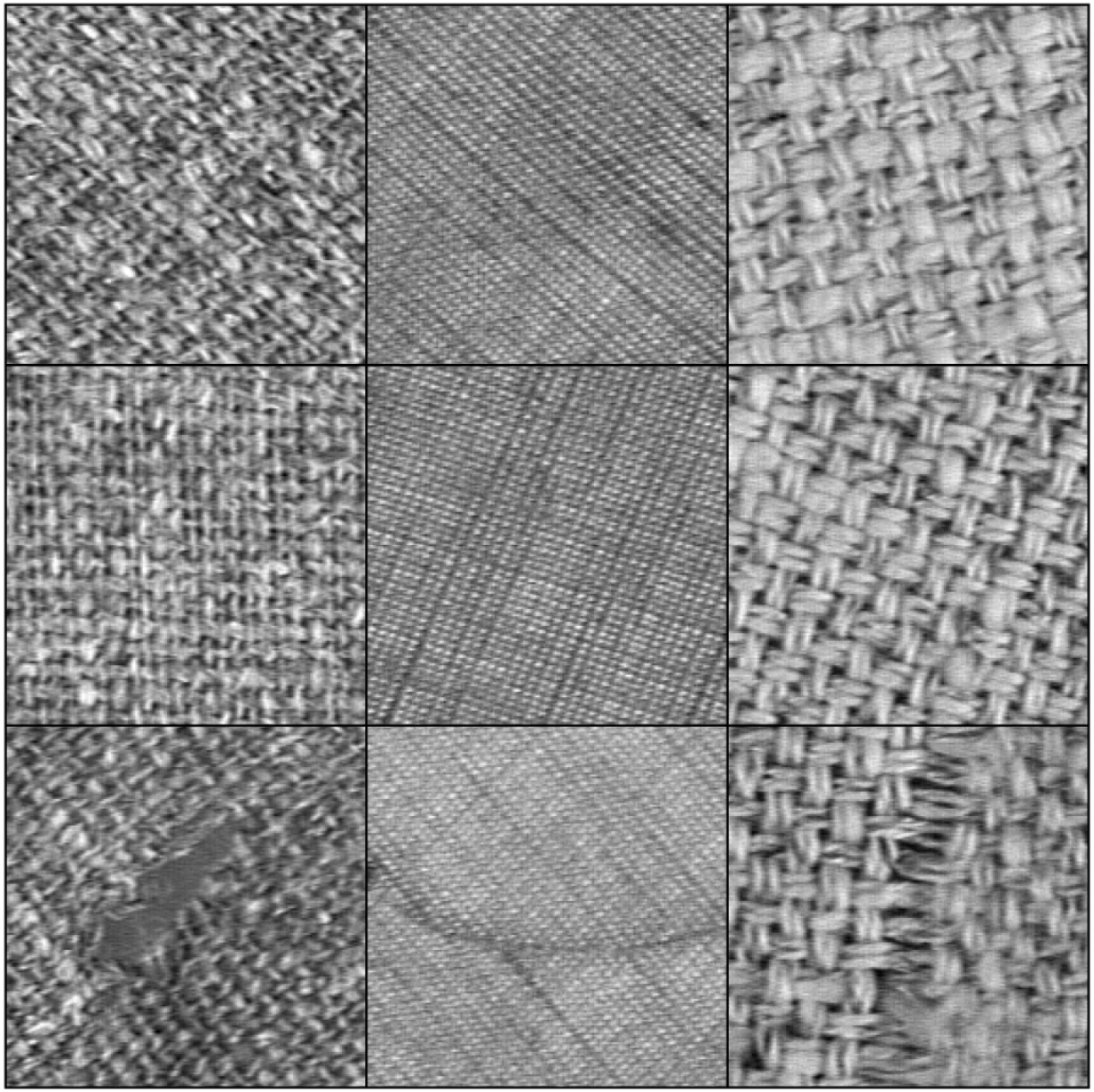
# Chap. 5b
# Applications:
# Invariants over group means

- visual inspection tasks (fabrics)
- image search engines (query by example) SIMBA and MICHELSCOPE
- automatic classification of pollen

