

Methods and means of diagnostics of oncological diseases on the basis of pattern recognition: intelligent morphological systems – problems and solutions

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Abstract. The development of methods of pattern recognition in modern intelligent systems of clinical cancer diagnosis are discussed. The histological (morphological) diagnosis – primary diagnosis for medical setting with cancer are investigated. There are proposed: interactive methods of recognition and structure of intellectual morphological complexes based on expert training-diagnostic and telemedicine systems. The proposed approach successfully implemented in clinical practice.

1. Introduction

Cancer put before the world community serious complex issues associated with the disability (total or partial) of the various layers of the population.

The direction for the development of new advanced technologies of cancer diagnosis is an important place in addressing these issues. Pattern recognition is one of them.

The success of treatment is primarily determined by the timeliness and accuracy of diagnosis. Histological (morphological) method of research is one of the main methods of diagnostics of malignant tumors[1-3]. Light microscopy systems are used the most widely in clinical oncology due to the significant centuries of accumulated diagnostic medical experience. These systems work in the visible range of electromagnetic radiation.

Generalized block diagram on Fig.1 shows the process of recognition of digital images of histological slides of the tumors.



Figure 1. A generalized block diagram of image processing in the recognition system tumors.

The images pre-processing of the objects of study (histological macro - or micro specimens of tumors) may be required to reduce interference factors. In General, preprocessing is needed to transform the source image in a form suitable for the implementation of the key recognition stage – descriptions.

Description is the presentation of the investigated object as signs – characteristics, reflecting the essential properties of the object. Signs are called informative if they provide separation of different classes of objects.

Classification is associated with deciding on the type of the class object. For example, primary diagnostic interest are urgent (express, intra surgery) biopsy studies during surgery to determine the type of class of tumors – benign or malignant.

Fig.2. demonstrates a generalized technique for urgent biopsy studies with histological application of computer systems and telemedicine technologies to provide guidance to the physician –pathologist in difficult diagnostic cases[2].

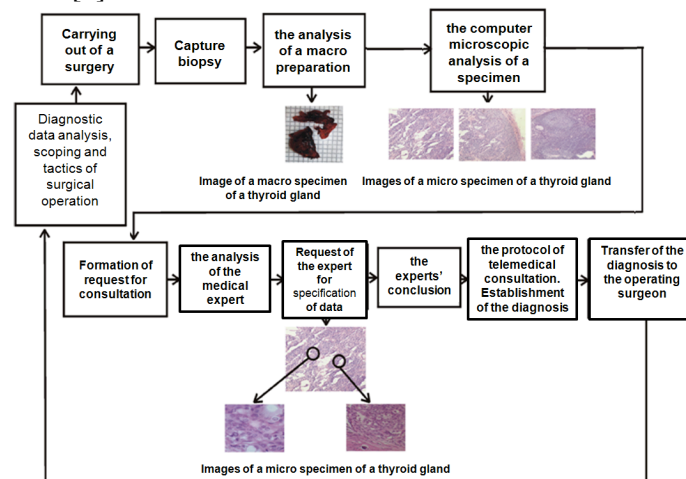


Figure 2. Urgent biopsy studies technique during surgery with the use of computer systems and histological telemedicine technologies.

Widespread introduction of methods and means of pattern recognition in the diagnosis of malignant tumors is hindered by a number of existing problems[5], the main of them are shown in the diagram Fig.3.

The aim of this work is to develop methods and tools of pattern recognition for histological diagnostics of oncological diseases.

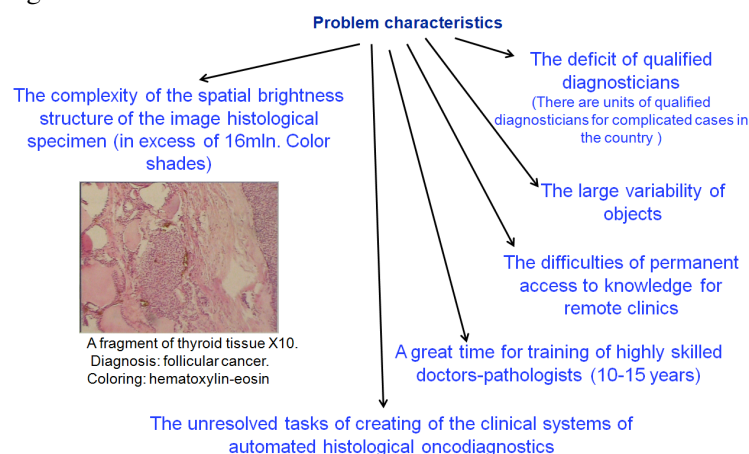


Figure 3. Problems characteristic in the field of cancer diagnostics using the histological research method.

