RESOLUTION ENHANCEMENT IN OPTICL COHERENCE TOMOGRAPHY

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INTRODUCTION: OCT performs high-resolution, cross-sectional tomographic imaging of the internal structure in materials and biological systems by measuring the coherent part of the reflected light. The physical depth resolution in OCT depends on the coherence length of the light source and lies around 10-15µm. The new parametric super-resolution method described in this paper does not depend on the coherence length of the light source, but rather on the noise level of the measurement.

The key idea is to describe the OCT measure of a multi layer sample by a parametric model containing the location of the layer and its amplitude. We then find these parameters by minimizing the distance between the model and measure.

METHOD: One can express the OCT signal as the convolution of the coherence function *ρ(x)* with the impulse response *h(x)* of the sample. Assuming a model with superficial layers of single scattering tissue and negligible absorption the impulse response *h(x)* of the sample is simply a sum of shifted Dirac distributions $\delta(x-b_k)$. If there exist K layers in the sample, then the OCT signal takes the form

$$I(\mathbf{p},x)=\sum_{k=1}^{K} a_k\,\rho(x-b_k) \qquad (1)$$

where a_k and b_k represents the reflectivity and the position of the corresponding layer in the sample, respectively and where $\mathbf{p}=[a_1,b_1,\ a_2,b_2\ldots a_K,\ b_K]$.

Our super- resolution method boils down to estimating the parameters a_k and b_k of each layer. Given the data $I_d(x)$ and model $I(\mathbf{p},x)$ we build the error function

$$f(\mathbf{p})=\sum_{i=1}^{N}\left(I(\mathbf{p},x_i)-I_d(x_i)\right)^2 \qquad (2)$$

which expresses the distance between the model and measures.

Starting with a global search method to get a good initial estimate $\mathbf{p}_0$, we then iteratively perform a Marquardt-Levenberg descent method:

$$\nabla^2 f(\mathbf{p})\left(\mathbf{p}^{i+1}-\mathbf{p}^{i}\right)=-2J(\mathbf{p})^T F(\mathbf{p}) \qquad (3)$$

in order to converge towards the parameter $\mathbf{p}\infty$ which minimizes the error function (2).

RESULTS

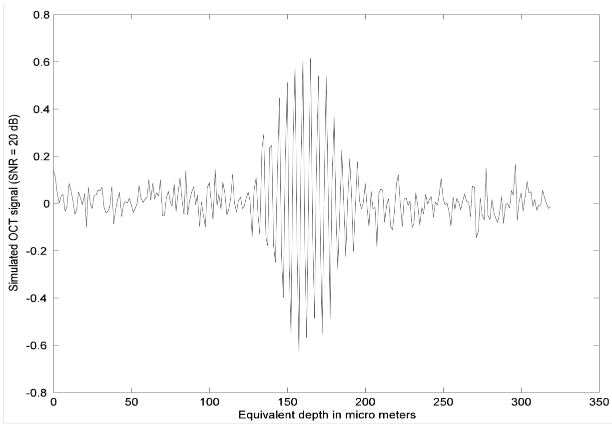

Fig. 1: Example of a simulated OCT signal with a Gaussian coherence function of temporal coherence length 20µm and corresponding to two layers separated by 2µm and with SNR=20dB.

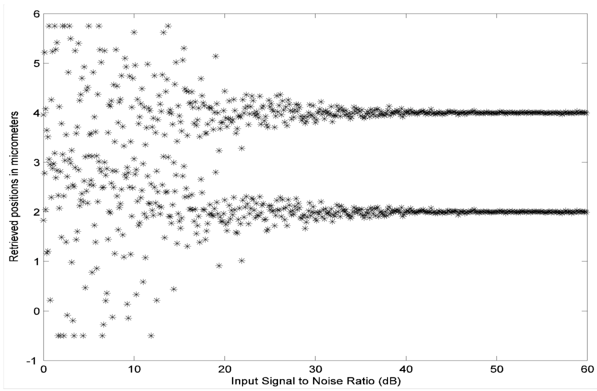

Fig. 2: Retrieved positions of the interfaces as a function of the input noise: for SNR>20dB, the two layers can be separated.

DISCUSSION & CONCLUSIONS: A parametric model for the processing of OCT signal has been described. The simulation results show that depending on the SNR we can retrieve layers, which are separated by a fraction of the coherence length. This shows that the resolution does not depend on the coherence length of the source but on the noise level.

REFERENCES: [1] T. Blu, H. Bay, M. Unser (2002) *Proceedings of the First 2002 IEEE International Symposium on Biomedical Imaging: Macro to Nano (ISBI'02)* **3**:777-780.

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