STSM REPORT

STSM Application number: COST-STSM-BM1205-16455

STSM Grantee: Aleksandra Zienkiewicz

STSM title: Optoelectronic methods of human tissue measurement

Home Institution: Gdansk University of Technology

Host Institution: University of Oulu

STSM period: 01.02.2014 – 31.03.2014

STSM purpose: Elaboration of human tissue measurement method based on Near-Infrared Spectroscopy.

Description of the work carried out during the STSM:

There is a strong need to develop safe and non-invasive method, which will support the process of skin cancer diagnosis. Preliminary research has shown that healthy skin has different metabolism than skin affected by cancer. The concentration of some particular substances would then also be different. On the other hand, the spectrum of the light reflected from the tissue depends both on wavelength and concentrations of various substances in the tissue. It can be assumed that if there will be substances with known absorbance peaks, as a result there should be different spectra from measurement on healthy and unhealthy skin.

Oxy- and deoxygenated hemoglobin were chosen as reference absorbants, since they have different absorption spectra in the near-infrared range. Determination of the tissue oxygenation using NIRS is a popular method in brain studies, so it was assumed that depending on the chromophores NIRS would be a reliable solution. The calculation procedure which has to be performed to set the concentration of HbO and Hb is widely described in the works of Boas [1] and Cope [2]. The general idea is based on a Modified Beer-Lambert Law, and it consists in the fact that the absorption of the tested sample is proportional to the concentration of the absorber, its extinction coefficient and the path length of light travelling through.

$$\Delta OD = -\log\frac{I_{final}}{I_{initial}} = \varepsilon CLB, \quad \text{where}$$

ΔOD is the change in optical density ($\Delta OD = OD_{final} - OD_{initial}$), I_{final} and $I_{initial}$ are the intensities measured before and after a concentration change, C is the concentration of the absorbing substance, L is the distance between the light source and detector, B is a differential path length factor and ε is extinction coefficient.

In the examined case, the absorber is hemoglobin. To distinguish oxygenated and deoxygenated chromophores, the light reflected from tissue should be measured at least at 2 different wavelengths, located on both sides of the isobestic point of the absorption spectra of HbO and Hb (c.a. 805 nm).

The proposed method is based on NIRS device, developed in the Optoelectronics and Measurement Techniques Laboratory at the University of Oulu. It consists of a set of lights emitting diodes (LEDs), which are generating light on several separate wavelengths. All of the wavelengths are combined using the frequency modulation (FM) and guided simultaneously through the optic fibre. The basic idea of the measurement is to move the fibre probe step by step on the skin surface and illuminate the tissue. Several detectors are placed in the fixed distances of a light source to detect the intensity of back-scattered light on different depths of the tissue. The intensity changes of the different wavelengths are used for analyzing the concentrations changes in the tissue. Changes in absorbance may show differences when measuring area of healthy skin and skin containing tumor. This however, requires reference measurements for known skin cancer areas in order estimate if the method will be useful for the skin cancer detection purpose.

Description of the main results obtained:

Elaborated method was used in the preliminary measurements performed on the healthy skin. The light was emitted with wavelengths 830nm, 660nm and 905nm. Signals obtained from the first two wavelengths were used to calculate the values of Hb and HbO. The concentration levels calculated in different places of healthy skin surface gave stable frequency spectra, which are shown on Figure 1.

