Advancements in digital preservation: spectral 3D reconstruction of Impressionist oil paintings

Xingyu Zhou, Darlene In, Xing Chen, Heather McCune Bruhn, Xuan Liu, Yi Yang
Why 3D Digital Preservation?

- The 3D surface model of paintings can be used in classes to enhance viewing experiences, especially for online courses. Students will be able to rotate, zoom in and out to view details such as brushstrokes and learn about various painting styles.

- 3D printed painting samples can be used to assist visually impaired users to experience various painting techniques, such as Van Gogh's brushstrokes and pointillism demonstrated by Seurat’s works.

- The OCT provides a minimal invasive method to generate the cross-sectional information of paintings, which can be used for art conservation.

- Hedge against worst case scenario
Current Optical Methods

- Laser Triangulation
- Stereophotogrammetry
- Structured Light
- Laser Scanner
- Time of Flight Sensors

A high-resolution color laser scanner based on trigonometry was used to scan the famous painting Mona Lisa and then generated the 3D space structure.
What is Optical Coherence Tomography

Swept source OCT (SS-OCT)
- Illuminated by broadband source that outputs wavelength swept light
- Fixed reference arm because of Fourier domain detection

The sample and the reference arm (Michelson interferometer) of the swept source laser scanning OCT will be illuminated by the laser light.
Benefits and limitations of OCT

**Benefits**
Super high resolution (10um)
Non-contact
Able to scan the under layer structure

**Limitations**
Limited Field of View (FOV)
Huge data
Slow
The Solution

Increase the FOV
The first sample

We performed macro-OCT imaging study on the oil painting produced by an artist that mimics the Impressionist style. This oil on canvas painting is of 10 cm by 10 cm in size. We chose the Impressionist style for its unique brushstrokes to demonstrate the 3D reconstruction capability of the optical imaging system.
OCT signals

(a) A scan
(b) B scan
(c) Enface image
(d) 3D surface reconstruction
Imaging Stitching Algorithms

(a) Stitched enface image of the ROI; (b) Stitched surface topography of ROI. Scale bar = 5 mm.
Digital 3D Spectral Reconstruction

Spectral and texture of the ROI from the impressionist oil painting.
3D Printed Sample
Acknowledgments

- Dr. Kristin deGhetaldi and Prof. Brian Baade of University of Delaware provided critical advice on art conservation methods. Both Dr. deGhetaldi and Mr. Baade have substantial experience working as art conservators in teaching and practicing.

- The painting sample is produced by Kali Wallace, who is a New Jersey based artist. She received her BFA and BA in art history from William Paterson University. She is current pursuing MFA at Guizhou Minzu University, China. She is experienced in various painting styles and materials. She was recognized as 2014 New Jersey Visual Artist of the Year by RAW.

- “Spectral 3D reconstruction of Impressionist oil paintings based on macroscopic OCT imaging” will be published in Applied Optics, an OSA journal.