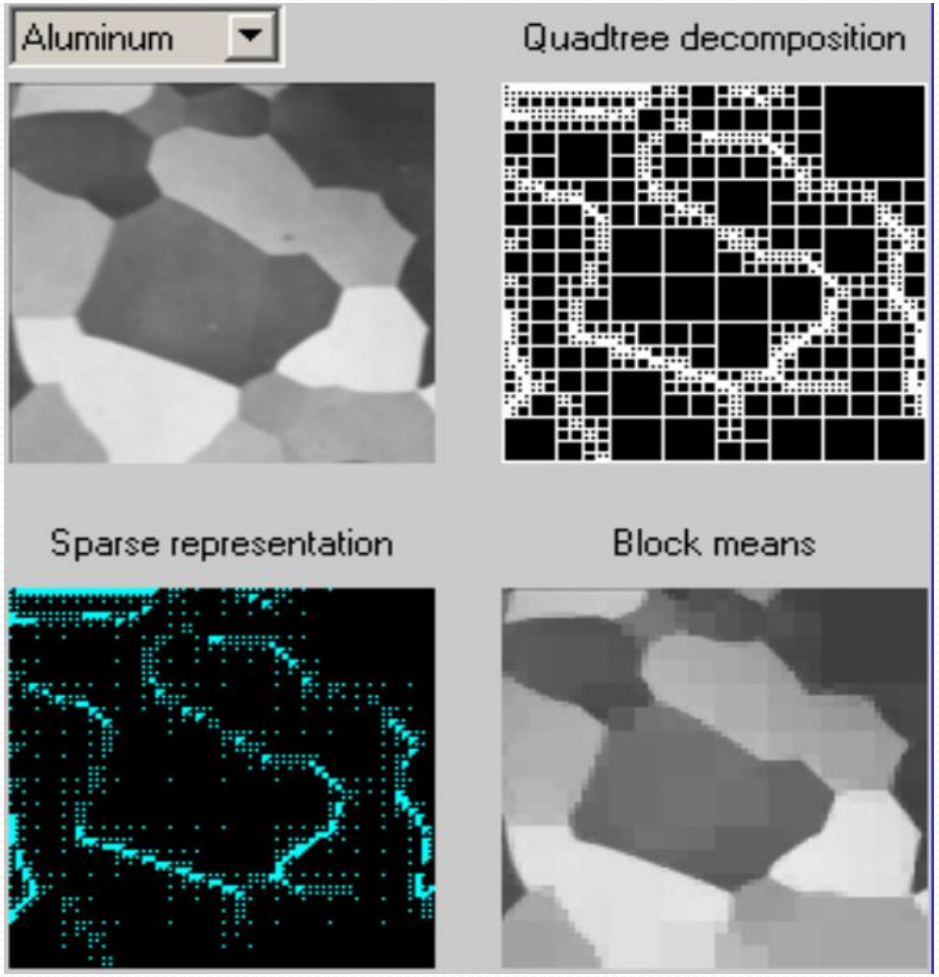


Image segmentation

Watershed algorithm

Grayscale image is treated as a terrain, where the brightness of the pixel corresponds to its height.

Local minima are treated as floodplains.

The algorithm works by connecting successive neighbouring points until encountering a local maximum, which is the boundary of two areas.

