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Algorithmization of the Process of Recognition of Biological Objects by Computed Tomography

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This article discusses a modification of the approach to algorithms for visualization of computed tomography data, which aims to automate the process of tumor detection. In this case, the main task is to identify tumor models and facilitate the ability to determine the normal state of tissue and identify deviations from the norm.

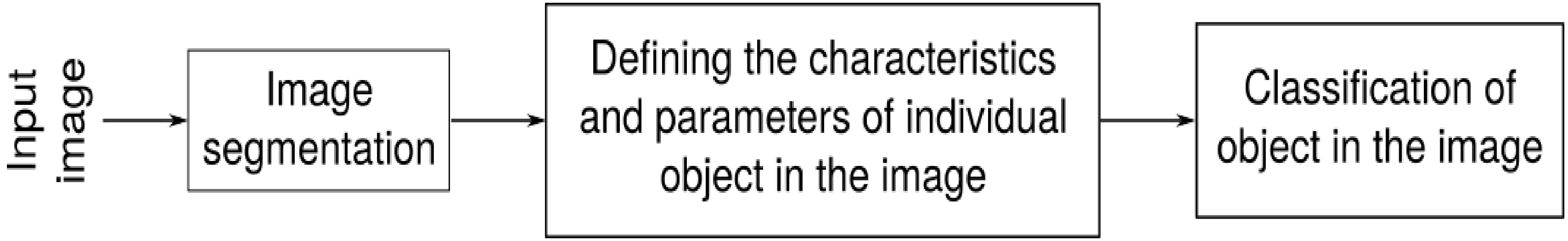
The general principle in image analysis is to find ways to divide the image into a set of individual objects that match certain characteristics.

The process of image analysis can be split into stages, as shown in Figure

At the image segmentation stage, different algorithms are applied to separate the main objects from their connecting elements and shape them as separate areas (segments) on the image. The goal is to simplify the image without losing essential information about the objects. The relevance of obtained information depends on the specific application and the requirements.

At the second stage different quantitative and descriptive parameters and characteristics of each object, identified at the previous stage, are determined. As a result, an array of data is accumulated for each object. This array stores information about the dimensions, shape of objects, etc.

At the last stage the obtained parameters and characteristics of the objects are evaluated and analyzed. Subsequent classification of the individual objects is performed based on its class or type



Sequence of image processing includes the following principal points:

- **improving the image;**
- **image segmentation;**
- **binarization;**
- **morphological processing of the binary image;**
- **assessment of objects parameters;**
- **countouring;**
- **classification**.

Segmentation algorithms fall into two large categories:

- In the first category are those who use the abrupt change in brightness that usually occurs at the border of objects;
- The algorithms of the second .category divide the images into areas that have a relatively uniform brightness and meet certain requirements.

The realization of **morphological processing** is somewhat similar to spatial filtering, since a mask is also constructed, consisting of 0 and 1, which is successively moved around the whole image

The **binary image** is produced by threshold processing. It compares the value of each pixel with a threshold value:

$$g(m,n) = \begin{cases} 1, f(m,n) \geq T \\ 0, f(m,n) < T \end{cases} \qquad (1)$$

The threshold can be selected interactively by an operator. The following iterative procedure can be used to automatically set a threshold:

1.The initial value of the threshold is selected. An appropriate value is the average between the maximum and minimum brightness in the image:

$$T = \frac{B_{max} + B_{min}}{2}$$

2. The pixels are divided into two groups G1 and G2. In group G1 are pixels whose brightness value is greater than or equal to the threshold, and in group G2 are pixels whose value is less than the threshold.

3. The average brightness μ_1 and μ_2 are calculated for both groups:

$$\mu_1 = \frac{B_{max}(G_1) + B_{min}(G_1)}{2}, \mu_2 = \frac{B_{max}(G_2) + B_{min}(G_2)}{2}$$h

4. A new threshold value is calculated according to the following equation:

$$T = \frac{\mu_1 + \mu_2}{2}$$

5. Steps 2 – 4 are repeated until the difference in the estimated threshold values for two subsequent iterations becomes less than a preset value T_0

One ubiquitous technique to describe an object is through the **parameters of its shape**. These are measured properties of the objects. The aim is to use different parameters by which it is possible to unambiguously classify the object at the last stage. This allows automating the process of tracking objects. The quality of the measurement of the characteristics depends on the quality of the original image and the adequacy of the pre-processing of the objects.

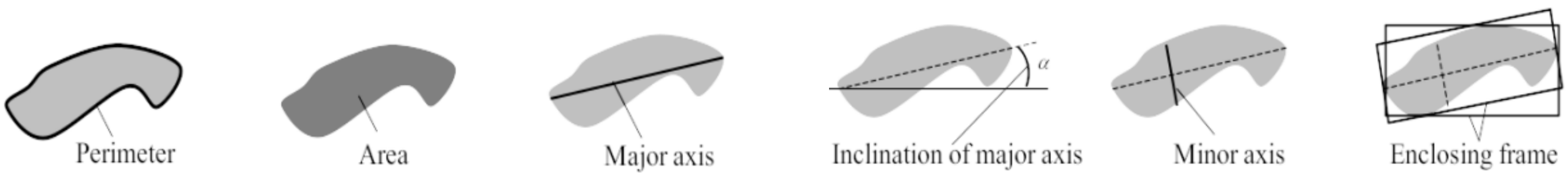


Fig. 2. Parameters of the object (shape)

Classification is the last stage of image analysis. The description and characteristics of the objects obtained at the previous stage must be compared with those of known objects or with pre-formulated criteria. This allows to determine whether an object falls into a certain category or not. At this stage, the operator can set a range for given parameters or ranges for a combination of parameters, thus differentiate only the objects with the desired properties.

