Microcirculation Diagnosis with Synchronous Electrocardiography Capturing and Contrast Enhancing Illumination

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Serving as the point of substance exchange between the blood and the tissues, microcirculation plays a critical role in cardiovascular function [1]. To observe and characterize superficial capillaries, arterioles, and venules, we have customized a microscope for synchronous capturing of blood flow and electrocardiography (ECG) [2]. Note that hemoglobin (Hb), one of the main components in blood, absorbs strongly in the ultraviolet (UV) and visible light regimes. Illumination at 420 nm is chosen where the spectral absorption of Hb is not overwhelmed by melanin [3]. Optically clearing agent, such as glycerin, is also applied on skin to better match the index of refraction and to lower the scattering and diffusive reflection on skin due to keratin. In this way, we are able to visualize heart beats and measuring the minute timing differences in the cardiac cycles, which reflects physiological conditions [4].

Note that blood flow is driven by cardiac output, therefore the integration of ECG with the video capturing of microcirculation allows further extraction of physiological signals related to cardiac cycles. The blood volume in the microvascular tissues changes in response to the cardiac cycle. Higher blood volume indicates higher light absorption, i.e., lower recorded pixel values, as shown in Fig. 1.

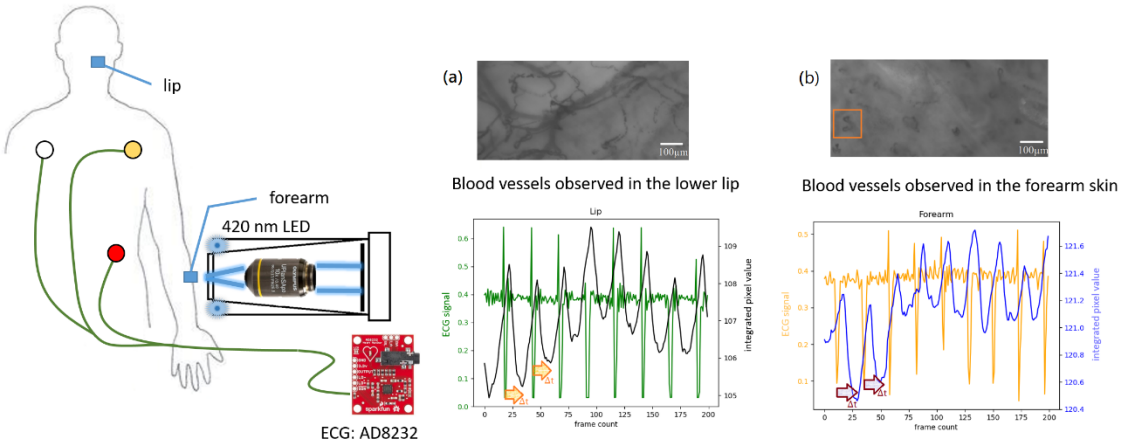

Fig 1. The schematic of micro-angiography. (a) and (b) show the angiography and the temporal evolutions of integrated pixel values in the lip and the forearm versus the ECG signal. The timing differences, Δt, between the integrated pixel values and the ECG indicate pulse wave velocity in the blood vessels, estimated to be 1,200 m/s.

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