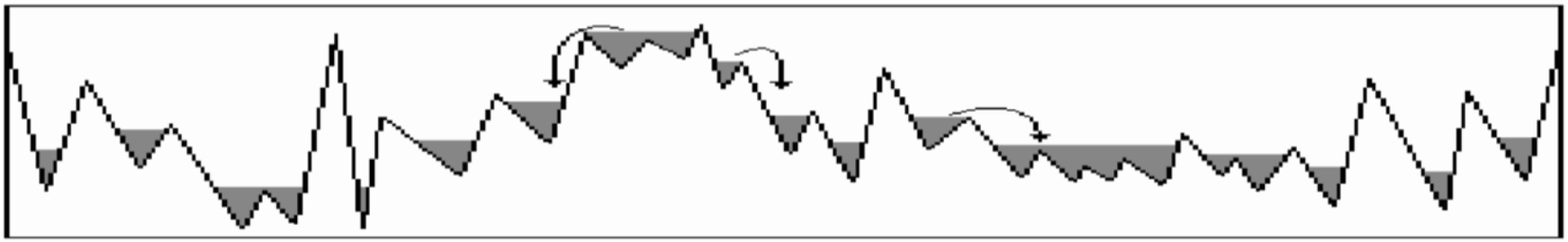


Image segmentation

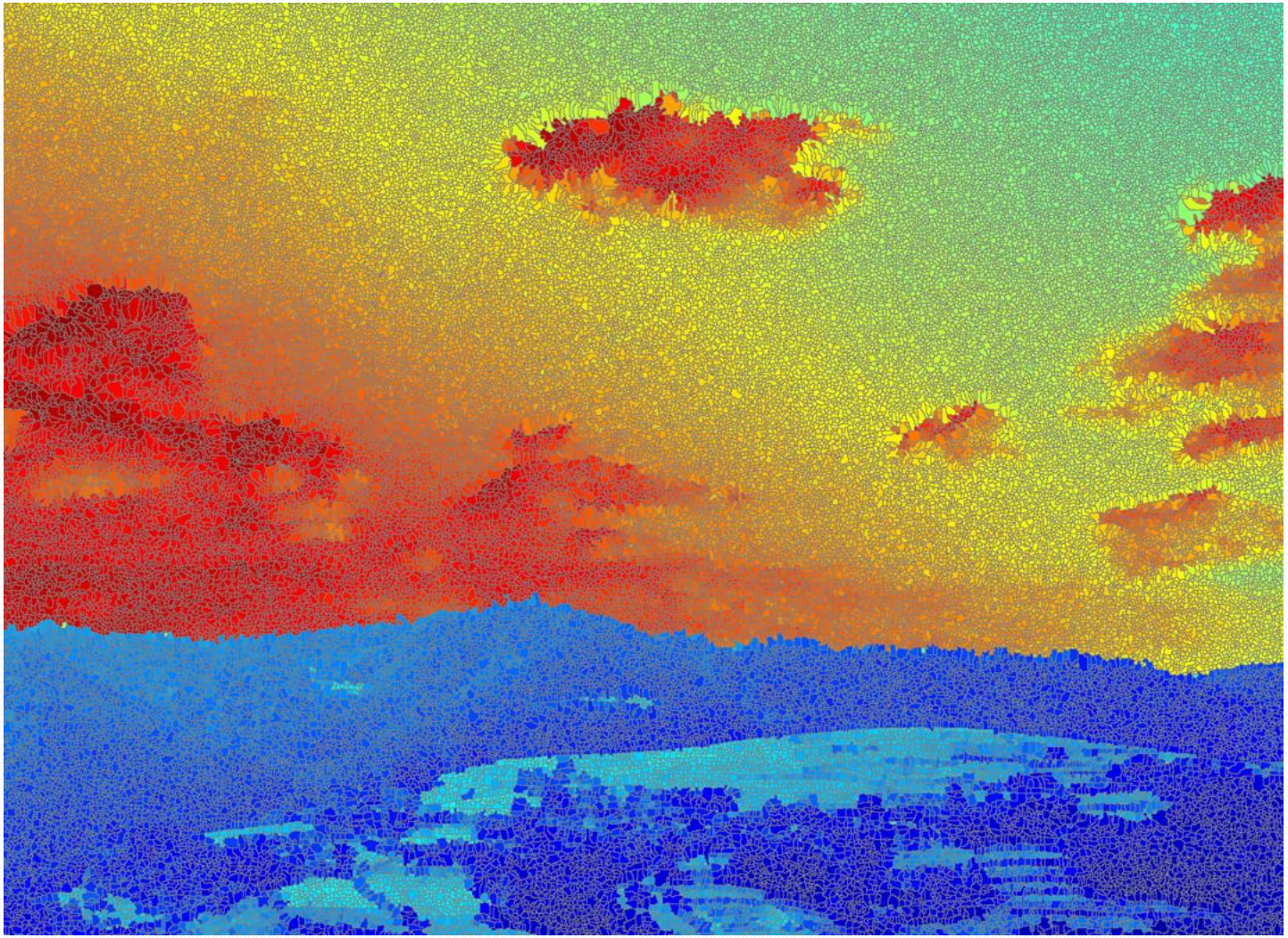


Image segmentation

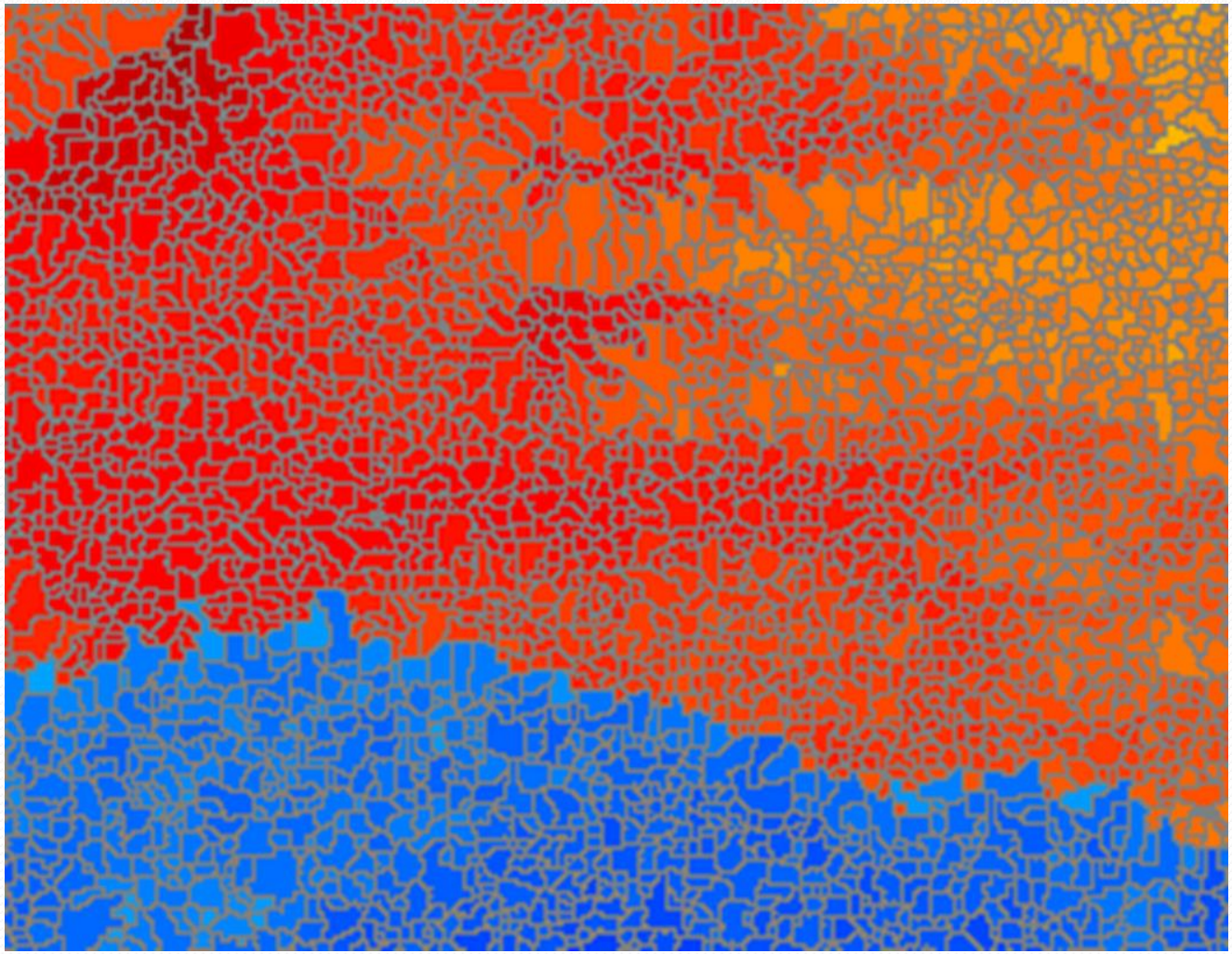


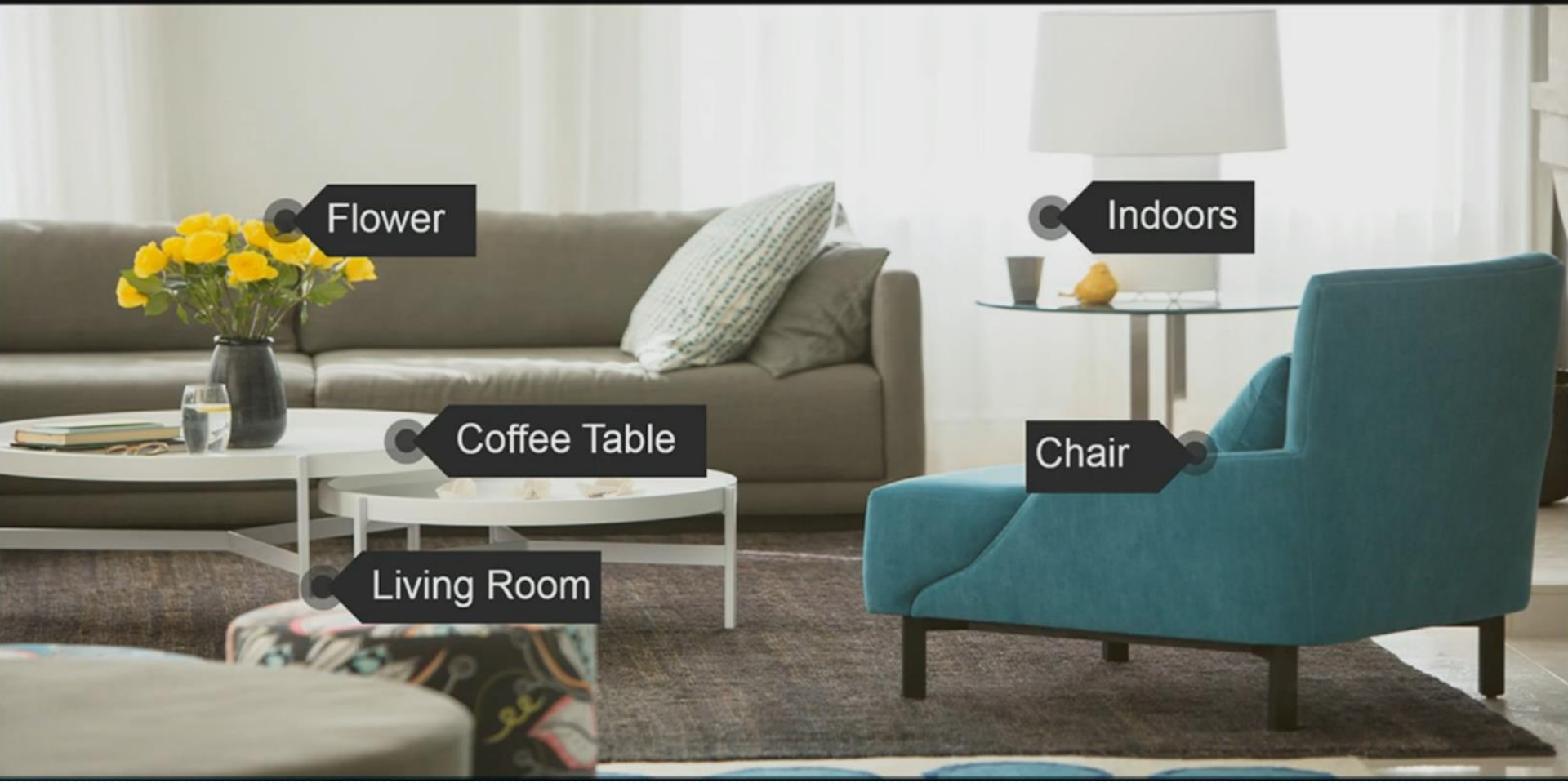
Image segmentation

