Smart Diagnosis

Technische Universiteit Eindhoven University of Technology

SUPPORTIVE AUTOMATIC ANNOTATION OF EARLY ESOPHAGEAL CANCER USING LOCAL GABOR AND COLOR FEATURES

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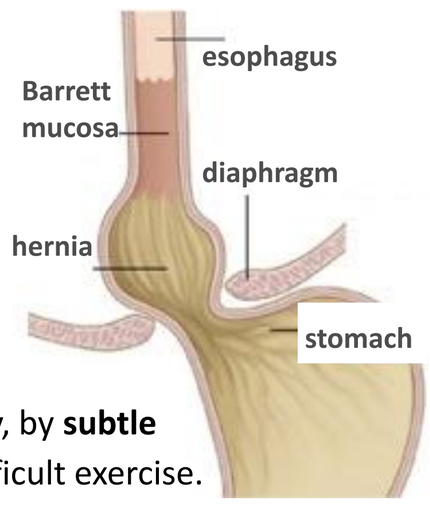
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ABSTRACT: We present a novel algorithm for automatic detection of early cancer in HD endoscopic images. The algorithm detects the region of interest and computes local color- and texture features based on the original and the Gabor-filtered image. Using spectral analysis of early cancerous tissue we select optimal filter parameters. The features are classified by a trained SVM, after which the region containing early cancer is annotated. For 7 patients, we compare 32 annotations made by the algorithm with the delineations made by an expert gastroenterologist, yielding an accuracy of 85.7%.

Background

Esophageal cancer

- Fastest rising type of cancer in the Western world.
- 10-15% five-year survival rate.
- 80% of patients diagnosed at a late stage.
- Late diagnosis → esophagectomy → **poor prognosis**



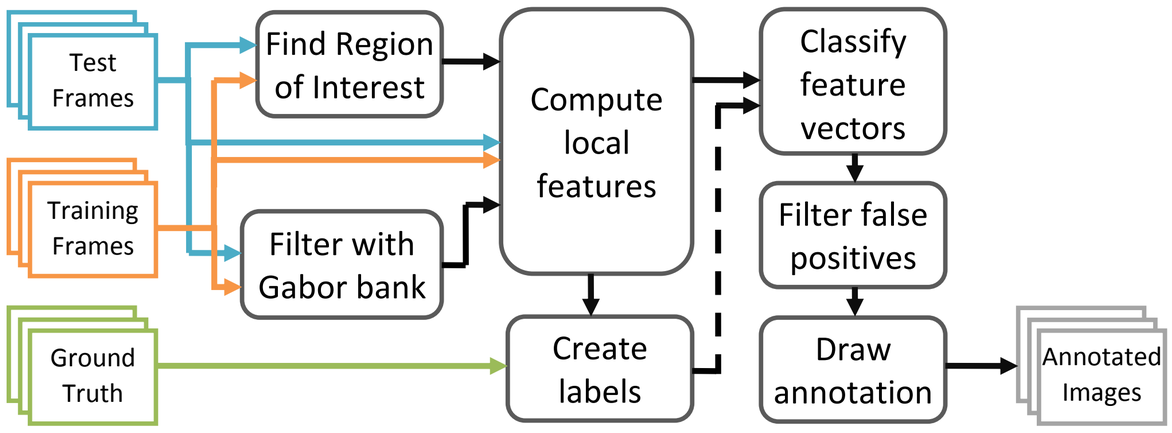
High Definition Endoscopy

- Enables expert physician to identify the disease early, by **subtle differences in color and texture**, but it remains a difficult exercise.
- Early diagnosis → cancer removed locally → **good prognosis**

Goal of this study

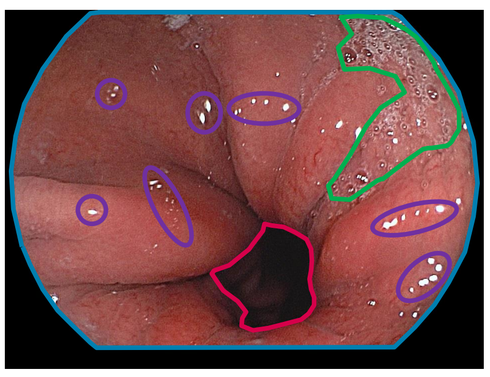
Automatically find and annotate early Barrett's cancer in HD endoscopic images.

