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# HISTOLOGY IMAGE ANALYSIS ON BASE SPACE-SCALE PIRAMIDE

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In this paper method of histology sample analysis is proposed. This method is based on scale properties of histological objects. Different characteristics of tissue are calculated on levels of scale image pyramid and allow to define more complete description for diagnostics or monitoring of disease.

## Introduction

For representation image information the data structure play important role for the successful solution of an image processing task. The image pyramid is a data structure that is used for supporting of efficient multy-scaled convolution. It consists of a sequence of copies of an original image in which resolution are decreased in regular steps [1].
There is a limited set of structures that may be located on the histological images. All these structures have specific properties, which can greatly influence to the process of image processing and analysis.
For histological images the group of morphological features depends from image resolution. They are used at the allocation of the closest and similar types of cells and tissues, as well as the analysis of bodies and their fragments. However, the transition between different kinds of characteristic is usually not possible, therefore, each kind of fragment histological organ, tissue, etc. by their morphological features separated from all other species, including those from the most similar to him. Systematization of morphological characteristics for their determination using computer technology is a very important element for the histological diagnosis.
In this paper we propose methodic of multy-scale analysis for histological samples for common tasks of diagnostics and monitoring of complex diseases.

## Image pyramids

Image pyramids have shown to be efficient data structures for digital images in a variety of vision applications. An image pyramid is a stack of images with exponentially decreasing resolutions. The bottom level of the pyramid is the original image. In the simplest case each successive level of the pyramid is obtained from the previous level by a filtering operation followed by a sampling operator. Image pyramids have the following merits [2]:
- The influence of noise is reduced in the lower resolution images by smoothing.

In the low resolution images, the regions of interest for correspondence analysis in levels of higher resolution can be found at low cost because irrelevant details are no longer available there.
- This reduces computational cost as the divide-and-conquer principle can be applied: in high resolution images, the region of interest can be split into several patches which can temporarily be handled individually.

Each layer of the pyramid can be processed and analyzed. And if the way of analysis is the same for all the levels, the sequence of descriptive data is received. This sequence of data provides an opportunity for the comprehensive image analysis leading to determination of some specific image characteristics which haven't been available before.
Image pyramids combine the advantages of both high and low resolutions of digital images compared in Table 1 without increasing the demand for disk space too much. The lower levels of an image pyramid provide detailed

information, but a great amount of data, whereas the higher levels contain less information but give an overview and require a smaller amount of data [4].

**Table 1. Qualities of images in different resolutions**

| | **High resolution** | **Low resolution** |
|---|---|---|
| **Data amount** | Huge | Small |
| **Details** | Rich and many | Very few |
| **Overview** | Bad | Good |
| **Position** | High | Low |

There are two ways to construct a regular pyramid:

1. Parallel graph contraction
2. Decimation of the neighborhood graph

The main purpose for the introduction of irregular pyramids was the rigid behavior (e.g. shift variance) of regular structures. Irregular pyramids offer greater flexibility for the price of less efficient access.

One can consider the contents of a cell as a model of the region which it represents. In the simplest case a cell stores only one (grey) value. We call such pyramids grey level pyramids. In more complicated cases several parameters of general models are stored in a cell. But the basic property that numeral values are stored in a cell remains. Subsequently we will call these pyramids numerical pyramids.

Besides numerical values it is possible to store symbolic information in a cell. In this case we have a finite number of symbols, and a cell stores a symbol relation among them. We call such pyramid symbolic pyramid.

The main property of processing in a pyramid is that it occurs only local, the brothers, and/or the parents a new value and transmits it to one or more cells of its pyramid neighborhood. In the bottom-up construction phase input comes from the sons but for some algorithms the flow of information is also in the top-down direction.

## Histological Objects

Histological objects to be extracted are defined according to tasks to be solved. It is convenient for automated histological specimen analysis to be based on topological features of images. It allows to define the whole procedure of study for object extraction. One of the most important properties of histological specimens is that one king of objects is to be determined but other king of objects is not due to optical magnification of the image. Every magnification there is a certain group of topological features of tissue and its components. This fact has prompted to consider histological objects over magnifications of histological specimens. (Fig 1).

