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Computer Microscopy of Biological Fluid Dry Patterns for Medical Diagnostics

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Abstract

We elaborate hardware and software system that implements the principle of diagnosis based on the standard procedure of pattern preparation including digital recognition of image and its computer analysis based on specially developed algorithms by comparing with the expert descriptors and extensive database of dry pattern samples obtained from clinical treatments which include more than 1500 samples to high selective and accuracy recognition of pathologies, for recognition of wide range of pathologies, in particular, the endogenous intoxication.

Keywords: biological fluids, image analysis, medical diagnostics, endogenous intoxication.

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1. Introduction

In current clinical practice, there are a variety of methods for a diagnostics of the human health. There is actively searching for improve the diagnostic techniques to determine the objectives of the body response to the impact of external factors including radiation, radioactivity, etc; to determine the natural resistance and adaptation reserves of the body, to predict the direction of the pathological process (especially the diagnosis of cancer), to accelerate the diagnostic analysis of high accuracy with minimizing cost consuming. It is important to develop the high-precision computerized methods for medical rapid diagnostic which is generalizing the unique clinical experience obtained in the past decade as specialized solutions for diagnostic problems of control of specific diseases and, potentially, for a wide health monitoring of virtually healthy population,

identify the reserves of human health and take the actions to prevent of these reserves depletion.

We have carried out own research in collaboration with medical diagnostic centers and formed the electronic database for recognition the following types of diseases: infectious and parasitic diseases; candidiasis; neoplasms; cancer of larynx; endocrine; diabetes; diseases of the circulatory system; hypertensive heart disease; ischaemic heart disease; cerebrovascular disease (encephalopathy); diseases of the digestive system; gastric ulcer; duodenal ulcer; gastritis; diseases of the genitourinary system; renal failure; external causes of morbidity and mortality; factors relevant to the work; factors associated with environmental pollution; factors related to lifestyle.

After dehydrating of the drop of biological fluid molecules and supramolecular complexes are distributed in strictly defined locations over the drying drop area in the form of concentration zones [1, 2]. As a result, the film is formed, possessing a structure, whose specificity is defined by the chemical composition and by the interactions between different substances in biological fluid. Appearance of the pattern is significant for diagnostics of a wide range of diseases. Pathological changes, occurring in the body, lead to violation of qualitative and quantitative composition of biological fluid, what influence the solid phase morphology.

2. The process of biological fluid dehydration

Formation of cracks and concretions occurs in the process of biological fluid dehydration. Due to a complex component composition this process occurs phase-by-phase accompanied by formation of solid phase concentration zones, which are formed through corresponding components of biological fluid with definite physicochemical parameters. After evaporation of free water, the drop of biological fluid fully goes over into a solid phase and forms the patterns. As a result of bound water evaporation being continued, in the pattern structure there are developed rather powerful processes of stretching and compression of material, also due to protein molecule's coagulation, what causes the drying film cracking with formation of cracks. Concretions are formed as a result of homogeneous substance accumulation in different pattern zones, as a rule, surrounded by cracks.

3. Experimental studies

In the course of experimental and clinical studies it has been shown that cracks and concretions possess a well-defined interrelation with definite physiological and pathological states of the human body. Figure 1 shows differences between pattern of blood serum collected from healthy and sick persons. Therefore the study of quantitative characteristics of cracks and concretions (a form, distribution homogeneity over the pattern area, a size, a number and et al.) provides information on the microstructural facies inhomogeneity.

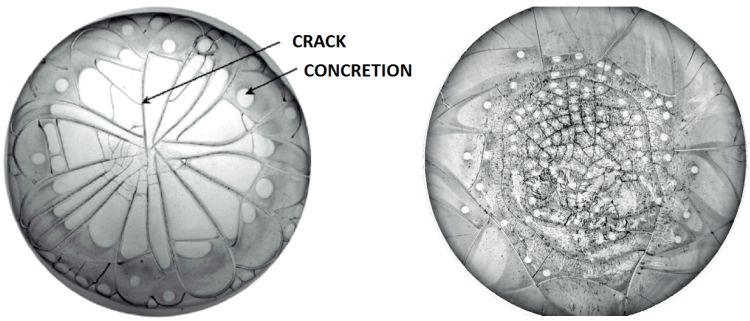

Figure 1: Image of blood serum pattern (Left) Patient in normal state (Right) Patient with pathologic process.

