Detection of skin cancer

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DTU Informatics
Department of Informatics and Mathematical Modeling
Biomedical

- Neuroimaging (PET, EEG, fMRI)
- EEG sensor for early warning of low blood sugar
- Improved SP in hearing aids
- Cognitive modeling

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Extraction of meaningful and actionable information by ubiquitous learning from data

Skin cancer

- More than 800 cases in Denmark yearly
- Annual increase 5-10%

- Benign nevi
- Atypical nevi
- Malignant melanoma

- Inexperienced doctors detect 31%
- Experienced doctors detect 63-75%
Skin cancer

- More than 800 cases in Denmark yearly
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- Benign nevi
- Atypical nevi

Objectives

- Develop a cost-effective and practical tool for diagnosis support
- Gain more insight into the understanding of factors in the development of skin cancer
Outline

- Machine learning framework for skin cancer detection
  - Involves all issues of machine learning
- An image processing system for skin cancer detection
  - Involves feature selection, projection and integration
    - Involves linear and nonlinear classifiers
- Other approaches
- Summary
The potential of learning machines

- Most real world problems are too complex to be handled by classical physical models
- In most real world situations there is access to data describing properties of the problem
- Learning machines can offer
  - Learning of optimal prediction/decision/action
  - Adaptation to the usage environment
  - New insights into the problem and suggestions for improvement

A short history of learning machines

- ADALINE
- Neural nets
- Kernel machines
- Mixture of experts
- Gaussian processes
Issues in machine learning

**Data**
- quantity
- stationarity
- quality
- structure

**Features**
- representation
- selection
- extraction
- integration

**Models**
- structure
- type
- learning
- selection and integration

**Evaluation**
- performance
- robustness
- complexity
- interpretation and visualization
- HCI

**Issues in machine learning**

- parametric: linear, nonlinear, mixture models
- non-parametric: kernel, Gaussian processes, clustering
- noise models
- integration of prior and domain knowledge
- cost function
- maximum likelihood
- Bayesian
- online vs. off-line

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Dermatoscopy imaging technique

Domain knowledge – dematoscopic features
Feature extraction

Median filtering

Removal of impulsive noise
Feature extraction

Preprocessing

Segmentation

Feature description

Lesion asymmetry (sum of SD moments in first sum of asymmetry)

Edge discrimination (measure edge gradient in grey-scale image)

Golgi discrimination (compares with other permutations)
Feature extraction

1. Image acquisition
   - Dermaphot scanner
   - Ektachrome scanner
   - RGB image (600x390)

2. Preprocessing
   - Neuron filtering (Tikhonov)
   - 1st principal component
   - Segmentation
   - Optimal thresholding
   - Lesion shape mask

3. Feature description
   - Lesion asymmetry (measured using 1st and 2nd moments in first moments of asymmetry)
   - Edge asymmetry (measures edge gradient in grey-scale image)
   - Edge thickness (comparing with outer protoplasmic

Assymetry
Feature extraction

Edge abruptness

Edge abruptness (measures edge gradient) in grey-scale image

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Edge abruptness

Feature extraction
Color prototypes

Segmentation into color prototypes
Bayes classifier

\[ p(C_i|x) = \frac{p(x|C_i)p(C_i)}{p(x)} \]

where

\[ p(x) = \sum_{i=1}^{c} p(x|C_i)p(C_i) \]
Neural network classifier

Likelihood learning

\[ p(y|x, w) = \prod_{i=1}^{c} p(y_i|x, w) = \prod_{i=1}^{c} (\bar{y}_i(w))^{y_i} \]

\[ p(T|w) = \prod_{k=1}^{N} p(y(k)|x(k), w) = \prod_{k=1}^{N} \prod_{i=1}^{c} [\bar{y}_i(x(k), w)]^{y_i(k)} \]

Training set: N samples of related x(k) and classes y(k)
Generalization

- How well are we doing on future data from the same problem?

\[ G(w) = E_{x,y} \{ \ell(x, y, w) \} = \int \ell(x, y, w)p(x, y) \, dx \, dy \]
## Confusion matrix

Confusion matrix for test set

<table>
<thead>
<tr>
<th></th>
<th>Benign nevi</th>
<th>Atypical nevi</th>
<th>Melanoma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benign nevi</strong>†</td>
<td>0.732 ± 0.019</td>
<td>0.727 ± 0.000</td>
<td>0.241 ± 0.037</td>
</tr>
<tr>
<td><strong>Atypical nevi</strong>†</td>
<td>0.032 ± 0.017</td>
<td>0.000 ± 0.000</td>
<td>0.000 ± 0.019</td>
</tr>
<tr>
<td><strong>Melanoma</strong>†</td>
<td>0.236 ± 0.013</td>
<td>0.273 ± 0.000</td>
<td>0.730 ± 0.024</td>
</tr>
</tbody>
</table>

† indicates the estimated output classes.
Other techniques – Raman spectroscopy

- A NIR laser beam excites molecules in the skin
- The Raman scattering is a frequency shift in the reflected light which is related to the molecule structure

Raman spectrum

- MM: malignant melanoma
- NV: pigmented navi
- BCC: basal cell carcinoma
- SK: seborrhoeic keratosis
- NOR: normal
Raman classification results

<table>
<thead>
<tr>
<th></th>
<th>BCC</th>
<th>MM</th>
<th>NOR</th>
<th>NV</th>
<th>SK</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCC</td>
<td>97.9</td>
<td>4.5</td>
<td>1.1</td>
<td>0.0</td>
<td>4.3</td>
</tr>
<tr>
<td>MM*</td>
<td>0.0</td>
<td>85.5</td>
<td>0.0</td>
<td>2.4</td>
<td>0.0</td>
</tr>
<tr>
<td>NOR*</td>
<td>0.0</td>
<td>0.0</td>
<td>95.5</td>
<td>19.5</td>
<td>0.0</td>
</tr>
<tr>
<td>NV*</td>
<td>2.1</td>
<td>10.0</td>
<td>3.4</td>
<td>78.0</td>
<td>0.0</td>
</tr>
<tr>
<td>SK*</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>95.7</td>
</tr>
</tbody>
</table>

Ref: Sigurdur Sigurdsson  *'s are predicted values using a NN

Further reading

- Have, A. S., *Datamining on distributed medical databases*, Informatics and Mathematical Modelling, Technical University of Denmark, DTU, 2003
- Papers accessible via [http://isp.imm.dtu.dk](http://isp.imm.dtu.dk)
Related courses

- 02450 Introduction to Machine Learning and Data Modeling
- 02451 Digital Signal Processing
- 02457 Nonlinear Signal Processing
- 02459 Machine Learning for Signal Processing
- 02501 Digital image analysis, vision and computer graphics
- 02505 Medical Image Analysis
- 31565 Advanced topics in Biomedical Signal Processing

Summary

- Machine learning is, and will become, an important component in most real world applications
- Designing a system involves cross-disciplinary competence – domain knowledge, features, classifiers etc.
- Automatic detection of skin cancer for diagnosis support is possible