Frequency domain diffuse optical tomography with a single source and detector via high-speed hypocycloid scanning

Matthew B. Applegate
Boston University, USA, mapple03@bu.edu

Darren Roblyer
Boston University

Follow this and additional works at: http://dc.engconfintl.org/biotech_med_xv

Part of the Engineering Commons

Recommended Citation

This Abstract and Presentation is brought to you for free and open access by the Proceedings at ECI Digital Archives. It has been accepted for inclusion in Advances in Optics for Biotechnology, Medicine and Surgery XV by an authorized administrator of ECI Digital Archives. For more information, please contact franco@bepress.com.
High-speed spatial frequency domain imaging (SFDI) with temporally modulated light

Matthew Applegate & Darren Roblyer

ECI Advances in Optics XV
Snowmass, CO

July 25, 2017
1. Introduction to SFDI
Outline

1. Introduction to SFDI
2. How we’re using it
Outline

1. Introduction to SFDI
2. How we’re using it
3. Temporally modulated SFDI
Outline

1. Introduction to SFDI
2. How we’re using it
3. Temporally modulated SFDI
4. Conclusion and Future directions
Intro. to SFDI

- General info.
  - SFDI is a widefield diffuse optical technique
  - Fairly large penetration depth (1-5 mm)
  - Image tissue optical properties
  - Chromophore concentrations
Intro. to SFDI

General info.
- SFDI is a widefield diffuse optical technique
- Fairly large penetration depth (1-5 mm)
- Image tissue optical properties
- Chromophore concentrations

Method
- Project light at multiple spatial frequencies onto sample
- Demodulate
- Compare to reference
- Fit to model
Intro. to SFDI

- **General info.**
  - SFDI is a widefield diffuse optical technique
  - Fairly large penetration depth (1-5 mm)
  - Image tissue optical properties
  - Chromophore concentrations

- **Method**
  - Project light at multiple spatial frequencies onto sample
  - Demodulate
  - Compare to reference
  - Fit to model

Demodulation techniques

- Original Method:
  - Three phase images
  - Two spatial frequencies
  - At least 2 wavelengths to fit chromophores

Vervandier & Gioux, 2013
Demodulation techniques

- Original Method:
  - Three phase images
  - Two spatial frequencies
  - At least 2 wavelengths to fit chromophores

- Single shot method
  - Only 1 image required for demodulation
  - Manual switching of wavelengths
  - Sensitive to changes in ambient light
Demodulation techniques

- **Original Method:**
  - Three phase images
  - Two spatial frequencies
  - At least 2 wavelengths to fit chromophores

- **Single shot method**
  - Only 1 image required for demodulation
  - Manual switching of wavelengths
  - Sensitive to changes in ambient light

Vervandier & Gioux, 2013
Temporally modulated SFDI

Goals:

- High-speed SFDI of multiple wavelengths
- No manual switching
- Insensitive to ambient light
- Scalable
Temporally modulated SFDI

- **Goals:**
  - High-speed SFDI of multiple wavelengths
  - No manual switching
  - Insensitive to ambient light
  - Scalable
Acquisition

Image of mouse phantom during TM-SFDI acquisition

Video
Processing
Temporal demodulation

- **Green** (519 nm)
- **Red** (652 nm)
- **IR** (740 nm)

Steady

Temporally Demodulated

5 cm
System details

- 10×8 cm field of view
- 3 wavelengths (519 nm, 652 nm, 740 nm)
- Temporal frequencies of 6, 8, 12 Hz
- 55 frames per second video
- 128 images per scan
- 2.4 s acquisition time (compared with about 30 s for standard device)
Image of biomimetic phantom

A

1 cm

B

C

\( \mu_a (\text{mm}^{-1}) \)

\( \begin{array}{cccc}
0.000 & 0.016 & 0.032 & 0.049 & 0.065 \\
\end{array} \)

D

\( \mu_s (\text{mm}^{-1}) \)

\( \begin{array}{cccc}
0.000 & 1.250 & 2.500 & 3.750 & 5.000 \\
\end{array} \)
Comparing Scattering

Comparing Absorption

Wavelength
- Green
- Red
- IR

Accuracy
Effect of ambient light

Insensitivity to background light

Calibrated DC Reflectance

SSOP
TM–SFDI

Ambient Illumination (counts)
Conclusion & Future directions

Conclusion:

- Clean separation of excitation wavelengths
- Accurate, multi-wavelength SFDI
- 10x improvement of imaging speed
- Not affected by background light
- Additional wavelengths can be added without increasing acquisition time

Future directions:

- Start imaging tumors
- Add additional wavelengths
Conclusion & Future directions

Conclusion:
- Clean separation of excitation wavelengths
- Accurate, multi-wavelength SFDI
- 10x improvement of imaging speed
- Not affected by background light
- Additional wavelengths can be added without increasing acquisition time

Future directions:
- Start imaging tumors
- Add additional wavelengths
Conclusion & Future directions

Conclusion:
- Clean separation of excitation wavelengths
- Accurate, multi-wavelength SFDI
- 10x improvement of imaging speed
- Not affected by background light
- Additional wavelengths can be added without increasing acquisition time

Future directions:
- Start imaging tumors
- Add additional wavelengths
Acknowledgements

- Members of the BOT Lab at BU:
  - Prof. Darren Roblyer
  - Vivian Pera
  - Yanyu Zhao
  - Syeda Tabassum
  - Kavon Karrobi
  - Raeef Istfan
  - Hannah Peterson
  - Fei Teng

- Also:
  - Joe Angelo

- And:
  - DoD (Award No. W81XWH-15-1-0070)