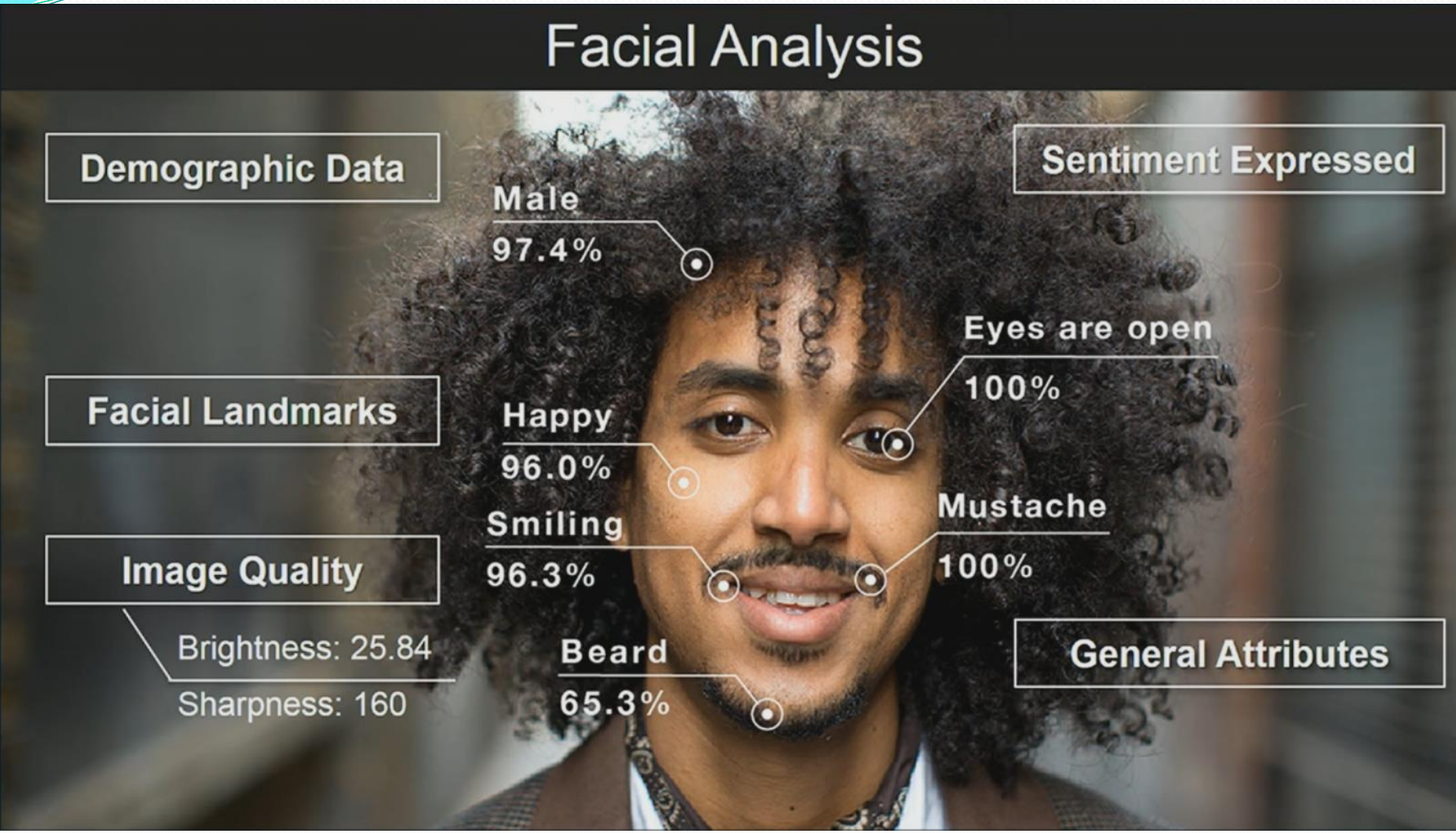
Applications of image segmentation

- medical imaging,
- satellite imagery,
- face recognition,
- video surveillance,
- traffic control,
- CBIR (content-based image retrival) oraz QBIC (query by image content)
- .....