An image of a human brain obtained from a CT scanner was used to validate the proposed sequence of operations. This image is shown in Figure

Initially, the contours of this image has been enhanced by applying a 3x3 pixel Sobel mask. The resulting image is presented in Figure 4a.

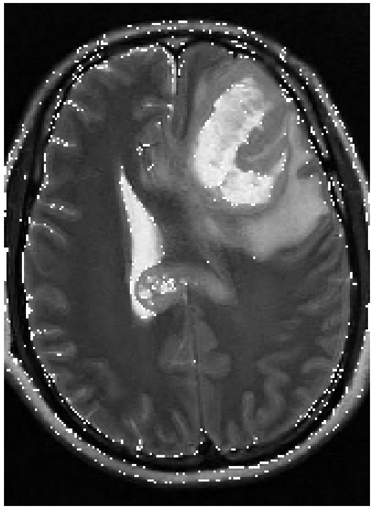


Fig. 4a

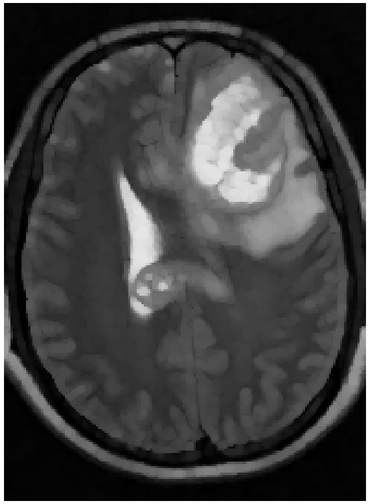


Fig. 4b

Fig. 4c

After enhancing the contours, the morphological operation of partitioning with a structural element in the form of a disk with a radius of 5 pixels was applied, the results of which are shown in Figure 4b. A morphological gradient using the same structural element was applied to separate the contours of the objects. The image obtained after this operation is shown in Figure 4c. As can be seen from the last figure, the outlines of the objects are well emphasized.

After the contouring stage is completed, the image is converted to binary using an Otsu global threshold. The resulting binary image is shown in Figure 5a.

In the next step, the gaps in the image are filled, the resulting image being shown in Figure 5b. The filling of the objects (closed contours) in the image is evident. To remove small details, a binary partition with a structural element in the form of a disk with a radius of 4 pixels is applied. The comparison of Figures 5b and 5c shows the disappearance of small details from the image.

Fig. 5a

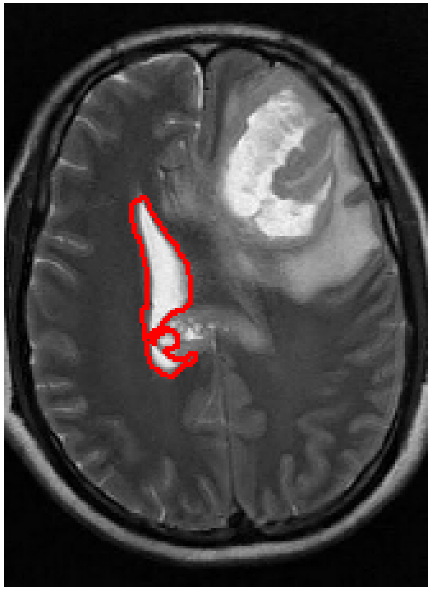
Fig. 5b

Fig. 5c

After the preliminary processing, the properties of the objects on the image were evaluated by calculating the parameters of their shapes. For the purpose of this study, we are interested in the lengths of the major and minor axes, the area, the perimeter, the orientation of the major axis. The parameters of 35 objects in Figure 5c were evaluated. They can be examined sequentially by the operator, and he can choose which objects to take the quantitative parameters.

To classify the objects, the ratio between the evaluated perimeter P of the objects and their area S is used:

PSR=P⁄S



The boundaries of all objects for which the PSR ratio is less than 0.1 are delineated on the original image. From the figure it can be observed that only one object is classified for the given object are the following:

- area – 8831 pixeindicator (PSR ratio). The quantitative properties of this Is;
- length of major axis – 231.7 pixels;
- length of minor axis – 63.1 pixels;
- perimeter – 693.3 pixels;
- orientation of the major axis – 83.6 degree.

The longitudinal and transverse dimensions of the object can be calculated from the lengths of the major and minor axes. From the area, an estimate of the part of the organ occupied by the given object could be made.

Image segmentation has shown excellent efficiency for processing images obtained by computed tomography. There is a range of masks for finding the boundaries of objects when utilizing different models. The practical application of the model results in a satisfactory assessment of the boundaries of a pathologic formation in human cranium. The proposed model of a system for diagnosis has substantially enlarged the possibilities for an integrated approach when solving problems and discovering pathologies.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