Extraction of nerve cells in images with herpetic infections

Nedzved A[1]*, Ablameyko S[1], Oczeretko E[2]

[1] United Institute of Informatics Problems of the National Academy of Sciences of Belarus, Minsk, Belarus
[2] Institute of Informatics, University in Białystok, Poland

Abstract

In this paper, algorithms for extracting and diagnosis of nerve cells with herpetic infections are proposed. Degree of herpetic lesions is divided into four classes. Morphological characteristic of herpetic lesions for cell is accomplished by analyze cells structure. Because virus of herpes change shape of nucleus. Therefore automated analysis of herpetic lesion carry out by morphology segmentation and cells structure identification. The algorithms have been successfully used in practical systems and showed good results.

Key words: herpes, nervous system, diagnostic, image processing.

Introduction

The herpes simplex virus has been studied actively comparatively not long ago, although it is a well-known disease since antiquity. It is connected with the fact, that prevalent majority of the world population which is older 15 years being infected is enduring quite safely to the most widespread and harmless local forms of herpetic infections such as herpes nasalis and labialis [1-3]. Only in the past decade the role of VHS was established in the formation of the secondary immunodeficiency at the patients. The deterioration of ecological situation, the increase of oncological diseases, the expansion of human immunodeficiency virus (HIV) and extension of infections caused by AIDS-virus are result in the growth of the human herpetic lesions. Physicians of all over the world note the significant increase of complicated forms of herpetic infection.

Number of publications about various aspects of herpetic infections, concerned only the local VHS presentations (f.e. stomatitis, oftalmoherpes, herpes of genitals, skin diseases, etc.), has sharply increased during last ten years. However, the most terrible form of this pathology is disseminated herpes infection (DHI). If one of these forms is a disseminated infection of newborns which has described in the literature many years ago, the questions about an opportunity and mechanisms of DHI development at children under 1 year and adults are discussed. It is explained by the absence of sufficient number of clearly diagnosis cases of disease and sufficient qualified medical supervision and investigation [2,3].

Diagnosis of this disease is very complicated task since the main methods of immunofluorescence and polymerase chain reaction used in practice bring to positive results in the acute period of disease or exacerbation of chronic current of DHI only. At the same time, it frequently give false results, because of about 90% population of our planet has this infectious agent. Therefore the basic diagnostic method is morphological, i.e. the image analysis of the cells. It makes possible to reveal the presence of inflammatory process and etiological factor as original herpes inclusions.

Beside that the problem of diagnostics of herpes viruses is very important in the biopsy material from the brain. It is very important in a choice of the treatment methods and definition of diseases prognosis. The establishment of the diagnosis of the herpetic infection allows to escape of fatal diagnostics mistakes. Analysis of biopsy brain material is based on extracting and diagnosis of nerve cells with herpetic infections.

Modern tools like digital microscopy and developed mathematical methods allow an automatization of cell image analysis. There are known cell image analyzers [4] although most of them are developed and used mainly for image segmentation but not for diagnosis of disease.

The analysis of cell images can be considered as image segmentation problem where cells or their kernels should be

* CORRESPONDING AUTHOR:
United Institute of Informatics Problems of the National Academy of Sciences of Belarus
6 Surganov Str, 220012, Minsk, Belarus
e-mail: NedzvedA@newman.bas-net.by (Alexander Nedzved)

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Figure 1. **Image of good neuron**