PERSON
99.3%
OUTDOORS
83.1%
CREST
83.0%
MOUNTAIN BIKE
99.1%
ROCK
82.8%

Object and Scene Detection




Facial Analysis
Demographic Data
Male
97.4%
Sentiment Expressed
Eyes are open
100%
Facial Landmarks
Happy
96.0%
Mustache
100%
Smiling
96.3%
Image Quality
Brightness: 25.84
Sharpness: 160
Beard
65.3%
General Attributes

Binarization

Image binarization

Binarization (thresholding)

Transforming the image with many gray levels into a black and white (or binary) image (with a bit depth of 1)

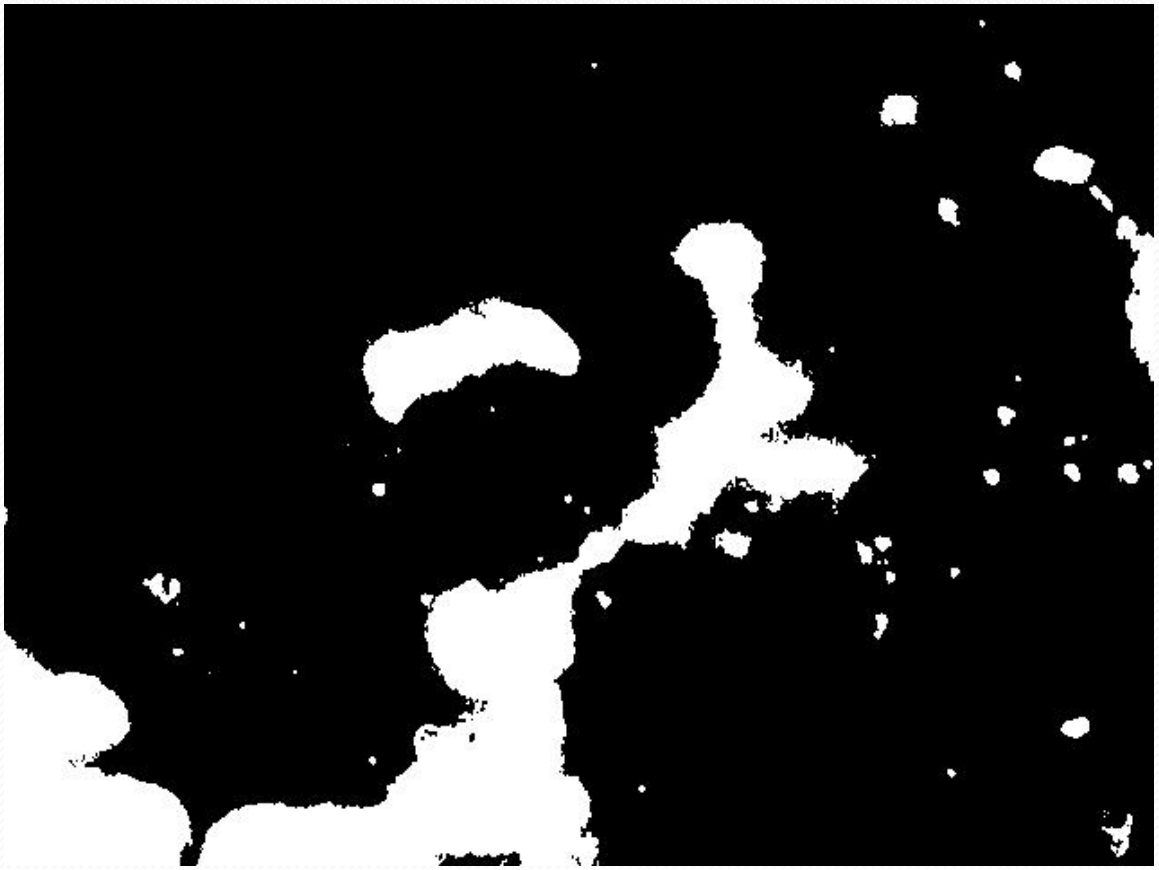


Image binarization

Binarization goals:

- the ability to take measurements of basic image parameters (number of objects, surface area, length),
- modifying the shape of objects (filling holes, separating glued particles, smoothing the contour),
- analysis of the shape of elements,
- defining transformations of images in the grayscale (treated as a set of as many binary images as many grey levels they contain),
- vectorization, recognition of the writing.

Image binarization

Definitions:

Image segmentation - the division of the image into areas that fulfill a given homogeneity criterion (for example: brightness).

Thresholding - comparison of the values of each pixel with a given threshold value. Appropriate selection of the threshold allows proper separation of areas of a given type.

Image binarization

Binarization with one threshold (bottom)

The simplest method of thresholding

$$J_w(x,y) = \begin{cases} 1, & J(x,y) > t \\ 0, & J(x,y) \leq t \end{cases}$$

t - binarization threshold

As a result of that transformation, the grayscale image is transformed into a binary (1-bit) image, in which pixels with brightness $J(x,y) \leq t$ will be the object's points, while the remaining pixels will be background points.

