Detection of skin cancer

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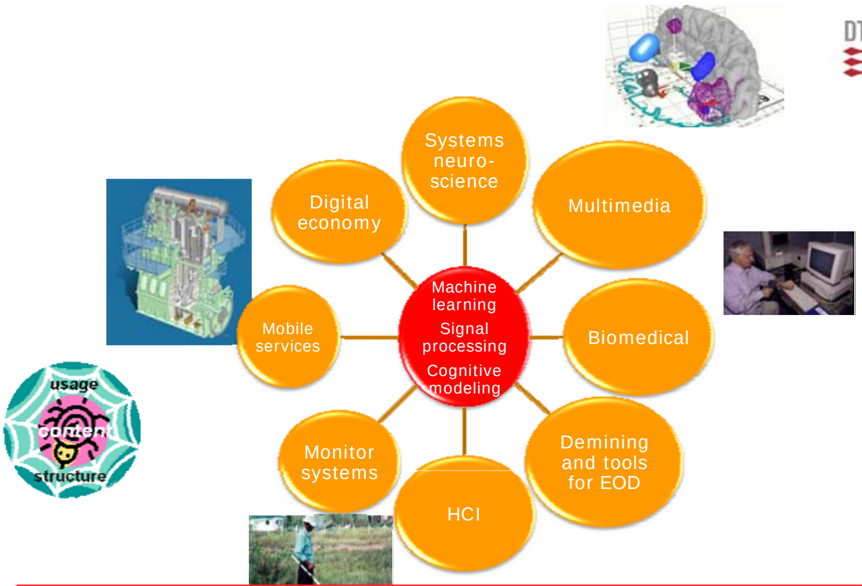
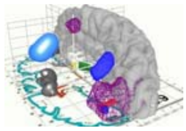


extraction of meaningful and actionable information by ubiquitous learning from data



DTU

Biomedical

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

Systems neuro-

www.intelligentsound.org

www.cimbi.org

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and tools for EOD

HCI

extraction of meaningful and actionable information by ubiquitous learning from data

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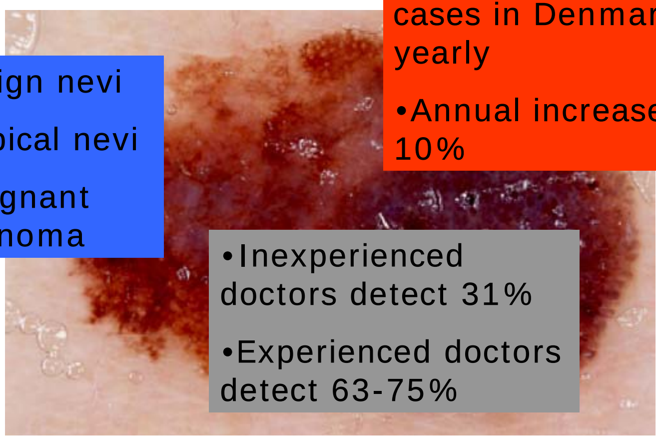
Skin cancer



- Benign nevi
- Atypical nevi
- Malignant melanoma

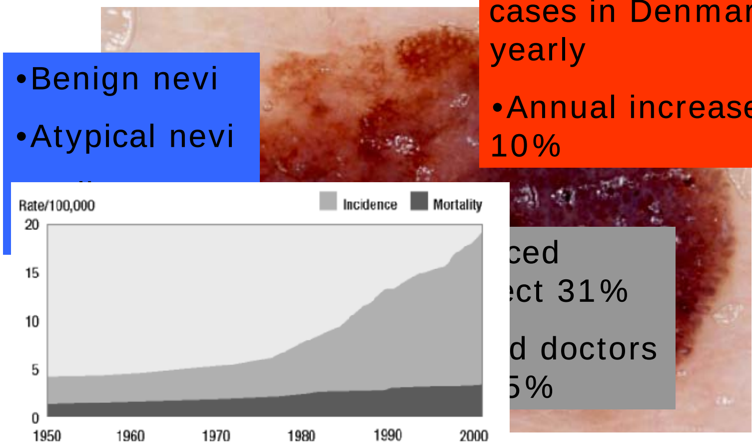
- More than 800 cases in Denmark yearly
- Annual increase 5-10%

