1

Introduction to Medical Imaging (5XSA0)

Medical image acquisition and analysis: Endoscopy

Fons van der Sommen
(f.v.d.sommen@tue.nl)

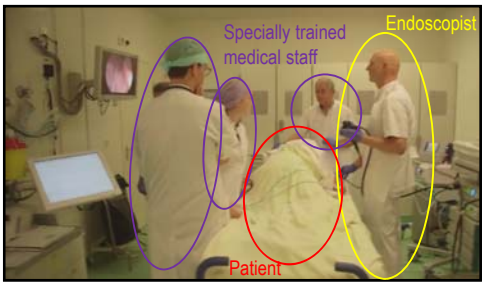
2

Endoscopy: Introduction – (1)

* Endo-scopy: looking inside (the body)
  - Minimally invasive procedure.
  - Mostly through natural openings of the body.

3

Endoscopy: Introduction – (2)



4

Endoscopy: Introduction – (3)

* Types of endoscopic procedures
  - Bronchoscopy (lungs)
  - Colonoscopy (colon)
  - Gastroscopy (stomach & esophagus)
  - Laparoscopy (internal organs)
  - Rhinoscopy (nose)
  - Hysteroscopy (uterus)
  - ….

5

Endoscopy: Introduction – (4)

* Example: gastroscopy (video)

6

Outline

* History
* Data acquisition
  - White light endoscopy
  - Wireless capsule endoscopy
  - Narrow-band imaging
  - Autofluorescence imaging
  - Hyperspectral imaging
* Medical image analysis in endoscopy
  - Example: cancer detection
* Summary

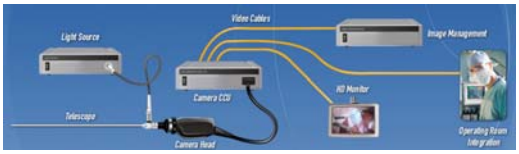
History (1)

* First attempts
  - Bozzini: Lichtleiter (1805) / Desormeaux: Endoscope (1853)
  - Light guiding instruments. *Utenary tract, rectum, bladder.*
* Early 1900s
  - Gastroscope: tube with external light source.
* Fiberscopes (1) (1960s)
  - Capture light through a bundle of flexible glass fibres.
  - Light from an external source through a seperate fiber.

History (2)

* Fiberscopes (2)
  - Use of one fiber and lenses to transfer the image.
* Videoscopes
  - Connect a camera to the fiberscope.
  - Allows for more persons to look at the body interior.
* High Definition (HD) endoscopy
  - Allows to detect very subtle changes in tissue.

Data acquisition

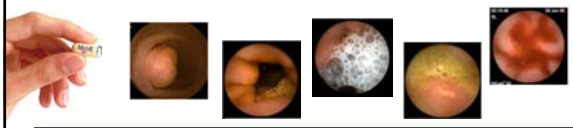


* White-light endoscopy
  - Light source emits light
  - Reflected by surface tissue
  - Captured by a camera

Light source and camera can be at the tip or external

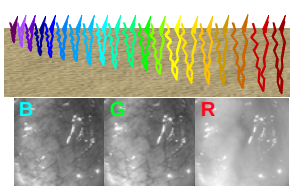
Data acquisition

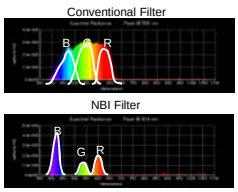
* Wireless Casule Endoscopy (WCE)
  - Given Imaging (2000)
  - 8-hour journey through the gastro-intestinal tract
  - 2-3 frames/sec → 60.000 images
  - 256 x 256 pixels



Data acquisition

* Narrow-band imaging
  - Shorter wavelengths only penertrate top mucosa
  - Narrow the (sensor) bands to better seperate the layers