Image binarization

Binarization with one threshold

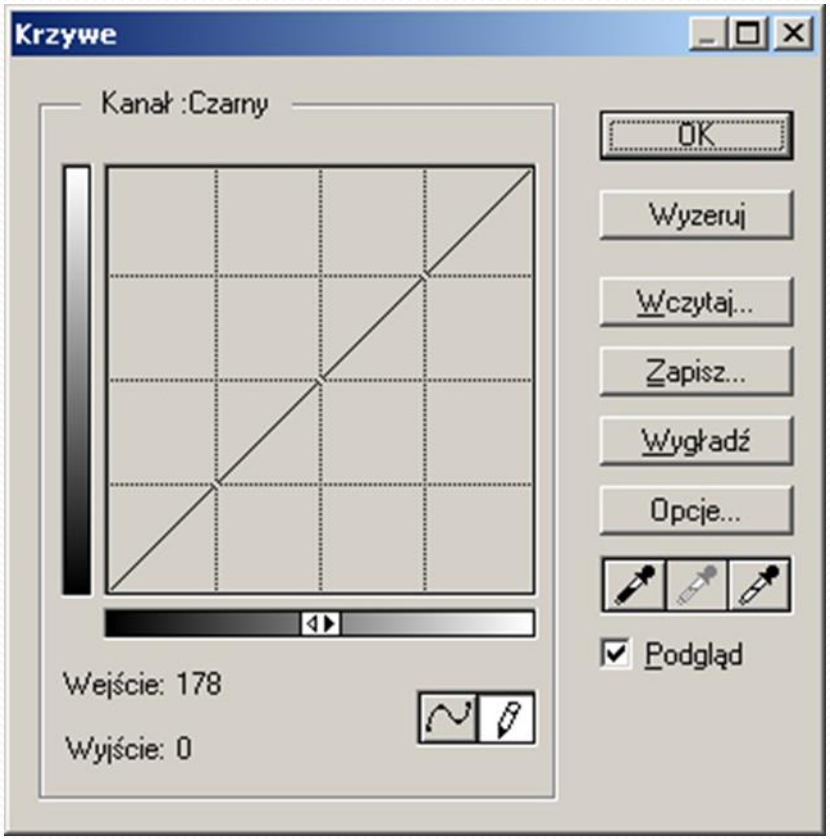


Image binarization

Binarization with one threshold

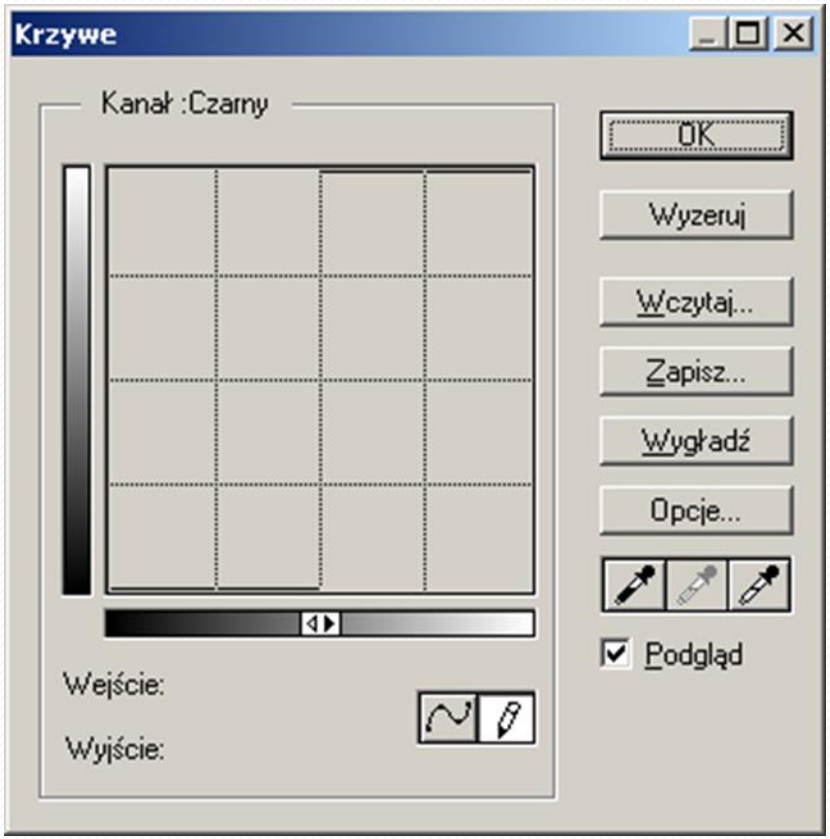


Image binarization

Binarization with one threshold (top)

$$J_w(x,y) = \begin{cases} 0, & J(x,y) > t \\ 1, & J(x,y) \leq t \end{cases}$$

t - binarization threshold

The resulting image can be treated as a negative image obtained as a result of thresholding with the bottom threshold.

Image binarization

Binarization with one threshold

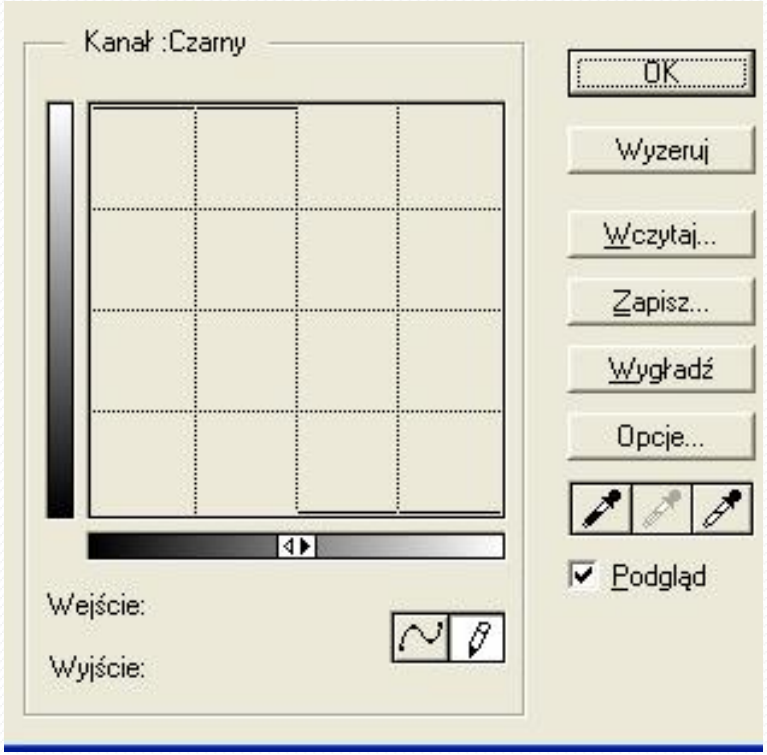


Image binarization

Pseudothresholding

$$J_w(x,y) = \begin{cases} J(x,y), & J(x,y) > t \\ 0, & J(x,y) \leq t \end{cases}$$

t - binarization threshold

As a result of this transformation image is more useful for analysis because the background details are filtered out.

Image binarization

Pseudothresholding

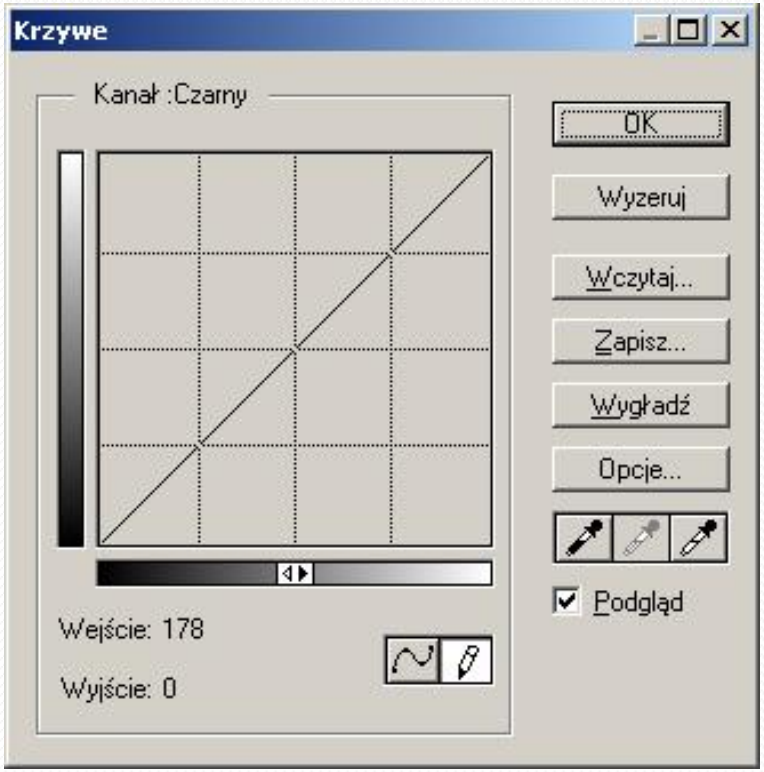
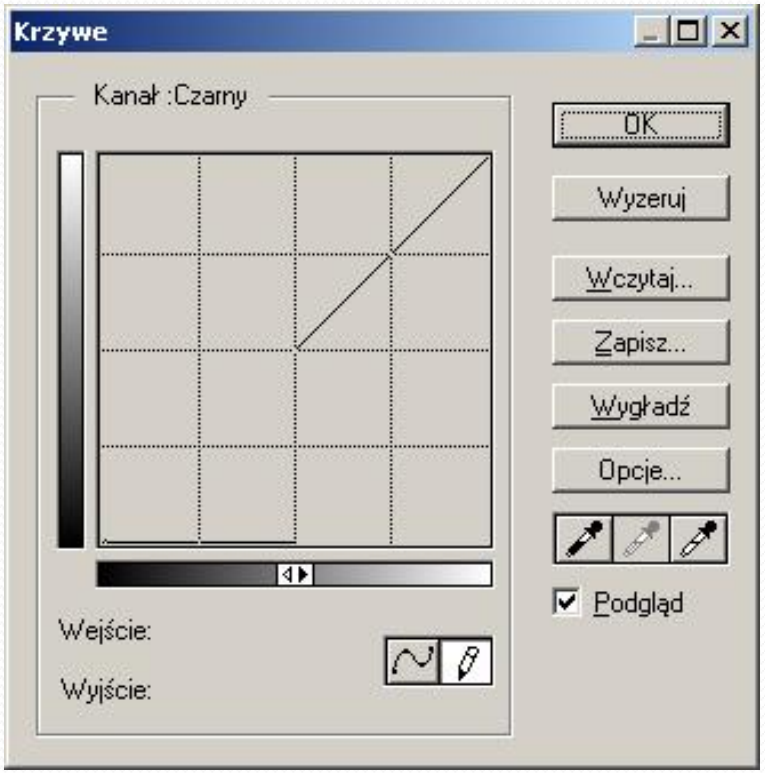


