MORPHO-FUNCTIONAL *IN VIVO* IMAGING OF BIOLOGICAL TISSUES BASED ON NIR TRANSILLUMINATION

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We present a NIR-VCSEL-based portable transillumination system for morpho-functional in vivo imaging of biological tissues. The setup has been successfully exploited for the analysis of human upper limbs and incubated chicken eggs.
Keywords: NIR-transillumination, *in vivo* morpho-functional-imaging

Transillumination is a non-invasive imaging technique based on the use of non-ionizing light sources to investigate the internal structure of biological tissues *in vivo*. It consists in illuminating the sample under test and then collecting the photons that have been transmitted or scattered to extract morpho-functional information [1,2].
The transillumination system we developed is a portable instrumental configuration based on the use of low-cost, narrow band Near-Infrared (NIR) light sources emitting at the wavelength of 850 nm (Fig. 1). The emission spectrum falls within the so-called diagnostic and therapeutic window (600-1200 nm), a range of wavelengths where water absorption is minimum and the penetration depth of the radiation achieves the highest value [3]. The illuminator consists of a 5cm×5cm-area-matrix of 36 VCSELs, each driven by a DC current of 11 mA to provide an optical power of approximately 5 mW over a bandwidth of 0.85 nm. The tissue is positioned upon the illuminator and images and videos are acquired with a CMOS camera, provided with two optical filters for efficient visible ambient light rejection and USB3.0-connected to a notebook for data acquisition using dedicated software (FlyCapture2, Point Grey Research Inc.). During the experiments, the tissues are not subjected to any kind of pressure or thermal stress.
The setup was first tested on human volunteers by acquiring pictures of their upper limbs that allowed to visualize the dorsal vein pattern with good contrast and resolution, as shown in Fig. 2a that reports the raw hand picture of a white-skin male subject. Afterwards, video sequences were collected and elaborated. By calculating the evolution of the pixel grey level as a function of time and computing the Fast Fourier Transform (FFT) of this signal it was possible to extract the heart and respiratory rates corresponding to the peaks of the frequency spectrum (Fig. 2b). Since the setup is portable, it was exploited also for in-field measurements of fecundated and incubated chicken eggs. Even in this case, it was possible to obtain pictures showing the egg internal structure as well as videos proving embryo movements and to extract the heartbeat of the chick embryos, which were found in agreement with typical values reported in the literature [4].
In conclusion, in this work, we demonstrate the successful operation of our portable optoelectronic instrumental setup for efficient NIR transillumination of *in vivo* biological tissues. Achieved results about the detection of morphological details and vital signs of several human subjects and chick embryos in a completely safe and non-invasive manner are reported.

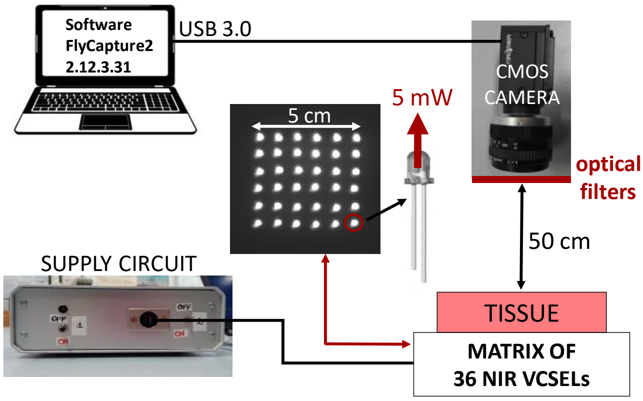

Fig. 1 Instrumental configuration of the portable setup for near-infrared transillumination.

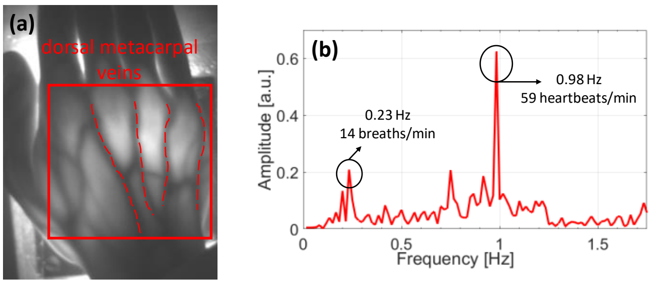

Fig. 2 Raw picture of a human upper limb (a). Frequency domain signal extracted from the video sequence (b).

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