# Visual inspection of textiles with anisotropic texture

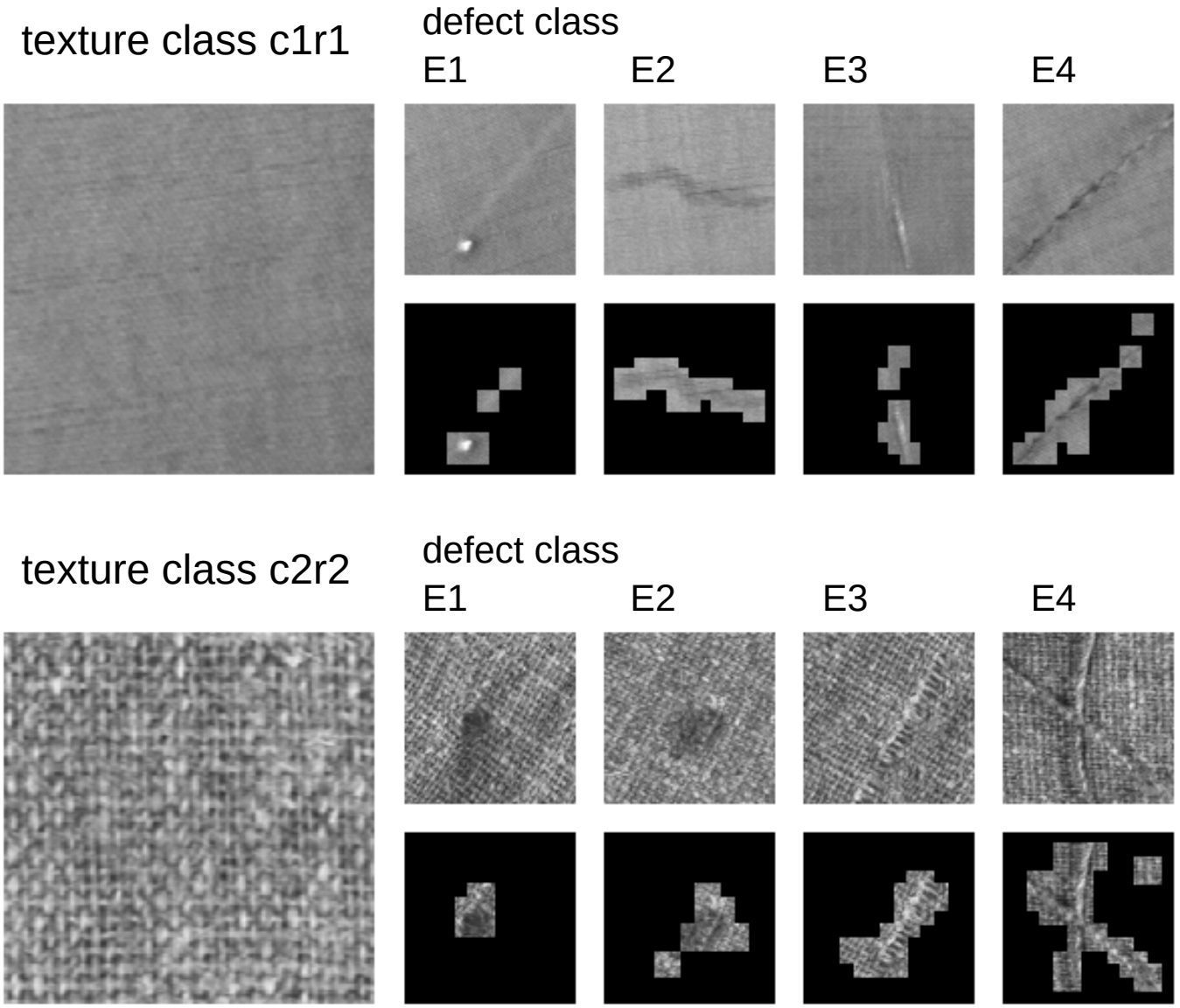


Textile database TILDA

http://www.informatik.uni-freiburg.de/~lmb/tilda (ca. 3200 images)

# Texture defect detection for textiles/fabrics

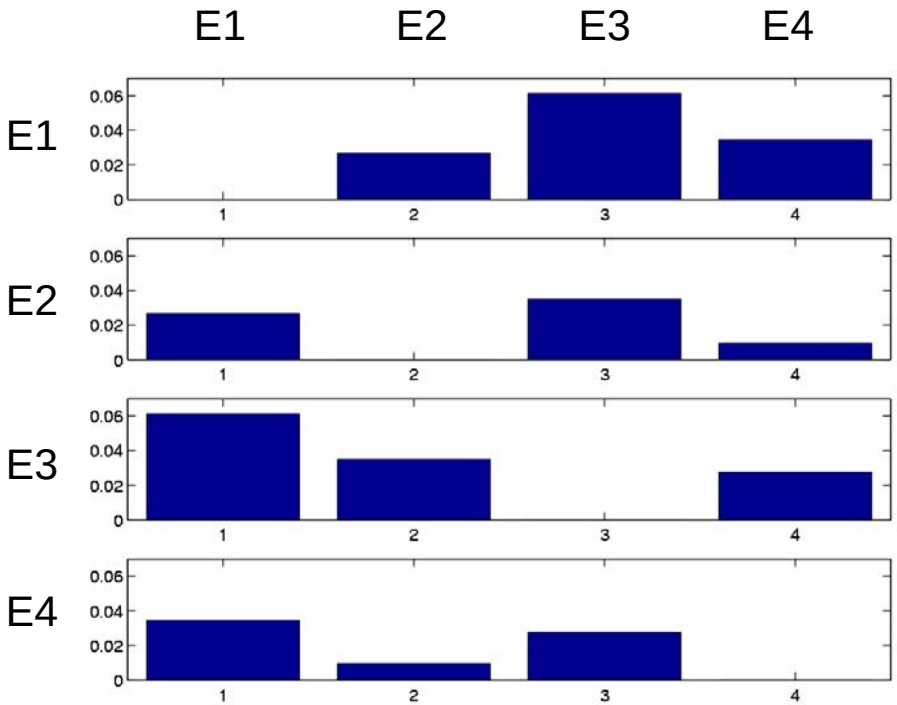
## Segmentation of the defects



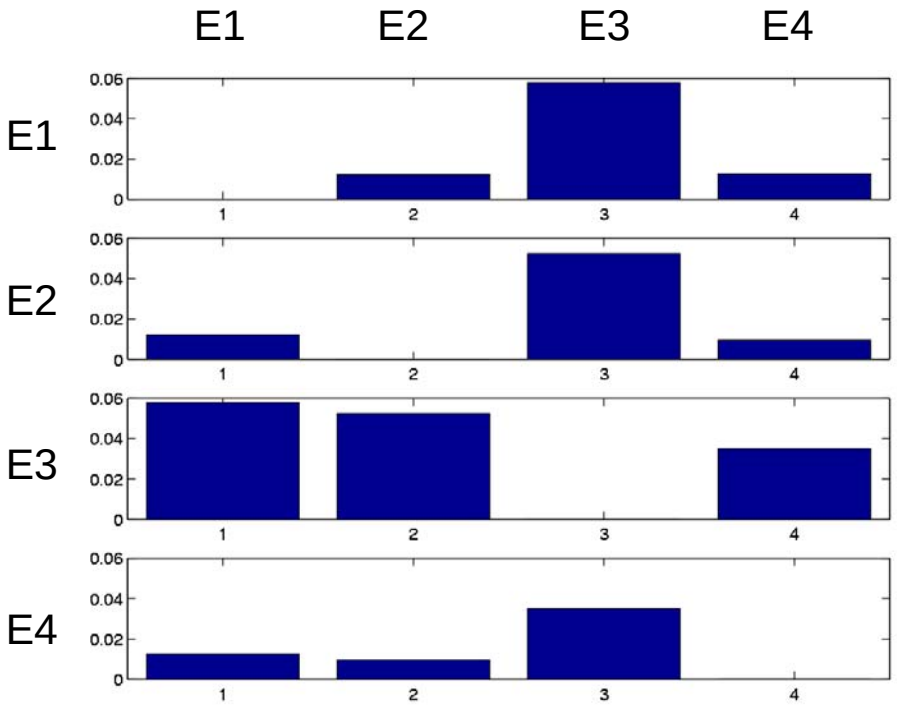
# Texture defect detection for textiles/fabrics