Image binarization

Pseudothresholding



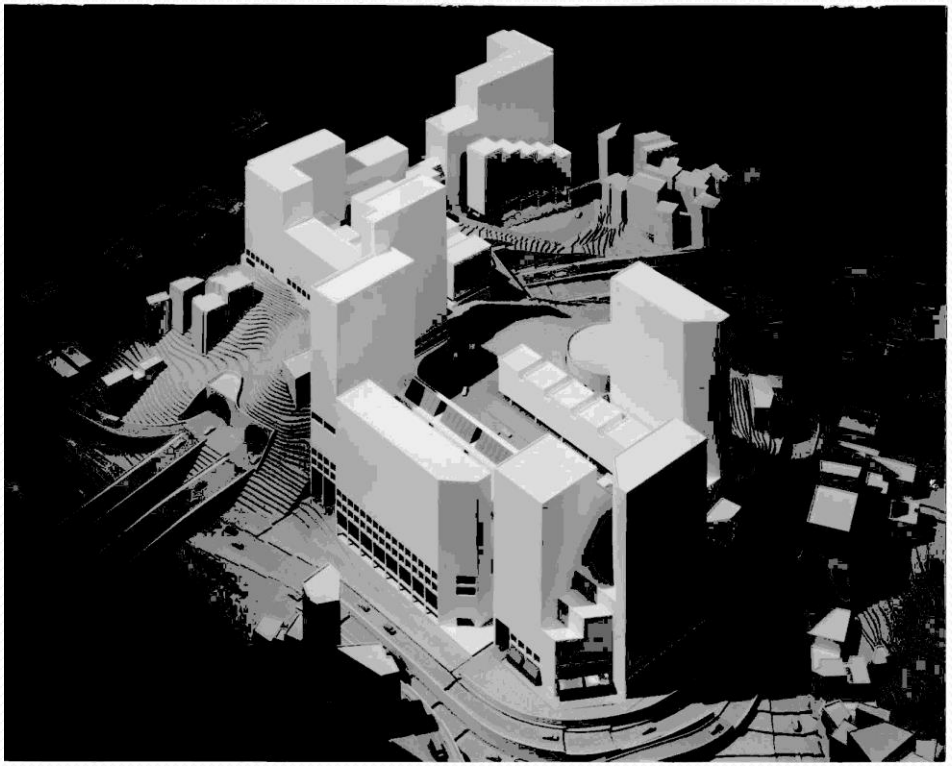


Image binarization

Double-treshold binarization aims to isolate areas with a given brightness range

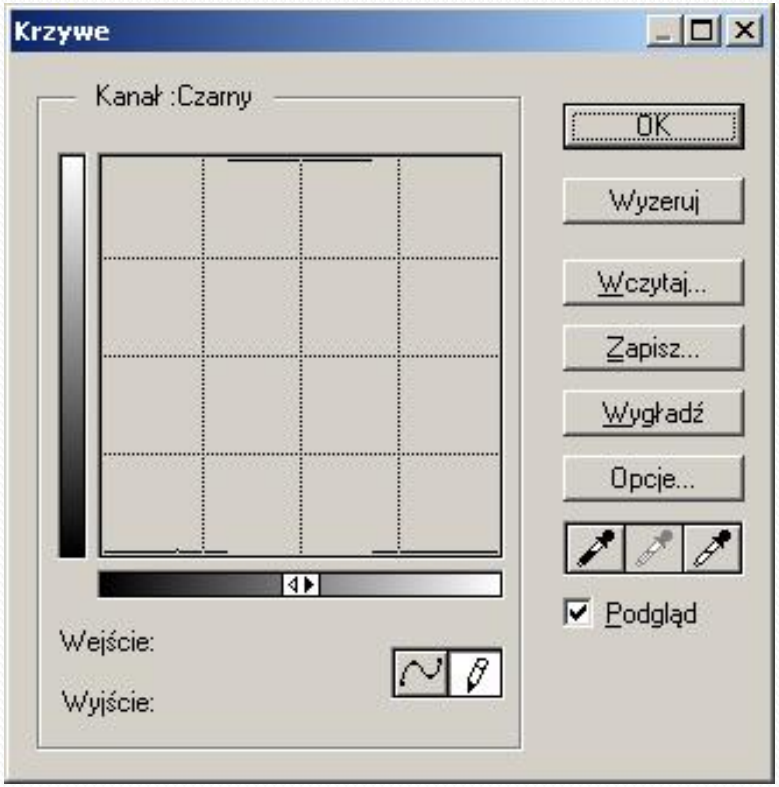
$$J_w(x,y) = \begin{cases} 0, & J(x,y) \le t_1 \\ 1, & t_1 < J(x,y) \le t_2 \\ 0, & J(x,y) > t_2 \end{cases}$$

t_1, t_2 - binarization thresholds, where $t_1 < t_2$

As a result of this transformation, a binary image is obtained, in which pixels with a brightness value between the threshold values are highlighted.

