EFFECTIVE METHOD OF IMAGES SEGMENTATION OF THE OBJECTS WHICH ARE ON A NON-UNIFORM BACKGROUND

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The problem of isolation coherent components of the image (segmentation) on which there is a set of the objects which are on a non-uniform background most sharply is represented practically in any problem of digital processing of images, considering complexities of the realization. By the present moment of time the set of approaches to the decision of a problem of segmentation of objects on the image is offered, however there is no method, completely satisfying to requirements of modern systems of the machine sight which appointment consists in detecting, recognition and identification defined, of interest, objects.

The purpose of the given work is creation of an effective method of segmentation of images of the objects which are on a non-uniform background. For a specific target solved by light system of prompting – objects will act flying machines, as a non-uniform background – heavenly space with various level of overcast. For object in view achievement it is required to solve following problems: to formulate criterion of an optimality, applicable to procedure of isolation coherent components on the image; to put in conformity to each point of the given criterion functional, characterizing a mathematical measure of conformity of a concrete method of segmentation optimum possible; to develop a technique of testing of methods of the segmentation which are candidates for a role of most effective of the offered.

Let's formulate the criterion of an optimality characterizing degree of conformity of procedure of segmentation to operating conditions of system of detecting as a whole:

1. duration of procedure of segmentation should be is minimum possible for algorithms such;
2. time of functioning of the block of segmentation should be final and, substantially, not to depend on complexity, topology and the size of the image;
3. each object giving in to allocation representing the isolated image in which area, value of function considerably changes $F(x, y)$, i.e. brightness component R, G, B in points with coordinates (x, y) in a picture, should be subject to unequivocal allocation, not break into separate segments and not comprise the internal detected contours.

The first point as a special case of a problem of optimum control we will write down in a following kind:

$$Q(\gamma, \delta) = \int_{t_1}^{t_2} 1 \, dt = t_2 - t_1 \to \min , \tag{1}$$

where the difference $t_2 - t_1$ symbolizes duration of procedure of segmentation.

To the second point of criterion we will put in conformity functional, displaying aspiration to a minimum of the sum of all values of an operating time of procedure of the segmentation, received at various making noise image components:

$$\Theta(B) = \int_{B_1=0}^{B_2=1} T(B) \, dB \to \min , \tag{2}$$

where $B_1 = 0$ - corresponds to topology of the image in the absence of a noise component, $B_2 = 1$ - condition of the image which is completely covered by noise, by analogy with (1) $T(B)$ represents the function which value is the operating time of the block of segmentation at

degree of noise of the image, equal B. $T(B)=\int_{t_1}^{t_2}1\,dt$, where t_1 - time of the beginning of functioning of procedure of segmentation, t_2 - time of the termination of work of procedure.

To brightness changes speech about which goes in the third point of criterion of an optimality, it is possible to carry the state symbolics represented on object, protective colouring etc.

Let there are two sets a connectivity component: $W=\{M_1\ ,M_2\ ...\ M_i\}$, where i - quantity coherent components, allocated at visual survey initial RGB images; $V=\{N_1\ ,N_2\ ...\ N_j\}$, where j - quantity coherent components, allocated with algorithm of segmentation of the image; $M_i=\{x_1,x_2,y_1,y_2\}$, $N_j=\{\xi_1,\ \xi_2,\ \theta_1,\ \theta_2\}$, where $\{x_1,x_2,y_1,y_2\}$ and $\{\xi_1,\ \xi_2,\ \theta_1,\ \theta_2\}$ - corresponding values of coordinates of tops of a rectangle in which the allocated object is entered. Then $\forall k\in 1...\max\{i,j\}\ \exists\ U(k)=\left|x_1-\xi_1\right|+\left|x_2-\xi_2\right|+$ $+\left|y_1-\theta_1\right|+\left|y_2-\theta_2\right|$, where $\{x_1,x_2,y_1,y_2\}\in M_k$, $\{\xi_1,\ \xi_2,\ \theta_1,\ \theta_2\}\in N_k$. It is important to notice that equality $i=j$ symbolizes identical to the connectivity component, containing in sets M_i and N_j detected on the image (one and that is object), and

$$\begin{aligned}&\forall M_k=\varnothing\ \exists\ x_1=0,\ x_1\in M_k,\ x_2=0,\ x_2\in M_k,\ y_1=0,\ y_1\in M_k,\ y_2=0,\ y_2\in M_k,\\&\forall N_k=\varnothing\ \exists\ \xi_1=0,\ \xi_1\in N_k,\ \xi_2=0,\ \xi_2\in N_k,\ \theta_1=0,\ \theta_1\in N_k,\ \theta_2=0,\ \theta_2\in N_k.\end{aligned}\qquad(3)$$

