METHOD OF CONGLOMERATES RECOGNITION AND THEIR SEPARATION INTO THE PARTS

Volodymyr Hrytsyk, Viktor Vlakh

***Abstract**: The article presents a method of identification and separation of visual objects that partially overlay each other. We also had investigated this method for example cell conglomerates division.*

***Keywords**: decision support systems, pattern recognition.*

***ACM Classification Keywords**: I.2.1 ARTIFICIAL INTELLIGENCE-Applications and Expert Systems*

Introduction

Today there are strong tendencies in attempts to replace the man in all of the processes where possible. Computer technology is so ingrained in our society, that today one cannot imagine any activity not related somehow to the computer [D. Forsyth, J. Ponce, J ,2004]. Increasingly there are attempts to introduce automated systems that are designed to perform routine work instead of rights, for it is during this kind of person most often mistaken. This affects many factors foremost of which is loss of concentration, i.e. inattention. This may lead to an increase in the number of erroneous decisions, and thus to distort the results.

Especially important to avoid such mistakes in areas that require precision and performance man. Among the existing lines of automation is a special place computer vision problem. This is due to the fact that the human operator about 90% of all information receives through the visual analyzer [9]. Vision allows to perceive form, color, brightness and motion of objects.

To research the subject area selected, which best shows the need of automation of all listed aspects of computer vision. That automation in microbiology [V. Hrytsyk, M. Vlakh , 2006], [V. Hrytsyk, N. Pelykh, 2009] combine high demands on the quality of their work and high responsibility for shutting errors during processing. Today, however, complete automation is impossible. This is due primarily to complexity of research in which technology is not yet able to fully replace the man.

In this article the description of the developed method, which allows to automate the solution of complex problem, which becomes an obstacle in automating many microbiological studies – the problem of separation of conglomerates. We introduce the definition of conglomerate, which may be defined as a *group of objects combined in a single structure that is difficult to separate*.

Identification and separation of conglomerates problem is currently difficult to resolve, and existing efforts do not give enough accurate results. This is due to simultaneous influence of several factors, main of them are: accidental overlay objects, natural objects (i.e. all objects are different in nature and never repeated), technology only highlights the labeling of the object (thus the whole body of object is not always visible).

The existence of conglomerates on the images makes it impossible to get accurate results, since not following the separation of objects of interest is included in the conglomerate, it is impossible to make a classification of certain formal characteristics. This in turn will affect the results. Minimal impact from such events will be in cases when objects share not taken into account in the samples is small. Usually the situation is such that not taken into account objects have a significant impact on all results. Moreover, the danger of conglomerate wrong interpretation always exists, because of possible visual similarity of conglomerate and the object of attention. This would mean that the automated system will conglomerate of some object that can also distort the results of the study.

This method is used to minimize the number of objects in the field of attention, which are included in the composition of conglomerates and can be incorrectly interpreted in this case.

Problem Statement. Aim of research

The following aims of the research have been identified:

1) To develop a method of searching for images conglomerates.

2) To develop a method that will most completely and accurately select the objects of interest, as part of the conglomerate.

3) To confirm the efficiency of the technique with tests.

Solutions of the above mentioned problems allow to computerize the system of image classification and are intended for specific types of samples, improving their reliability and accuracy with minimal cost to their modification. This approach will increase the degree of automation of processing samples in all areas of microbiological research. Therefore, feasibility and scientific importance of this research cannot be overstated.

Partitioning problem into subtasks

Considering all the features of images conglomerates research should include the following related subtasks:

- To develop a method of separating components of conglomerate formations up into objects.
- To develop a method for splitting control process.
- To define criteria for splitting.

Priority of subtasks results from their mutual bindings. The first step is to develop a method for separation of conglomerates. Having such a method elaborated, one can proceed to the development of process monitoring and automatic control. This will remove person from this process, and this is the primary motivation for this work.

Solving problems. Problem conglomerates

Fig.1. demonstrates a few examples of images that contain conglomerate formation. They can be carefully analyzed to note the fact that conglomerates are very different in structure, number of objects that form them, and so on. The simplest case is a conglomerate formed by a combination of two objects (cells) which are laying low. This conglomerate can be divided with almost no loss of information about objects that were included. This can be achieved by increasing the stiffness parameters of filtration, using a simple analysis of the shapes of objects. However, there are conglomerates, which are made up of three or more objects of significant mergers and laying them. In such cases the restoration of conglomerate becomes very challenging task. Its solution requires a better and more universal approach.

