Low-cost diffuse optical tomography for the classroom

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ABSTRACT
We have developed a LEGO based Diffuse Optical tomography set-up that could be introduced to the advanced undergraduate or early graduate curriculum. A recent highschool graduate has learnt diffuse optics and the process of tomography through building the set-up. The concept was tested, and a 3D tomographic image was reconstructed at the end of study.

INTRODUCTION

• An educational experimental set-up for undergraduates/early graduates to learn diffuse optical spectroscopy (DOS) and diffuse optical tomography (DOT).
• A recent high-school graduate has spent a month to build a LEGO based DOT scanner.
• LEGO Mindstorms NXT (NXT) facilitates students to learn robotics of set-up and control codes quickly.
• It’s fun to learn and teach DOS and DOT through LEGO set-up!

SETUP

• NXT to control a LED(631 nm), a photo-diode, a 2D scanning platform and the data acquisition process.
• A plastic container filled with water mixed with scatterers (Lipofundina, LIPO) with a hidden black sphere (3 mm diameter).
• Two sets of experiments were performed: measurement of \( \mu_s' \) in homogeneous media and a tomographic image reconstruction.

RESULTS

Characterization of homogeneous media

- LIPO 1.0% Linear Fit
- LIPO 1.0% Measured
- LIPO 1.9% Linear Fit
- LIPO 1.9% Measured

- Surface fluence of 30x31 points were fitted with:
  \[ \ln \Phi = -\sqrt{3 \mu_s' r + \text{const.}} \]
  for different LIPO concentrations
- Measurements have a deviation of 23-34% from the Time Resolved Spectroscopy (TRS) estimates

3D Tomography

- We have used 6 surface fluence scans for reconstruction (3 source positions with/without a black sphere).
- Succeeded localizing a black sphere hidden in turbid medium

There is a strong absorption peak in the position of the object.

REFERENCES


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CONCLUSIONS

• Total cost of approximately 400 Euros.
• The data fidelity was sufficient to estimate the scattering coefficient and the tomographic reconstruction. The student succeeded to localize the hidden black sphere in turbid medium.
• We have introduced the concept of diffuse optics and tomographic image reconstruction to a recent high-school graduate.
• Further details on how to replicate and utilize for education are available in [11]