Biophotonics Congress: Biomedical Optics Congress 2020 (Translational, Microscopy, OCT, OTS, Brain) © OSA 2020

Multi-laboratory efforts for the standardization of performance assessment of diffuse optics instruments – the BitMap Exercise

Pranav Lanka[1], Lin Yang[2], David Orive-Miguel[3], Joshua Deepak Veesa[4], Susanna Tagliabue[5], Aleh Sudakou[6], Saeed Samaei[6], Mario Forcione[7], Zuzana Kovacsova[8], Anurag Behera[1], Thomas Gladytz[2], Dirk Grosenick[2], Lionel Hervé[3], Giuseppe LoPresti[5], Lorenzo Cortese[5], Turgut Durduran[5], Karolina Bejm[6], Magdalena Morawiec[6], Michał Kacprzak[6], Piotr Sawosz[6], Anna Grega[6], Adam Liebert[6], Antonio Belli[7], Ilias Tachtsidis[8], Frederic Lange[8], Gemma Bale[8], Luca Baratelli[9], Sylvain Gioux[9], Kalyanov Alexander[10], Martin Wolf[10], , Sanathana Konugolu Venkata Sekar[11], Marta Zanoletti[1], Ileana Pirovano[1], Michele Lacerenza[1], Lina Qiu[1], Edoardo Ferocino[1], Giulia Maffeis[1], Caterina Amendola[1], Lorenzo Colombo[1], Mauro Buttafava[13], Marco Renna[13], Laura Di Sieno[1], Rebecca Re[1], Andrea Farina[12], Lorenzo Spinelli[12] , Alberto Dalla Mora[1], Davide Contini[1], Paola Taroni[1], Alberto Tosi[13], Alessandro Torricelli[1], Hamid Dehghani[4], Heidrun Wabnitz[2], and Antonio Pifferi[1]

[1]Politecnico di Milano, Dipartimento di Fisica, Milano, Italy.
[2]Physikalisch-Technische Bundesanstalt (PTB), Berlin, Germany.
[3] CEA-Leti: Laboratoire d'électronique des technologies de l'information, Grenoble, France.
[4]School of Computer Science, University of Birmingham, Birmingham, UK.
[5]The Institute of Photonic Sciences(ICFO), Castelldefels, Spain.
[6]Nalecz Institute of Biocybernetics and Biomedical Engineering, Warsaw, Poland.
[7]National Institute for Health Research Surgical Reconstruction and Microbiology Research Centre, University Hospitals Birmingham, UK.
[8]Medical Physics & Biomedical Engineering, UCL, London, UK
[9]University of Strasbourg, Strasbourg, France
[10]Biomedical Optics Research Laboratory, Department of Neonatology, University Hospital Zurich, Zurich, Switzerland
[11]IPIC, Tyndall National Institute, Cork, Ireland;
[12]Istituto di Fotonica e Nanotecnologie, Milano, Italy
[13]Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy
sriramapranav.lanka@polimi.it

Abstract: A multi-laboratory exercise, involving 29 diffuse optical instruments, aimed at performance assessment of diffuse optics instruments on standardized protocols is presented. The overarching methodology and future actions will also be discussed.

1. Methodology

A wide range of diffuse optics instruments belonging mainly to the partners of a European level Marie Curie Consortium BitMap[1], covering different approaches (continuous wave, CW; frequency domain, FD; time domain, TD and spatial frequency domain imaging , SFDI) and applications (e.g. mammography, oximetry, functional imaging, tissue spectroscopy) were chosen for this performance assessment exercise. As a first step performance assessment tests were performed on the instruments based on 3 well accepted protocols [2-4] which was followed by an initial comparison of the results. Future actions aim at deploying these measurements onto an open data repository and investigate common analysis tools for the whole dataset.

2. Implementation

2.1 Instrumentation

A total of 29 diffuse optics instruments were enrolled for the exercise. Table 1 gives a brief summary of the different instruments enrolled, based on their applications and modalities.