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

Skin cancer

- Benign nevi
- Atypical nevi

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



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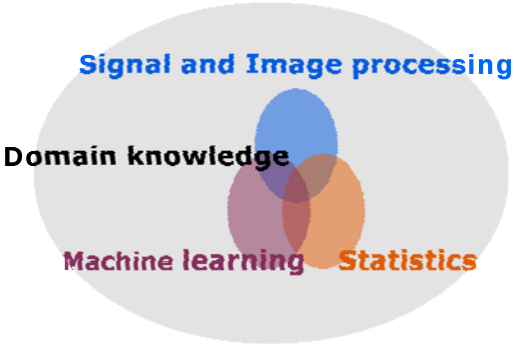
ect 31%

d doctors
5%

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

Cross-disciplinary research



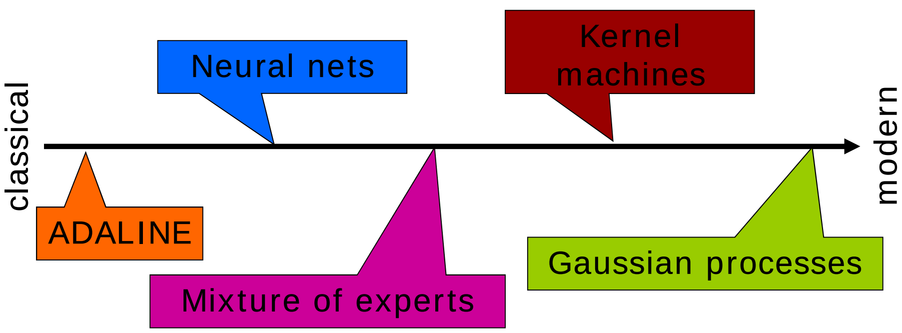
Outline

- 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



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

Data
- quantity
- stationarity
- quality
- structure

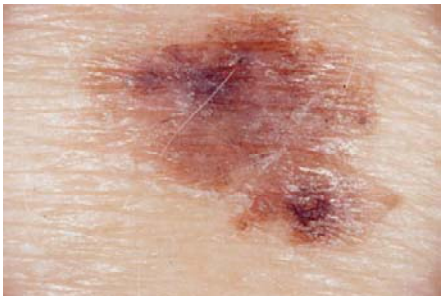
Features
- unsupervised
- semi-supervised
- supervised

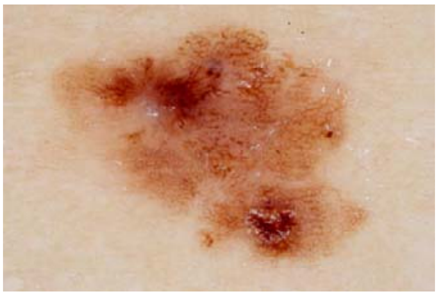
Models
- structure
- type
- learning

- parametric: linear, nonlinear, mixture models
- non-parametric: kernel, Gaussian processes, clustering
- noise models
- integration of prior and domain knowledge

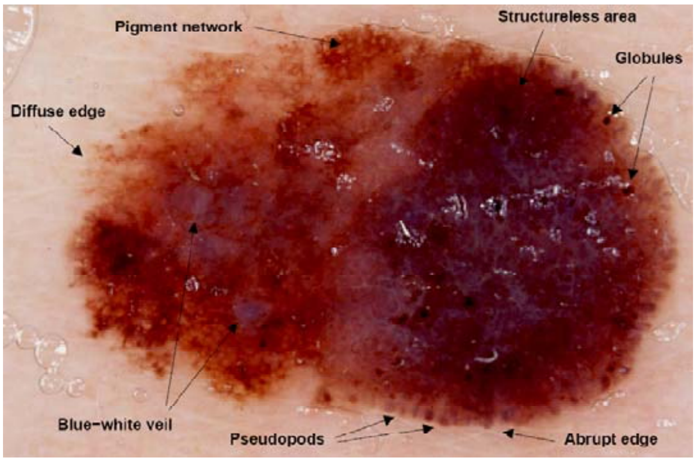
- cost function
- maximum likelihood
- Bayesian
- online vs. off-line

