# Abstract of Doctoral Dissertation

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Title of Doctoral Dissertation

Fluorescence diffuse optical tomography using time-domain peak time asymptotic analysis
（時間領域ピーク時間の漸近解析による蛍光光拡散トモグラフィー）


This thesis concerns an inverse problem for time-domain fluorescence diffuse optical tomography (FDOT) reconstructing multiple point targets from the boundary measured data. The targets are fluorophores. The FDOT process is modeled by two diffusion equations coupled with the source term in a half-space domain (DE model). Our measured data are the time-domain data (temporal response function), measured at some detector points as the temporal response of the fluorescence intensity to an instantaneous injection of the excitation light from a source point. For a fixed pair of detector and source points (S-D pair), the time-domain data has a unique time when the fluorescence intensity reaches its maximum. We call this time the peak time of time-domain data. Physically, the peak time has three unique advantages: (i) it is unique, (ii) it is the least noisy data point in time-domain data, (iii) it can reflect the optical path length distribution. Considering these advantages, the ill-posedness of the inverse problem and large-scale computation costs, we give a precise mathematical analysis and propose an efficient reconstruction algorithm as follows.

We start with studying the asymptotic formulae of the solution to the DE model and its derivative in the case of a single point target. Based on this, we introduce an approximate peak time satisfying a polynomial function, which agrees very well with the peak time obtained by the numerical calculation using typical optical parameters. Then, using approximate peak time and combining it with the bisection method, we propose a mathematically rigorous bisection reconstruction algorithm to reconstruct the target. For multiple point targets, we show the asymptotic formulae of the corresponding solution and its derivative. By choosing a localized S-D pair, we derive a localized asymptotic analysis on a specific target and define its approximate peak time. A localized reconstruction algorithm is proposed under the assumption of well-separateness to the targets. Finally, we consider the target with a small volume and extend the bisection reconstruction algorithm to reconstruct its approximate location.

The novelty of this thesis is that we apply asymptotic analysis to derive reconstruction formulae containing the physical properties of the data. Several numerical experiments show that our proposed algorithms are efficient, robust and accurate even for deeply embedded targets.