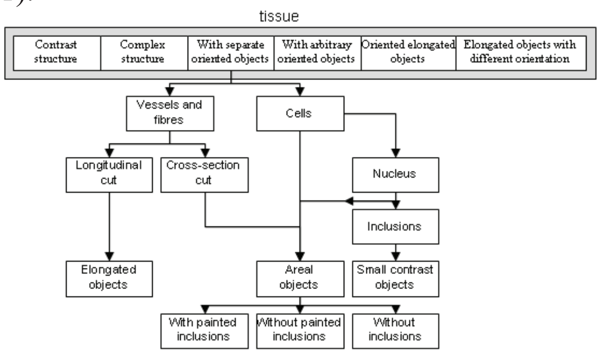



Fig. 1. Hierarchical scheme of histological objects.

The second level – is cells, fibers and vessels as objects of interest forming fragments of tissue. It A correlation of gray-level background and objects characteristics is significant for those images. A background mostly formed with hollows, very small cells, fibers and other particles. Furthermore background commonly contains different clutter and noise, which may appear at the stage of registering an image. That why the background is characterized by mostly homogeneous pixel intensity excepting single pulses. Pixel intensity of background is in dependency of tissue density distribution, quality of section and lightning and of electronic noise.

Classifying the scheme thee are two types of vessels and fibers distinguished for longitudinal cut and for cross-section cut. Cross-section cut vessels and fibers are ring-like objects which engird the region with other densitometrical characteristics. Density of pixel's intensity inside the fiber is always uniform, but particles of substance (blood) appear in vessels. The segmentation process of these images is the same as of cells when it carried out by geometrical parameters. Images of vessels and fibers in longitudinal cut are the elongated branching objects. It is quite complicated task to determine such an objects because of their inconstant intensity, which is varied with intersection thickness or overlappings. A centerline or skeleton optimally describes longitudinal cut objects.

### Pyramid analysis

Histological object analysis requires a specially prepared binary image with the explored objects displayed on by the binary data. The scale should be specified for the image (it can be determined by the calibration function) and calculated characteristics should be determined. Specialized object analysis requires preliminary calibration only. This process is divided into four steps mentioned below.

1. Preprocessing
2. Image segmentation
3. Shape correction
4. Image characteristics determination.

Here is the specific description of the approach. Every image pyramid layer is analyzed and described by some value of the basal function. It is apparent that some descriptive statistic value can be associated with every level of the pyramid according to the values of basal function on this level. So, the dependence between the scale and pyramid level descriptive value can be analyzed and used for some conclusions or sometimes pattern recognition.

Different histological structures can be determined on different levels of the image pyramid if the bottom level is represented by the nucleus or cell structures. The sequence of transformations is represented in Fig. 1.

Firstly, after nucleus and cell structures objects are prevailing structure on the lower resolution images. After that cells conglomerates start to prevail. And finally, the structure which refers to the lowest resolution levels is tissue objects.

In the Figure 2 the dependency of the prevailing structures on the resolution levels of the image pyramids is represented. Where complex structures are represented by nucleus, cell structures or their combination and simple structures include conglomerates and tissue objects.

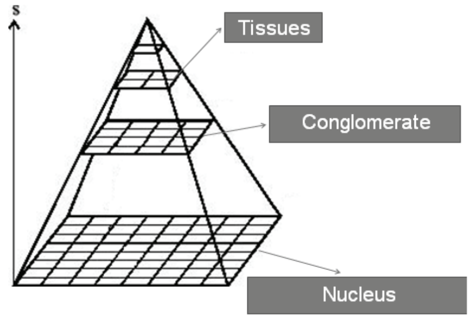
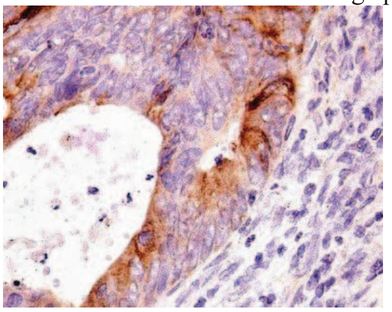
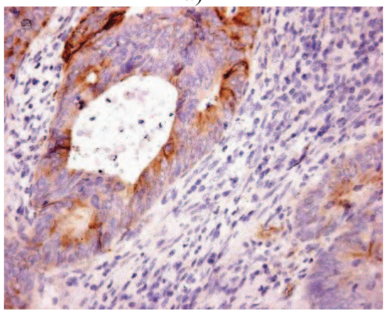