## Discrimination of the defect classes

class distances texture class c1r1

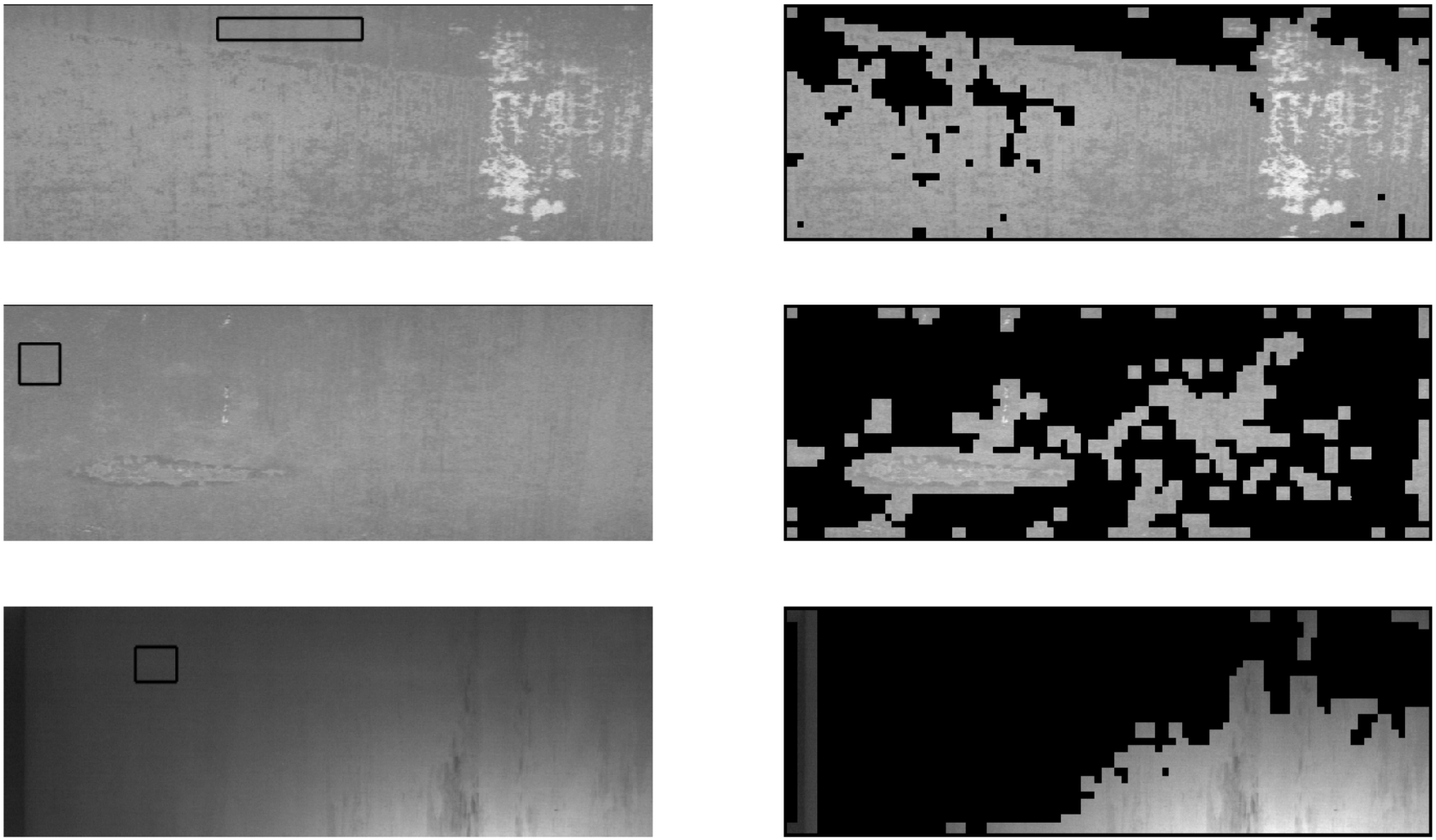



class distances texture class c2r2

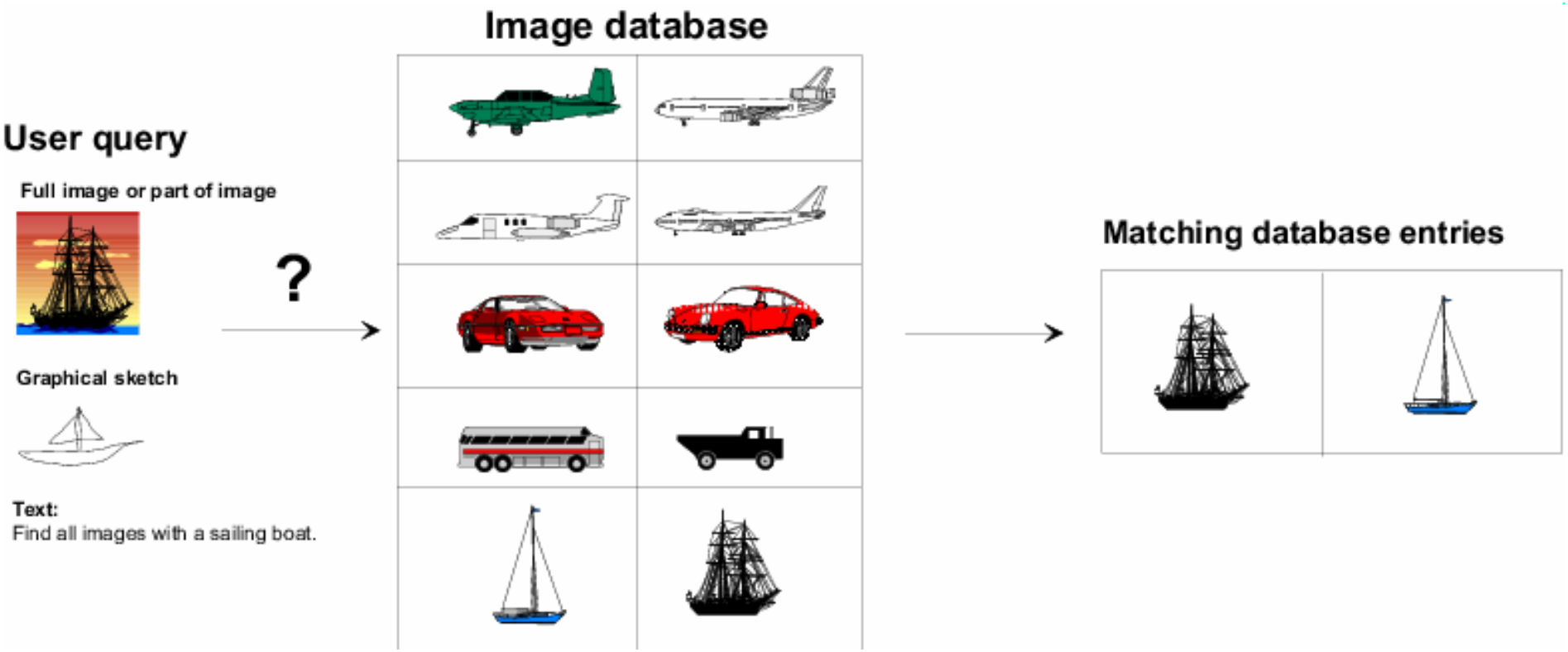


# Texture defect detection on steel surface areas

## Segmentation of the defects



# Content based image retrieval




http://simba.informatik.uni-freiburg.de/

Query image

0.978

0.828

0.792

0.686

0.674

0.649

0.630

0.595

Query image

0.98

0.82

0.81

0.79

0.78

0.78

0.77

0.76

Query image

0.99 0.79 0.77 0.68

0.68 0.66 0.66 0.66

Query image

0.98

0.82

0.79

0.77

0.74

0.73

0.71

0.71

Query image

0.98

0.79

0.77

0.68

0.68

0.65

0.65

0.63

Query image

0.98

0.80

0.78

0.74

0.70

0.60

0.59

0.57

