

# Biomedical Imaging Endoscopy

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# Endoscopes



- Mostly Optical
  - Relay Lenses (e.g. Hopkins Relay)
  - Fiber Bundles (About 30,000 Fibers)
  - Scanners
  - Small Cameras
- Some Ultrasound (e.g. Intra–Vascular Ultrasound)
- Combine Imaging with Therapy/Surgery
- Rigid vs. Flexible
- Side or Forward View
- Diameter
  - Mostly 2 to 14 mm (3 French = 1 mm)
  - Imaging Channel May Be Smaller
  - Remember  $\lambda/NA$

# Some Diameters



Application	Technology	Diameter
Laposcopic surgery (eg. knee)	Hopkins relay	5mm to 1cm, some smaller
Bronchoscopy	Fiber or video	Few mm. Some rigid endoscopes to 1 cm
Rhinoscropy	Hopkins relay	4 mm
Esophagus	HDTV	Few mm
Urethra or bladder	Fiber bundle	2 to 7 mm or Hopkins relay to 5.4mm
Ureter or kidney	Fiber bundle	2mm
Uterus or fallopian tubes	Fiber bundle	2 to 10 mm
Colonoscopy	Video camera	Few mm up to 1.4cm

# Relay Lenses

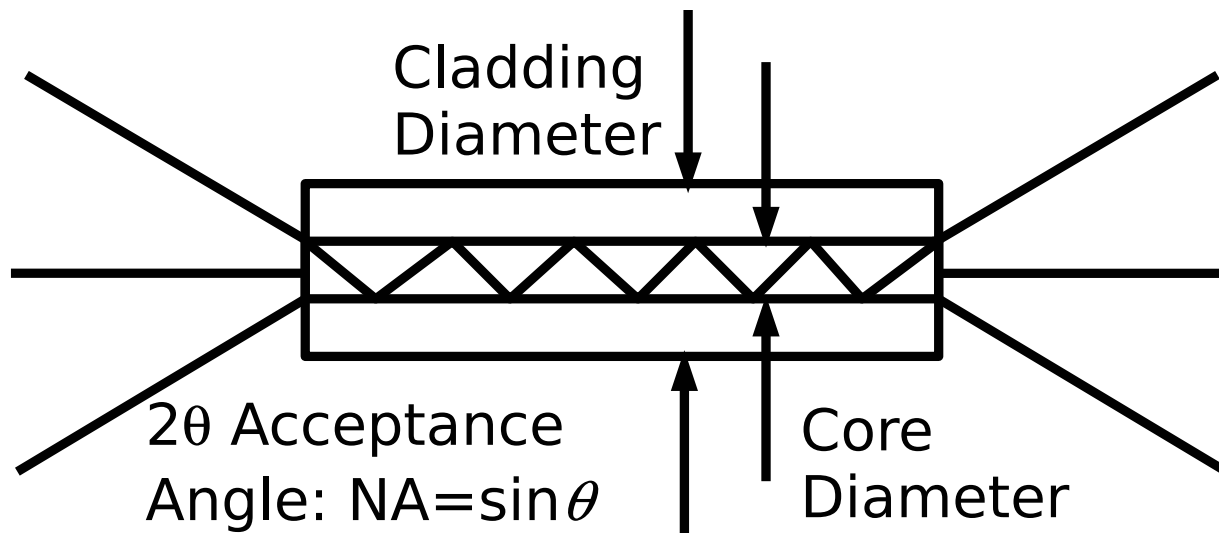


- Reasonably Flexible
- Limited NA
- No Scanning Required
- Hopkins Relay
  - Glass Rods as Lenses

# Optical Fibers



- Total Internal Reflection:  $NA = \sqrt{n_{core}^2 - n_{clad}^2}$
- Etendue:  $\frac{\pi^2 D^2}{2} \left(1 - \sqrt{1 - NA^2}\right) \approx? \frac{\pi^2 D^2 NA^2}{4}$
- Single-Mode:  $NA \approx \frac{\lambda}{D}$       Multi-Mode:  $NA > \frac{\lambda}{D}$
- SM Etendue:  $\frac{\pi^2 \lambda^2}{4}$



# Fiber Bundles



- “Coherent Bundle”
- Fiber Size
- Fiber NA
- Cross-Talk
- Discrete Imaging

# Cameras



- Only Need Wires and Illumination
- Probably White Light
- Pixel Size
- Pixel Number
- Lens (NA)

# Scanners



- Rotating

- MEMS Azimuth and Elevation

[https://washington-seattle.digication.com/jonliu/Point-of-care\\_pathology](https://washington-seattle.digication.com/jonliu/Point-of-care_pathology)

[https://washington-seattle.digication.com/jonliu/spectral\\_imaging\\_device](https://washington-seattle.digication.com/jonliu/spectral_imaging_device)

- Oscillating Fiber End



# Spectral Encoding



- Grating on a Fiber
- Diameter 0.5 mm or Less
- Wavelength Encodes Angle
- Varifocus Lens (Water) for Depth

<http://gmwgroup.harvard.edu/pubs/pdf/1236.pdf>

- Intravascular Ultrasound
- Coronary Artery
- Side-Viewing
- Theta Dimension by Rotating
- Radial Dimension by Time-of-Flight
- Axial Dimension by Pulling
- Also IV-OCT