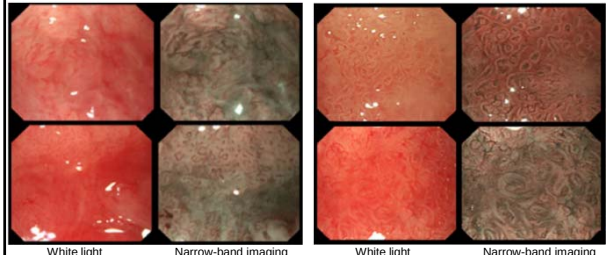




Data acquisition

* Narrow-band imaging: examples

Kara *et al.*, Gastrointest Endosc. 2006 Aug;64(2):155-66.

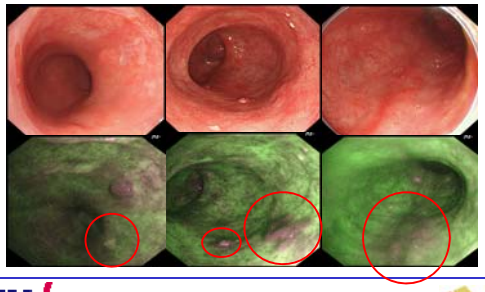


Data acquisition

* Autofluorescence imaging
  - When biological structures are exposed to certain wavelengths, they emit light with a spectral signature.
  - Use light sources at these wavelengths and sensors to capture these spectral signatures.
  - Light Induced Fluorescence Endoscopy (LIFE)

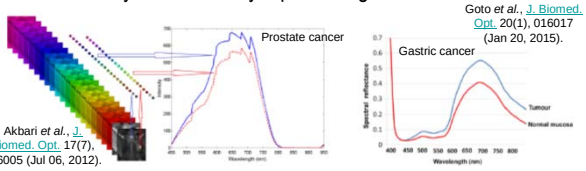
Data acquisition

* LIFE: examples



Data acquisition

* Hyper spectral imaging
  - Divide the spectrum in many bands.
  - Create an intensity spectrum for each pixel.
  - See if you can identify "spectral signatures".



Akbari *et al.*, J. Biomed. Opt. 17(7), 076005 (Jul 06, 2012).

Goto *et al.*, J. Biomed. Opt. 20(1), 016017 (Jan 20, 2015).

Medical image analysis in endoscopy

* Support the endoscopist
  - Identify tumors / malignant lesions
  - Detect bleeding *(remember WCE: 60.000 images!)*
  - Indicate anatomical structures
* Challenges in endoscopic image analysis
  - Dynamic environment
  - Lighting conditions & Specular reflections
  - Intestinal juices
  - Imaging equipment is limited in size! *(Image quality)*

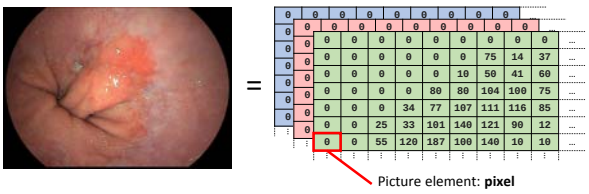
Medical image analysis in endoscopy

* Example:

  Early cancer detection in the esophagus

Example: Early cancer detection

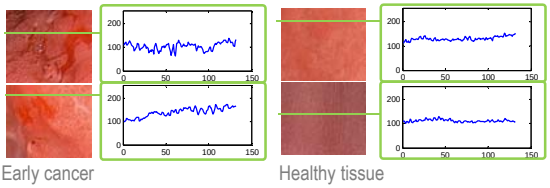
* How can we quantify early cancer?
  - An image is just a set of numbers



19

Example: Early cancer detection

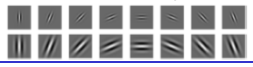
* How can we quantify early cancer?
  - An image is just a set of numbers
  - From literature: Observable difference in color and texture of the surface tissue.