Dermatoscopy imaging technique

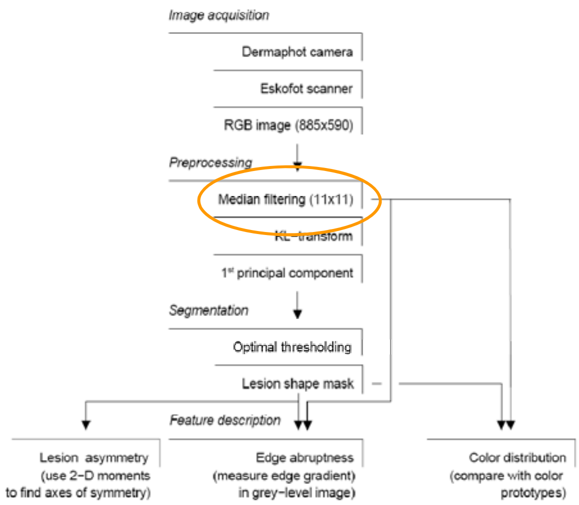




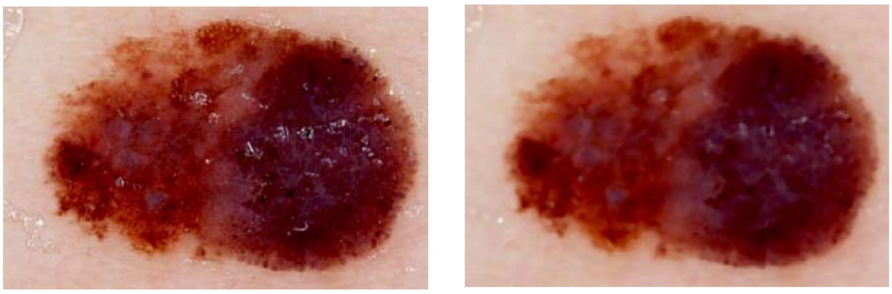
Domain knowledge – dematoscopic features