# SIMBA – Search IMages By Appearance

COLOR only

Search template

96827

63939.4

62383.7

60840.3

59997.4

59316.6

59061

58323.8

# SIMBA – Search IMages By Appearance

Search template

87948.7

85491.7

85163

84896.4

84603.2

84379.5

84065.4

83475.7

# SIMBA – Search IMages By Appearance

Search template

96689.4

81479.3

77883.8

71489.1

70400.4

67864.2

66298.7

66249.5

# SIMBA – Search IMages By Appearance

Search template

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81203.6

77685.85

75091.55

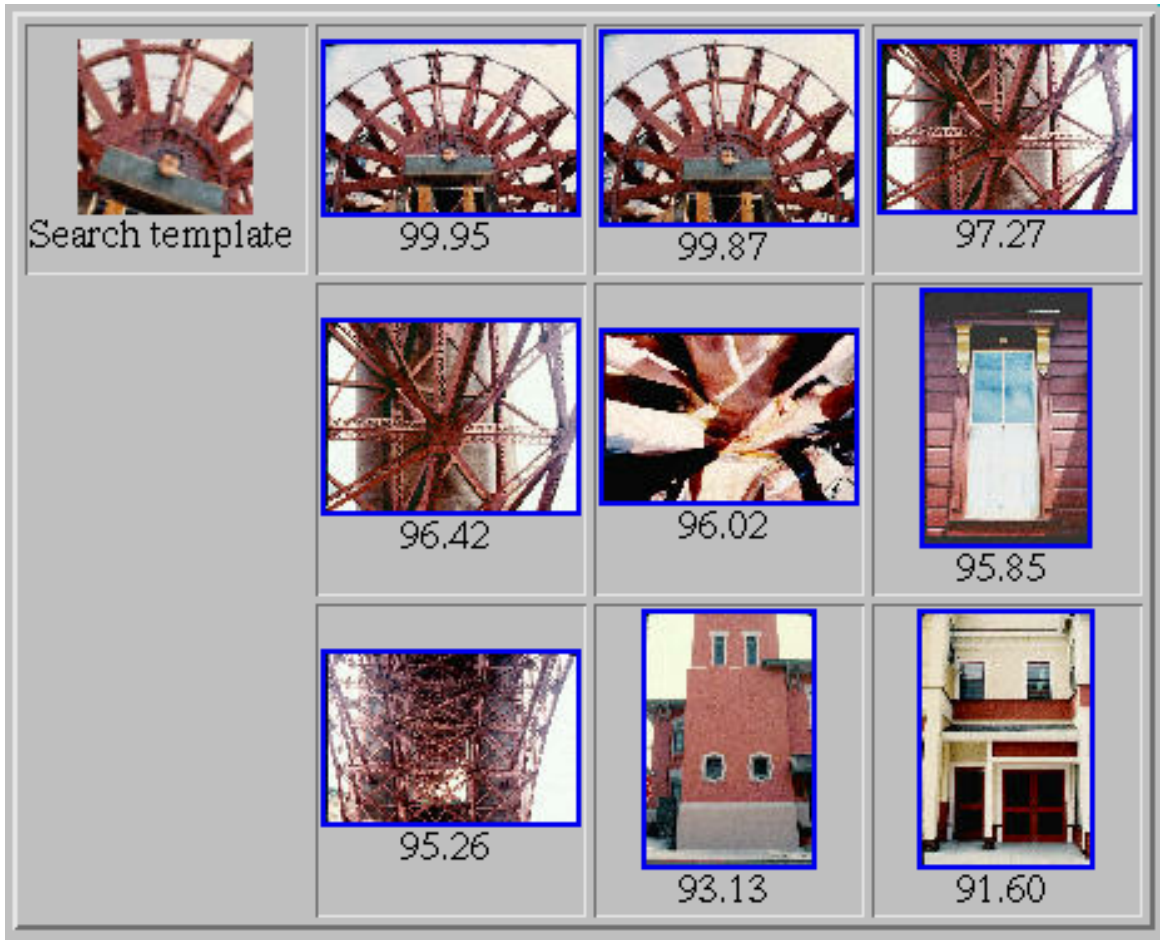
71376.85

70761.3

69292.6

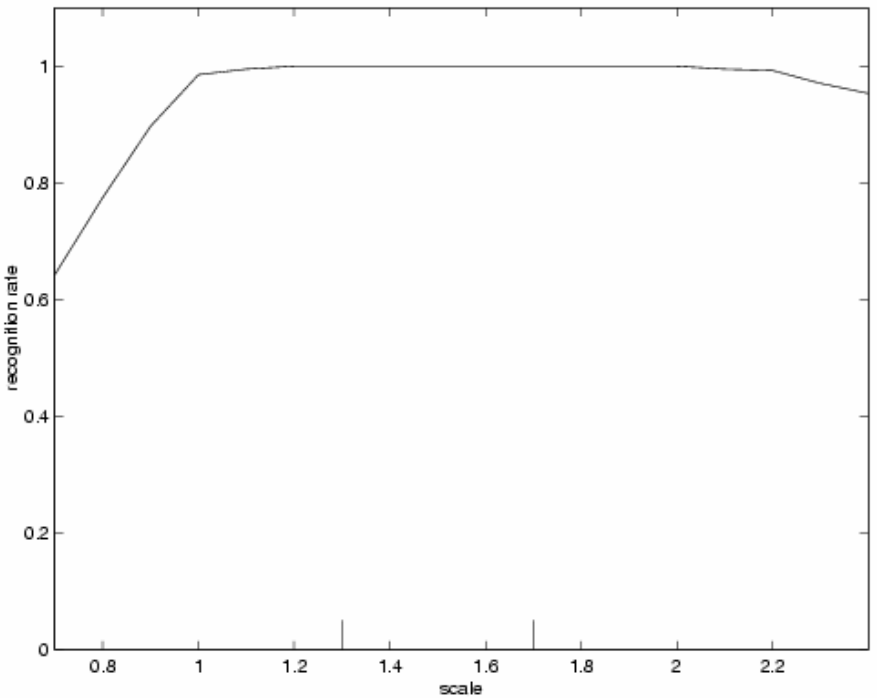
68030.95

# Experiments



# Robustness to scaling

- Database as before, grayvalue features only
- Kernels **M**(1,0)**M**(0,2), **M**(2,0)**M**(0,4)
- Images reduced/zoomed (bilinear interpolation) to scales from 0.7 to 2.4
- Database contains scales 1.3 and 1.7 only




⟶ Good recognition from scale 1 to 2.2, i.e. scale 4.8 in area

# SIMBA
# Searching Images by Appearance

http://simba.informatik.uni-freiburg.de/

Suchbild
Suchmethode
Farbe
Textur
Motiv
Größe
Seitenverhältnis
Datenbank
BRD
Suche starten
Ergebnisse
Brd0644
Brd0638
Brd0732
Brd0689
Brd0729
Brd0636
Brd0727
Brd0637
Brd0645
Brd0640
Brd0642
Brd0635
Brd0691
Brd0730
Brd0639
Brd0643

Suchbild
Suchmethode
Farbe
Textur
Motiv
Größe
Seitenverhältnis
Datenbank
BRD
Suche starten
Ergebnisse
Brd0644
Brd0637
Brd0689
Brd0636
Brd1138
Brd0489
Brd0727
Brd0502
Brd0494
Brd0854
Brd0193
Brd0492
Brd0191
Brd0635
Brd0168
Brd0857

