Radiometric calibration method for dim sources

Maritoni Litorja, Yuqin Zong and Cameron Miller

National Institute of Standards and Technology
Gaithersburg, MD, USA
Corresponding e-mail address: litorja@nist.gov

Light sources with total emittance at or lower than femtowatt power can be used to calibrate sensitive cameras used for biomedical imaging. We employ a system to calibrate these dim sources by using a light source split by a high ratio (99:1) bifurcated optical fiber. The measured transmittance ratio along with the calibration of the high emittance branch using current measurement capabilities with low uncertainties facilitates calibration of dim sources.

INTRODUCTION

Fluorescence and bioluminescence-guided imaging devices are used to help clinicians visualize the extent and distribution of cancerous tissue, especially during surgical excisions. Driven by the goal of minimizing toxicity from both the fluorescent contrast agent and the excitation source intensity, the luminescence emitted at the tissue surface is very dim. This necessitates the use of dim light sources, which may be electrically - driven (light bulbs) or optically driven (fluorescent polymeric tissue phantoms) as monitoring artifacts to track the performance of an imaging device during its development or in preclinical studies (Fig. 1). [1]

The camera systems in luminescence-guided imaging vary in form factors (e.g endoscope, robotic-assisted surgical systems), the types of sensors and associated electronics, and operate in different wavebands depending on the contrast agent emission band which can vary from the blue to near infrared spectral region. Thus, it is convenient to have these portable dim light sources presented to the imager at the site of use. These sources have been generally used as monitoring artifacts; with radiometric calibration, they can transfer SI-traceable scale to the imager.

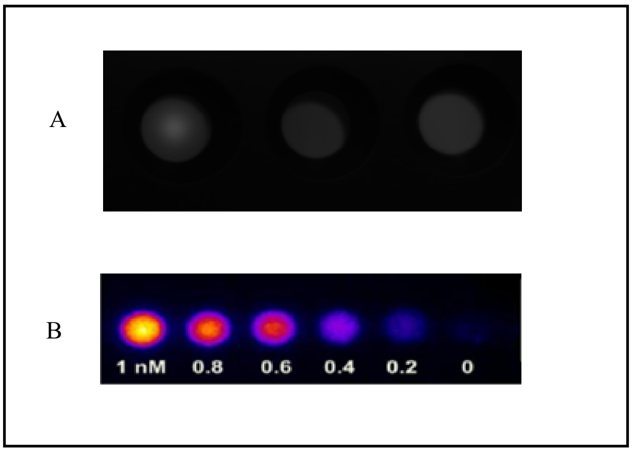

Figure 1. Example of a light-emitting diode artifact (A) and a fluorescent tissue phantom (B).

METHOD

We have set up a system to calibrate dim sources using commercially available components, as shown in Fig. 2. This consists of a light emitting diode (A) at the desired waveband matching the unit under test

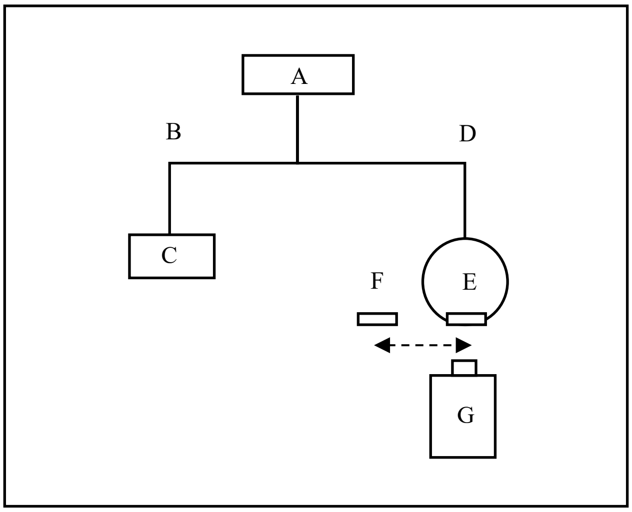

Figure 2. Illustration of the bifurcated optical fiber system for calibrating dim light sources.

(F), input into a high-ratio bifurcated optical fiber (B,D) (99:1 ratio). The higher emittance branch (B) is coupled to a photodiode (C) calibrated by the NIST SCF. [2] The low-emittance branch of the fiber (D) is input into a 50.8 mm (two-inch) diameter integrating sphere with a 12.7 mm (half inch) exit port (E), attenuating it further. The optical fiber and integrating sphere are calibrated for their transmittance and throughput respectively. The integrating sphere exit port is presented to a low-noise camera (G), used here as a transfer imager, alternated with the dim light source being tested (F); the light emitting diode source drive current is adjusted such that the radiance of the sphere source matches the dim source under test as imaged on the transfer camera. The radiance of the sphere source is calculated from the responsivity of the calibrated photodiode and the fiber transmittance and sphere throughput. The dim source derives its radiance value through the comparison with the sphere output.

The calibration is done at higher flux, where measurement uncertainties are lower and utilizes commercially available components.

REFERENCES

1. B.W. Pogue et al, "Fluorescence-guided surgery and intervention—an AAPM emerging technology blue paper", Medical Physics 45, 2681-2688, 2018.
2. T.C Larason and J.M. Houston, "NIST Measurement Services: Spectroradiometric Detector Measurements: Ultraviolet, Visible and Near-Infrared Detectors for Spectral Power," NIST Special Publications 250-41, 2008.