Different volume fraction of absorbing and scattering agents producing similar spectral reflectance in agarose-gel skin phantom

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1. Introduction

Spectral measurement of human skin has often been used to provide knowledge about skin conditions and sometimes physical condition mainly by analyzing spectral reflectance curve. Such analysis generates information about skin parameters, largely about absorption coefficient μ_a and scattering coefficient μ_s. Now, these μ_a and μ_s are used to evaluate pigments concentration (melanin and hemoglobin) and tissue morphological information. However, such an evaluation of μ_a and μ_s by reflectance spectra goes through unpredictability as some different values of μ_a and μ_s produce similar spectra. In this study, we investigate the phenomena of similar spectra from different μ_a and μ_s in 3-layered agarose-gel phantom and finally we confirm those divergent μ_a and μ_s values of phantoms by inverse Monte Carlo (IMC) method.

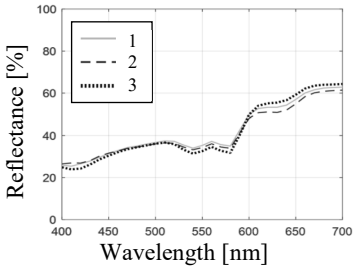

Fig. 1 Example of similar spectra.

2. Three-layered phantom and IMC

A three-layered agarose-gel phantom[1] was used to emulate the human-skin characteristics. Each of the three layers has specific thickness, they are: layer 1 (epidermis)-0.06cm, layer 2 (dermis)–0.68cm and layer 3 (subcutaneous)-0.45cm. As absorbing agents, coffee solution in layer 1, and horse blood with 44% hematocrit in layers 2 and 3 are used. For scattering agent, 20% intralipos solution in different volume fraction in layers 1, 2 and 3 is used. Also, agar solution is used as the binding agent in each layer. To find out the actual μ_a and μ_s values of the phantoms having different volume fraction of absorbing and scattering agents IMC was employed, in which layer-wise reflectance and transmittance were used as inputs and as output, it resulted in generating μ_a and μ_s values of each layers respectively.

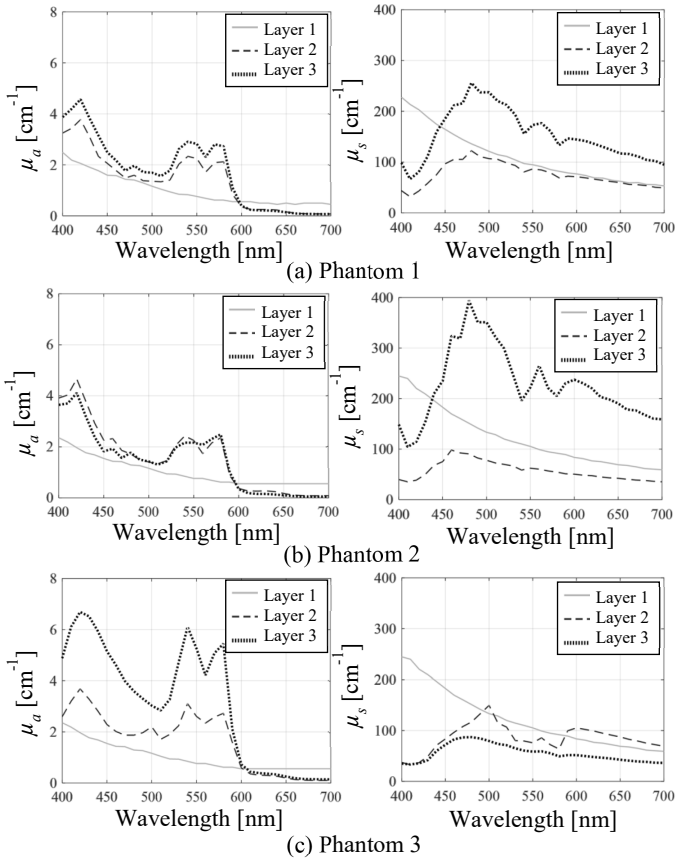

Fig. 2 Extracted μ_a and μ_s of phantoms obtained by IMC.

3. Results and discussions

Figure 1 demonstrates that three different phantoms having different volume fraction of absorbing and scattering agents produced similar spectra. Figure 2 shows the extracted μ_a and μ_s values layer-wise of those three different phantoms by IMC. It can be seen from the IMC results that there are variations in μ_a and μ_s values of the three phantoms used. Also, it was found in the extracted μ_a and μ_s values that small μ_a and μ_s values and large μ_a and μ_s values have produced similar spectra. Furthermore, various phantom experiments will be carried out to justify our observation.

5. References

1) I. Nishidate *et al*., “Estimation of melanin and hemoglobin in skin tissue using multiple regression analysis aided by Monte Carlo simulation”, Journal of Biomedical Optics. Vol.9(4). 2004. pp.700-710.