Record (3) narrates about equating to zero of coordinates nonexistent a connectivity component, i.e. the actions spent in case of discrepancy of quantity coherent component in sets M_i and N_j. Taking into account the aforesaid we will receive the functional:

$$\Omega(k)=\sum_{k=0}^{\max\{i,j\}}U(k)\to\min.\qquad(4)$$

Discrepancy of methods of colour segmentation to the third point of criterion of an optimality and unacceptably long operating time of algorithm of segmentation on watersheds allows to switch attention to ways of segmentation of the binary images described by function, accepting only pair values: 0 and 1. For definition of rules of segmentation of binary images we will accept $I=\{S_1\ ,S_2\ ...\ S_n\}$, where n - quantity of the coherent components on image, then $\forall B(x,y)=1\quad\exists\ S_i=\{z_1\ ,z_2\ ...\ z_k\}\ \ i\in 1...n$, where $z_k=B(x,y)$, k - quantity of the elements containing in a component. Let G, F - sets of values of brightness which the image element can accept, $G=\{0,1\}$, $F=\{1\}$ and $p=B(x,y-1),\ p\in G$; $q=B(x-1,y),\ q\in G$; $z=B(x,y),\ z\in F$, then

$$\begin{cases}z\in S_i\quad p\notin S_i\quad q\notin S_i\ ,\ p=q=0\\ z\in S_i\quad p\notin S_i\quad q\in S_i\ ,\ p=0\quad q=1\\ z\in S_i\quad p\in S_i\quad q\in S_i\ ,\ p=q=1\\ z\in S_i\quad p\in S_i\quad q\notin S_i\ ,\ p=1\quad q=0\\ z\in S_i\quad p\in S_i\quad q\notin S_i\quad q\in S_j\quad S_j\not\subset S_i\ ,\ p=q=1\ \Rightarrow\ S_j\subset S_i\end{cases}.\qquad(5)$$

For an exact estimation of time characteristics of work of known algorithms of segmentation of binary images definition of dependence of time of segmentation from degree of noise the initial image is necessary. As degree of noise of images we will understand probability of replacement of initial colour of pixel of a picture on white or black. The given colours with the greatest possible probability will create difference of brightness which will be allocated by means of any differential operator at a stage of binarization and will serve as a serious hindrance to algorithm of segmentation.

Let $P(A) = B$, where A is event of change of colour of pixel, B - value of probability of approach of event A ($B \in 0,001,...1$). For example, value 364 on an axis of abscises of the schedule represented on a figure 2 symbolizes equality $B = 0,364$. On a figure 1 the original image in the sizes 640×480 is presented with absence of noise and the same image with noise presence.

After the carried out research about conformity to points of criterion of an optimality of procedure of segmentation became clear that three basic methods of segmentation of binary images [1] – [3] do not answer all points of criterion.

During the further work the new algorithm of segmentation of the binary images, answering to all points of the above described criterion of an optimality concerning functioning of procedure of segmentation has been received.

At creation of the given algorithm, were considered strengths of algorithm of line marks and the modified variant of classical algorithm of marks coherent components on the basis of structure of the data for association – search.

а *в* Figure 1. The multispectral image before introduction of a noise component and after. (a) Initial multispectral RGB image: $P(A) = 0$. (b) The initial image at $P(A) = 0,364$.

The created algorithm scans the image consistently, but instead of treelike structure of the data for association – search the usual vector is used, values which component correspond to a certain index. In process of performance of rules (5) there is a change of internal structure of a vector in such a manner that during necessary merge two component of connectivity is not required the recursive reference to components of a vector, values necessary a component simply change at consecutive scanning.

On a figure 2 the unequivocal superiority of algorithm of segmentation with use of a vector for storage of the time information over other algorithms of segmentation of binary images is traced. Also it is visible that two algorithms from four are not capable to function adequately at low and average degree of noise of images (segmentation time, equaled ∞), therefore two schedules on a figure 2 break.

Having compared a figure 2 and a figure 3 it is easy to understand character of dependence of time of performance of procedure of segmentation from degree of noise the initial image. Peak of the schedules represented on a figure 2 which functions are defined on all area of values of parametre $P(A)$ is necessary on size $P(A) = 0,192$, taking into account a step of change of value $P(A)$. The figure 3 (b) explains the reason of coincidence of peaks of schedules: it is visible that on size $P(A) = 0,192$ the maximum quantity of references to the procedure described in 5 line of rules (5) is necessary – 9419 time occurs reassignment necessary components of vector. Also it is visible (see a figure 3 (a)) that performance of rules, 1 – 4 lines (5) productivity influences of a method of segmentation considerably to a lesser degree, than a rule tracing in the fifth line (5).