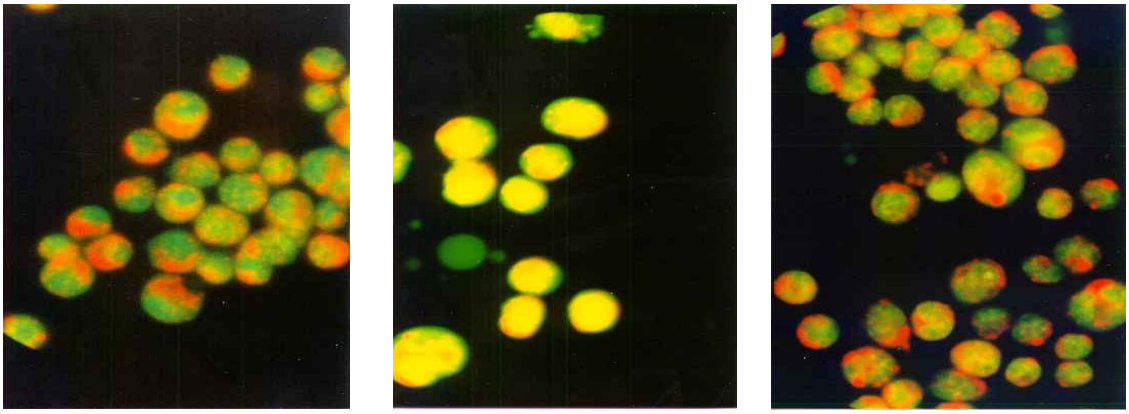


Fig. 1. Aggregation of blood cells: monocytes, lymphocytes and neyrofils

Decomposition of objects method

Note that each object (part of the conglomerate) is unique (shape, size, color, and their ratio, even density and brightness). The one that is common is a convex shape of the object. If [8] show us objects are detected by spectral analysis, we can't use this method for the conglomerate, since, as an object can be taken conglomerate.

Fig. 2 is an example of merging two objects in common conglomerate. Picture is schematic. Circles mark pixels that form the image of the object of analysis.

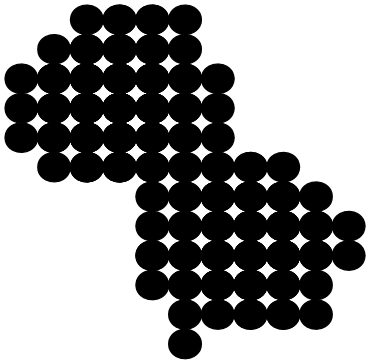


Fig. 2 Pixel based representation of conglomerate

The main characteristic of conglomerate is a sharp change of direction to follow the contour of the object (See Fig. 3 a). The exceptions are the merger objects at which levied a large part of their area. This merger is shown in Fig. 3 b. Such sharp changes in the contour course are thinner section of the local conglomerate. This phenomenon is the basis for separation of layers method.

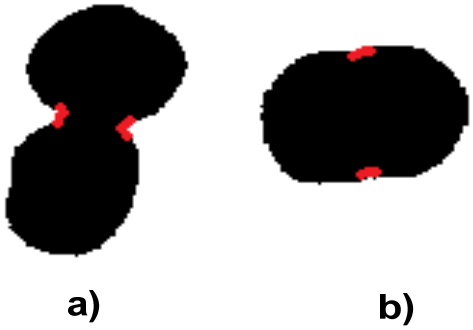


Fig.3 a) outline course changing at the confluence of two objects
b) No significant difference of contour course when overlap of the objects is considerable.

As thinner is present at the confluence place of the objects, then we remove layers (step by step) from the object contour, sooner or later we will get a break of the conglomerate confluence. Two parts of conglomerate which contains only pixels that belong to each object - it is split algorithm result. Two tasks are especially important for this algorithm:

- Cutting layers of the object in order to separate it into components.
- Restoring layers separately for each component of conglomerate.

