Determination of Optical Parameters in Biological Tissues and Application to Medical Imaging

A Dissertation

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by

Cheng Chen

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Abstract

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Quantitative characterization of biological tissues through determination of optical parameters has attracted intensive research efforts due to its fundamental importance and potential applications in medicine. Defined by the radiative transfer theory, these optical parameters and their spectra can provide optical markers for early detection of lesions such as skin cancers. The goal of this dissertation research is to develop a reflectance imaging method to inversely determine the optical and geometric parameters of skin tissues through phantom study. The dissertation research consists of three major parts: an experimental system to acquire diffuse reflectance images in a wide spectral range; mathematical models to simulate/calculate light-tissue interaction; inverse determination of optical parameters.

To achieve the above goal, we have constructed a reflectance imaging system and developed a voxel-based Monte Carlo model to simulate light transportation in heterogeneous media. Various techniques have been investigated, including a diffusion model, to increase the simulation speed. Optical parameters of two types of homogeneous phantoms made in our laboratory were inversely determined based on both

Monte Carlo and diffusion models with full-field illumination in a spectral window from 500nm to 950nm for validation of the imaging method. In these cases, we proved the uniqueness of the inverse solution of the optical parameters within the investigated ranges of these parameters. Furthermore, the determination of thickness of an embedded region in heterogeneous tissue phantoms was investigated using the reflectance imaging method. As a preliminary study, multispectral reflectance images of eight patients with pigmented lesions in skin have been processed to extract optical parameters of the pigmented lesion region to demonstrate the feasibility of our reflectance imaging method. The reflectance imaging method developed in this dissertation provides a new approach to determine the optical parameters of turbid media and biological tissues under full-field illumination condition. When combined with multispectral measurement and multivariate analysis, the reflectance imaging method has significant potentials on *in vivo* diagnosis of skin cancers and non-invasive detection due to its capacity for quantitative analysis.

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APPROVED BY:

ADVISOR OF DISSERTATION: ______________________________

XIN-HUA HU, PH.D.
DEPARTMENT OF PHYSICS

COMMITTEE MEMBER: ______________________________

JOHN KENNY, PH.D.
DEPARTMENT OF PHYSICS

COMMITTEE MEMBER: ______________________________

MARTIN BIER, PH.D.
DEPARTMENT OF PHYSICS

COMMITTEE MEMBER: ______________________________

DAVID W. PRAVICA, PH.D.
DEPARTMENT OF MATHEMATICS

COMMITTEE MEMBER: ______________________________

HENG HONG, M.D., PH.D.
DEPARTMENT OF PATHOLOGY

DEAN OF THE GRADUATE SCHOOL: ______________________________

PATRICK J. PELLICANE, PH.D.

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