When performing quantitative microscopy in clinic studies, one of the most important methodological problems is specifying of structures' characteristics which are most informative from the point of view of the medicine problem. For example, in samples with a protein component (blood serum, saliva, tear and et al.) the main structural elements are cracks and concretion.

4. The program library

Software implements the previous experience in methodology of studying a structure of polymeric systems and other solid body objects, it is meant for a wide use in the field of investigating different structures of multi-component systems, including biopolymer films. Special components of program library allow digitizing of structural pattern elements and calculating the pathology markers parameters (number and sizes of objects, their distribution uniformity, arrangement symmetry, deviation angle, fractality et al.). The program allows to detect pathology by the use of image processing (Figure 2). This program calculates distribution of the concretions by area.

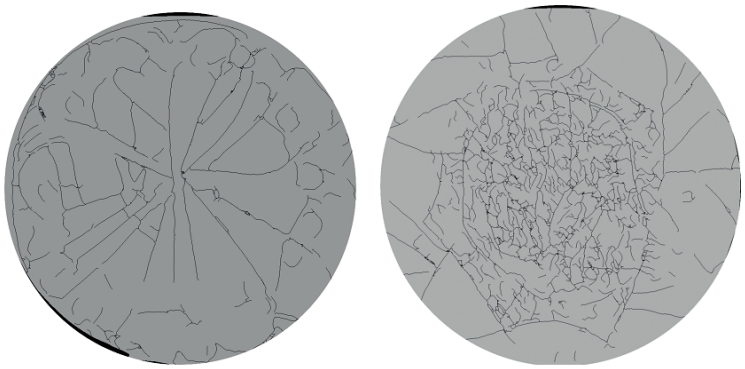

Figure 2: Image of blood serum pattern after processing (Left) Patient in normal state (Right) Patient with pathologic process.

Distribution diagram for concretions by area is shown in Figure 3. For the pattern of blood serum, which is corresponded to patient with pathologic process (II—stage vascular encephalopathy), the amount of small-area concretions increases strongly. Analysis of many different patterns allows finding quantitative characters for the pathologic processes in the human organism.

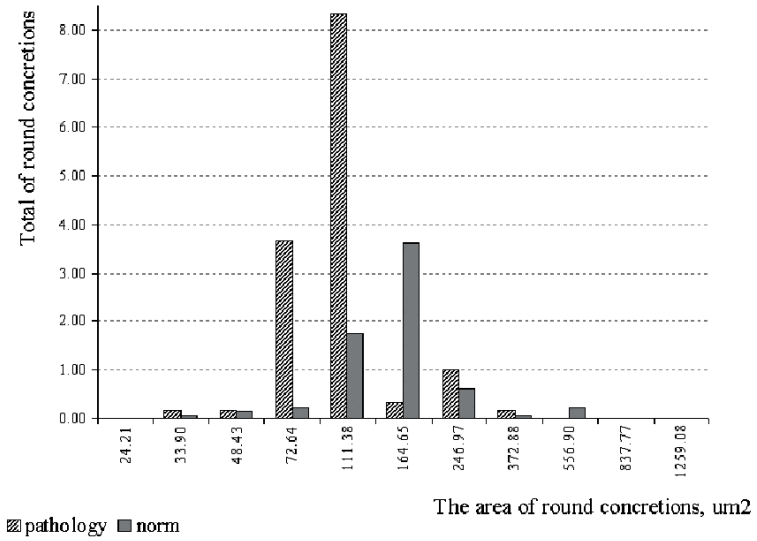

Figure 3: Distribution diagram for concretions by area.

5. The method and software for determination the stage of endogenous intoxication

Mathematical algorithm for computation the stage of endogenous intoxication [3] by image of saliva pattern was created. Our algorithm is based on scientific researches in the field of analysis of structural changes in saliva pattern depending on the stage of

endogenous intoxication. During the development of our algorithm we analyzed saliva probes belonged to 60 patients (training set) and received expert scores for these probes. After that the developed algorithm was tested on 40 saliva probes belonged to the others patients (test set).