Feature extraction

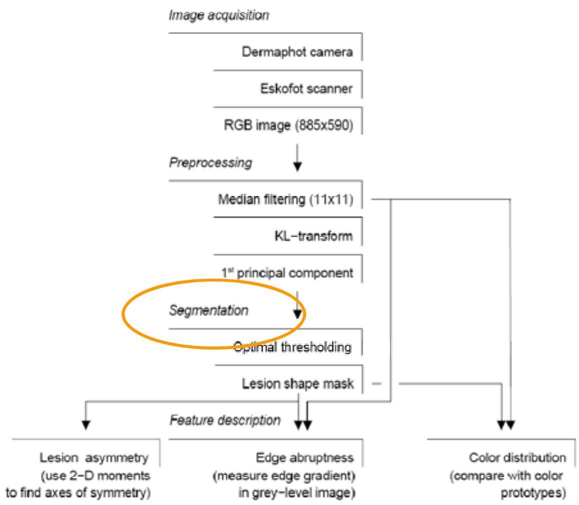


Median filtering

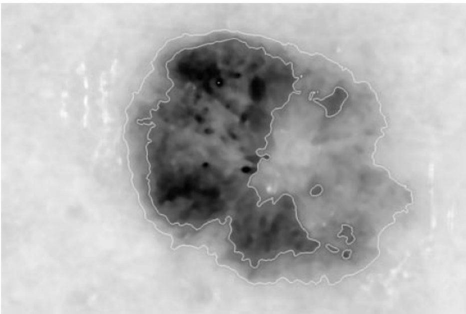


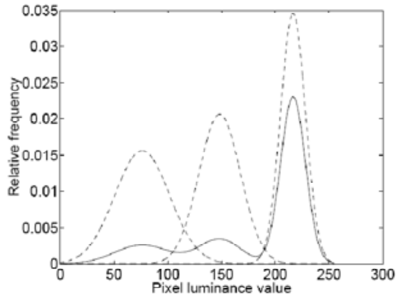
Removal of impulsive noise

Featu

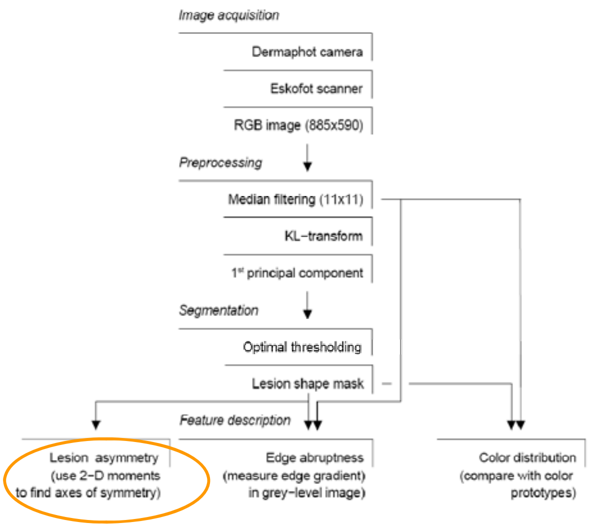


Segmentation

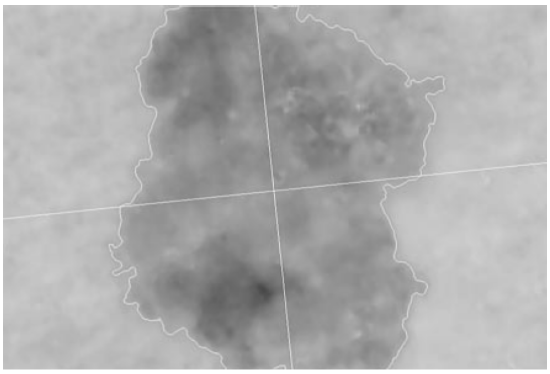




