Sharpening Transmissive Images using Parallel High Frequency Illumination

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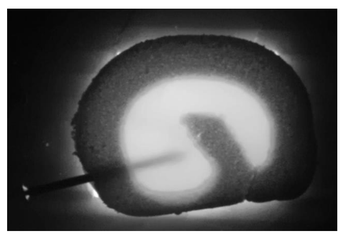
Transmissive Image

- Visualization of the inside for
  - Security
  - Medical care
  - Industry
- Unclear images due to scattering

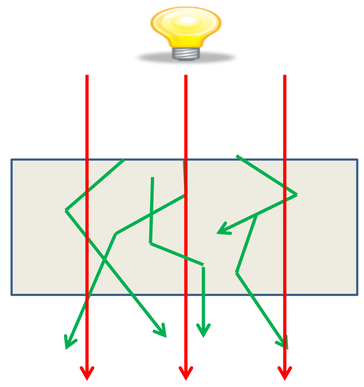


Food

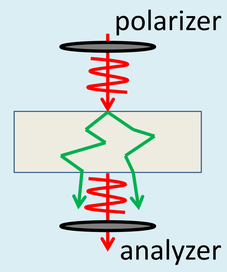
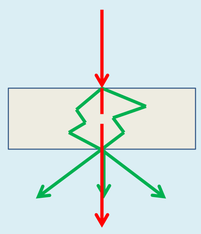
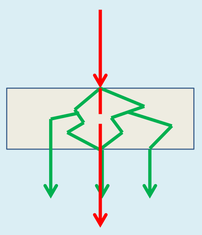
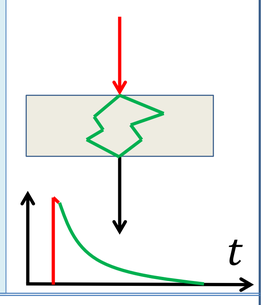
Vein

Purpose

- Separation of Transmissive and Scattered lights



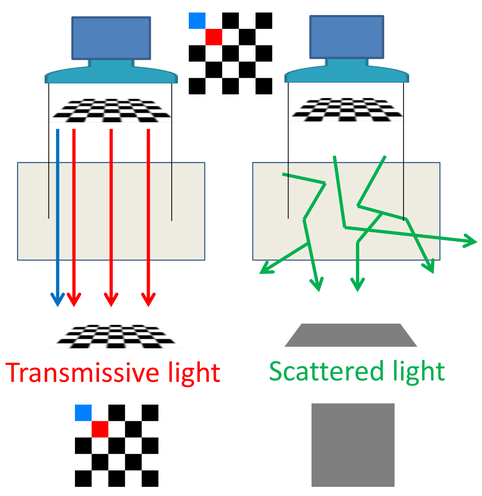
Clues for Separation

Clue	Polarization	Angle	Position	Time
Transmission	Kept	Same as incident	On the line	Fast
Scattering	Gradually lost	Spread	Spread	Delay
				

We combine three clues for sharpening

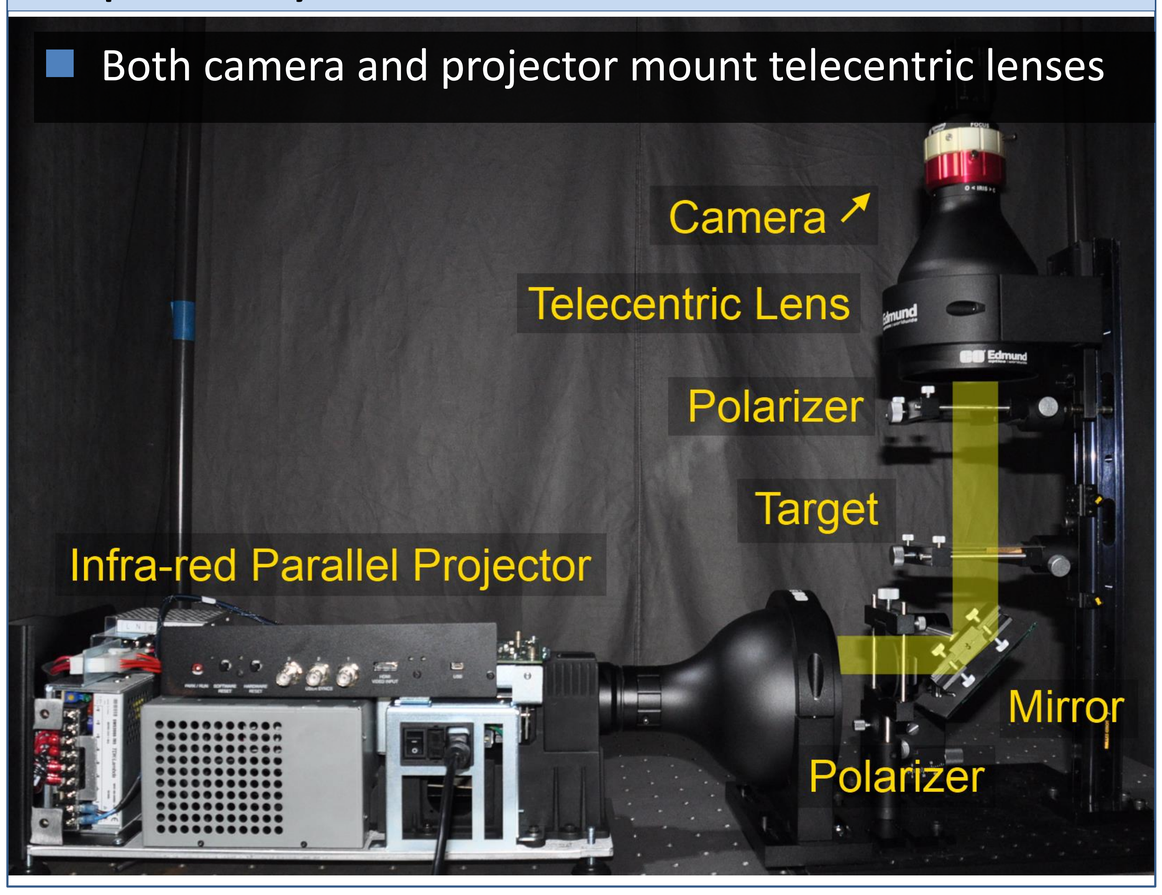
Separation Idea

- Direct transmission
  - Keeps incident patterns
- Scattered light
  - Low-pass filter