20

Example: Early cancer detection

* How can we quantify early cancer?
  - An image is just a set of numbers
  - From literature: Observable difference in color and texture of the surface tissue.
  - Color = pixel values
    - Use the local mean and variance!
  - Texture = local changes in pixel values
    - Use selective filters to find patterns!

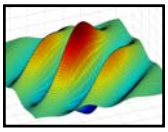


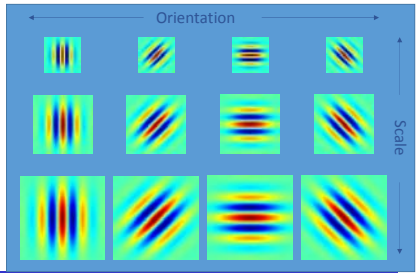
21

Example: Early cancer detection

* What filter should we use?

Good canditate:
Gabor filters

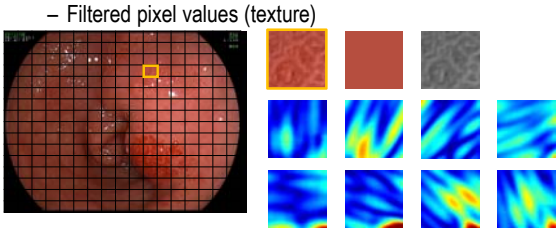




22

Example: Early cancer detection

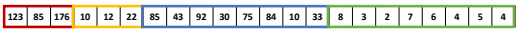
* Compute the local mean and variance of:
  - Pixel values (color)
  - Filtered pixel values (texture)



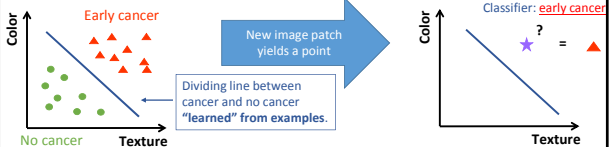
23

Example: Early cancer detection

* How can we use this for a learning system?
  - After quantification: a set of numbers for each image patch

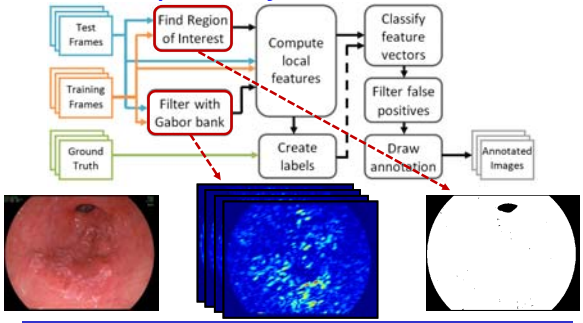


  - What numbers indicate early cancer?

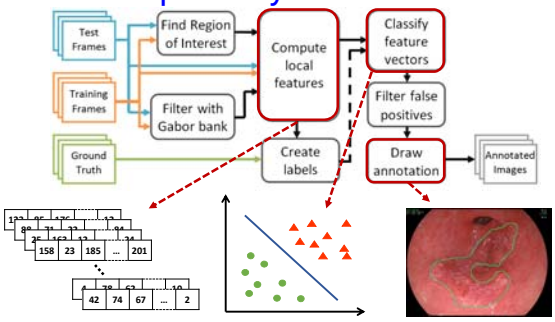


24

Example: Early cancer detection



Example: Early cancer detection

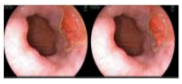


Summary

* Endoscopy
  - Minimally invasive imaging technique.
  - White-light / Wireless Capsule Endoscopy (WCE).
  - Autofluorescence-, Narrow-band-, Hyperspectral imaging.
* Endoscopic image analysis
  - Can be of great benifit to the endoscopists.
  - Challenging due to lighting conditions, small-scale technology and dynamic environment.

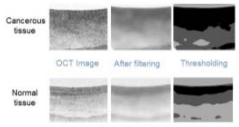
Internships

* Cancer detection using HD endoscopy



TU/e

* Computer-aided diagnosis using OCT imaging



TU/e am