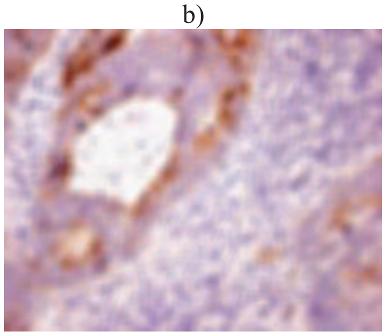

Fig. 2. The dependency of the prevailing histological objects on the resolution levels of the image pyramid.



a)



b)



c)

Fig. 2. Histological images for different levels of pyramid.

According to the characteristics of the structures mentioned above and the corresponding pyramid layer resolutions it is possible to make conclusions about the specific physical or physiological characteristics of the observed histological objects. But this is a topic refers to another area and, therefore, is not to be covered in this article [5].

The scheme of histological objects and structures which is proposed above plays a key part in automated analysis of tissue and its components. So it is important when the methods for object extraction to be chosen

Histological objects varied depending on individuals. In general, its geometrical characteristics which are important for preliminary diagnostics are changing. Overall tissue characteristics are studied at low magnification which are: tissue structure and shape, presence of polyferation, tissue uniformity, etc. Characteristics of cells and its surrounding are determined at high magnification (500 - 2000 times). At low magnification a tissue fragments are visible (Fig.2), there are cells presented here as small contrast objects. Clusters of cells form tissue regions, which are different functionally from each other, so features of cell groups play a significant part to characterize a tissue structure. It is necessary to carry out the analysis of geometrical, topological and texture characteristics of cells to appreciate tissue fragment at oncological abnormalities (polymorphism, polychromism and anaplastics) [3].

Summarizing all aforesaid, we describe a morphological analysis, which is discovered in general as follows: low optical magnification (50-100 times, a presence of tumor is determined by studying of these characteristics and features of tissue and cell clusters:

a. Uniformity of tissue layer:
   i. Smoothness of layer edge; ii. Form-factor of layer edge;
b. Cells organization of layer in tissue:
   i.Distribution of cells by its area in layer; ii. Orientation of cells in layer; iii. Intercellular distance.

2) High optical magnification (500-2000 times).

A diagnosis verification is provided by studying of cell characteristics:

a. Cell morphometrical parameters:

i.Sizes; ii.Form; iii.Nucleocytoplasmic ratio.

b. Nucleus parameters:

i.Sizes;ii.Form;iii.Inner topological structure:

1. sulci;
2. inclusions;
3. mitoses (pathology in nucleolus organization).

For the qualitative specimens definition does work well for the most of features.

Moreover it is very important to consider patterns of cells, vessels and fragments of tissue together for correct identification of object extracted from image. In the next section of the paper we propose a new algorithm of feature extraction based on these fundamentals.

## Conclusion

While conducting the research described above the following steps have been made:

1. The main histological image structures have been determined and analyzed.
2. Image pyramid data structure has been used for comprehensive image representation.
3. The dependency between the pyramid level and prevailing structure has been detected and analyzed.
4. The dependency between structure type and its characteristics has been detected.
5. The developed technology has been tested for magnet optic structures from histological images, fibers, neural vessel and cells structures of histology samples.

There are several directions which this approach can be efficient to be applied to. All of them refer to pattern recognition.

The approach, described above, shows to be an efficient tool of object shape analysis and processing.

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