Computer-aided detection of early esophageal cancer

Fons van der Sommen

Over 30 times increased risk of esophageal cancer!

Treatment: late detection

Treatment: early detection = very hard...

Could my endoscope detect early cancer?

Goal: computer-aided detection system

Can we develop a system that helps the gastroenterologist find early Barrett’s cancer?

How do experts find these early cancers?

From literature:

• “... the endoscope should be gradually withdrawn to examine the inflated Barrett’s segment in overview for any mucosal irregularities”

• “The primary step in diagnosis is to identify the presence of an area of the mucosa slightly discolored (more pale or more red), an irregular microvascular network, or a slight elevation or depression...”

Quantify discriminative information

• Abnormal color

• Irregular mucosal patterns
Spectral analysis

Each image patch quantified by a set of numbers:

Average color | Std. dev. color | Average texture | Std. dev. texture
---|---|---|---
123 | 85 | 176 | 10 | 12 | 22 | 85 | 43 | 92 | 30 | 75 | 84 | 10 | 33 | 8 | 3 | 2 | 7 | 6 | 4 | 5 | 4

Quantify local image information

Machine learning

\[ \mathbb{R}^D \rightarrow \text{Model} \rightarrow \mathbb{R}^C \]

Mapping learned from examples
Machine learning

(Classification)

Number of classes

Features

How good is our classification model?

Experts

Model

System Annotation

van der Sommen et al., Endoscopy 2016
However, what is not captured by the camera, cannot be detected...
Clinical prediction model
(Swager et al., Gastrointestinal Endoscopy 2016)

<table>
<thead>
<tr>
<th>VLE PREDICTION SCORE</th>
<th>ROC Curve</th>
<th>AUC = 0.81</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layering</td>
<td>Layering present (&gt;50%)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Lack of layering (&lt;50%)</td>
<td>6</td>
</tr>
<tr>
<td>VLE surface signal</td>
<td>Surface signal &lt; subsurface</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Surface signal = subsurface (&gt;50%)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Surface signal &gt; subsurface (&lt;50%)</td>
<td>3</td>
</tr>
<tr>
<td>Gland architecture</td>
<td>Irregular glands (0-5 glands)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Irregular glands (&gt;5)</td>
<td>5</td>
</tr>
</tbody>
</table>

Quantify information: Layer Histogram

van der Sommen et al., SPIE Medical Imaging 2017
Conclusions

As the amount of medical data and the signal complexity increase, computer vision methods can be of great help to medical doctors.

I. A computer might recognize patterns which appear to be noise to the human eye;

II. Algorithms are generally much faster in signal interpretation and can learn from millions of examples;

III. Machine learning algorithms can handle many signals at once, enabling large-scale, multi-modal analysis.

In addition, we found that using prior clinical knowledge typically leads to the best results, especially when not much data is available.