Disponible en ligne sur
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com

IRBM ••• (••••) •••–•••

IRBM

RITS 2017

Spectrophotometry and Photoacoustic Imaging: A Comparative Study

A. Dolet [a,c,*], F. Varray [a], E. Roméo [b], T. Dehoux [b], D. Vray [a]

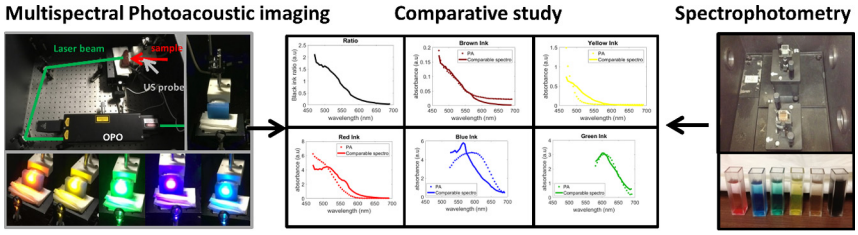
[a] *Univ. Lyon, INSA-Lyon, Université Claude Bernard Lyon 1, UJM-Saint Etienne, CNRS, Inserm, CREATIS UMR 5220, U1206, F-69621, Lyon, France*
[b] *Institut Lumière Matière – UMR CNRS 5306, Université Lyon 1, 69622 Villeurbanne, France*
[c] *Department of Information Engineering, University of Florence, Florence, Italy*

Received 14 March 2017; received in revised form 5 October 2017; accepted 6 October 2017

Highlights

- Spectrophotometry of six diluted inks.
- Multispectral photoacoustic imaging of agar phantoms coloured with the six inks.
- Similar multispectral evolutions obtained with both modalities.
- Spectrophotometry as reference to classify multispectral photoacoustic images.

Graphical abstract



Abstract

Photoacoustic imaging is a hybrid modality that is used to image biological tissues. Using multispectral optical excitation, a functional image is obtained due to the tissue specific optical absorption that depends on the wavelengths. To classify multispectral photoacoustic images, supervised methods are classically used. However, definition of the reference spectra is often difficult, and this choice can have a large impact on the classification results. A possible approach to build relevant reference spectra is to use spectrophotometry. This study aims at comparing absorbance measured by a spectrophotometer and multispectral photoacoustic signals of various coloured phantoms. We compare qualitatively the shape of the spectra obtained, using these two modalities for each sample. Our data suggest that spectrophotometry is a promising way to define reference spectra for classification of multispectral photoacoustic datasets.
© 2017 AGBM. Published by Elsevier Masson SAS. All rights reserved.

Keywords: Multispectral photoacoustic imaging; Spectrophotometry; Supervised classification method

1. Introduction

Photoacoustic imaging is a hybrid method that combines the advantages of acoustic and optical imaging [1]. This modality is based on the detection of acoustic waves that are produced by a medium under pulsed laser illuminations. The acoustic wave is created by the thermal expansion of the optical ab-

* Corresponding author at: CREATIS, Bat Blaise Pascal, 7 avenue Jean Capelle (ouest), 69100 Villeurbanne, France.
E-mail address: aneline.dolet@creatis.insa-lyon.fr (A. Dolet).

https://doi.org/10.1016/j.irbm.2017.10.003
1959-0318/© 2017 AGBM. Published by Elsevier Masson SAS. All rights reserved.

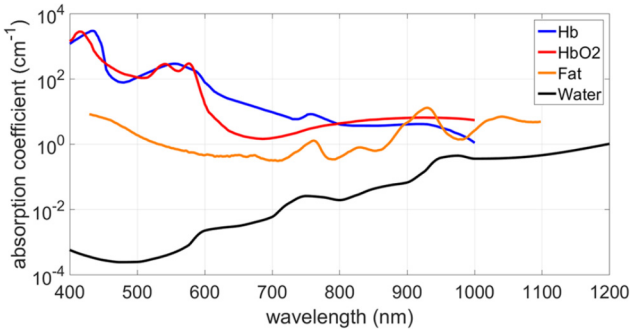


Fig. 1. Absorption coefficients of different media as a function of wavelength; adapted from [2,3].

sorbers, due to the local increase in temperature during the laser pulse. Each medium creates a specific acoustic wave [2, 3] that is related to its optical absorption at the wavelength used (Fig. 1). After propagation through the media to the surface, acoustic pressure waves can be detected using an ultrasound probe. A photoacoustic image of the region of interest can then be reconstructed.