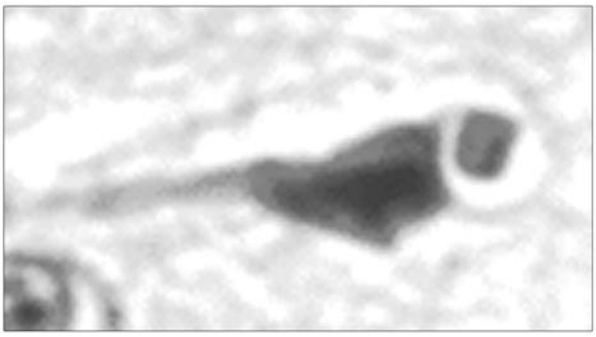
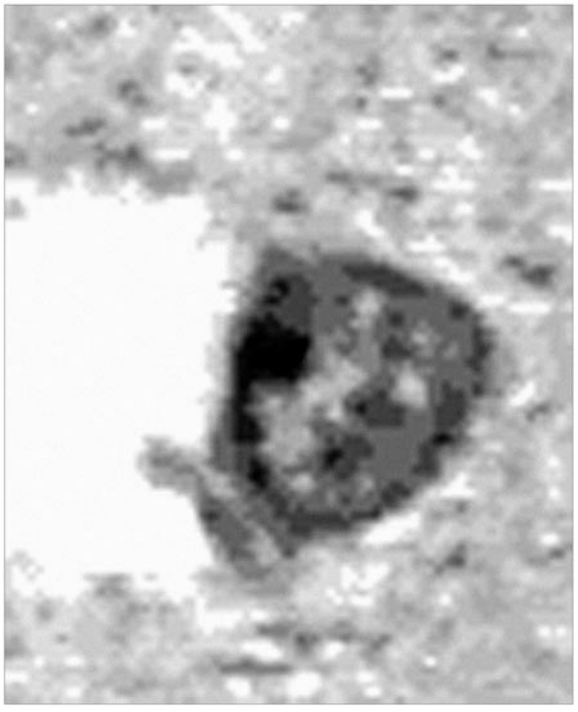


Figure 3. **Nerve cells with the second type of affection**

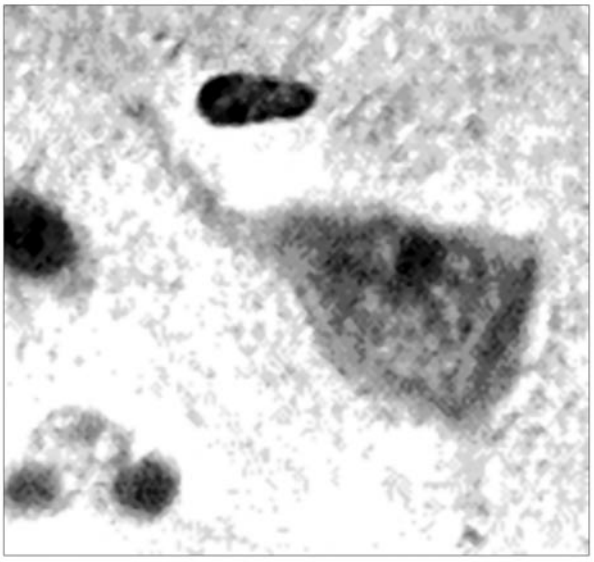


extracted. Being extracted, object characteristics should be computed, analysed and used by doctors.

There were already made many attempts to solve this problem. Review of cell image segmentation methods can be found in papers [5-7]. However, due to the very complex nature of brain images, it is not possible to select or develop automatic segmentation and recognition methods that could be applied for any type of such images. This is why most of the papers consider separate features of cell images and methods of their segmentation. The results also depend on a cell image quality. If the difference between cell or kernel and background is small, most of the methods do not work properly.

In this paper, algorithms for extracting and diagnosis of nerve cells with herpetic infections are proposed. The algorithms have been successfully used in practical systems and showed good results.

Figure 2. **Nerve cells with the first of affection**



Nerve cells images with herpetic infections

The neurons in human brain affected tissues are classified as healthy ones (*Fig. 1*), and cells of the first type (*Fig. 2*) and second type of affection (*Fig. 3*). One of the main features of a cell is its diaphragm, which outlines its boundary. The task is to extract nerve cells with herpetic infections.

Since an image background is inhomogeneous, and the image includes separately positioned objects of the same type, and, besides, the grayscale value for the pixels of the background varies uniformly and does not have abrupt jumps, good results are obtained by the morphological segmentation. The designed algorithm is based on the grayscale thinning of the morphological gradient, accompanied by tailing at each iteration which allows one to obtain closed contours bounding the regions corresponding to the objects. Taking into account the fact that the areas of the pyramidal neurons vary from 8 to 2000 μ^2, the objects which do not fall into this interval are eliminated. Thereafter, a hierarchical image of the cells for the cleared nuclei is constructed.

