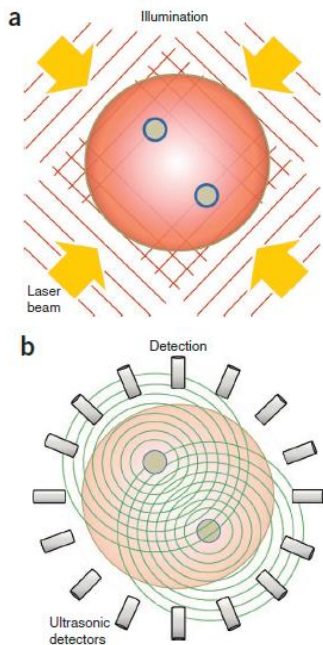# WG34: PHOTOACOUSTIC IMAGING SUPPLEMENT 229

Final Text – IOD Summary

WG34 Secretary: Amanda Kalkwarf, SPIE
WG34 Chairs: Brian Bialecki, ACR
Allison Bertrand, Seno Medical

Contributing members:
Bryan Clingman, Seno Medical
Ben Cox, UCL
Patricia Smole, iThera Medical
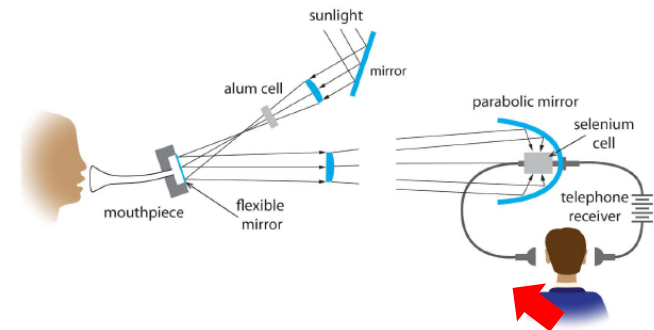Patrick Leisching, iThera Medical

Overview – Photoacoustic (PA) Imaging

Photo-

Narrowband laser pulses (nanosecond duration at milli-joule energies)

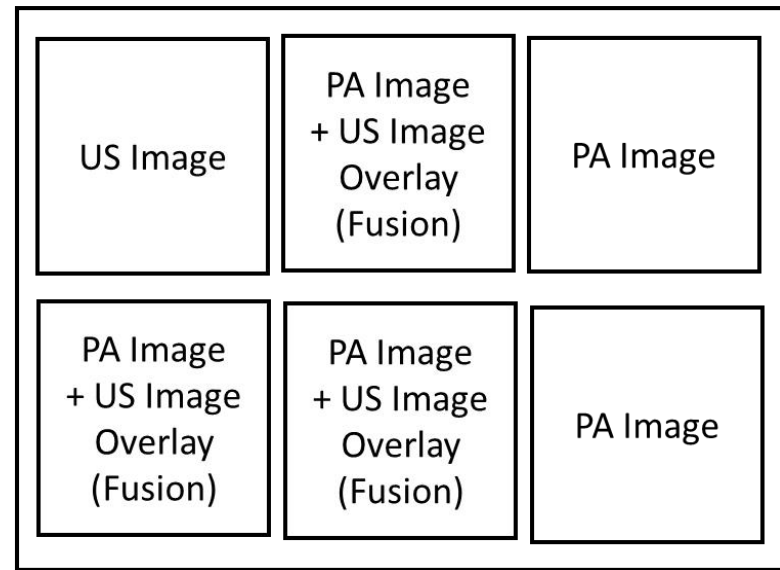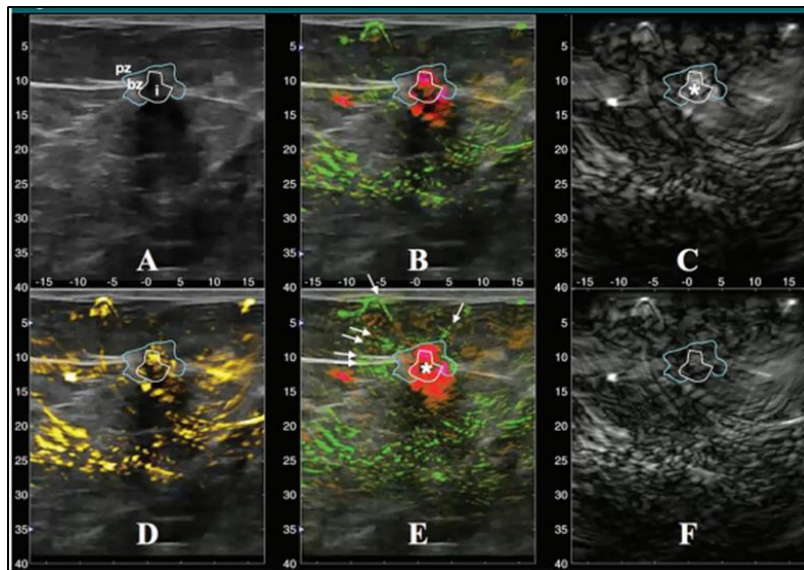## Acoustic

