Diagnostic Medical Image Processing

Introduction

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Endoscopy

Definition

An ***endoscope*** (Greek: endo = inner, scopein= view, inspect) is a tube device for minimally invasive diagnostic medical procedures that allows the inner view and the inner manipulation of the human body.

A simple endoscope has the following three components:

- light source
- optical fibers
- lens system to transmit the signal to the optical fibers
- rigid or non-rigid tube

Examples of Rigid and Flexible Endoscopes

Figure: Rigid (upper) and flexible (lower) endoscopes

Examples of Rigid and Flexible Endoscopes

Figure: Wrapped rigid endoscope with light source

Major Types of Endoscopes

- **arthroscopy**: diagnosis and treatment of interiors of joints
- **bronchoscopy**: diagnosis and treatment of the trachea or the lung's bronchial system
- **colonscopy**: diagnosis and treatment of the inside of the colon
- **cystoscopy**: diagnosis and treatment in urology, where the endoscope is inserted through the urethra
- **thorascopy**: examination and treatment of the organs in the chest.
- **gastroscopy**: examination and treatment of the lining of the esophagus, stomach, and duodenum.
- **laryngoscopy**: examination and treatment of the larynx.
- **laparascopy**: examination and treatment of the interior of the abdominal or pelvic cavity.

History of Endoscopy

1806 Philipp Bozzini introduced the light conductor.

1822 William Beaumont introduced the first endoscope into a human body

1850 Hermann von Helmholtz introduces a special mirroring technique for endoscopy

1879 Maximilian Nitze manufactures the first rigid endoscope

1958 B.I. Hirschowitz introduces the first flexible endoscope (flexoscope)

1976 S.E. Miederer develops the first device for the disinfection of flexible endoscopes

2000 practical use of the video pill (capsule endoscopy)

History of Endoscopy

1942 Heinz Kalk: first laparoscopic puncture of human liver

1980 Kurt Semm: first laparoscopic appendicectomy

1985 Erich Mohe: first laparascopic cholecystectomy

2004 Natural Orifice Transluminal Endoscopic Surgery (NOTES)

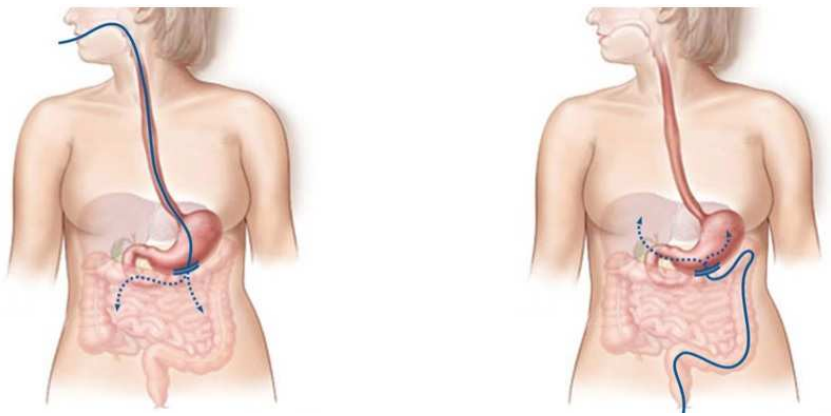

Figure: Transgastric per-oral (left) and transcolonic per-rectal (right) access to the peritoneal cavity (images borrowed from http://www.noscar.org)

Laparoscopic Cholecystectomy

Figure: Laparoscopic cholecystectomy: surgeon (1), monitor (2), assisting surgeon (3), theater nurse (4), anesthesiologist (5, scarcely visible), patient (6), video-endoscopic system (7, scarcely visible) that includes a rack, an endoscopic camera, a light source, a carbon dioxide insufflator and video monitors (2) (image courtesy of Dr. Florian Vogt).

Major Endoscope Research at LME

- image enhancement: undistortion, smoke elimination, homogeneous illumination, elimination of specular reflection, color normalization
- human-endoscope-interface and navigation
- pose estimation of endoscope (incl. hand-eye-calibration)
- 3-D endoscopy, MUSTOF-technology

Figure: Multi sensor time of flight endoscope (MUSTOF endoscope)

Image Pre-Processing in Endoscopic Imaging

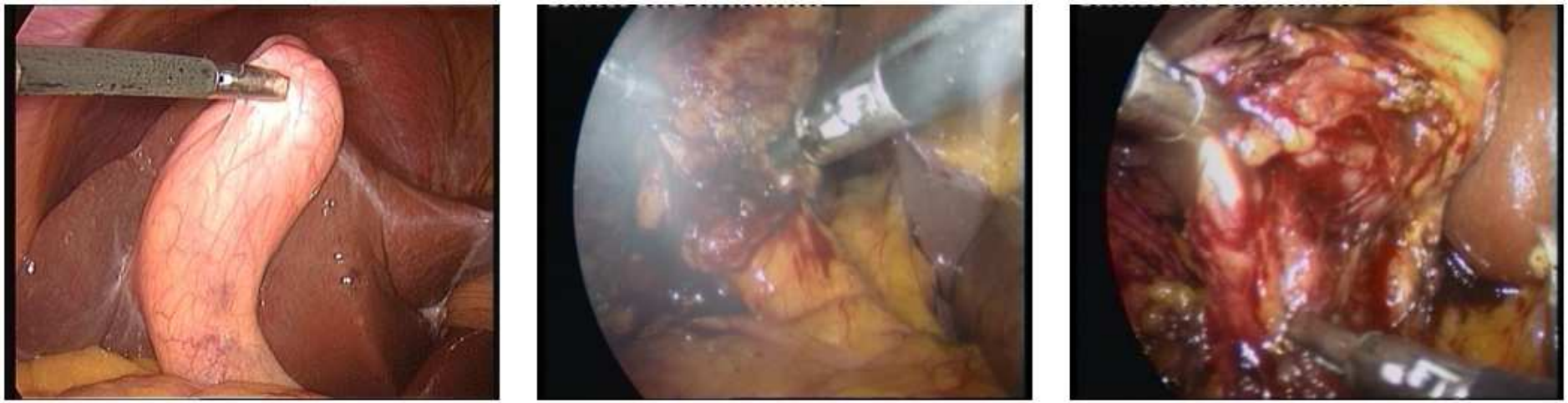

Figure: Examples of degradations in endoscopic images: image distortion (left), where the surgical instrument is bent; smoke (middle) that hampers vision. Specular reflections are in all images, but particularly in the right one (image courtesy of Dr. Florian Vogt).

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Take Home Messages

- Endoscopes work with visible light.
- Endoscopy has a long tradition, but no Nobel Laureates grew out of this field.
- Endoscopy has changed the field of surgery significantly (minimally invasive surgery, keyhole surgery).
- NOTES and 3-D endoscopy define the new paradigm in this field and is a **must** in cutting edge medical image processing research.

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Further Readings

- An overview of current image processing methods in endoscopy is given in:
  Florian Vogt: Augmented Light Field Visualization and Real-Time Image Enhancement for Computer Assisted Endoscopic Surgery, Logos Verlag, Berlin, 2006
- All about NOTES can be found in http://www.noscar.org/
- ... and if you are interested in virtual endoscopy based on CT, you should have a look at:
  Patrick Rogalla, Jer Terwisscha van Scheltinga, and Bernd Hamm: Virtual Endoscopy and Related 3D Techniques, Springer, Heidelberg, 2001.