Morphological segmentation of cell images

Fig. 4 shows a gray scale image of neuron of head brain with indistinct boundaries and noisy background. Our task is to find a cell boundary, which would best correspond to its diaphragm.

According to our approach, at a first stage, the morphological gradient is computed that is the difference of the outputs of erosion and dilation in one iteration (*Fig. 4*). Obviously, an optimal border should pass on the sharpest overfall of brightness in a diaphragm, which corresponds to highest grayscale values on the image obtained with the help of morphological gradient. The obtained borders usually have more than one pixel thickness. Therefore, thinning of border lines is applied.

Figure 4. **Result of morphological gradient extraction of nerve cells**

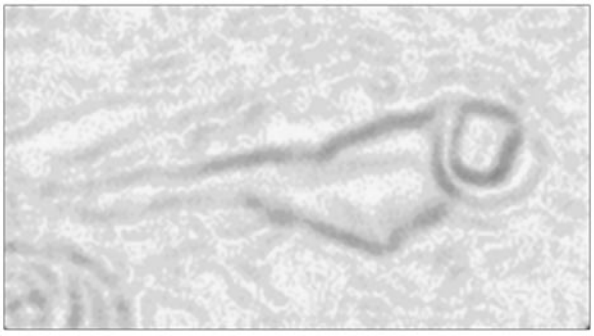
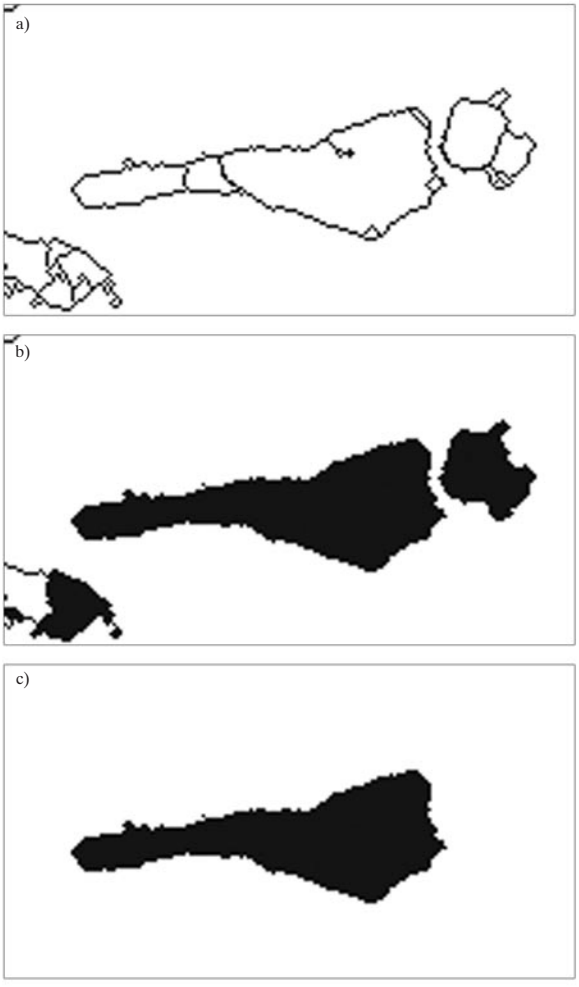


Figure 5. **Extraction of neuron: a) contour extraction after thinning operation, b) object filling, c) a binary image of a neuron obtained in the result of area measurements**



However, quite many false branches are obtained after thinning that should be deleted. To avoid this problem, we use two possibilities. The first one is to reduce noise at the preprocessing stage. Morphological operations can be used for this aim. For example, closing operation allows smoothing object contours that give better processing result. The second possibility is that we check and delete false branches after thinning. The result contains only closed contours, where the exterior contour corresponds to the border of a cell (*Fig. 5a*). To delete interior contours in binary image, contour filling is performed. As a result of all these operations, the binary cell image is obtained (*Fig. 5b*).

To delete objects not being cells, the computation of their area parameters is performed. The objects that do not satisfy apriori given geometric or optical parameters are deleted from the image (*Fig. 5c*).