Broadband response kHz-MHz range

Photophone designed and built by Alexander G. Bell and Charles S. Tainter is considered the first implementation of wireless telephony or, in fact, of an optical communication device [32]. The first voice telephone message was transmitted by means of light over some 213 m in Washington, D.C. in June 1880.

Photophone, 1880

Ntziachristos, Vasilis, and Daniel Razansky. 'Molecular Imaging by Means of Multispectral Optoacoustic Tomography (MSOT)'. *Chemical Reviews* 110 (2010): 2783–94.
Manohar, Srirang, and Daniel Razansky. 'Photoacoustics: A Historical Review'. *Advances in Optics and Photonics* 8, no. 4 (31 December 2016): 586–617.

Photoacoustic Image Display - Examples in Literature
Illustrates some of the potential use cases

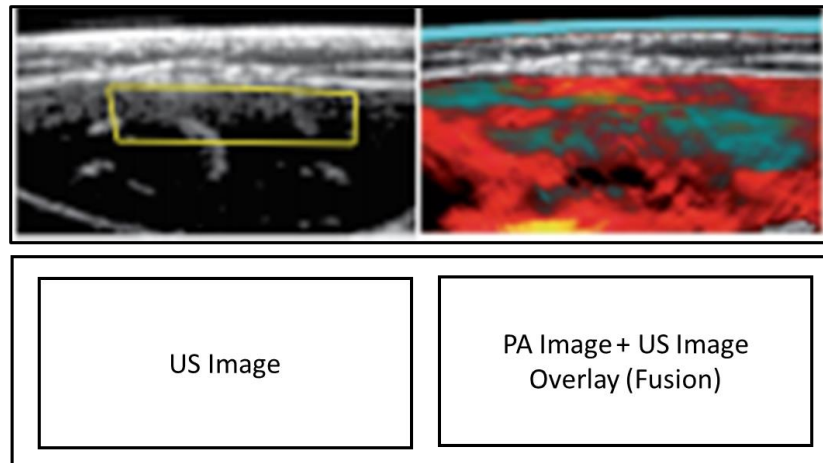https://doi.org/10.1148/radiol.2017172228

Photoacoustic (PA) acquisition with two input wavelengths and ultrasound (US), representing three imaged properties, displayed in six different panels with PA Images (C, F), US images (A), and three overlay (fusion) images with PA and US (B, D, E) generated from three algorithms for processing the Photoacoustic wavelengths and fusing with ultrasound..

3

Photoacoustic Image Display - Examples in Literature
*Illustrates some of the potential use cases*

Photoacoustic (PA) acquisition with two ranges of multispectral input wavelengths and ultrasound (US), displayed in two different panels with the US image (left) and the PA image (right), representing two imaged properties, generated from two algorithms for processing of the Photoacoustic wavelength in a "cyan" and a "hot" colormap and fusing with ultrasound.