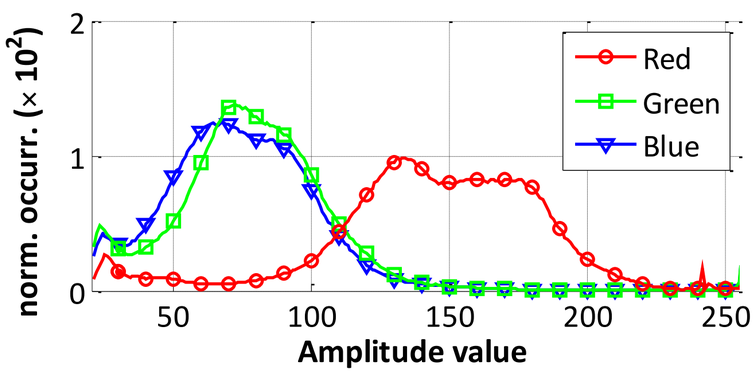
Computer-Aided Detection (CAD) system



Finding the Region of Interest

- Some parts of the image are **not relevant** for cancer analysis:
  - ➢ **Intestinal juices, Lumen, Specular Reflections, Border**

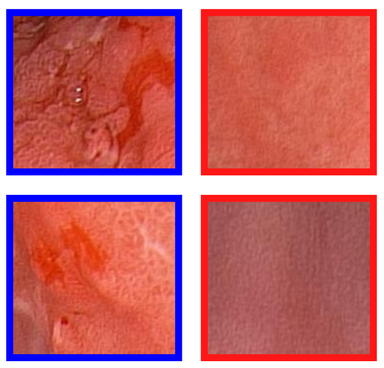




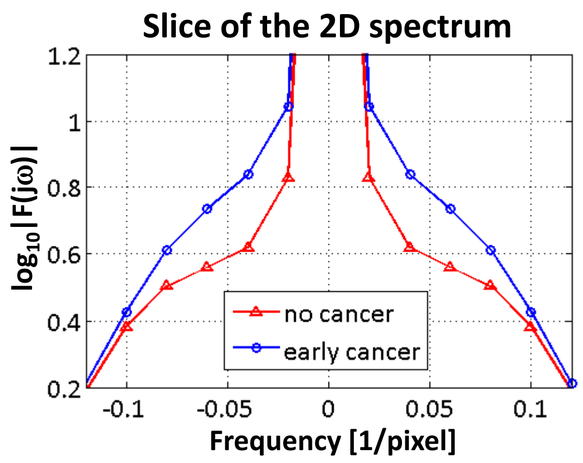
- Use histogram-based **thresholding** for segmentation of these elements
  - Red component: information typically in the **high amplitude range** → **high-pass** threshold for excluding the dark **lumen** and **image border**.
  - Blue component: information typically in the **low amplitude range** → **low-pass** threshold for excluding the bright **reflections** and **juices**.

Gabor filters for early cancer

Cancerous tissue shows **different texture**: analyze the frequency spectrum:

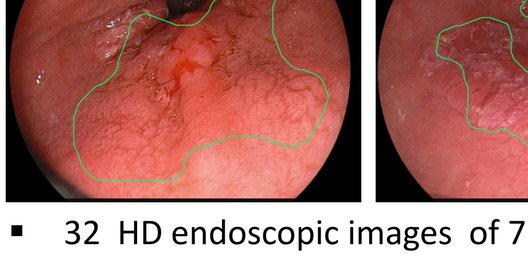


↑ Examples of **cancerous** and **non-cancerous** tissue



Clear difference observed in a omnidirectional band around $\omega = 0.05$ Hz

➢ Place the Gabor filters on this frequency in all orientations:



↑ Real parts of the Gabor filters

Half-peak isolines of the Gabor spectra



Features & Classification

Scan the image with a 50×50 pixel window, and for each window:

1) Take the mean and variance of the absolute **Gabor filter response;**
2) Add **sample mean and variance per color component** for color information;
3) Normalize to range $[-1, +1]$ and classify with a **Support Vector Machine**.

Clinical validation & Results

- 32 HD endoscopic images of 7 patients
- Leave-one-out cross-validation on patient basis

	Lesions detected	Pixel accuracy
Overall	36 / 38	85.7%
P1	2 / 2	77.8%
P2	6 / 6	89.0%
P3	2 / 4	88.7%
P4	7 / 7	84.5%
P5	7 / 7	85.4%
P6	8 / 8	80.9%
P7	4 / 4	90.5%

Detection results ↑

Conclusions

- The **deviating texture patterns** associated with early Barrett's cancer, that are described in literature, are **observed in the frequency domain**.
- **Gabor filters** are able to **capture these patterns.**
- The local mean and variance of (1) the Gabor filter output and (2) the color components prove to be **good features for describing early cancer**.