Optical, Non-Invasive Diagnostic Imaging Methods

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Introduction. In the digital era, the gadgets for medical diagnostics are developing rapidly. This study demonstrates two simple, optical, non-invasive device prototypes for medical diagnostic imaging that have been designed in the Institute of Atomic Physics and Spectroscopy, University of Latvia.

Aim, Materials and Methods. The aim of the study was to demonstrate non-invasive diagnostic methods that are based on optical methods to show the application in diagnostic medicine and to create portable, easy-to-use and affordable devices for specialists such as anaesthesiologists, dermatologists and primary care doctors.

The two main methods described are: remote photoplethysmography (rPPG) for regional anaesthesiology (RA) and diffuse reflectance (DR) with autofluorescence (AF) in onco-dermatology for skin cancer screening. The basic concept of rPPG is to illuminate the tissue with a light source and to measure the back-scattered light with a video camera. Light pulsations induced by blood volume changes in tissue become visible after processing the video, in this way human vital signs can be monitored remotely. The setup consists of 3D-printed holder, compact industrial camera equipped with low-distortion lens and optical band-pass filter (half-bandwidth 520–580 nm). Skin illuminating was done by warm-white-light surgical lamp. The camera was connected to a laptop computer. This procedure was done before a palm surgery when anaesthesiologist administers the RA. The rPPG allows to tell the moment when the drug has become effective.

The methods for skin malformation diagnostics are DR with introducing AF at 405 nm. The cylindrical prototype consists of a camera, LEDs arranged in a ring and a computer for data processing. The light source LEDs installed are at wavelengths: 525 nm, 630 nm and 940 nm, plus a set of 405 nm LEDs to induce AF. This method allows the dermatologist to perform skin screening, evaluating possible malignancy and distinguish malformations, like, basal cell carcinoma, melanoma and to distinguish benign seborrheic keratosis.

Results. The rPPG device was tested at the Hospital of Traumatology and Orthopaedics in Riga, Latvia. The results show increase of perfusion during all RA manipulations. The perfusion response slightly differs across patients. The ability of non-contact monitoring of skin microcirculation is essential in OR and allows anaesthesiologist to quantitatively and visually evaluate the moment when the anaesthetic drug has become effective. The skin screening device was tested at the Oncology Centre of Latvia. The results show that it is possible to distinguish certain skin malformations: in the acquired AF images of basal cell carcinomas (BCC) visually it is not possible to distinguish them from the nevi groups, but imaging analysis show that AF intensity from the pathology is always lower in comparison with the surrounding healthy skin. Also, the AF spatial distributions for seborrheic keratosis show similar features – most of the pathology area emitted more intensive AF signal compared to other pathology groups.

Conclusions. Both of the optical devices were successfully tested in a clinical environment.

The demonstrated rPPG algorithm can be used for automated perfusion calculation in palm angiosomes affected by RA in real-time. It is planned to build a wireless device and automate the algorithms.

Also, the proposed approach of skin AF imaging further might be implemented as a routine method for increasing the diagnostic accuracy of suspicious lesions that is crucial in skin cancer screening, as well as for full body examination for timely tumour detection.

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