Cell structure identification

Morphological characteristic of herpetic lesions for cell is accomplished by analyze cells structure. Because virus of herpes change shape of nucleus.

The algorithm of cells structure identification consists of two branches (*Fig. 6*). The first is intended for cells with a unpainted nucleus, another for the painted nucleus. In them according to hierarchical features binary images of cells, nucleus, nucleolus and inclusions are created. For reception of topological characteristics the cell is convenient for presenting as hierarchy of binary images. Where radically the column lays the binary image of a cell, at the following level there is an image of a nucleus, in branches the column lay nucleolus and various cellular inclusions.

Reception of each image is accompanied by logic operations of association and crossing of images, filling of holes in objects and the control on the area and diameter with the purpose of removal of noise. During identification cytoplasm of a nucleus, the certain bats mark nucleolus and cellular inclusions. In computer facilities for the characteristic of pixel the byte that is realized eight by byte more often is used. About eight levels of hierarchy, therefore, are optimum to allocate. Thus, all identified images are kept in the multiphase image. It makes presentation of result and ease of the automatic analysis of various cellular components and their analysis. Advantage of this method consists that under one multiphase image is possible to draw conclusions on all of a level of classification. Namely to receive the full information about structure of nerve cells.

Extracting of nerve cell types

All nerve cells are divided into four classes. First class consists of the healthy cells (*Fig. 7*). They have a triangular body. Therefore, a value of the factor of the shape is used, which vary in the range from 0.001 to 0.7, in order to classify these cells. The nuclei of these cells are well dyed and are darker than the cytoplasm, therefore they are not distinguished on the hierarchical image. Hence, the second parameter which specify these cells is Euler number (E8). In our case, it is equal to 0 for healthy neurons.

Second class consists of the cells with inclusions of the first kind (*Fig. 8*). Their shapes vary from triangular to the circular. Therefore, the factor of the shape for these cells vary from 0.001 to 1 and cannot serve as a basic classification parameter. The nucleus affected by the virus is not dyed and is lighter. Therefore, it is not distinguished by a separate color on the hierarchi-

Figure 6. **Block diagram of algorithm of construction of the hierarchical image of cells structrure from binary, where I – the binary image, G – the color image, C – the binary image of a cell, N – binary nucleus, V – the binary image nucleolus or inclusions, B – a morphological structural element. SCRAP (X) – function of removal of objects on the sizes of the area and diameter on image X. FILL (X) – function of filling of apertures in objects on image X. DIST (G) – adaptive threshold segmentation of image G**

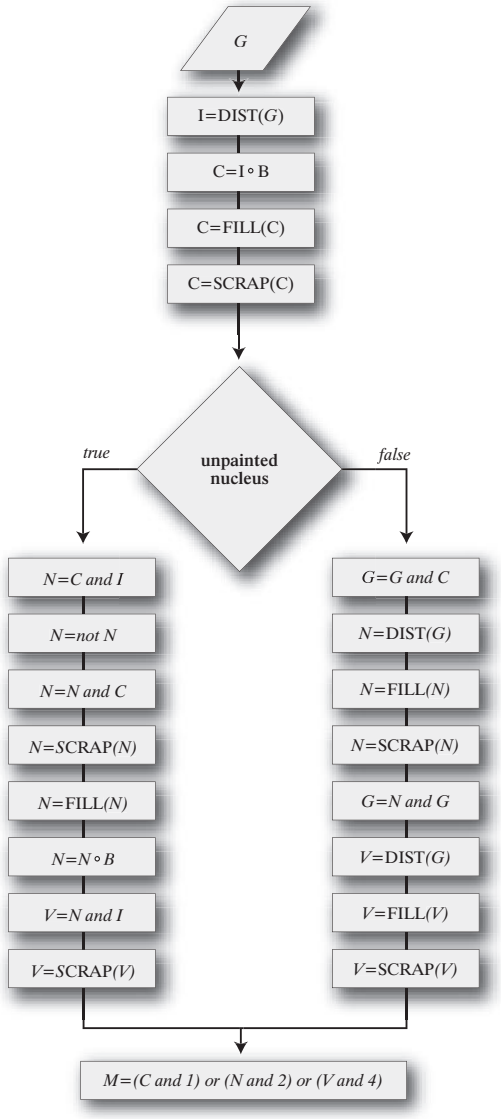


Figure 7. **Binary images of good neuron**

Figure 8. **Binary hierarchical image of nerve cells with the first type (second class) of affection**

