BIO-FLOWS MONITORING BY DIGITAL LASER SPECKLE TECHNIQUES

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ABSTRACT: A biospeckle pattern is produced by 3d interference of probing laser coherent light multiply scattered by the erythrocytes flowing inside living tissues, as in Fig. 1. 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 which exhibit the temporal and spatial variations in flowing erythrocytes.

Three methods of evaluating dynamic speckle patterns are described. Both decorrelation and auto-correlation analyses have been realized in real time mode, when a total digital specklegram treatment was performed during the time interval between successive frames (40 ms). Results in the form of 2D maps of subskin blood flux were visualized on the PC monitor with a frequency of 25 Hz.

The dynamics of speckle patterns produced by a moving rough surface have been extensively studied for velocity measurements. However, the spatial-temporal properties of bio-speckle are essentially different from those of the speckle patterns formed by a moving rough surface due to the effect of the multiple scattering and different velocities of the scatterers. This effect is important for Laser Doppler measurements as well, but the description of the scattered light using speckles has the advantage of including multiple scattering, even if we consider the simplest case of multiple scattering from the ”single” rough surface.

For single point measurements, the intensity fluctuations measured at the point are characterized by the time-correlation length defined by the time at which the normalized temporal autocorrelation function of intensity fluctuations falls to 1/e. This statistical quantity is inversely proportional to the fluctuating speed of the speckle intensity. Its reciprocal value measures the velocity of a diffuse object at least for the speckles scattered once. A more general description of dynamic speckle patterns is based on the use of multi-dimensional space-time cross- correlation functions.

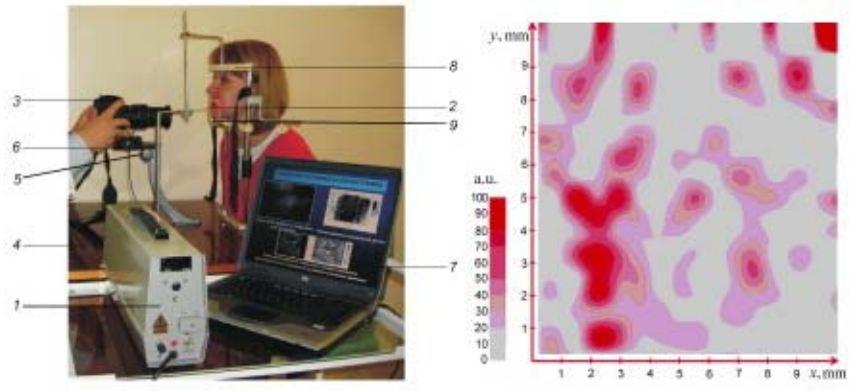

Fig. 1 In-vivo human tissues monitoring at Belarus State Medical University: 1, He − Ne laser with power supply; 2, waveguides for laser beam transportation; 3, Digital CCD camera of high resolution; 4, patient table; 5,6, mechanical supports; 7, PC; 8,9, mechanical supports. On the right, example of intensity of subskin blood microcirculation within a tested area in arbitrary units.