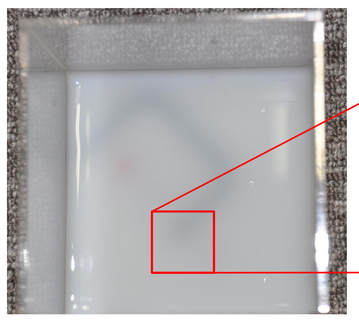
Optical System

- Both camera and projector mount telecentric lenses



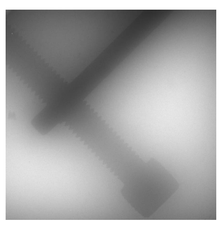
Experimental Results

- Metallic object in milky water

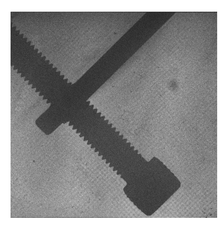


Top View of target object

Normal illumination using visible light



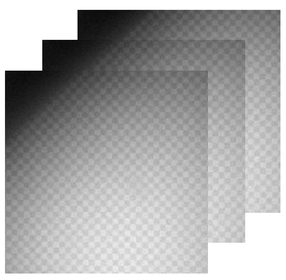
Normal illumination using near infra-red



Proposed Method

Formulation

- Shift the pattern



Maximum and Minimum Intensities are obtained

  - Fluctuation of the intensity

    = Direct transmission
- Observation

$$\begin{cases} I_{max} = I_{transmission} + \frac{1}{2} I_{scattering} \\ I_{min} = \frac{1}{2} I_{scattering} \end{cases}$$

Assuming "numbers of black and white pixel are same"

- Therefore,

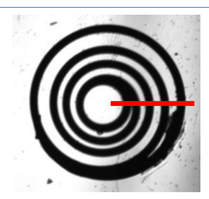
$$I_{transmission} = I_{max} - I_{min}$$

Fast and easy calculation

Numerical Evaluation

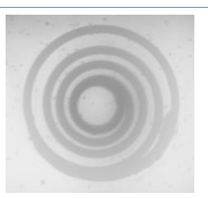
- A metallic wire in milky water (2.2 % density)
  - Ground truth: in pure water

Target Object

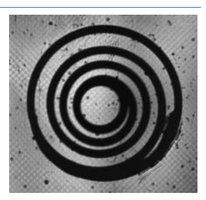


Ground Truth

White pattern in visible light

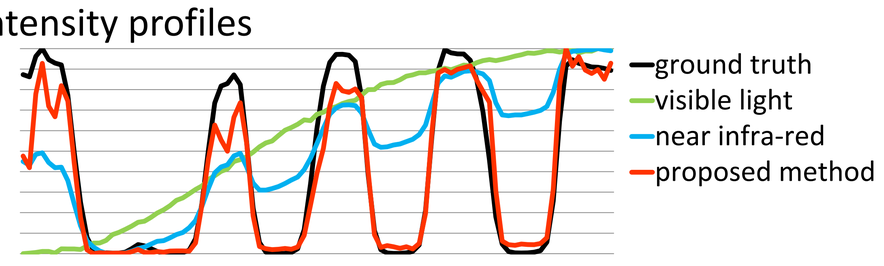


White pattern in near infra-red

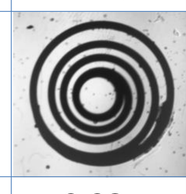
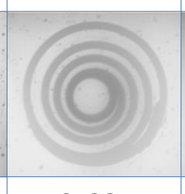
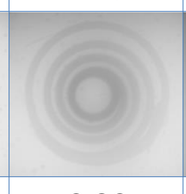
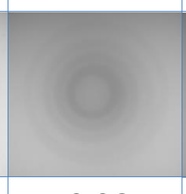
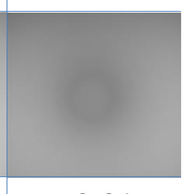
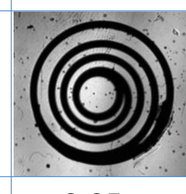
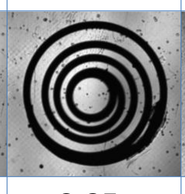
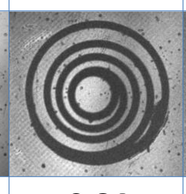
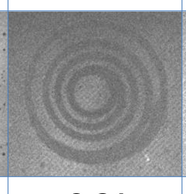
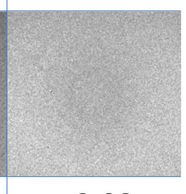


Proposed method

  - Intensity profiles



- A metallic wire in milky water for various densities

Density	1.9%	2.2%	2.5%	2.8%	3.1%
Normal Illumination					
Correlation	**0.98**	0.68	0.30	0.06	0.01
Proposed Method					
Correlation	0.95	**0.95**	**0.84**	**0.21**	0.03