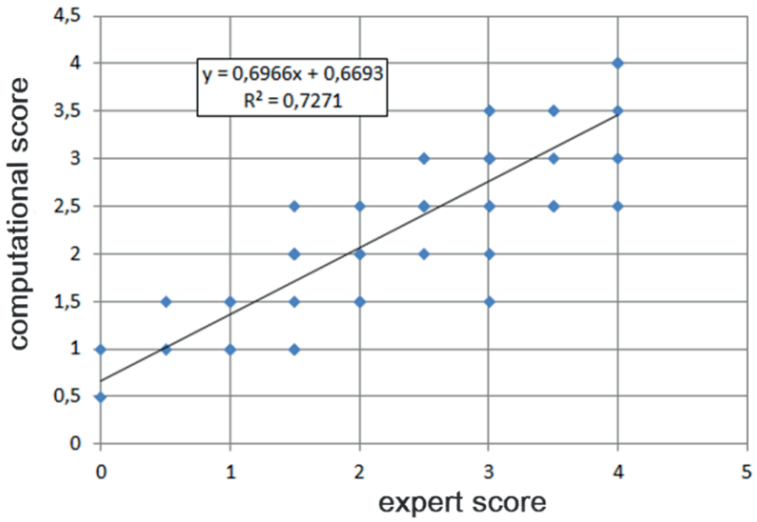

Figure 4: Dependence between computational score and expert score (training set).

For patterns which are contained in training set dependence between computational score and expert score is shown in Figure 4. This dependence has linear character.

Dependence between computational score and expert score for the patterns samples of test set is shown in Figure 5. This dependence has a linear character too. Increase of the accuracy can be explained by the decreasing of the patient amount.

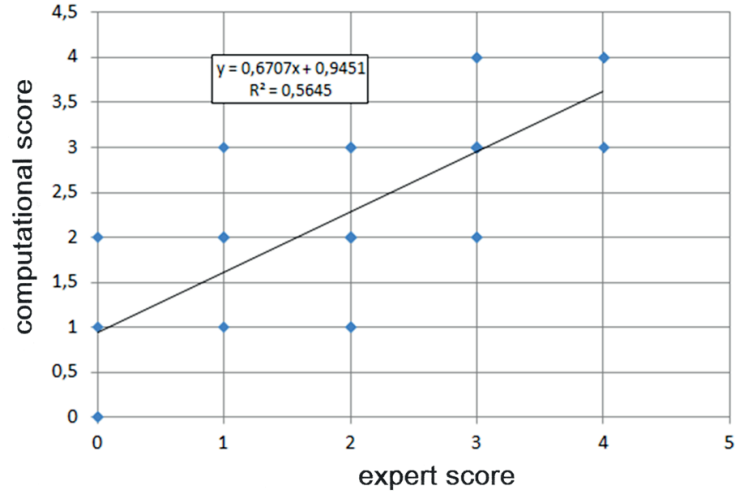

Figure 5: Dependence between computational score and expert score (test set).

Charts show that our diagnostic method is characterized by high test-sensitivity.

6. Conclusion

The paper demonstrates the capabilities and perspectives of the diagnostic method based on computer recognition of structure features of bio-liquid dry patterns. It is shown that hardware-software setup can be considered as a prototype of an effective device in the field of solving the diagnostics problems of the human body in normal state, and when pathology states. The device application has allowed obtaining of interesting results not only in biomedical applications, but also acquisition of interesting data on the processes of dried pattern structure formation (self-organization of the multicomponent colloidal fluids and solutions).

It is obvious that the further improvement of this method is interdisciplinary R&D problem including medical [3], engineering, physicochemical [4], and mathematical aspects. From a medical point of view, we have to legitimate the justification and regular specific connection between the specific change in the pattern structure from normal one and the presence of a corresponding pathology, true selection of diagnostic descriptors. With mathematical and computation points of view it is about creating an optimal algorithm of computer processing for realization of the principle "from abnormal pattern structure to specific diagnosis of pathology" based on the proposed structural descriptors, maximizing the percentage of recognition of pathology; creating of optimal software package. From an engineering point of view, the problem is to provide the optimum instrument system including a sample preparation system, the computer to digitize the image, analysis and diagnostic information issue.

Acknowledgments

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