The optical absorbance of tissue depends on the illumination wavelength, as does the photoacoustic signal. Scattering during acoustic propagation in tissues, which is also wavelength-dependent, has an impact also on the detection of the photoacoustic signals. Characterisation of media can thus be performed using multispectral photoacoustic signals obtained by acquisition of photoacoustic images of a region of interest at different wavelengths [4]. In this way, multispectral photoacoustic imaging allows a functional image to be obtained.

To classify multispectral photoacoustic images, supervised methods, such as the least-squares method, are typically used [5,6]. These methods require reference spectra for each medium to be classified. Most of the time, such references are calculated on selected pixels of the dataset, which does not accurately describe the point-to-point variation for the whole image. The quality of these reference spectra impacts a lot on the classification results, and they need to be as representative as possible. They have then to be independent of the calculation used in their construction, and their measurements with another modality might then be of interest.

Spectrophotometry has recently been suggested as a technique to construct such reference spectra [7]. To more deeply investigate this potential, in this study we aimed to compare the spectra provided by a spectrophotometer to the multispectral photoacoustic signal using a larger set of test media and a larger range of wavelength than seen in the literature [7]. In the future, such comparison should help in the development of complex multi-modal agar phantoms, to validate supervised multispectral classification methods. Here, we used agar phantoms coloured with six different inks for photoacoustic acquisitions. The spectrophotometry was conducted on the same six inks. The materials and methods used for the study are described first. Then, the results are presented. Finally, the data are discussed, and a conclusion to the study is provided.

2. Materials and methods

2.1. Spectrophotometry

Absorbances were measured from 400 to 1200 nm with 1 nm steps. These acquisitions were made on a Perkin Elmer Lambda900 spectrophotometer (Fig. 2, left) at the Institut Lumière Matière. We used a standard arrangement that measures the contributions of both the absorption and the scattering (i.e., the absorbance). The maximum absorbance that can be measured by the spectrophotometer made it impossible to perform the acquisitions directly on pure inks. The absorbance measurements were thus performed on diluted inks, with a dilution factor of 1:1601 (Fig. 2, right).

2.2. Multispectral photoacoustic imaging

Multispectral photoacoustic signals were acquired on the photoacoustic experimental set-up (Fig. 3a) in CREATIS. This is composed of a Nd:Yag laser coupled with an optical parametric oscillator (SpectraPhysics, USA) for the generation, and of an ultrasound scanner (ULA-OP) coupled with a CMUT probe for the detection [8]. The acquisitions were made from 410 to 690 nm, with 5 nm steps (Fig. 3c) on coloured 4% agar phantoms with a dilution factor of 1:1629 (Fig. 3b). For each medium, twenty images were acquired at the same location at each wavelength. The spectrum was averaged over the region of interest, corresponding to the laser beam illumination spot on the phantom. The spectra obtained in this way were then averaged over the 20 images, to remove any point-to-point variation.

2.3. Comparison method

The aim of the present study was to compare the absorbance measured by the spectrophotometer with the multispectral photoacoustic signal, as also done in [7] on a smaller selection of samples, and on a smaller range of wavelengths. This comparison will be useful for future photoacoustic dataset classification. However, data acquired with the two different modalities cannot be compared without previous cross-calibration. The absorbance measurements have first to be post-processed to make them comparable to the multispectral photoacoustic signals, as described below.

First, the photoacoustic laser energy has to be taken into account. As the absorbance spectra of black ink has a decreasing exponential shape, an optical signal is available for all of the wavelengths of the selected spectrum. This medium was used to calculate the ratio given in Equation (1) (Fig. 4a), to normalise the spectrophotometer spectra and compare them with the photoacoustic spectra:

$$Ratio = \frac{PA_{black}}{S_{black}}, \quad (1)$$

where PA_{black} is the multispectral photoacoustic signal, and S_{black} is the absorbance measurement of black ink. Then the

Please cite this article in press as: Dolet A, et al. Spectrophotometry and Photoacoustic Imaging: A Comparative Study. IRBM (2017), https://doi.org/10.1016/j.irbm.2017.10.003

Download English Version:

https://daneshyari.com/en/article/7235349

Download Persian Version:

https://daneshyari.com/article/7235349

Daneshyari.com