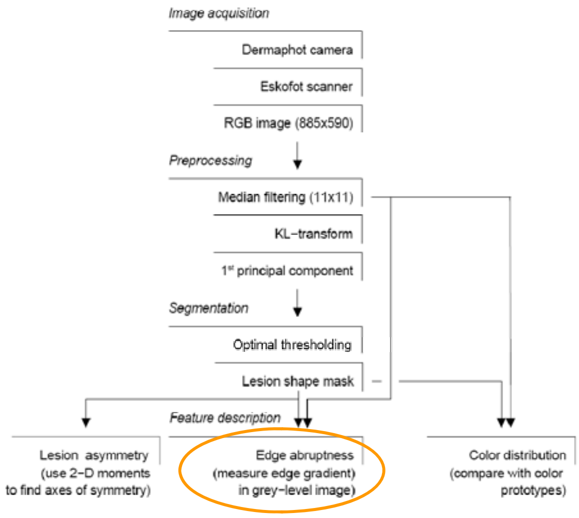
Feature extraction



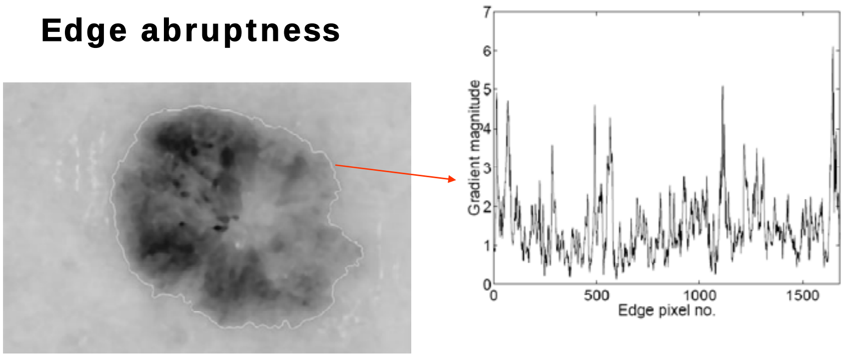
Assymetry



Feature extraction



Edge abruptness



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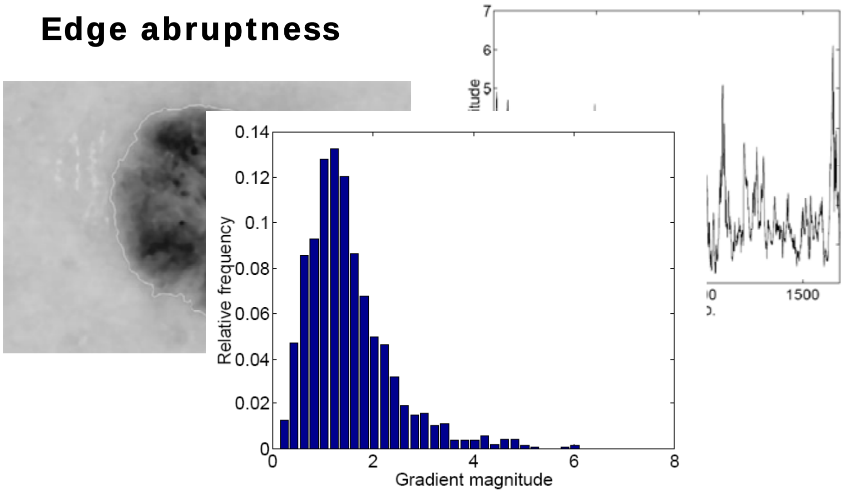
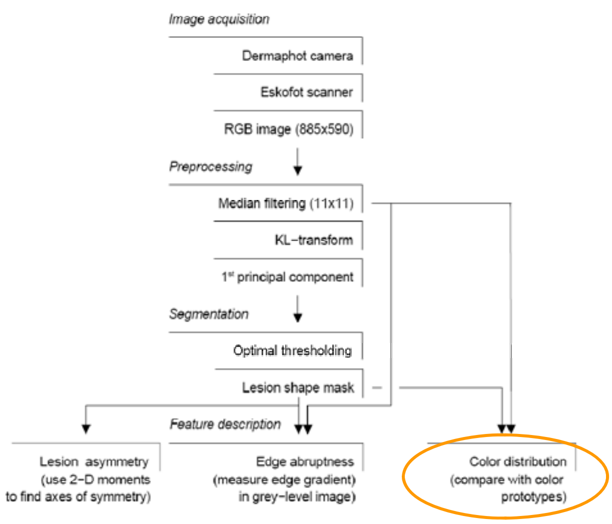
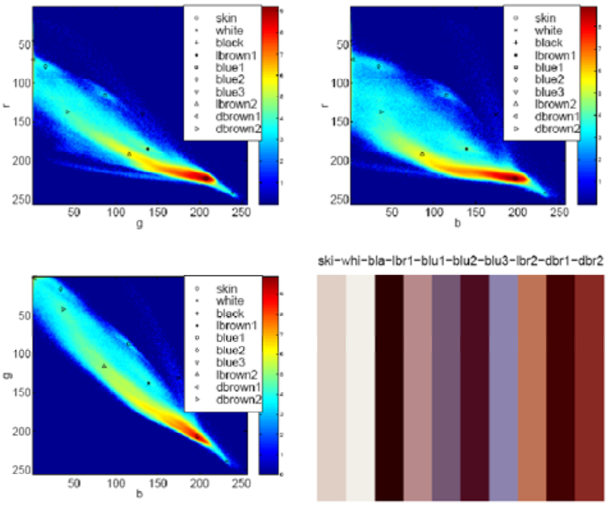