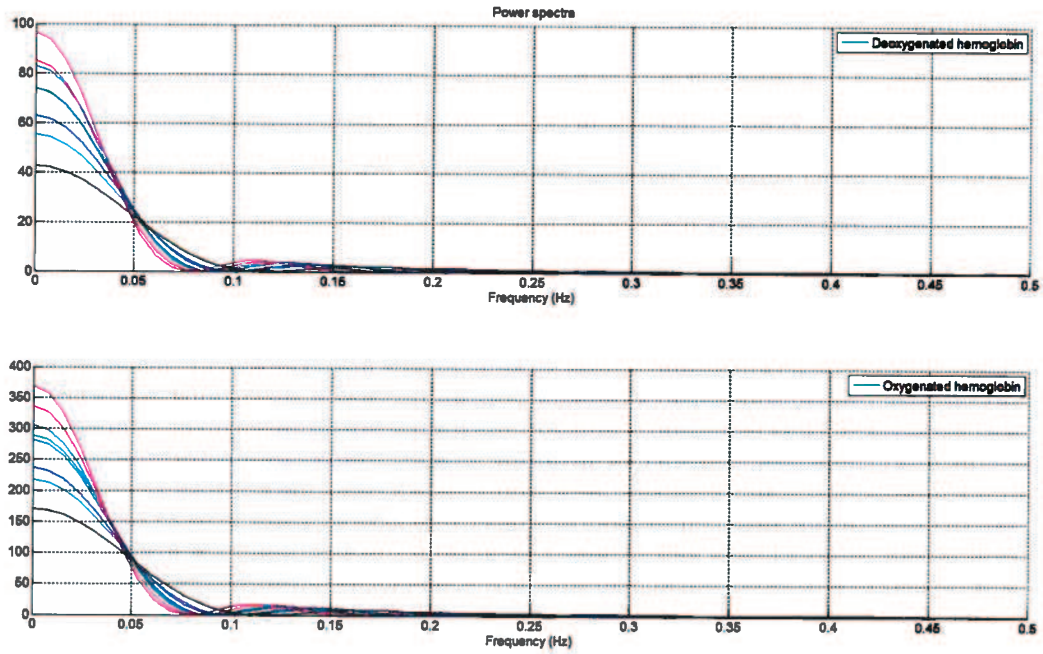

Figure 1 Power spectra of deoxygenated and oxygenated hemoglobin. On each graph signals measured in different spots of the skin surface are plotted.

It was important to exclude the probability, that the method will give various results depending on the probe placement on healthy skin. Obtained results give a strong hope, that the elaborated method will provide reliable reference spectra, which could be then compared with the measurements performed on the skin affected by cancer.

References:

[1] Boas, David A., et al. "The accuracy of near infrared spectroscopy and imaging during focal changes in cerebral hemodynamics." *Neuroimage* 13.1 (2001): 76-90;

[2] Cope, Mark. "The application of near infrared spectroscopy to non-invasive monitoring of cerebral oxygenation in the newborn infant." *Department of Medical Physics and Bioengineering* (1991): 342;

Mutual benefits for the Home and Host institutions: The Optoelectronics and Measurement Techniques Laboratory at the University of Oulu and the Department of Metrology and Optoelectronics at the Gdansk University of Technology both have strong research groups interested in development of biomedical solutions. The continuous collaboration between the researchers gives the opportunity of sharing specialized equipment and exchange of the knowledge.

It also provides an invaluable chance for young researchers to improve skills and gain the experience while working with in the international team.

Future collaboration with the Host institution (if applicable): The next step will be utilizing NIRS for further cancer studies. Since in Oulu there is a strong cooperation between university and hospital, the efforts will be made in order to start measurements on patients with skin cancer. The draft of the article with preliminary results was written- it has been attached to this report, since it consists of the expanded description of the measurement method. However, few parts of the article are missing, until the representative group of results from both healthy and unhealthy skin would be obtained. Also the spectra of the non-cancerous lesions should be examined.

Moreover, the use of LEDs in the NIRS device enables a possibility to easily change combination of LEDs, so it can be easily used if in the future studies there would be a need to detect the concentration of the different substances.

Foreseen journal publications or conference presentations expected to result from the STSM (if applicable): Preliminary draft of the publication was written, and it is planned to be published when the measurement of skin with cancerous changes will be made.

Confirmation

Herewith I would like to confirm the completion of the STSM within the Optoelectronic methods of human tissue measurement project applied by Aleksandra Zienkiewicz.

She has worked on this project at the Laboratory of Optoelectronics and Measurement Techniques from 1st February to 31th of March 2014 and fulfilled the objectives of the STSM work plan. During that time he investigated human tissues properties, took measurements of skin and completed processing of the results.

The purpose of the measurements was to elaborate the human tissue measurement method based on Near-Infrared Spectroscopy.

Matti Kinnunen

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(Matti Kinnunen,
Head of the Laboratory of Optoelectronics
and Measurement Techniques, University of Oulu)