Suchbild
WOHLFAHRTSMARKE
10 5
FROSCHKONIG
DEUTSCHE
BUNDESPOST
Suchmethode
Farbe
Textur
Motiv
Größe
Seitenverhältnis
Datenbank
BRD
Suche starten
Ergebnisse
Brd0523
Brd0485
Brd0538
Brd0232
Brd0408
Brd0409
Brd0486
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Brd0386
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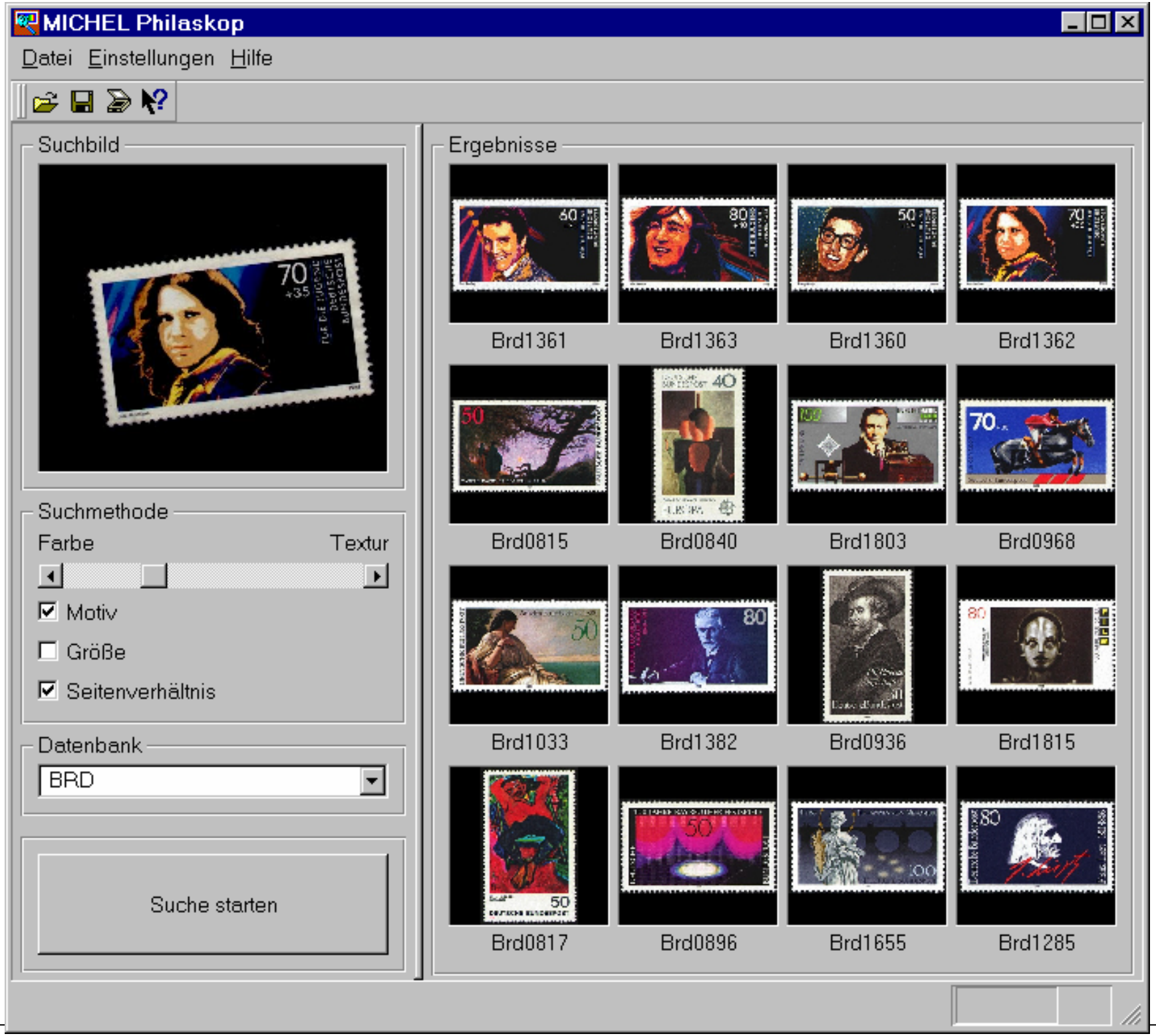
Brd1610
Brd0487


MICHEL Philaskop
Datei Einstellungen Hilfe
Suchbild
Suchmethode
Farbe
Textur
Motiv
Größe
Seitenverhältnis
Datenbank
BRD
Suche starten
Ergebnisse
Brd1361
Brd1363
Brd1360
Brd1362
Brd0815
Brd0840
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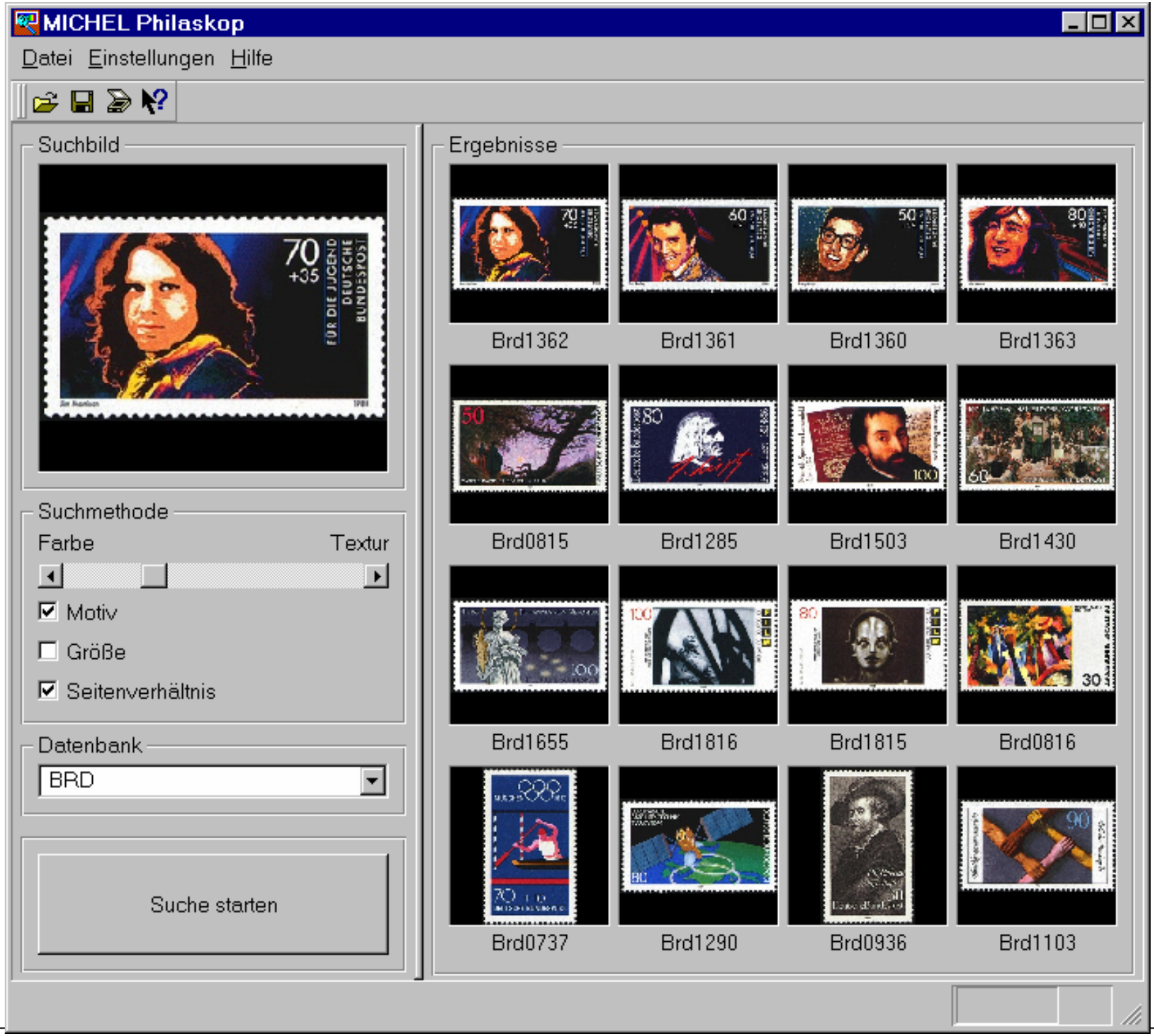
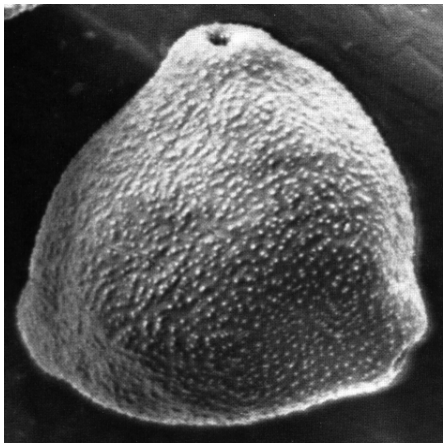
Brd1285