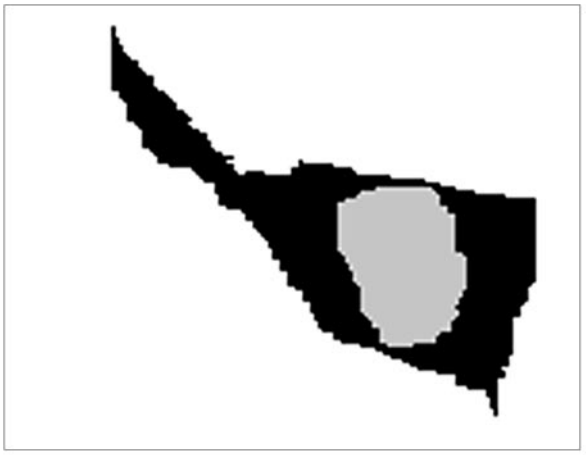


Figure 9. **Binary hierarchical image of nerve cells with the second type (third class) of affection**

cal image. In this case, the Euler number is equal to 1. Basic peculiarity of this class is characterized by the nucleus-cell ratio which is less than 0.8.

The third class consists of the cells with inclusions of the second type (*Fig. 9*). The shape of these cells is nearly circular, and there is practically no cytoplasm in the cell. Therefore, the following parameters are used for this class: the shape factor varies from 0.8 to 1, the Euler number is equal to 1, the nucleus-cell ratio varies from 0.8 to 1.

The fourth class includes all other objects which are eliminated immediately after their identification.

The result is an image containing healthy neurons and cells of the first and second kind. They have geometric and optical parameters which can be useful not only for the scientific research, but also in the problems of the practical diagnosis of a disease.

Conclusions

Algorithms for extracting and diagnosis of nerve cells with herpetic infections have been proposed in the paper.

These algorithms allow to extract nerve cells and make its classification by type of herpetic lesions. The algorithms have been successfully used in practical systems and showed good results.

Their usage allows to improve quality of diagnostic of herpetic lesions and exclude mistakes of human factor and decrease expended time for process of verification diagnosis.

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References

1. Vannier MW, Haller JW. Biomedical image segmentation. Proc of IEEE International Conference on Image Processing, 1998; 2: 20-4.

2. CIRES – Cell Image Retrieval and Evaluation System. Magazine for users of image analysis systems, Sept. 1992, pp. 18-9.

3. Walker RF, Jackway P, Lovell B,.Longstaff ID. Classification of cervical cell nuclei using morphological segmentation and textural feature extraction. Second Australian and New Zealand Conference on Intelligent information systems, Brisbane, 1994, pp. 183-9.

4. Vazquez L, Sapiro G, Randall G. Segmenting neurons in electronic microscopy via geometric tracing. Proc of IEEE International Conference on Image Processing, 1998; 3: 814-8.

5. Nedzvedz MK, Nedzvedz GK, Nedzvedz GE, Petrovich TM, Kulichkovskaja IV. Morphological peculiarities of demyelination in chronic herpetic meningoencephalitis. Russian scientific-practical conference of neurologists. Neuroimmunology, St.Petersburg, 2002; 193-5.

6. Nedzvedz MK, Guzov SA. Morphological characteristic of CNS lesions stipulated by VHS. Achievements of medical science and technology. Minsk, 1999; 1: 76-7.

7. Nedzvedz MK, Fridman MV, Nedzvedz AM. Modern views about morphogenesis of herpetic infection. Infection and immunity. Materials of Republican scientific-practical conference devoted to 75 years of BSRIEM. Minsk. 1999: 309-13.

8. Nedzved A, Ablameyko S, Pitas I. Morphological segmentation of histology cell images. Proc Int Conf on Pattern Recognit, Barcelona, Spain; 1: 500-3.