生醫光聲原理

Computer Homework #3: Photoacoustic Depth Profiling and SO_2 Measurement
Due 24:00, 12/12/2017

Part 1. Depth profiling

1. Assume the impulse response of the acoustic transducer is a delta function, i.e., having infinite bandwidth. By using numerical experiments, repeat Fig. 1 in the following reference paper.
2. Add 5% Gaussian random noise to the simulated photoacoustic signal in 1 (Fig. 1(a)). With this noise-added photoacoustic signal, repeat Fig. 2 in the reference paper. (5%: the ratio of standard deviation of the noise to the peak of the simulated photoacoustic signal)
3. Estimate the absorption coefficient of the simulated layered absorber by curve fitting Fig. 2.
4. Show the peak value of the simulated noisy photoacoustic signal as a function of absorption coefficient of the simulated layered absorber, with the range of absorption coefficient from 10 cm^{-1} to 180 cm^{-1} with a step size of 10 cm^{-1}. Assume that the incident laser radiant exposure is the same for all cases. Is the peak value proportional to the absorption coefficient? Justify your findings.
5. Show the estimated absorption coefficient with curve fitting as a function of the real absorption coefficient. Assume that the incident laser radiant exposure is the same for all cases. Is the estimated absorption coefficient proportional to the absorption coefficient? Justify your findings.
6. Repeat 4 and 5, but consider the impulse response of the acoustic transducer. Assume the impulse responses of the transducer used are Gaussian pulse centered at 5 MHz, 10 MHz, 25 MHz, and 50 MHz, respectively, with -6 dB fractional bandwidth of 60%. Justify your findings about how the impulse response of the transducer affects the results.

Reference:

J. A. Viator, S. L. Jacques, and S. A. Prahl, “Depth profiling of absorbing soft materials using photoacoustic methods,” IEEE Journal of Selected Topics in Quantum Electronics, vol. 5, pp. 989-996, 1999.

Part 2. SO_2 measurement

By replacing the simulated sample in Part 1 by blood and incorporating multi-wavelength excitation, the experimental setup used in Part 1 can be potentially

used as an oximeter for SO_2 measurement. Assume that the system is free of noise, and there are 5 blood samples waiting for the test. The 5 blood samples are with SO_2 of 20%, 40%, 60%, 80%, and 100%, respectively.

1. Based on the simulation in Part 1 and with the excitation of light with wavelengths of 578, 584, 590, and 596 nm, estimate the SO_2 level by the peak values of the detected photoacoustic signals. Show the estimated SO_2 level as a function of its real SO_2 level. Take the impulse response of the acoustic transducer into account. The impulse responses of the transducer used are Gaussian pulse centered at 5 MHz and 50 MHz, respectively, with -6 dB fractional bandwidth of 60%. Is the peak value of the detected photoacoustic signal suitable for SO_2 estimation? Justify your findings.
2. Repeat 1 but with the excitation wavelengths being changed to 760, 780, 800, 820 nm.

References:

1. You may find how to calculate the absorption coefficient of the blood with different oxygenation level at http://omlc.ogi.edu/spectra/hemoglobin/index.html
2. H. F. Zhang, K. Maslov, M. Sivaramakrishnan, G. Stoica, and L. V. Wang, "Imaging of hemoglobin oxygen saturation variations in single vessels *in vivo* using photoacoustic microscopy," Applied Physics Letters **90**, 053971, 2007.
3. M.-L. Li, J. T. Oh, X. Xie, G. Ku, W. Wang, S. Ke, C. Li, S. Similache, G. F. Lungu, G. Stoica, and L. V. Wang, "Simultaneous molecular and hypoxia imaging of brain tumors *in vivo* using spectroscopic photoacoustic tomography," *Proceedings of the IEEE*, vol. 96, pp. 481-489, 2008.

Notice:

1. Name your solution word file as "EE6265_HW3_StudentID.doc" and your Matlab codes as "EE6265_HW3_StudentID.m", and archive all the files into a zip or rar file.
2. Please upload your zip/rar file to the LMS elearning system
3. The first line of your word or Matlab file should include your name and some brief description, e.g., % EE 6265 王小明 u9512345 HW3 12/12/2017
4. Don't just show me the results. Please justify the results you've obtained.