Laser Speckle Contrast Imaging of Blood Flow

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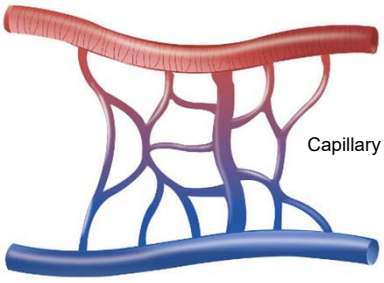
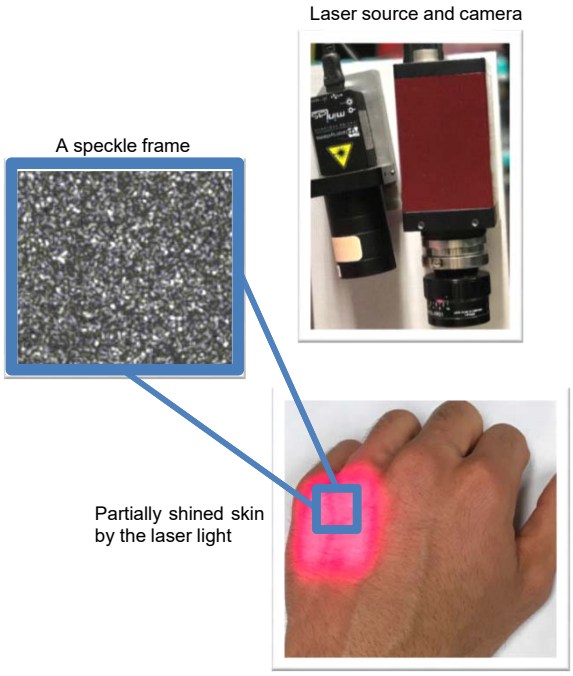
Virtually 40 percent of blood is made of red blood cells (RBCs) and interaction of such moving RBCs flowing in the tiniest networks of blood vessels with light can be analyzed in order to extract some information. Such information consists of concentration and velocity of RBCs delivering oxygen and nutrition for live tissues in capillaries (See the right hand side figure).

This process is called microcirculatory perfusion imaging which has application in staging burn wounds, studying psoriasis, monitoring healing process of a wound in foot caused by diabetes, and so on.



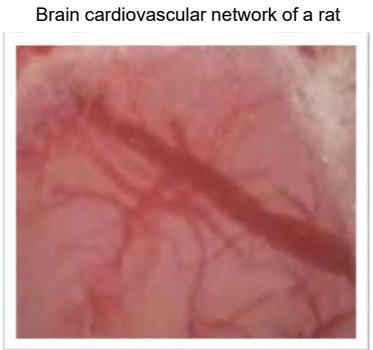


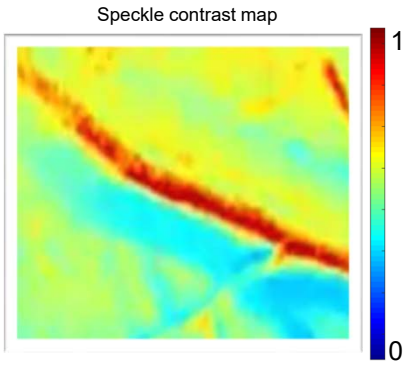
A well-known technique of imaging the microcirculatory perfusion is called laser speckle contrast imaging (LSCI) in which a part of the test subject to be imaged is shined by a uniform pattern of a laser light. The laser wavelength is preferably close to red due to the low absorption of such wavelength by the RBCs.

Since the laser light is coherent and the skin surface is rough with respect to this light wavelength, an interference pattern, namely, speckle pattern will be projected on the detector side which can be either a human eye, or a photo-detecting device such as a camera (see the left-hand-side figures). Owing the fact that the RBCs are randomly flowing within the capillaries, the photons penetrated through the dermis part of the skin will experience Doppler shifts with the maximum frequency shift deepening on the flow value. Therefore, what can be captured by a camera is a series of frames including dynamic speckles.

The camera exposure time can be adjusted in such a way that a blurred version of the dynamic speckles are captured. Then, the spatial contrast value of a speckle grayscale frame, defined as the standard deviation of the pixels within the frame divided by their mean value, represents the relative flow index.

In the right-hand-side figures, a network of blood vessels are shown where the relative blood flow of the vessel in the center is demonstrated in the contrast map achieved by LSCI technique in order to monitor the temporal variation of blood flow in the brain cardiovascular network of a rat.





A. Ponticorvo and Dunn, A. K., “How to build a Laser Speckle Contrast Imaging (LSCI) system to monitor blood flow.,” *Journal of visualized experiments : JoVE*, 2010.