MICHEL Philaskop
Datei Einstellungen Hilfe
Suchbild
70 +35
FÜR DIE JUGEND
DEUTSCHE BUNDESPOST
Suchmethode
Farbe
Textur
Motiv
Größe
Seitenverhältnis
Datenbank
BRD
Suche starten
Ergebnisse
Brd1362
Brd1361
Brd1360
Brd1363
Brd0815
Brd1285
Brd1503
Brd1430
Brd1655
Brd1816
Brd1815
Brd0816
Brd0737
Brd1290
Brd0936
Brd1103

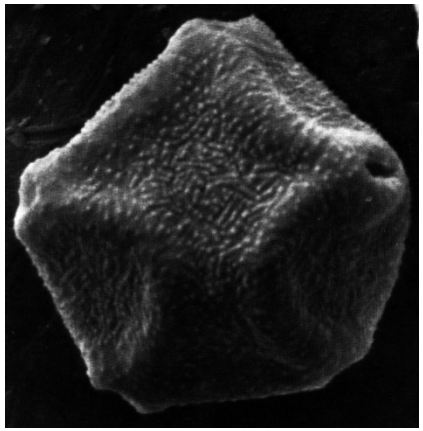
Suchbild
50
JEDERZEIT SICHERHEIT
DEUTSCHE BUNDESPOST
Suchmethode
Farbe
Textur
Motiv
Größe
Seitenverhältnis
Datenbank
BRD
Suche starten
Ergebnisse
Brd0700
Brd0694
Brd0697
Brd0773
Brd0703
Brd0702
Brd0698
Brd0696
Brd0701
Brd1623
Brd1140
Brd0695
Brd1379
Brd1137
Brd0699
Brd1038

MICHELphilascope
Datei Einstellungen Hilfe
Suchbild
Suchmethode
Farbe
Textur
Motiv
Größe
Seitenverhältnis
Datenbank
Deutschland
Suche starten
Ergebnisse
0509
0507
0506
0510
0286
0287
0290
0288
0508
0289
0231
0140
1143
0042
0032
0145
Deutschland Berlin (West) 0042

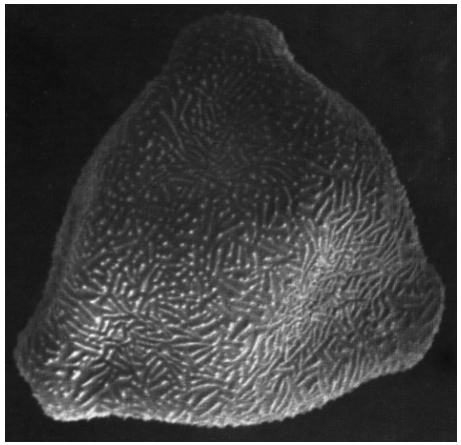
# Project “automatic pollen recognition” - Electron microscopic pollen images