Photoacoustic Image Display - Examples in Literature
Illustrates some of the potential use cases
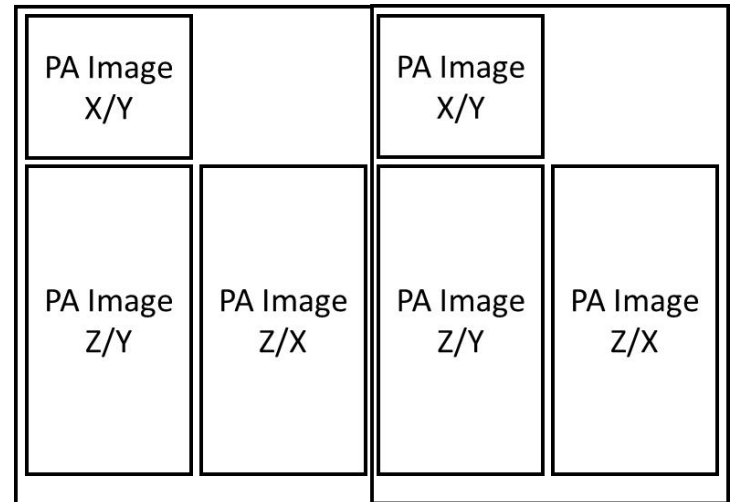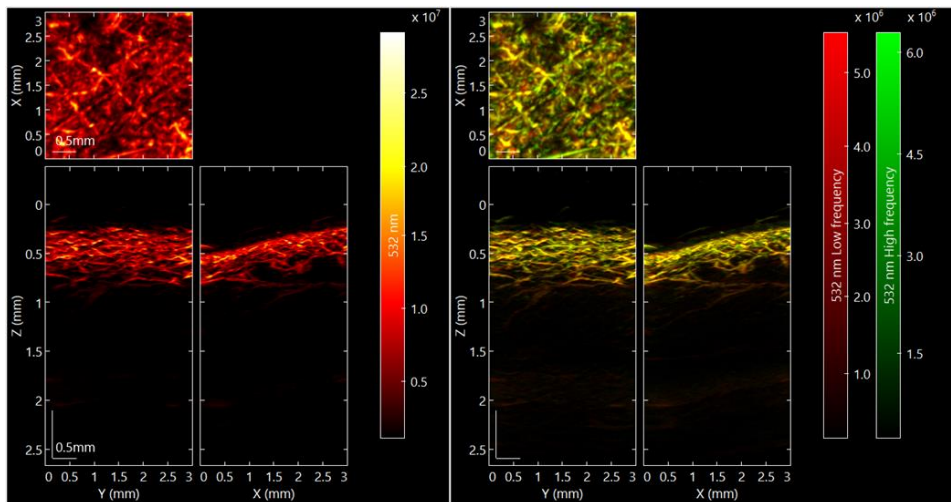
Photoacoustic (PA) acquisition with one input wavelength displayed as a Photoacoustic image in three planes (left) and a Photoacoustic image (right) representing a range of imaged properties, processed with an algorithm to show frequency separation in three planes.
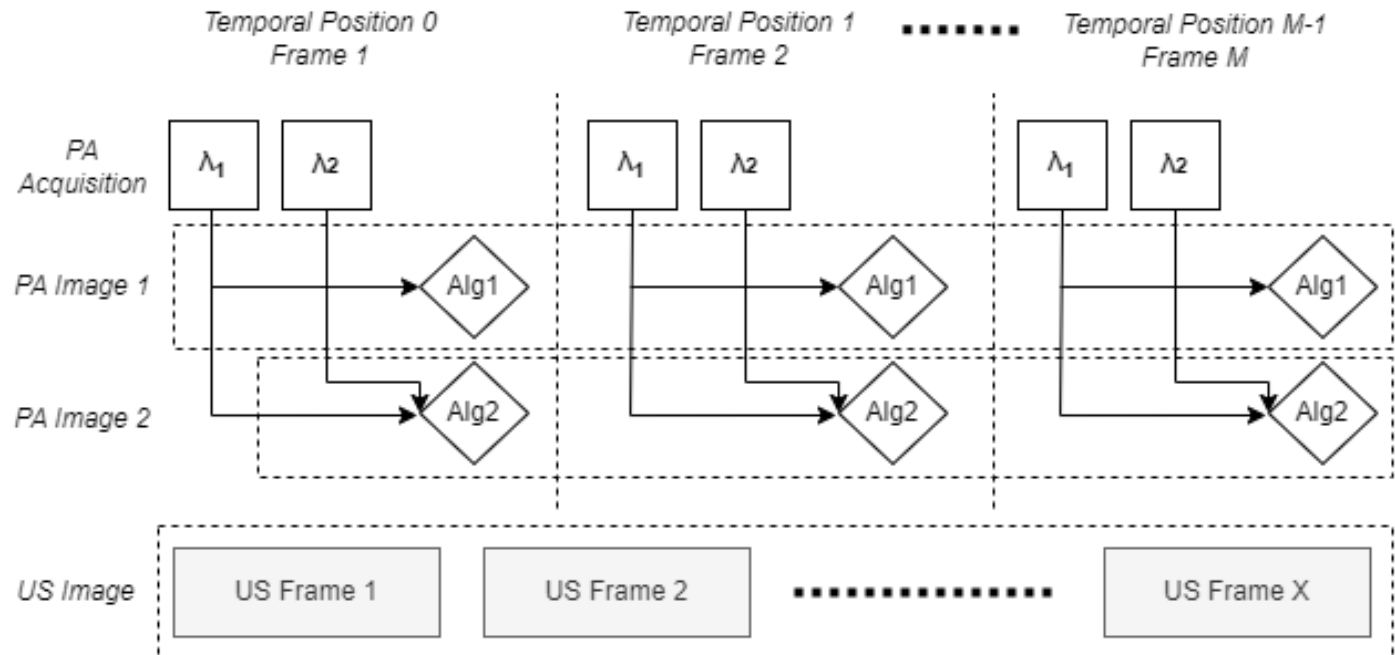
Photoacoustic Image IOD Overview