Image binarization

Double-treshold binarization



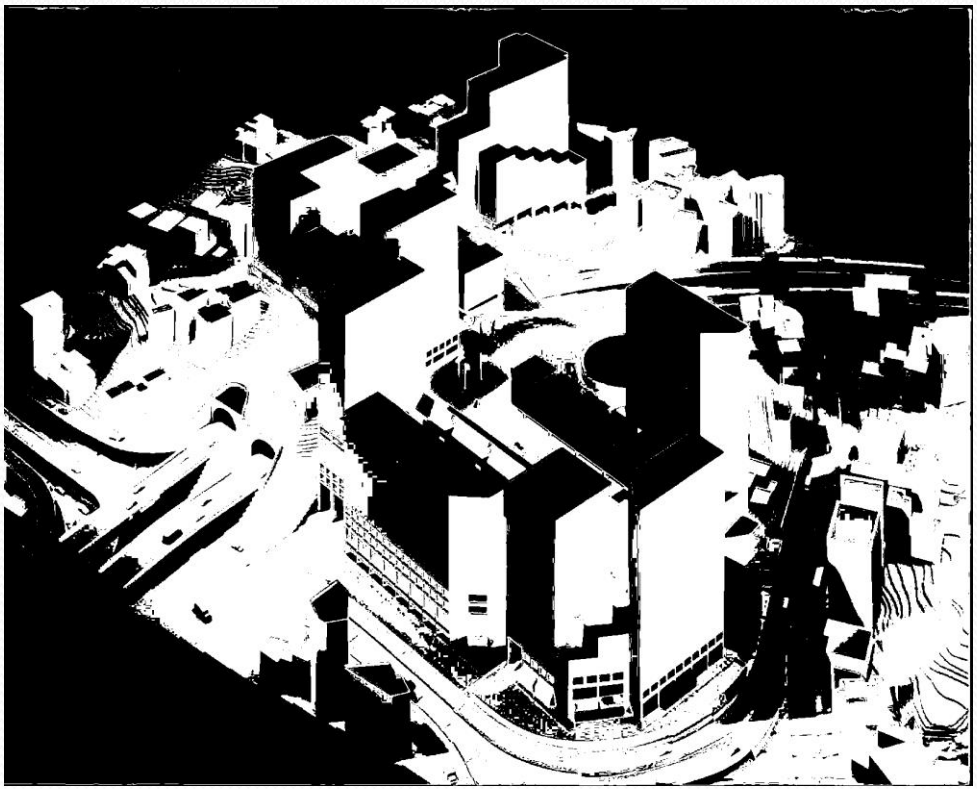
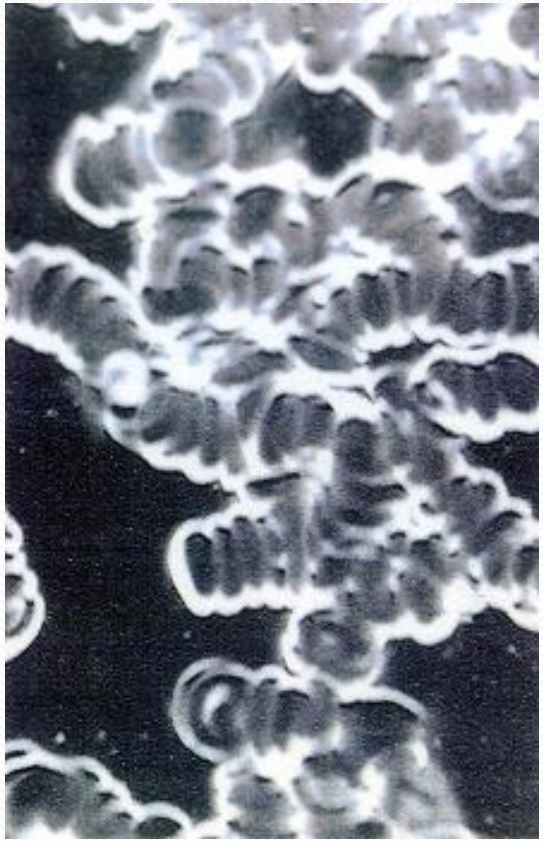


Image binarization

Double-treshold binarization



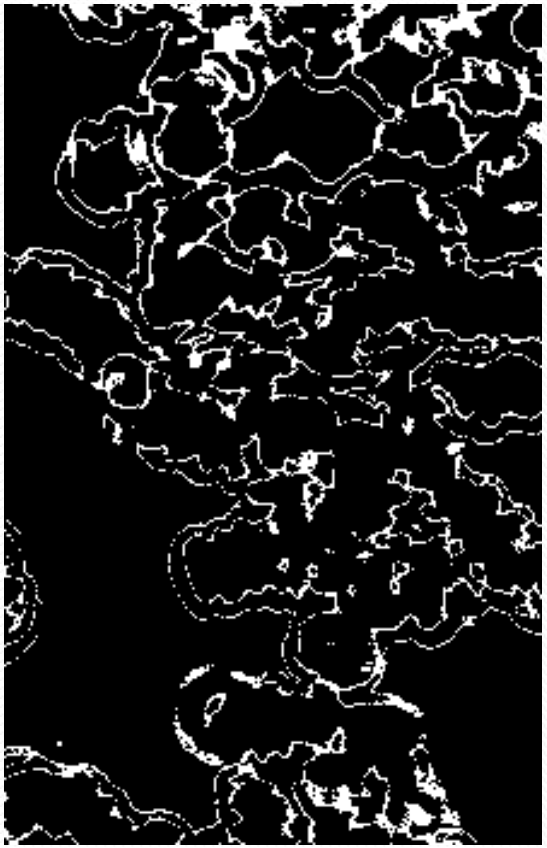


Image binarization

Binarization with hysteresis (conditional)

$$J_w(x,y) = \begin{cases} 0, & J(x,y) \le t_1 \\ s, & t_1 < J(x,y) \le t_2 \\ 1, & J(x,y) > t_2 \end{cases}$$

t_1, t_2 - binarization thresholds, where $t_1 < t_2$

s – value of neighbouring pixels

Image binarization

The biggest problem that accompanies the thresholding operation is proper selection of the threshold. The classification of pixels to classes (background and image) depends on this and, consequently, the usefulness of the resulting image for further analysis.

If the threshold value is the same for the whole image then we call it **global**. It happens, however, that points of the same object have different values depending on their position (eg. due to the unevenness of lighting). It is better to use **local** methods then.

Image binarization

Global thresholding methods:
- based on histogram analysis,
- based on the brightness gradient,
- Otsu method - based on discriminant analysis.

Local thresholding methods:
- Bernsen's method,
- Chow and Kaneko method,
- Eikvila method,
- Niblack's method.

Image binarization

Global thresholding based on histogram analysis

If the histogram has a bimodal distribution, the threshold is assumed at the local minimum between the histogram peaks.

The method applies only to one or two thresholds, even if the histogram can be used to distinguish a larger number of peaks.