Key objectives associated with the formation of the feature space, the creation of reference base of the histological images, the choice of the method of making diagnostic decisions. Three main groups

of conceptual alternatives have significant (relevant) importance in the area of pattern recognition of micro specimens (the most problematic in the clinical histological diagnosis) (figure 4).

2. Analysis of alternatives of clinical systems creation for histological microimages recognition

Now it is discussed the selection of features models for digital images of histological micropreparations. Currently, qualitative approach is dominant in the histological oncodiagnostics in the analysis of micropreparations of the tumors (in contrast to the study of macropreparations, which can be implemented for quantitative evaluation)[6]. This is due to the traditional (classical) scheme of training of the doctor – the pathologist. That is primarily due to the unresolved problems of deciphering of the phenomenon of visual perception in general (although some successes exist), and histological microimages, in particular. It should be noted that the attempt of introducing a quantitative approach in image recognition of tumors histological micropreparations have been doing with the announcement of the relevant achievements in scientific publications and mass media. Of course, they should be viewed as an encouraging factor in the gradual ways of solving fundamental questions.

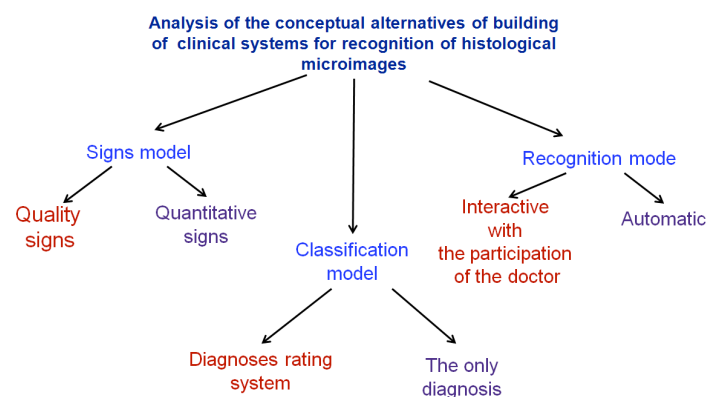


Figure 4. The main groups of conceptual alternatives for clinical systems creation for microscopic images recognition.

However, statement about reliable clinical implementation of the results of quantitative approach (taking into account variability of the histological environment, ensure of the necessary representativeness of the reference objects and the required volume of the experimental sample) have not sufficient grounds. Thus, qualitative approach is appropriate for the choice of signs in the process of creation of clinical systems for recognition of histological microimages tumors at the present stage [7]. The scheme of formation of signs of microscopic images in clinical recognition of tumors is shown in Fig.5. A more detailed description of the characteristics cases are presented in the works [2,8]

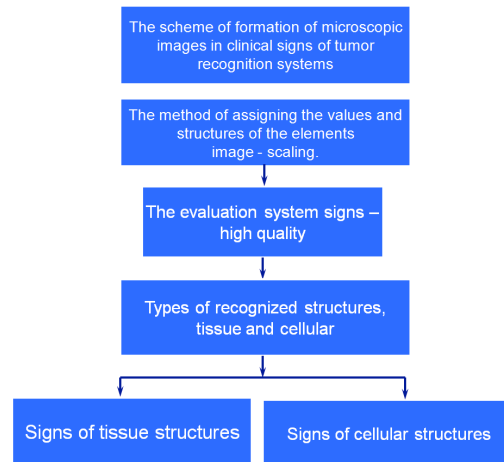


Figure 5. The scheme of formation of signs of microscopic images in clinical recognition of tumors.

Educational-diagnostic system with visual interpretation of informative features in a computer histological knowledge bases with training procedures and automatic control learning outcomes is necessary to ensure the proper level of training of doctors-pathologists (primarily young). Such systems are created in the National research nuclear University MEPhI in collaboration with the N. N. Blokhin Russian cancer scientific center (RCSC). This is based on the achievement of MEPhI in the field of pattern recognition for solving problems of cancer diagnostics and a unique archive of the RCSC [9].

