Breast Cancer - FACTS:

☑ Breast carcinoma leading cause of cancer death in women
☑ Every 8-10th woman affected during lifetime
☑ About 4000 new cases/a in Austria
☑ Clustered microcalcifications one of early sign's
Breast Cancer - FACTS:

SURVIVAL vs TUMOR SPREAD

- Total
- Local
- Regional
- Metastasis
- Unstaged
Mammography - TECHNIQUE:
Mammography - REPORTING:

- Clustered Microcalcifications are early signs of breast cancer (bright spots)
  - Size: 0.2-0.5 mm - search with a magnifying glass
  - Difficult perception in low contrast areas
  - Differentiate: cancerous vs non-cancerous
Mammography - DILEMMA:

- Special training of radiologists necessary
- Positive predictive value of radiologists: 20%
- „Double Reading“ (independent reporting by 2 radiologists): improves accuracy by 5 - 15%
Artificial Intelligence in Mammography -

HYPOTHESIS:

- Clustered microcalcifications be found reliably found by a computer application
- and a discrimination between cancerous and non cancerous microcalcifications be done using neuronal nets
Mammography - VISION

☑ CAD System (Computer Aided Diagnosis) can act as "never tired, second reader"
Patient Database:
- 100 patients = 272 Images with Mc´s
- High resolution film digitalization:
  8000x6000x15 -> about 90 Mbyte/image
- Resolution for image processing: 91.5 µm
ANN & Mammography - GROUNDTRUTH:

- All patients operated and biopsy reports available:
  - 54 malignant, 46 benign
- All patients rated to be:
  - benign, indeterminate, malignant
- Manual marking of:
  - 828 indiv. microcalcifications
  - 735 artifacts
ANN & Mammography - HARD & SOFT:

☑️ **Hardware:**
- SunSparc20
- Neurocomputer Synapse-1 (SNAT):

☑️ **Software:**
- Image Processing: IDL 5.0, Creaso Research System
- ANN - Synapse-1: neuronal Application Language (SNAT, Germany)
- C++ libraries
ANN & Mammo - WORKFLOW

Background correction

Detection:

Feature Extraction

Classification:

Feature Extraction

ANN

ANN

malign

benign

typical

indeterminate
ANN & Mammography - BACKGROUND KORRECTION
ANN & Mammography - FEATURES FOR DETECTION:

☑️ Linefeatures:
ANN & Mammography - FEATURES FOR DETECTION:

☑ Line features:
## RESULTS DETECTION:

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>min</th>
<th>max</th>
<th>mean</th>
<th>var</th>
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<tr>
<td>local contrast (object)</td>
<td>0.930</td>
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Az = 0.96
Sensitivity = 0.90
Specificity = 0.90
Mean vector of population: \( \mathbf{m}_x = \mathbb{E}\{\mathbf{x}\} \)
Covariance matrix: \( \mathbf{C}_x = \mathbb{E}\{(\mathbf{x} - \mathbf{m}_x)(\mathbf{x} - \mathbf{m}_x)^T\} \)
Calculate eigenvectors of \( \mathbf{C}_x \), and transformation matrix \( \mathbf{A} \)
Transform image: \( \mathbf{y} = \mathbf{A}(\mathbf{x} - \mathbf{m}_x) \) - Hotelling Transformation
ANN & Mammography - FEATURES FOR CLASSIFICATIONS

- Extension in 8 directions
- „Minimum Enclosing Rectangle“:
  - Center of gravity, excentricity, aspect-ratio
  .......

![Diagram of mammography features with annotations]
Features of individual microcalcifications:

- Mean value of greylevels of pixels within one mc
- Local contrast of one mc
- Border gradients
- Area, perimeter and compactness ($P^2/A$)
ANN & Mammography - FEATURES FOR CLASSIFICATIONS

- Clustering - recursive algorithm
- Area of the cluster - Convex Hull Procedure
Features from „Convex Hull“:
- Number of mc’s
- Area, perimeter and compactness of cluster
- Density (number of mc’s/A)
- Inter mc - distances
- Descriptive statistics of individual mc features
ANN & Mammography - FEATURES FOR CLASSIFICATIONS

- Total features: n=73
- Automatic selections process: patient based

"Leave-one-Out Test" for every feature:

10 suited for differentiation typical - indeterminate
12 suited for differentiation benign - malignant
Sensitivity: 98%
Specificity: 47%

Az = 0.8749