On a figure 2 – 3 it is visible that having resorted to such method of an estimation of efficiency of algorithm of segmentation of the binary image as introduction of a noise component in function $F(x, y)$ and tracking the subsequent values of change of an operating

time of algorithm it is possible to observe the most evident display of a picture of efficiency of functioning of a method of segmentation as a whole.

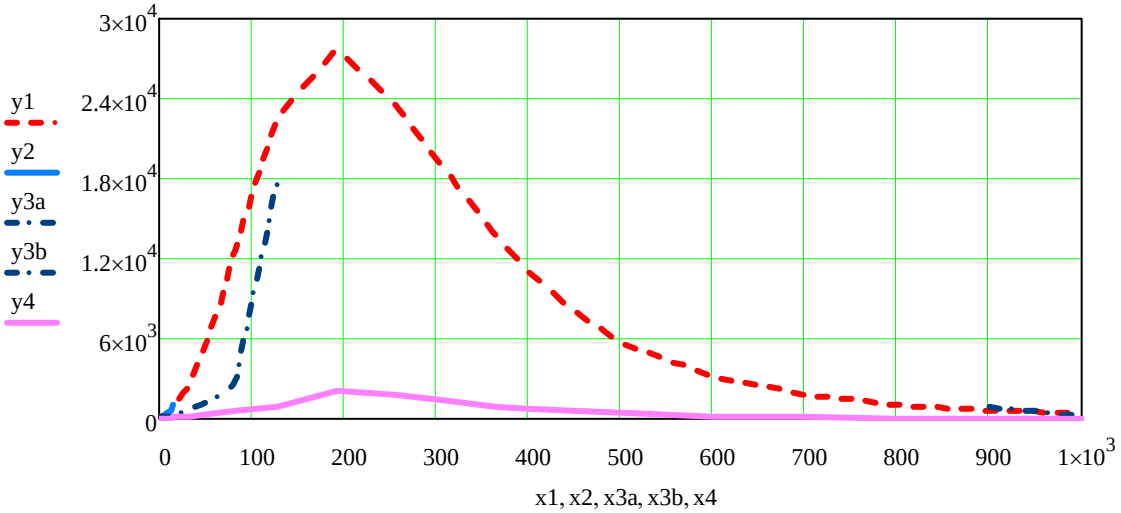
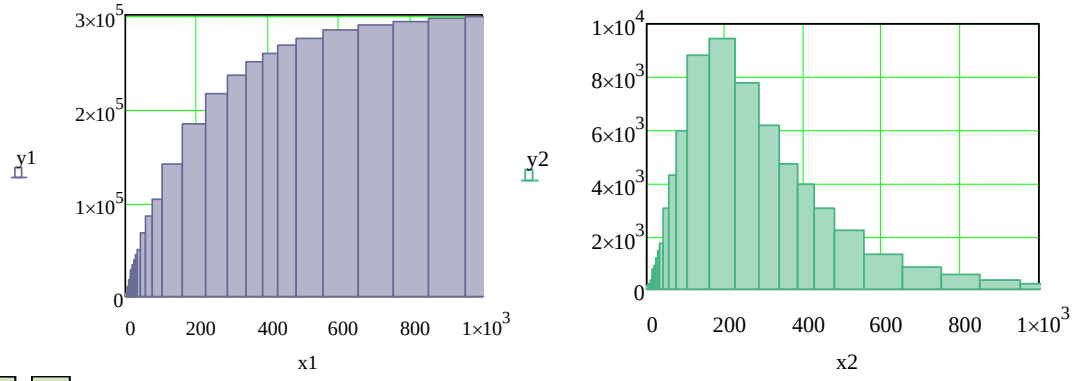


Figure 2. Schedules of dependence of time (an axis of ordinates) segmentations (ms) from degree of noise the initial image: a red dotted line – for algorithm of line marks ($y1$), a light blue line – for algorithm of recursive marks ($y2$), a dark blue dotted line with a point – for the modified variant of classical algorithm of marks coherent a component on the basis of structure of the data for association – search ($y3a - y3b$), a pink straight line ($y4$) - for algorithm of segmentation with use of a vector for storage of the time information.



а *в* Figure 3. Diagrammes of dependence of quantity of executing of various rules (5) – an axis of ordinates from degree of noise of images – an axis of abscises. (a) Performance of rules 1 – 4 lines (5). (b) Performance of a rule of the fifth line (5).

Summing up to the above-stated, it is necessary to establish the fact of creation of a new method of the segmentation answering to all points of described criterion of an optimality and, as consequence, of a method, capable as fast as possible to process binary images of any complexity and the size.

References

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