# BASICS OF THRESHOLD CONVERSION OF BRIGHTNESS IN COLOR IMAGES

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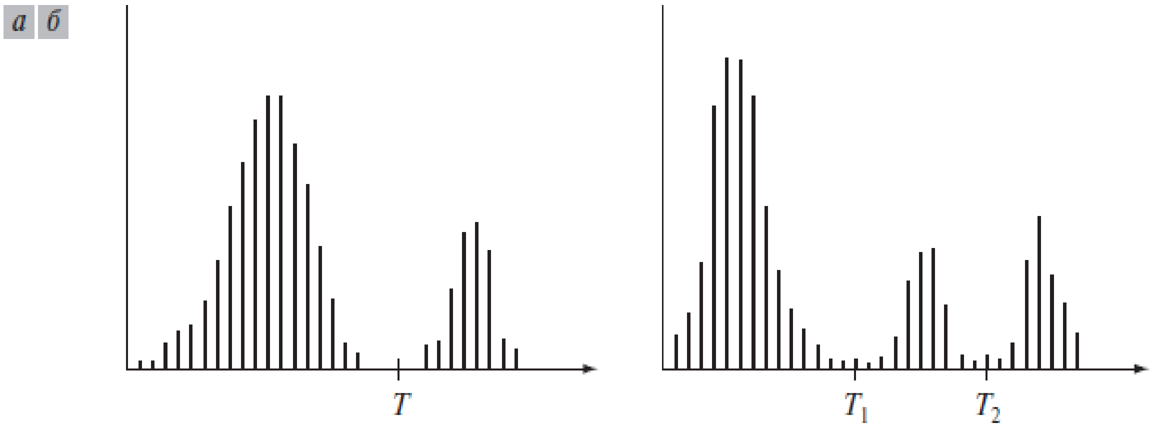
Threshold transformations occupy a central place in applied problems of image segmentation due to intuitive properties, ease of implementation, and computational speed. In this section, a more formal definition of the threshold transformation is given and on its basis much more general methods of threshold processing are constructed than are described so far.

Suppose that shown in fig. 2.3.1. (a) the histogram corresponds to some image $f(x,y)$, containing bright objects against a dark background, so that the brightness of the pixels of the object and background are concentrated near the two prevailing values. The obvious way to distinguish objects from the surrounding background is to select a threshold value $T$, delimiting brightness distribution modes. Then any point $(x,y)$, wherein $f(x,y) > T$, called the point of the object, otherwise, the point of the background. In other words, a segmented image $g(x,y)$ is defined by the relation

$$g(x,y) = \begin{cases} 1, & \text{если } f(x,y) > T \\ 0, & \text{если } f(x,y) \le T \end{cases} \qquad (2.3\text{-}1)$$

If the value $T$ since there is a constant applied to the entire image, this formula describes the so-called global threshold transformation. If the threshold value is not constant in the image, one speaks of a transformation with a variable threshold. Speaking of a threshold transformation, the terms "local" or "in the neighborhood" are sometimes used to indicate that a variable threshold $T$ anywhere in the image $(x,y)$ depends on the properties of the neighborhood $(x,y)$ (for example, from the average brightness of the pixels in this neighborhood). If the threshold $T$ depends on the characteristics of the processed image and changes with spatial coordinates $x$ and $y$, then this variable threshold transformation is often called dynamic or adaptive. The use of these terms is not generally accepted, and in the literature on digital image processing they can be found in a different sense.

Fig. 1. (B) shows a more complicated case of choosing a threshold when the histogram of the image is characterized by the presence of three distribution modes (for example, if there are two types of bright objects against a dark background of the image). Here, using a multi-level threshold transformation, the point $(x,y)$ classified as belonging to the background if $f(x,y) \le T_1$, object of one



a b

Fig. 1. Luminance histograms that allow separation by (a) a single threshold; (b) two thresholds

class if $T_1 < f(x,y) \leq T_2$, and an object of another class if $f(x,y) > T_2$. That is, a segmented image is defined by the ratio

$$g(x,y) = \begin{cases} a, \text{ если } f(x,y) > T_2 \\ b, \text{ если } T_1 < f(x,y) \leq T_2 \\ c, \text{ если } f(x,y) \leq T_1, \end{cases} \qquad (2.3\text{-}2)$$

where $a, b, c$ — any three different brightness values. Segmentation tasks that require more than two thresholds are difficult to solve (and are often not solved at all), and other methods, such as variable threshold processing or growing areas, usually lead to better results.

Based on the discussion above, it is possible to draw an intuitive conclusion that the success of the threshold transformation directly related to the width and depth of the depressions between the brightness distribution modes. In turn, the main factors affecting the characteristics of the depressions are: (1) the distance between the peaks in the histogram (the larger it is, the more likely it is to separate the modes); (2) the noise level in the image (as the noise increases, the distribution modes become wider); (3) aspect ratio of objects and background area; (4) uniformity of illumination; and (5) uniformity of reflection coefficient of objects and background.

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