The choice of the classification model. The choice of the classification model should be guided by the rating (probabilistic) system diagnoses. This is due to the fact that the formulation of the histological diagnosis in oncology is complex, ambiguous and informal procedure, when the same symptoms can correspond to different nosological forms/

Rating system of diagnosis is based on the comparative analysis of the frequency of occurrence of a set of characteristics of the studied image (patient) with a similar set of reference images, corresponding to the possible nosological forms. The structure of the reference knowledge base of the histological micropreparations images in the system of pattern recognition for the diagnosis of cancer is shown in figure 6.

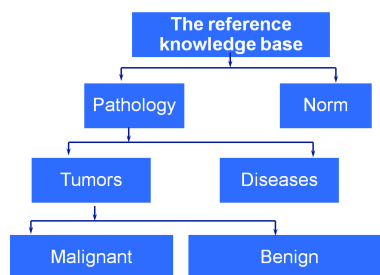


Figure 6. The structure of the reference database of the histological micropreparations of tumors in the system of pattern recognition for the diagnosis of cancer.

The reference knowledge base is created by experts of the Department of computer medical systems National research nuclear University "MEPhI" and the doctors of the Department of pathological anatomy of human tumors of the N.N.Blokhin Russian cancer research center[5]. The

knowledge base contains 7988 images at 2615 cases of tumors of the pancreas, thyroid, breast, esophagus, stomach, colon, lymph nodes, kidneys.

Rating system for assessing of histological cancer diagnosis in recognition of esophageal cancer is illustrated in Fig.7.

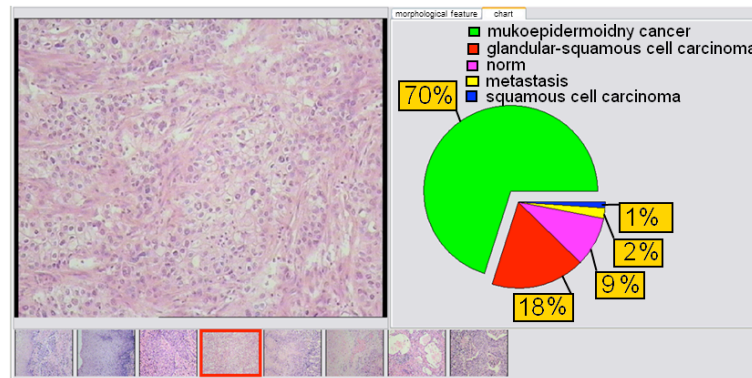


Figure 7. Detection of esophageal cancer with the rating diagnostics system.

The choice of recognition method. When choosing a method of recognition – interactive (physician-pathologist) at the stage of defining features of the studied images (patients) and automatic (without a doctor) it should be to take into account the above problems of visual perception, the complexity of the histological evaluation of objective environment, the classical training of doctors-pathologists, medical personnel shortages. The analysis of these problems allows to make a conclusion about the use as a working option for clinical practice an interactive method of image recognition of the histological micropreparations of tumors[7].

The success of interactive recognition method, as well as work to increase the level of automation in this area is associated with the creation and unification on a single hardware and software platform of clinical, research, training and telemedicine systems[5]. Such systems (ATLANT) was created and implemented as a result of joint activities of the National research nuclear University "MEPhI", N. N. Blokhin Russian cancer scientific center, clinics of Federal medical-biological Agency. Their implementation allows for the young (experience of 5 years) of doctors-pathologists to increase cancer diagnostics accuracy from 70% to 95% .

3. Conclusion

- The problems in the development of recognition systems for histological diagnostics of ontological diseases were analyzed.
- The method of interactive images recognition with the participation of a physician pathologist was proposed for the most problematic areas – computer histological microanalysis. The method follows the traditional training of pathologists, based on the qualitative characteristics of tissue and cellular structures with ratings of cancer diagnostics.
- The reference database of knowledge is created to implement the proposed recognition method. It contains 7988 images of histological micropreparations of cancers of the breast, pancreas, thyroid glands, stomach, lymph nodes, esophagus, kidney.
- The method of interactive recognition of tumors are successfully introduced into clinical practice in the N. N. Blokhin Russian cancer scientific center.

Acknowledgments

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