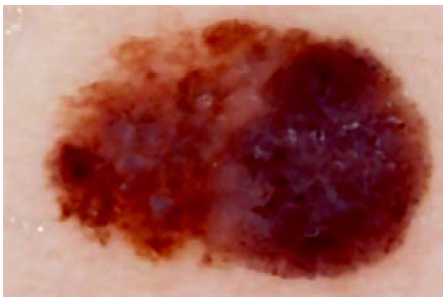
Feature extraction

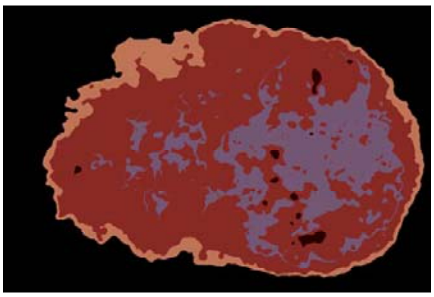


Color



Segmentation into color prototypes





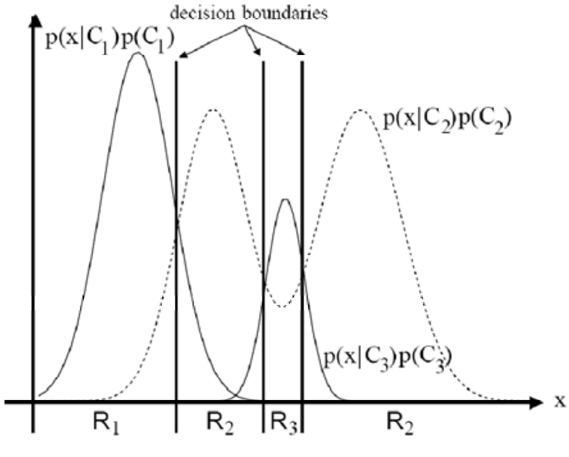
Bayes classifier

$$p\left(\mathcal{C}_i|\boldsymbol{x}\right) = \frac{p\left(\boldsymbol{x}|\mathcal{C}_i\right)p\left(\mathcal{C}_i\right)}{p(\boldsymbol{x})}$$

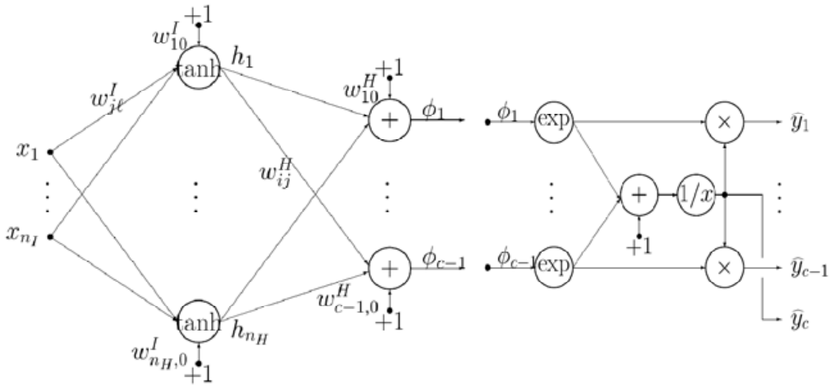
where

$$p\left(\boldsymbol{x}\right) = \sum_{i=1}^{c} p\left(\boldsymbol{x}|\mathcal{C}_i\right)p\left(\mathcal{C}_i\right)$$

Bayes classifier



Neural network classifier



Likelihood learning

$$p(\boldsymbol{y}|\boldsymbol{x},\boldsymbol{w}) = \prod_{i=1}^{c} p(y_i|\boldsymbol{x},\boldsymbol{w}) = \prod_{i=1}^{c} (\widehat{y}_i(\boldsymbol{w}))^{y_i}$$