Removing layers of conglomerate is actually repeating the removal operation applied to conglomerate. Contour is a set of pixels that belongs to object and touch the background pixels.

Fig. 4 b) represents conglomerate pixels, which belong to first cutting layer. Fig. 4 b) presents second cutting pixel layer. As this figure demonstrates in consequence two cut, we received two groups of pixels (A and B), which are independent pieces of objects that form this conglomerate.

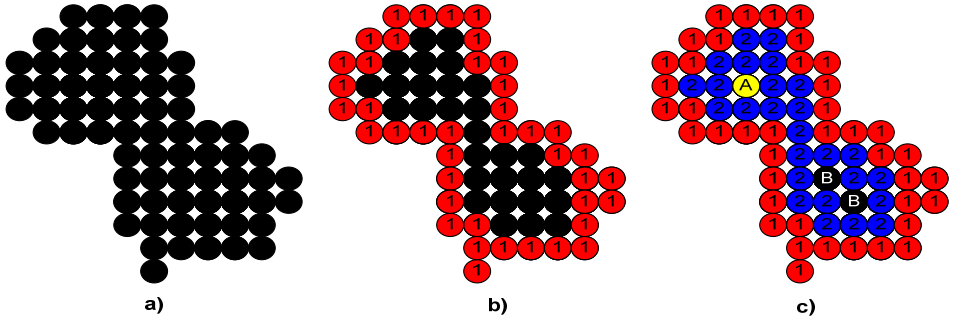


Fig.4. separation procedure.

a) input cell image; b) cut of first layer; c) cut of second layer.

The next step is to recover deleted layers. Important at this stage is to prevent the re-merging of objects. The solution of this problem is method of inverse increase of layers. Restoration of layers is performed in the order opposite to cutting process. Fig. 5 shows the input data set for the process of increasing. These are independent parts of objects (A and B) and truncated indexed pixel layers (that was cut).

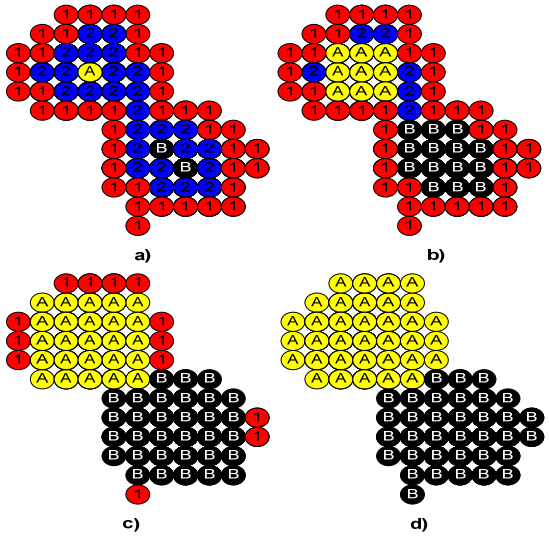


Fig. 5. Recovery of each cell. a) input image (object A and B); b) recovery of first layer; c) recovery of second layer; d) recovery of third layer.

Method of Identification of conglomerates in the image

Before the objects classification operations were defined, we introduced three major classes of objects: conglomerates, not conglomerates, objects with noise. In order to solve these following two approaches can be used.

First approach: further filtering of input images – use a series of filters and their combinations: contrasting, spectral analysis, morphological analysis and others. If an object splits into several separate units, one can assume that it is the conglomerate. The disadvantage of this approach is that the use of filters will work only on certain types of images. We have this situation because in most of cases of the structure of conglomerate is so

difficult that the color characteristics within the merger did not differ from the characteristics of separate objects. So, in most of cases, when we change the settings of filter incoming information, their options will vary too.

The second approach is the analysis of geometric characteristics of objects. This algorithm is enough to conduct preliminary processing of information – to bring the image to binary form: background images contain one value "0", and other images of cells value "1".