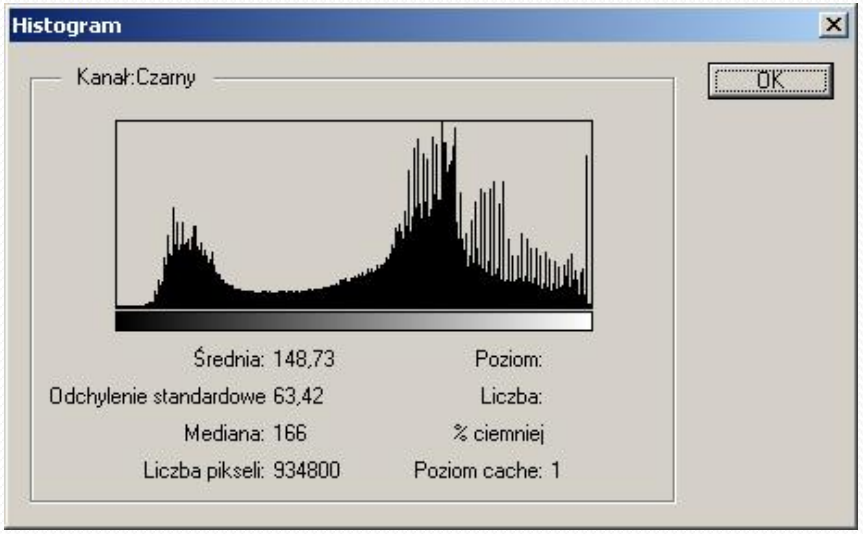


Image binarization

Global thresholding based on histogram analysis

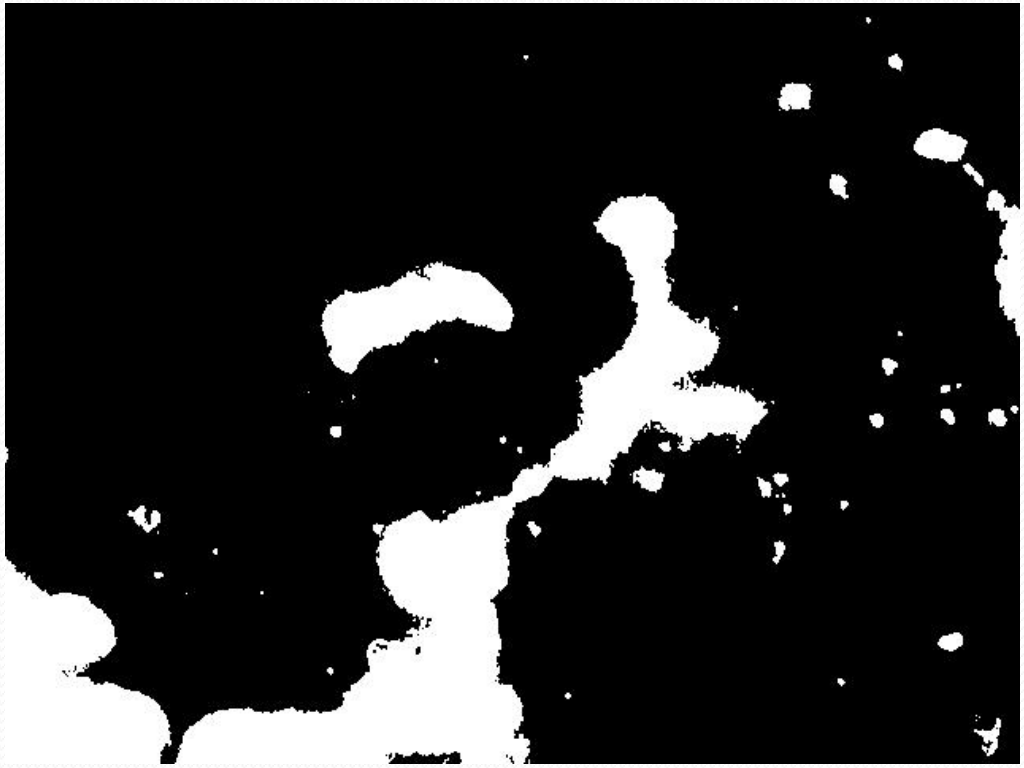


Image binarization

Global thresholding based on histogram analysis

Disadvantages:

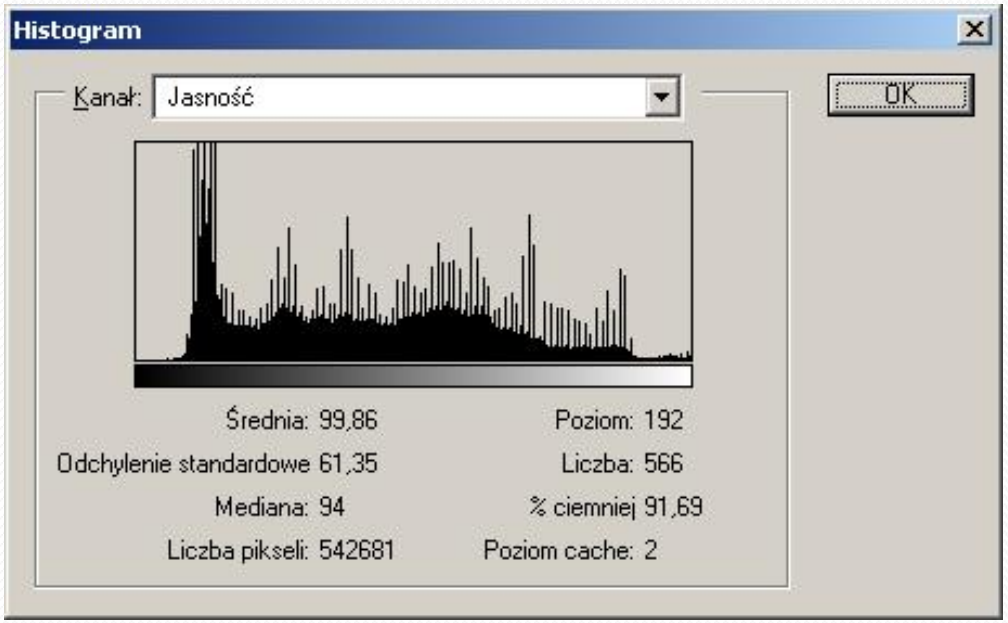
- local minimum is difficult to determine if the distance between the peaks is large or the peaks are poorly legible,
- the occurrence of noise makes it difficult to analyze the histogram,
- the method does not take into consideration the spatial arrangement of pixels, only their brightness. Therefore, there is no guarantee that neighboring pixels will be included in the same class and the new image will contain consistent areas.

Advantages:

- simplicity and speed,
- applicable both for the entire picture and its sub-areas.

Image binarization

Global thresholding based on histogram analysis



Example of an image, for which histogram-based method is not suitable.