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

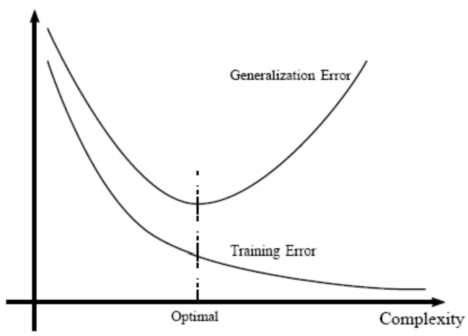
Training set: N samples of related **x**(k) and classes **y**(k)

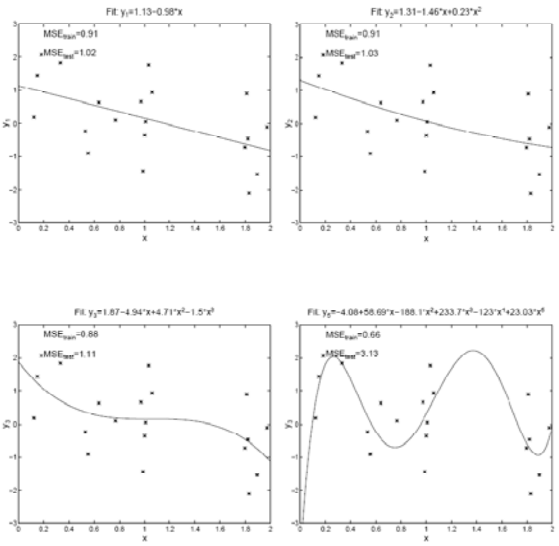
Generalization

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

$$G(\widehat{\boldsymbol{w}}) = E_{\boldsymbol{x},\boldsymbol{y}}\left\{\ell(\boldsymbol{x},\boldsymbol{y},\widehat{\boldsymbol{w}})\right\} = \int \ell(\boldsymbol{x},\boldsymbol{y},\widehat{\boldsymbol{w}})p(\boldsymbol{x},\boldsymbol{y})\,d\boldsymbol{x}d\boldsymbol{y}$$

Bias Variance dilemma





Confusion matrix

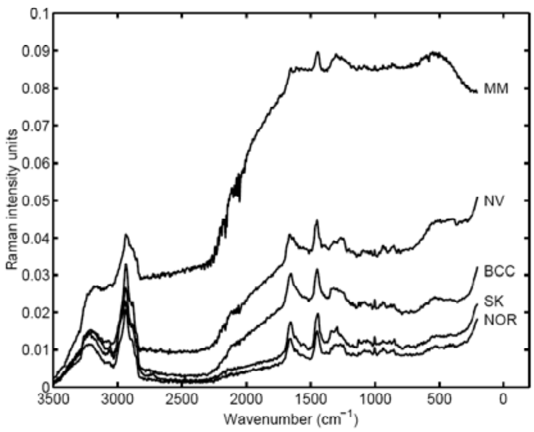
Confusion matrix for test set	Pruned neural classifier: Benign nevi	Atypical nevi	Melanoma
Benign nevi†	0.732 ± 0.019	0.727 ± 0.000	0.241 ± 0.037
Atypical nevi†	0.032 ± 0.017	0.000 ± 0.000	0.009 ± 0.019
Melanoma†	0.236 ± 0.013	0.273 ± 0.000	0.750 ± 0.024

† 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

	BCC	MM	NOR	NV	SK
BCC*	97.9	4.5	1.1	0.0	4.3
MM*	0.0	85.5	0.0	2.4	0.0
NOR*	0.0	0.0	95.5	19.5	0.0
NV*	2.1	10.0	3.4	78.0	0.0
SK*	0.0	0.0	0.0	0.0	95.7

Ref: Sigurdur Sigurdsson

*'s are predicted values using a NN

Further reading

- Hintz-Madsen, M., *A probabilistic framework for classification of dermatoscopic images*, pp. 156, Informatics and Mathematical Modelling, Technical University of Denmark, DTU, 1998
- Sigurdsson, S., *A Probabilistic Framework for Detection of Skin Cancer by Raman Spectra*, pp. 202, Informatics and Mathematical Modelling, Technical University of Denmark, DTU, 2003
- 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

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