Another possible solution is to use the method of circuit analysis. It is designed to determine whether the object is a conglomerate. The method is based on analysis of object shape. We can represent cell form as an incorrect ellipse (lack of symmetry relative radius), hence, this characteristic can be a basis for identifying the object as a conglomerate (and/or not cell). The contour of each object that is not a conglomerate satisfies the following rule:

Direction of the initial movement of analysis algorithm is the "north-east and clockwise"; the next steps will include: south-east, south-west, NW, and can't be modified and the availability of this sequence repeats in this scheme. Fig. 6 shows the changes of contour pattern direction.

If direction of outline turning does not meet this scheme, the object can be identified as a conglomerate, and program must divide an object before further analysis.

Fig. 7. represents the structure where this rule does not hold due to the fact that change in the direction "south-east" comes "north-east, this case is not typical for one object. Thus, this structure can be attributed to class of conglomerates or to class of objects which are affected by noise. To search for such changes we use the method of bypass contour.

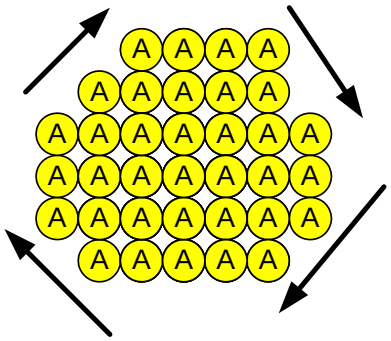


Fig. 6. Changing direction of contour characteristic for one object

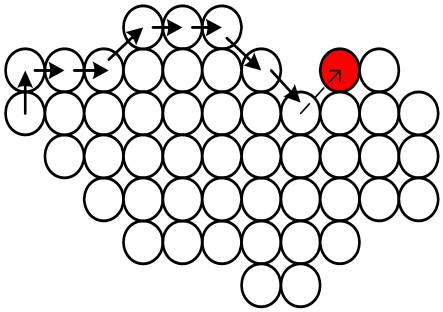


Fig. 7. Object with "broken-down" contour

Bypass object contour algorithm

To find local changes of contour directly algorithm must bypass all points that touch the background and belong to the object. Let the image is brought to binary form and recorded in the *vec array size m, n*, where values of 1 correspond to points belonging to object, and 0 belonging to the background. Then for the true contour points following condition:

$$\text{If } vec[x,y]=1 \quad \text{and}$$

$$vec[x,y-1]=0 \vee vec[x-1,y]=0 \vee vec[x+1,y]=0 \vee vec[x,y+1]=0 \Rightarrow (x,y) \in K(A) \quad (1)$$

where: $x=\overline{0,n}$; $y=\overline{0,m}$ $K(A)$ – circuit of object A.,

where: A – array of points that form the object of our image.

Simple scan the entire image to search for all points that satisfy condition (1) prevents the collection of data on the changing direction of the contour. The only approach to obtain such data is the method of bypassing contour based on the principle of the neighborhood.

The first step of this method is to capture of two contour points of an object that are "neighbors", that touch each another. You can apply a simple scan of matrix *vec* method for finding neighboring points of contour. Algorithm of finding neighboring points based on analysis of eight surrounding points principle. The next step is to establish the direction of contour movement. This parameter is determined from the ratio of coordinates of initial points.

Let Point1, Point2 – it is initial point; x1, y1, x2, y2 – it is according to the coordinates, and then the direction is calculated according to Table1.

After setting the initial direction, algorithm makes further movement on the contour of the object. All further iterating the order of important points for installing an accessory to the contour. The calculated direction is determined by one of the possible cases shown in Fig. 8. Numbered contour indicates the pixels that you want to check belonging to the object in order numbering. Contour analysis process stops, then when the current coordinates with start of which began bypassing. Changing directions, determined from Table 1 are the contour of the object characteristic, which can identify the object as a conglomerate, or nominate the statement that this circuit was subjected to noise.

