Tu-Pos600

MONTE-CARLO (MC) MODELING OF PHOTON TRANSPORT IN TISSUE (PTT) II. EFFECTS OF ABSORPTION ON 3-D DISTRIBUTION (3DD) OF PHOTON PATHS. Barbour, R.L., Graber, H., Lubowsky, J., and Aronson, R*. (Intro. by Brust, M.) SUNY at Brooklyn, and *Polytechnic Univ., Brooklyn, NY.

The attenuation of light by natural chromophores in tissue is one of the factors which determine the 3DD of the paths of emerging scattered photons (SP). In this study the effect of homogeneous absorption (HA) has on the intensity, **I**, avg. no. of collisions, **<n>**, avg. max. depth of penetration, **<Z>**, and on the 3DD of SP entering into selective detectors (D), was modeled by a MC method for photons experiencing isotropic scattering in a homogeneous medium. The efficiency of the MC simulation was maximized by considering the propagation of photon ensembles and employing techniques of correlated sampling, renormalization and Russian Roulette. Results obtained showed that an increase in HA produces an abrupt reduction in <Z> and <n> and a change in the functions relating them to distance, **R**, from linear and quadratic to square-root and linear, respectively. In addition, the dependence of <Z> and <n>, and hence 3DD, on the orientation of the D revealed that they vary markedly with elevation angle when the D are oriented towards, but not away from, the source. This dependence and the existence of enantiomorphic symmetry (see abst. #I in this series) were present at all values of HA (0-10%). These results indicate that the ability to selectively probe the subsurface properties of a random medium are not diminished by the presence of HA but that the volume of medium contributing to the D response is reduced by an increase in HA.

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MONTE-CARLO (MC) MODELING OF PHOTON TRANSPORT IN TISSUE (PTT) III. CALCULATION OF FLUX THROUGH A COLLIMATED POINT DETECTOR (CPD) Barbour, R.L., Graber, H., Lubowsky, J., and Aronson, R*. (Intro. by Gaetjens, E.) SUNY at Brooklyn, and Polytechnic Univ., Brooklyn, NY.

In this series (see abst. I and II) we have shown that the orientation and extent of detector (D) collimation are factors which influence the ability to selectively probe the subsurface properties of a turbid medium. Estimating the response of real D with narrow apertures, however, cannot be accomplished by conventional MC methods. Here we have applied the radiation transport equation (RTE) to the problem of determining angular flux (AF) through a CPD. Using an efficient MC method (see abst II), the detection of emerging flux through a CPD was determined by considering each collision site as the penultimate collision and randomly sampling a point along the acceptance axis for each CPD; thereby forcing the photons to contribute to the angular flux of all CPD. The scoring of AF, avg. max. depth of penetration, <Z>, and avg. no. of collisions, <n>, of the backscattered light entering through each CPD are derived from the RTE. Results showed that at a fixed distance from the source, <Z> and <n> are up to 4-fold less for a CPD oriented toward the source than for one with the opposite azimuth; the difference being greatest at surface-grazing elevation angles. This difference, and the presence of enantiomorphic symmetry (see abst. I) were found at all values of homogeneous absorption modeled. These results show that it is feasible to model responses of highly collimated D by a MC method.

Tu-Pos602

MONTE-CARLO (MC) MODELING OF PHOTON TRANSPORT IN TISSUE (PTT) IV. CALCULATION OF 3-D SPATIAL CONTRIBUTION TO DETECTOR RESPONSE (DR). Barbour, R.L., Graber, H., Lubowsky, J., and Aronson, R*. (Intro. by Lange, C.) SUNY at Brooklyn, and Polytechnic Univ., Brooklyn, NY.

Inferences about the subsurface properties of a random medium (e.g. tissue) will require an estimation of the 3-D distribution (3DD) of the paths of photons which contribute to the reponse of selective detectors (SD). For elastic scattering, a 3-D map of these contributing photons can be determined for any source-detector configuration as the product of collision density and the probability that a photon having a collision at this point will contribute to the DR. The former is directly calculated by a MC simulation. By employing a reciprocity theorem which considers the time reversal of photon paths entering a SD, the latter is determined through reinterpretation of a second 3-D collision density map as the 3-D map of expected contributions. In the limit of weak absorption, this product, called a "weight function" (WF), quantifies the absolute reduction in DR caused by absorption (A) at a given point in space. We have examined the dependence of WF upon the orientation of SD. Results obtained showed that while the volumes of medium having the greatest contribution to DR varied strongly with detector orientation, that lying beneath the receiver was most sensitive to these changes. Because the WF relates the DR to properties of specific volume elements, it can be used as the basis of methods for producing 3-D images of random media (e.g. tissue) from optical measurements.

Tu-Pos603

MONTE-CARLO (MC) MODELING OF PHOTON TRANSPORT IN TISSUE (PTT) V. MODEL FOR 3-D OPTICAL IMAGING OF TISSUE. Barbour, R.L., Graber, H., Lubowsky, J., and Aronson, R*. (Intro. by Ostashevsky, J.) SUNY at Brooklyn, and *Dept. of Physics, Polytechnic Univ., Brooklyn, NY.

The essence of any imaging technique requires that the detected signal be related to the properties of a particular volume in space. For multiple scattering media (MSM) a large number of, in principle infinitely many, voxels contribute to the detector (D) response in a nonlinear fashion which varies with the source-detector configuration (SDC); i.e. position and orientation of the D relative to the source. We have shown (see abst. IV in this series) that the 3-D distribution of these contributions can be calculated for any SDC. In this study we have developed a 3-D image reconstruction algorithm which employs weight functions (WF) in an unfiltered backprojection scheme. The attenuation (A) of backscattered light from a MSM, due to multiple (8) subsurface absorbers buried deep in the medium, corresponding to each SDC was calculated by a MC simulation for multiple source positions. Image reconstruction was accomplished by summing the products of the WF in each voxel and their corresponding A for all SDC and source locations. The resultant image, though convoluted, correctly resolved the 3-D horizontal and vertical boundaries and internal divisions of the absorber array. This study directly demonstrates that the reconstruction of 3-D images of subsurface structures buried at depths not visible from the surface in a random medium (e.g. tissue) is feasible.