- Imaging data - Photoacoustic Images

- Imaging metadata - derived from IPASC* Metadata, tailored more towards clinical use

    - Photoacoustic Image IOD Attribute Modules

        - Photoacoustic Image Module

        - Photoacoustic Acquisition Configuration Module

        - Photoacoustic Transducer Module

        - Photoacoustic Reconstruction Module

        - Per-Frame Functional Groups

            - Photoacoustic Excitation Characteristics Macro

            - Photoacoustic Image Frame Type Macro

        - Shared Functional Groups

            - Photoacoustic Image Data Type Macro

            - Photoacoustic Reconstruction Algorithm Macro

- Other standard DICOM modules (Patient, Study, Series, Image)

IPASC = International Photoacoustic Standardisation Consortium

Photoacoustic Example with Complementary Images

Photoacoustic (PA) Images – one or more wavelengths processed with vendor-defined algorithms

Optional: Complementary Images (outside of the scope of the Photoacoustic IOD)

Photoacoustic Image IOD vs Ultrasound

- The Photoacoustic Image IOD is a stand alone as a modality separate from ultrasound

- Some implementations might only acquire Photoacoustic imaging (optical wavelength data), which others might acquire complementary data from another modality.

- Because many implementations do use standard pulse/echo ultrasound systems for data acquisition, the Photoacoustic Image IOD was modeled loosely on the Enhanced US Volume IOD

  - For ease of compatibility where presentation might include side-by-side synchronized display or overlay (fusion) of Photoacoustic images on the display of US images.

- Fusion details are outside the scope of this IOD, but it is suggested that the Advanced Blending Presentation State (ABPS) could be used.

Photoacoustic Dimension Indexing

- Dimension Indexing attributes:

  - Temporal Position Time Offset (0020,930D)

  - Image Position (Volume) (0020,9301)

  - Image Data Type Sequence (0018,9807)

Image Data Type Sequence (0018,9807) Codes
Sequence of CID 11006 Photoacoustic Imaged Property

Coding Scheme Designator	Code Value	Code Meaning
DCM	110819	Blood Oxygenation Level
DCM	130823	Blood Deoxygenation Level
SCT	38082009	Hemoglobin
DCM	110830	Elasticity
DCM	110831	Perfusion
SCT	59094002	Melanin
SCT	11713004	Water
SCT	70106000	Lipid

CID/TID Tables

- Extension to CID 12033 Ultrasound Transducer Geometry

  - Added two transducer geometries

- Template for Skin Type Acquisition Context

  - A skin type acquisition template will be defined in a future DICOM Change Proposal (CP).

Context Groups

- CID 11001 Photoacoustic Illumination Method

  - Description of the arrangement of optical illumination sources

- CID 11002 Acoustic Coupling Medium

  - Acoustic coupling medium that was used to allow sound propagation from the imaged subject to the transducer

- CID 11003 Ultrasound Transducer Technology

  - Technology employed by the receiving transducer (piezo, MEMS, interferometric)

- CID 11004 Speed of Sound Correction Mechanism

  - Speed of sound correction mechanism used in image reconstruction

- CID 11005 Photoacoustic Reconstruction Algorithm Family

  - Families of algorithms to be used in image reconstruction

- CID 11006 Photoacoustic Imaged Property

  - Physical properties represented in a Photoacoustic image

PS3.17 – Explanatory Information

- AAAAA.1 Introduction

- AAAAA.2 Use Cases

- AAAAA.3 Acquisition Examples

- AAAAA.4 Real World Display Examples

PS3.17 – Acquisition Examples

- Example 1: Photoacoustic Standalone Image

  - Example 1a: Photoacoustic Single Wavelength Standalone Image

- Example 2: Photoacoustic/Ultrasound Coupled Acquisition

- Example 3: Stationary Tomographic 3D Photoacoustic/Ultrasound Coupled Acquisition