Table 1

x2 - x1	y2 – y1	Direction
1	1	1
0	1	2
-1	1	3
1	0	4
-1	0	5
1	-1	6
0	-1	7
-1	-1	8

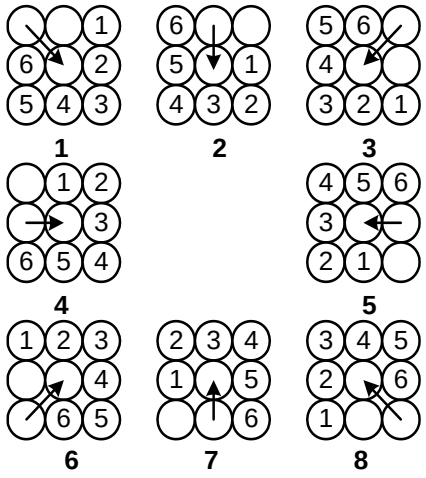


Fig. 8. Rules for establishing order of analysis of pixels for belonging to the object contour

Algorithm for automatic separation of conglomerates

The structure of this algorithm contains the following three main blocks:

1st Block - preparatory stage is to bring the image to a standard view.

Step One - finding objects and background. The main objective of this stage is to find a background pixels. You can apply algorithms that can be based on finding the background color brightness limits, methods of contour bypass and clustering

Step Two – converting image to binary form

Fig. 9 shows image which is converted to binary form

2nd Block - Phase decomposition

1. Step one – At this step, the main task is to select the objects for further analysis. You can use a method to unify all the neighboring points, which is based also on the analysis of 3x3 matrix.
2. Step Two - analysis facility for the presence of local changes in the direction of the move path. If the presence of such changes on this object is copied to the clipboard for further decomposition.
3. Step three - find the next object on the input image. In case of success finding the transition to phase 1.
4. Step Four - check presence in the buffer objects that require decomposition. In the absence of such facilities move to step 6.
5. Step Five - decomposition of objects and their indexation. Changing the input image for buffer of layers that are cut. Go to step 1.
6. 6th step - completion of decomposition

Fig. 10 presents a binary image that had processed of bringing all objects to one standard: the lack of progress towards local contour changes.

