BIO –TISSUES MONITORING USING DYNAMIC LASER SPECKLE PHOTOGRAPHY IN A QUASI-REAL TIME OPERATION MODE

N. Bazylev[1], N. Fomin[1], T. Hirano[3], E. Lavinskaya[1], T. Mizukaki[2], A. Nakagawa[3], S. Rubnikovich[4], K. Takayama[2]

[1]*Laboratory of Physical-Chemical Hydrodynamics, Heat and Mass Transfer Institute, National Academy of Sciences of Belarus, P. Brovki 15, Minsk, 220072, Belarus*
e-mail: fomin@hmti.ac.by

[2]*Shock Wave Research Center, Institute of Fluid Science, Tohoku University, Katahira 2-1-1, Aoba-ku, Sendai, 980-8577, Japan*
e-mail: takayama@rainbow.ifs.tohoku.ac.jp

[3]*Department of Neurosurgery, Tohoku University School of Medicine, Sendai, Japan*

[4]*Department of Orthopedy, Belarusian State Medical University, Minsk, Belarus*

Joint development of a laser monitor for the real-time bio-tissue analysis is presented. The monitor is based on the digital dynamic laser speckle photography and deals with soft and hard bio-tissues. In soft tissues, the dynamic bio-speckles are formed in a scattered from a tissue laser light. An optically transparent model of hard bio-tissue was prepared and preliminary analysis of a stress field in the stressed model was performed using the dependence of the refractive index of transparent solids upon the state of stress and the double exposure speckle photography data. The refractive index of the stressed material was evaluated and the state of stress was reconstructed using the stress-optical law.

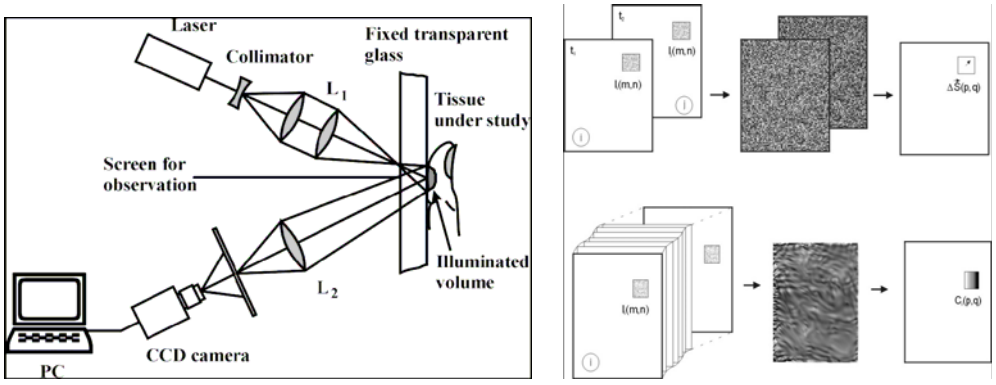

Fig. 1. Experimental installation for sub-skin blood flux monitoring (a) and block diagram of image correlation analysis (b). Upper part corresponds to double (multiple) exposure speckle photography with subsequent cross-correlation analysis of the obtained speckle pattern. The lower part corresponds to single (prolonged) exposure speckle photography with the exposure time comparable with the characteristic time of the process studied

Monitoring of the blood microcirculation activity in living tissues is of considerable importance for many tissue diagnostic purposes. The use of laser for imaging through or into bio-tissue is currently an active area of research. Optical methods based on the analysis of the laser light scattered by the tissues are very attractive due to the possibility to use that in real-or quasi-real time mode, see Fig.1. The image of living tissue illuminated with the light of a laser differs from an image taken under white light illumination by the extremely grainy structure (speckles) that is superimposed on the surface features of the tissue. Dynamic (moving) speckles are carriers, in addition, of the living tissue information and cross-correlation analysis of a sequence of the speckled images allows to determine, for instance, blood microcirculation parameters. Such technique becomes one of the principal directions in biological and medical application of laser monitoring. The technique is particularly attractive and promising because of non-contacting and

non-disturbing character of measurement and the possibility of its implementation in vivo, see Fig.2.

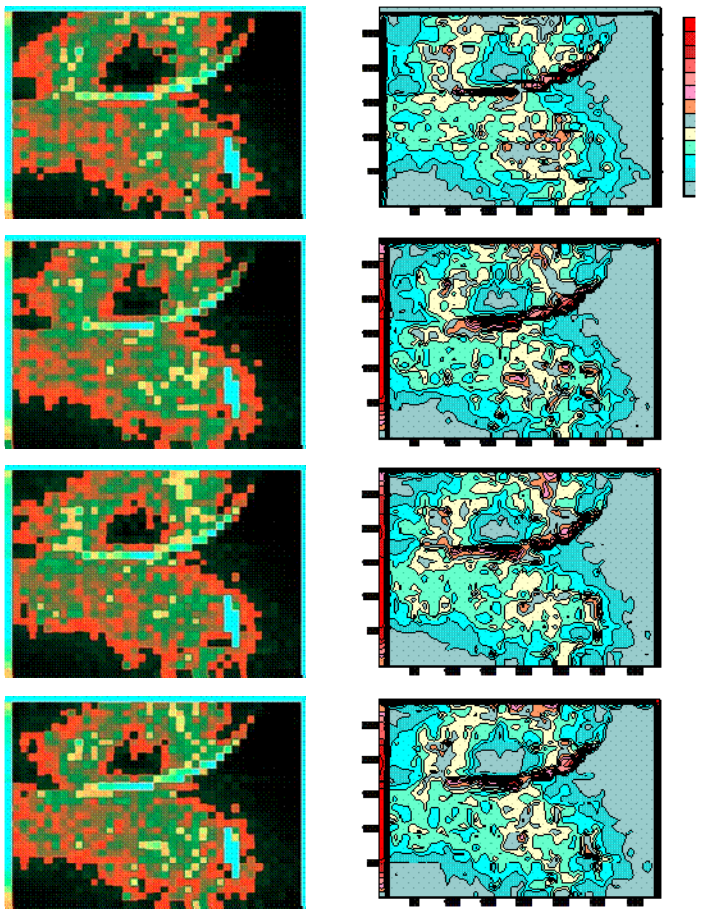

Fig. 2. Real time maps showing the intensity of the subskin blood flux reconstructed by the contrast variation in single (prolonged) exposure speckle photography (scheme left) and isolines of these maps (right)

Dynamic speckle photography methods were developed and employed for soft tissue microcirculation monitoring. Preliminary results for hard tissue structure analysis are presented. Detailed analysis of multiple scattering on bio-speckle formation and its dynamics shows that the time-space cross-correlation analysis of the temporal evaluation of the bio-speckle patterns is an effective means of real time flow and stress visualization of a living tissue. Digital processing of bio-speckle patterns records yields 2D maps exhibiting the blood flow temporal and spatial variations.

Three methods of the dynamic speckle patterns evaluation were tested. Both decorrelation and auto-correlation analysis were realized in a near-to-real time mode, when all digital specklegram treatment was performed during the time interval between subsequent frames (40 ms), and results in the form of 2D maps of subskin blood flux were visualized on the PC monitor with frequencies being 10-25 Hz. The full cross-correlation analysis of the dynamic bio-speckle pattern needs a little more PC time and only quasi-real time operation with present hardware was achieved at a frequency of about 5 maps/s. The information obtained with cross-correlation analysis seems to be a little excessive for the present task as contains the direction of the averaged bio-speckle displacement. For such random fields as subskin blood flux it seems that decorrelation and/or auto-correlation analysis is faster and sufficient to extract only the value of the averaged blood flux intensity.

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