Optical Engineering

Part 22: Imaging in medical systems, endoscopes, surgery
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- Endoscopy
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Key Limitation of Optical Imaging in Medicine

\[
\frac{I}{I_0} = \exp\{- (\mu'_s + \mu_a) d \}
\]

\( \mu'_s \): reduced scattering coefficient (typ. \(10^1 - 10^2 \, cm^{-1}\))

\( \mu_s \): scattering coefficient (typ. \(10^2 - 10^3 \, cm^{-1}\))

\( \mu_a \): absorption coefficient

Penetration / Resolution:

Ballistic light \((\mu_s)\) – few mm / several \(\mu m\)

Diffuse light \((\mu'_s)\) – depth \(d\)
Optical Imaging in Medicine

Optical Medical Imaging

- Diagnostic Imaging
  - Ophthalmology
  - Dermatology
  - Others
  - Neuro/Spine
  - Gynaecology/Urology
  - ENT
- Surgical Imaging
  - Ophthalmology
  - Dental
- Endoscopy
  - Gastroenterology
  - Cardiology
  - Urology
  - Pulmonology
  - Others
Endoscopes: Relay Systems

Endoscopes use various light guiding principles to relay the image over distance:

- Rigid endoscopes – slab lens relay
- Combination of several relay subsystems
- Large field-angle objective lens

Ref.: M. Rill
Rigid Endoscopes

Example: Systems by Storz
diameter 3.7 mm
Use of fiber bundle array as relay

- Each fiber transmits one image point
- Diameter: typ. 0.5-1.5 mm for 4k to 18k fibers (data points = pixels)
- Pixel size: typ. 6-10 µm

Example: System by Storz

Endoscope - Child Surgery

Systems of Storz:

3. Several tools for surgery incorporated

4. Modified setups for object sided viewing angle conditions

Ref: W. Lei
Greenough Type
- Well-corrected objective lenses
- Inclined image planes

CMO Type
(Common Main Objective)
- Main objective used off-axis
- Varying aberrations on both channels (globe effect)
Historical Development of Surgical Microscopes

1. Head worn loupe (1876)
2. Corneal loupe (von Zehender/Westien 1887)
3. Corneal loupe (Schanz/Czapski 1899)
4. OPMI (Littmann 1953)
5. Contraves Stativ (Yasargil 1972)
Modern surgical microscopes are stereo systems combining ocular and digital imaging.
Surgical Microscope

- HNO

Ref.: C. Zeiss