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Towards non-invasive fetal blood oxygen level acquisition: ECG-triggered separation of superimposed PPG

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Introduction

Measuring fetal blood oxygen levels with non-invasive pulse oximetry is expected to provide useful information about the status of a fetus. The main challenge of non-invasive transabdominal fetal pulse oximetry is to extract the weak fetal PPG (photoplethysmogram) from a superimposed PPG containing information about expectant mother and fetus. We present two basic experimental setups and triggered averaging methods useful for non-invasive fetal PPG acquisition.

Methods

The first setup uses opto-electronical averaging, i. e. averaging photodiode signals, of finger-PPG of two persons in combination with ECG recording. For the second experimental approach forefingers of two persons are placed on top of each other, such that LED light (λ_{peak} = 700 nm) passes through the lower finger (mother) and reaches the upper finger (fetus), the scattered and reflected light finally reaches photodiodes besides the LED. Due to the different heart rates of mother and fetus and the correlation between ECG and PPG, QRS events can be used to extract the fetal from the superimposed PPG: QRS-triggered averaging of suitably chosen PPG-segments. In the case when no fetus but mother ECG is available, the mother PPG is estimated and subtracted from the superimposed PPG to obtain fetus PPG. If the obtained signal is not clean enough, the process is iterated. Superimposed PPG, reference PPG and ECG of 5 volunteers were recorded with Biopac's MP36R and stored for analysis.

Results

First Results show that the principles of the developed experimental setups and signal separation methods work: successful separation of superimposed PPG. The comparison of reference and separated PPG showed that also for the respective second approaches the correlation between true and estimated "fetal" PPG can be 0.95.

Conclusion

The introduced approaches are expected to be useful for the development of devices for non-invasive fetal blood oxygen level acquisition.

Automatic detection of pediatric craniofacial deformities using Convolutional Neural Networks

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Introduction

The geometric shape of our skull is very important, not only from an esthetic perspective, but also from medical viewpoint. However, the lack of designated medical experts and wrong positioning is leading to an increasing number of abnormal head shapes in newborn and infants. To make screening and therapy monitoring for these abnormal shapes easier, we are developing a mobile application to automatically detect and quantify those shapes.

Methods

By making use of modern machine learning technologies like deep learning and transfer learning, we have developed a convolutional neural network for semantic segmentation of bird's-eye view images of child heads.

Results

Using this approach, we have been able to achieve a segmentation accuracy of approximately 99 %, while having sensitivity and specificity of above 98 %..

Conclusion

Given these promising results, we will use this basis to calculate medical parameters to quantify the skull shape. In addition, we will integrate the proposed model into a mobile application for further validation and usage in a real-world scenario.

Use of Electrical Impedance Spectroscopy to Distinguish Cancer from Normal Tissues with a Four Electrode Terminal Setup

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Introduction

Cancer and normal tissues are visually different, especially so in advanced cancer stages. Important, they are not only visually contrasting, but if an electric field is applied to both tissue types and the frequency is varied in a wide range, it will be seen that in general they have a spectral response divergent from each other. In this work, Electrical Impedance Spectroscopy (EIS) is applied to distinguish cancer from normal tissues by means of their impedance spectrum using a four-electrode-terminal setup (4T). The 4T setup is important to circumvent the effects of electrode polarization at low frequencies.

Methods

The severe combined immunodeficient (SCID) mouse was purchased from Charles River. The autosomal recessive scid mutation leads to the absence of functional B and T lymphocytes, therefore the human tumour cells can be xenografted onto mice of this strain. A total of 1 million human colon carcinoma cells HT29 were subcutaneously injected into the animal close to the right scapula. The animal was monitored concerning the tumor growth and when the tumor reached 1 cm^3 mouse was sacrificed, tumor and organs extracted and their impedance measured ex-vivo shortly after its death. Organs and tumor were kept in phosphate buffer saline (PBS) until the measurement. For the measurements, they were removed from PBS and fixed in a petri dish. An array of four needle electrodes was used to provide a four-terminal stimulation. The potentiostat Gamry Interface 1000™ was used to measure the impedance. A 14 mV amplitude voltage signal was applied and the frequency varied from 1 MHz up to 100 mHz. All results were processed and plotted in MATLAB.

Results

The impedance of the normal organs and the tumor were measured one by one in both longitudinal and transversal directions. Results were plotted together and compared. The tumour showed the lowest impedance, or equivalent the highest conductivity among all compared organs.

Conclusion

The results of this experiment showed that the distinction between tumor and normal tissues may be possible by means of Electrical Impedance Spectroscopy. In a previous experiment, we obtained similar results using a two-electrode-terminal setup and three other mice, one healthy and two implanted with UT-SCC-5 cell line (tongue squamous cell carcinoma) and UM-SCC-10A (laryngeal squamous cell carcinoma). In that case the two tumours also showed the lowest impedance among all compared organs. In a large set of experiments recently performed where we measured the same tumor type (human prostate cancer PC-3 cells) in five different mice, we observed the same tendency of the tumours to have either the smallest impedance or to be amongst the smallest together with mouse thigh muscle legs (own unpublished results). This bring us to expect that there is a tendency of tumours to have smaller impedance than healthy organs due to their internal composition: high water and salt content, loose connection between adjacent cancer cells, amongst other factors.

Introducing a Linear Gamma Variate Fit to Measure Pulmonary Perfusion with Electrical Impedance Tomography

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Introduction

A method to measure pulmonary perfusion with Electrical Impedance Tomography is the Indicator Dilution Method. The observed signal can be modeled as a gamma variate function, superimposed by other signal components that have to be eliminated to calculate perfusion parameters. Therefore, the gamma variate's parameters can be determined using a non-linear least squares (NLS) or using a linear least squares (LLS) approach we propose here. We compare both approaches on data of a procine study.

Methods

For both approaches, we described the gamma variate with $\gamma(t') = c_{max}t'^{\alpha}e^{\alpha(1-t')}$, $t' = (t-t_A)/(t_{max}-t_A)$. Applying the logarithm yields a function where α and c_{max} can be determined by LLS, when t_A and t_{max} are derived from the signal. For the nonlinear approach, a trust region reflective optimization implemented in Matlab® was used.
We compared both approaches calculating the root mean squared error (RMSE) and the correlation between the approximated and the original signals. We also counted the number of failed fits.

Results

For both approaches, correlation is approximately 0.97. The linear fit shows a lower number of failed fits but a larger variance in RMSE and correlation values. When reducing the NaCl concentration of the injected bolus, correlation stays unchanged for both methods. The number of failed fits increases stronger for the nonlinear fit.

Conclusion

The linear fit is more robust due to the lower number of failed fits. The slightly higher variance in RMSE and correlation values is not a problem to separate the signal components well.