OSEM reconstruction algorithm for fluorescence molecular tomography: a preliminary study

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Purpose

Due to the great advances in the development of smart fluorescence probes and fluorescence proteins, that operate in the visible and near infrared range of the electromagnetic spectrum, Fluorescence Molecular Tomography (FMT) is becoming a very important tool for biomedical research in small animals, since it retrieves non invasively and in vivo the spatial distribution of fluorophores deep in tissues. Fig 1.

The FMT reconstruction process involves two steps, the so called forward problem, that implies modelling the photon transport through tissues, and the inverse problem, that implies solving a system of linear equations. Solving the forward problem generates the system response matrix, whose elements are the coefficients of the system of equations to be solved in the inverse problem. The unknowns of this equations are precisely the fluorophore concentrations at each voxel of the volume of the digitalized sample.

In our lab we have design and developed a novel FMT CCD camera based system that works in non-contact geometry. The nature of this kind of experimental set-ups allows the retrieval of large data sets, as compared to those produced by previous fiber-based contact experimental set ups. The minimum matrix size that describes our system has about 10 million elements. Just to calculate this matrix, i.e solve the forward problem, is very computationally demanding, therefore a computationally efficient algorithm for solving the inverse problem would be desirable. Due to the large size of the datasets that can be generated, OSEM algorithms seem good candidates for this kind of problems, as the data set can be easily divided into different data subsets.

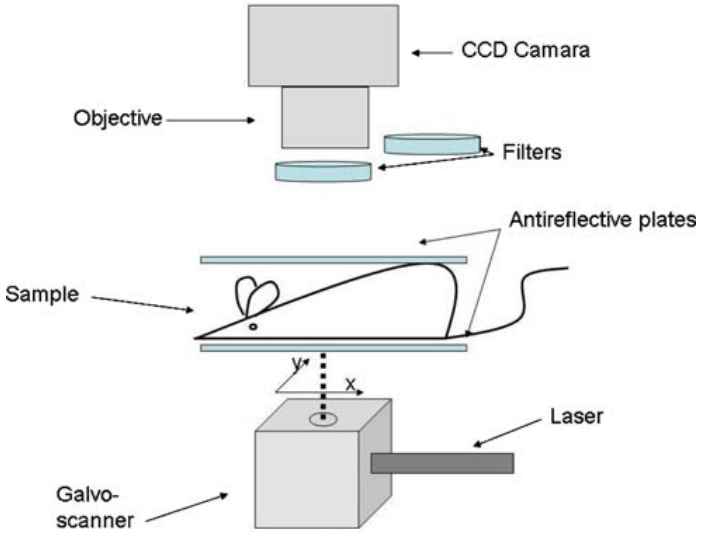

Fig. 1 Schematic drawing of the experimental set-up

Materials and methods

Experimental set-up and forward problem: In our setting, the mice can be illuminated at the desired points over its surface by guiding a laser beam in the constant wave regime with two mirrors moved by galvanometers. For each point, the transmitted laser light, and the light emitted by the fluorophore are captured with a CCD camera placing the appropriate filters. All the process is software controlled.

The mouse is located prone to the CCD detector, slightly compressed between two antireflective plates, achieving a planar-like geometry, without any matching fluids that would decrease the signal to noise ratio unnecessarily. Since the plates are parallel to the CCD detector, the free space contributions for every pixel are equivalent. Additionally, under this geometry light propagation is modelled by the analytical solution of the photon diffusion equation, given by the source image method for planar boundaries.

-Phantoms: To simulate the high scattering and absorption that governs the photon propagation in biological media we used slab-like optical phantoms made of agar with Ti02 to simulate the scattering and a specific type of India Ink to simulate the absorption without inducing autofluoresence.

Preliminary results

Our initial results on slab-like phantoms with different number of capillars filled with a near-infrared fluorophore placed at different positions, yielded to times of 200 seconds for solving the inverse problem in a computer with an Intel processor operating at 2,40 GHz and 2 GB RAM using 100 iterations, ensuring that the Log-likelihood curve was already plane. On the other hand, the same reconstructions were compared to conventional ART methods. Visual inspection show similar results for both algorithms in terms of image quality whereas. Further work will consist on comparing in detail both inversion algorithms in terms of computing time, and image quality.