Table 1. Instruments enrolled for the exercise

Application	**Modality**				**Total**
	CW	TD	FD	SFDI	
Spectroscopy	1	9	1	0	11
Imaging	0	4	0	1	5
Oximetry	2	8	1	0	11
DCS	0	2	0	0	2
Total	3	23	2	1	**29**

DCS = Diffuse Correlation Spectroscopy, CW = Continuous Wave, TD = Time Domain, FD = Frequency Domain, SFDI = Spatial Frequency Domain Imaging

2.2 Protocols and Phantoms

The performance assessment was based on the following 3 protocols.

Protocol	**Tests**	**Phantoms**	**Measurable**	**Characterizes**
MEDPHOT[2]	Accuracy, Linearity, Uncertainty, Stability, Reproducibility	Matrix of 32 homogeneous solid phantoms	Absolute absorption (μ_a) and reduced scattering (μ'_s) coefficients	Ability to accurately retrieve absolute optical properties
BIP[3]	General performance, Responsivity, DNL	Responsivity solid phantom	IRF, Background, DNL, Responsivity	Basic instrument performance
nEUROPt[4]	Depth selectivity, lateral resolution	Switchable solid phantom	Contrast, Contrast to Noise Ratio	Ability to detect an inhomogeneity

3. Results

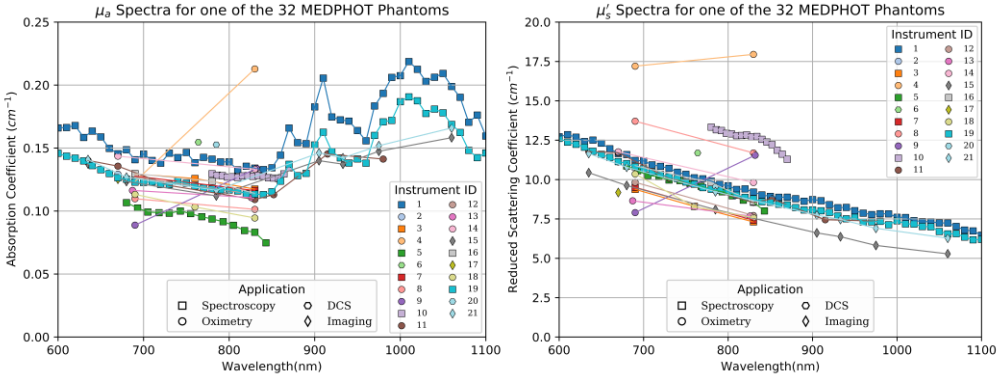

Fig 1. The absorption and reduced scattering coefficient spectra obtained by the different instruments on one of the 32 phantoms as a part of the first protocol: MEDPHOT. The legend corresponds to a unique identifier and the application of each instrument enrolled. Not all tests are applicable to all the instruments. The results of this test are shown here for only 21 out of the 29 instruments.

Figure 1 shows an example result of one of the performance assessment tests of the MEDPHOT protocol. Here we record the spectral response of the instruments when used to measure the optical properties one of the phantoms in the MEDPHOT protocol. There is a considerable variation in the detected optical properties which can partially be attributed to the diverse analysis methodologies employed to retrieve these results. The future actions of creating an open data repository and use of common analysis tools mentioned earlier could be of great interest in overcoming these issues. The 3 protocols in total test multiple other aspects like the contrast detecting capabilities, overall sensitivity of the detection system etc. On average, a total of 10 tests were performed on each instrument. In the interest of space, the results from the other tests have not been presented in this abstract but will be discussed in the presentation.

4. Conclusions:

In Conclusion, 29 diffuse optics instruments from 11 different institutions across 7 EU nations were enrolled in a large-scale multi-laboratory performance assessment exercise. A total of 10 tests based on 3 international protocols were employed and the preliminary data analysis was performed. These results could give valuable insights into the advantages and limitations of the field of diffuse optics.

5. References:

[1] "BitMap ITN - Home," <http://www.bitmap-itn.eu/> (15 November 2019).
[2] Pifferi, A., et al., "Performance assessment of photon migration instruments: the MEDPHOT protocol," Appl. Opt. 44, 2104 (2005).
[3] Wabnitz, H., et al., "Performance assessment of time-domain optical brain imagers, part 1: basic instrumental performance protocol," J. Biomed. Opt. 19, 086010 (2014).
[4] Wabnitz, et al., "Performance assessment of time-domain optical brain imagers, part 2: nEUROPt protocol," J. Biomed. Opt. 19, 086012 (2014)