3rd Block - composition process and selection of objects contours

- step one – Recovery objects
- step two – mark contour of objects

Fig. 11. represents binary image after the process of separating conglomerates

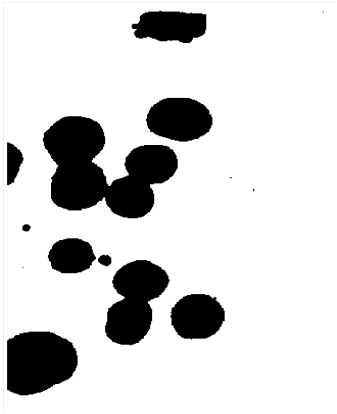


Fig. 9. Image of blood cells that are converted to binary form

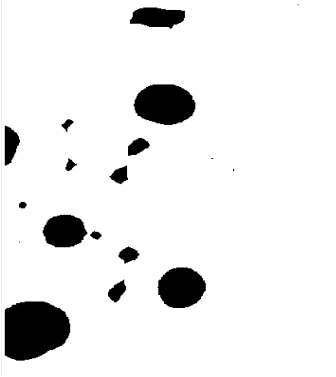


Fig. 10. Objects after decomposition process

Fig. 11. Image of objects that had passed all stages of processing

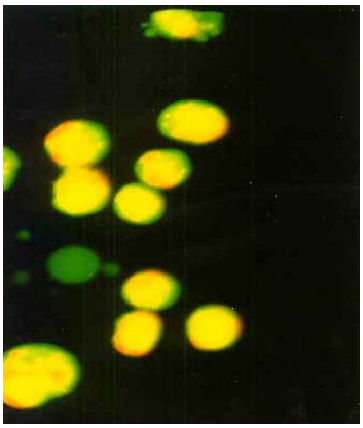
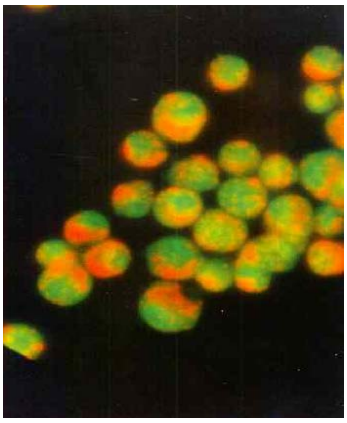
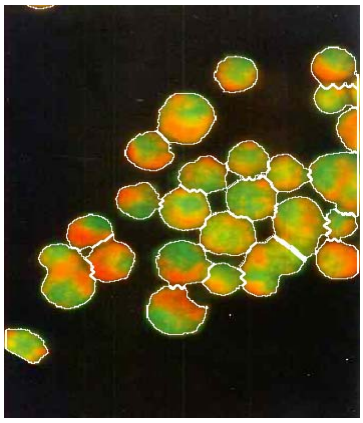
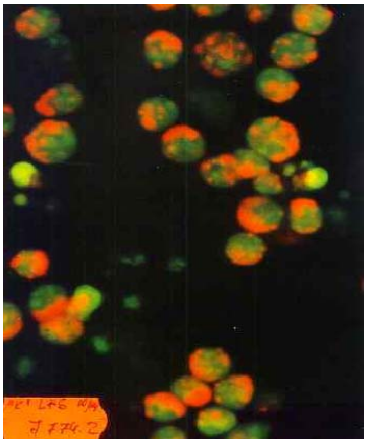
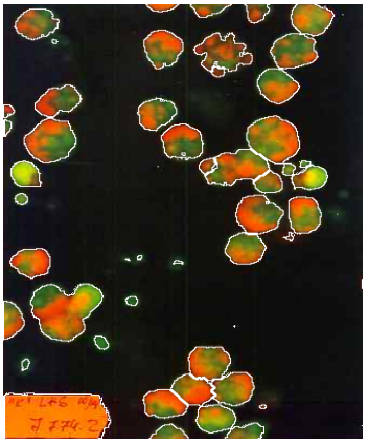
Test results

Table 2 shows the results of the separation of conglomerates in the complex background

Conclusion

Algorithm and data processing method of complex images and their recognition is effective for use. Considered test images in the real tasks. The developed method can be effectively applied to the most varied domains of knowledge in computer vision systems.

Table. 2. The results of the separation of conglomerates in the complex background

Input image	Output image
	
	
	

References

[D. Forsyth, J. Ponce, J ,2004] D. Forsyth, J. Ponce, J. Kompjuternoe zrenie. Sovremennyj podhod Izd. „Vilyams" Moskva, Sankt-Petersburg, Kiev, 2004, 926 c. // translate from (Forsyth, D.A. and Ponce, J., ``Computer Vision: A Modern Approach," 2002. Sample chapters appear on the book's)

[V. Hrytsyk, M. Vlakh , 2006] V. Hrytsyk, M. Vlakh “Software and hardware for recognition and analysis of Complex biological objects images”, Lviv ITIC. 2005. T.8, №1. C.17-28. (in ukr.)

[Bucki R , 2009] Bucki R., Modelling Flexible Production Systems, Artificial Intelligence, No. 4, Doneck, 2009, pp. 113-118, ISSN 1561-5359.

[Bucki R., Ceslya P., 2009] Bucki R., Ceslya P. management processes in automated warehousing systems control. – Kyiv. – 2009. – #54. – p. 36-43);

[Bucki R.,2007] Bucki R., Information Linguistic Systems, Network Integrators Associates, Parkland, Florida, USA, 2007, p. 102, ISBN 9780978860646.

[Bucki R., 2007,2] Bucki R., Thorough Analysis of the Technological Case Control, Management & Informatics, Network Integrators Associates, Parkland, Florida, Volume 1, No. 1, 2007, pp. 68-112, ISSN 1939-4187.

[Bucki R., F. Maretsky, 2006] Bucki R., F. Maretsky “Computer modeling of production lines”. – State Committee for Communications and Informatization of Ukraine, National Academy of Sciences of Ukraine, State Research Institute of Information Infrastructure. – Lviv. – 2006. – p.112.

[V. Hrytsyk, N. Pelykh, 2009] V. Hrytsyk, N. Pelykh // Classification Problem of Biological Objects. – Bulletin of National University "Lvivska Politechnika" Computer science and information technology. - № 650. - 2009. – p.10 (in ukr.)

Authors' Information

Volodymyr Hrytsyk *– Ph.D., sen. researcher , State Enterprise LVIV RADIO ENGINEERING RESEARCH INSTITUTE, Ukraine:* *stcu_1702@yahoo.com*

Viktor Vlakh *– programmer, State Scientific Research Institute of Information Infrastructure, Ukraine.*