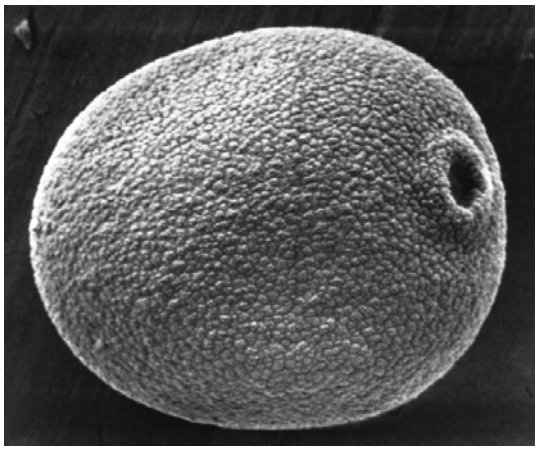
hazel



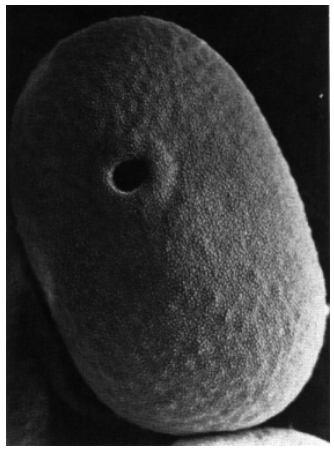
alder



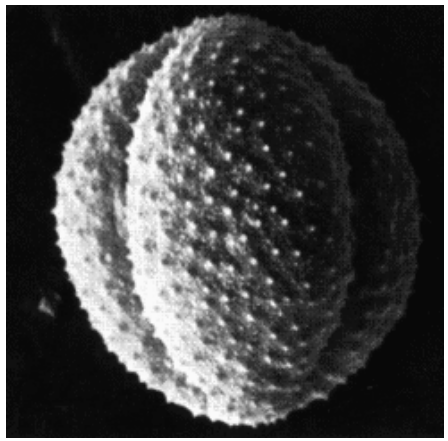
birch



grass



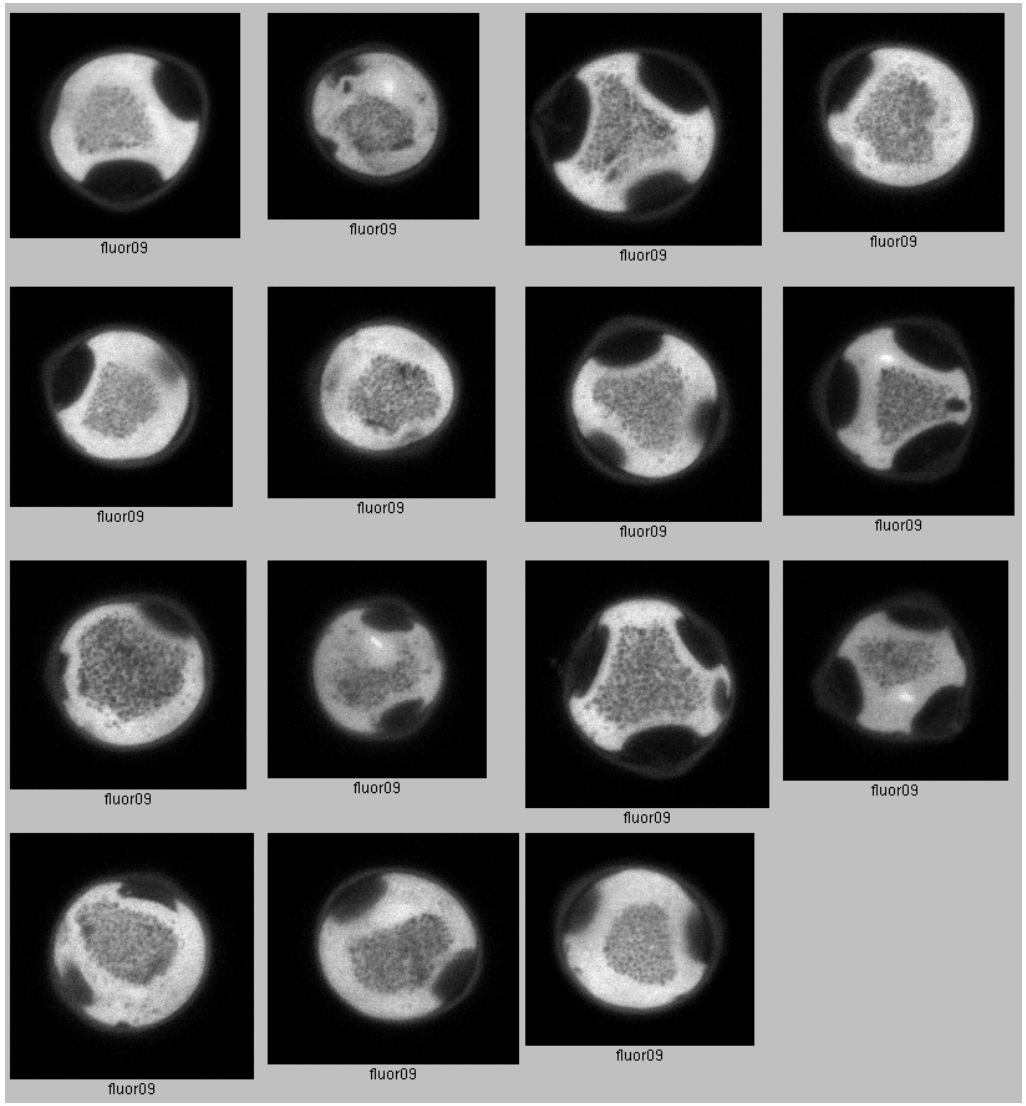
rye



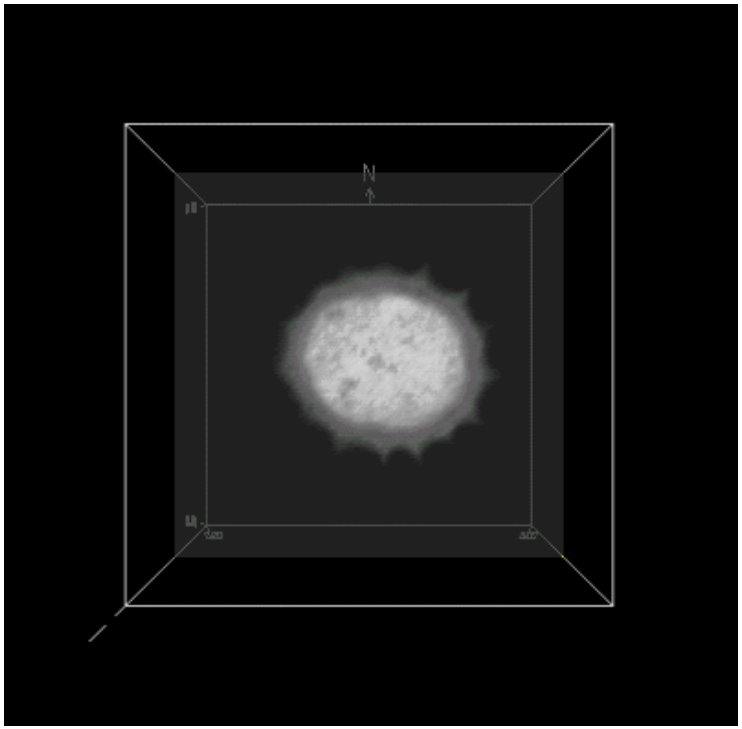
mugwort

+ 33 further species (not relevant for allergies)

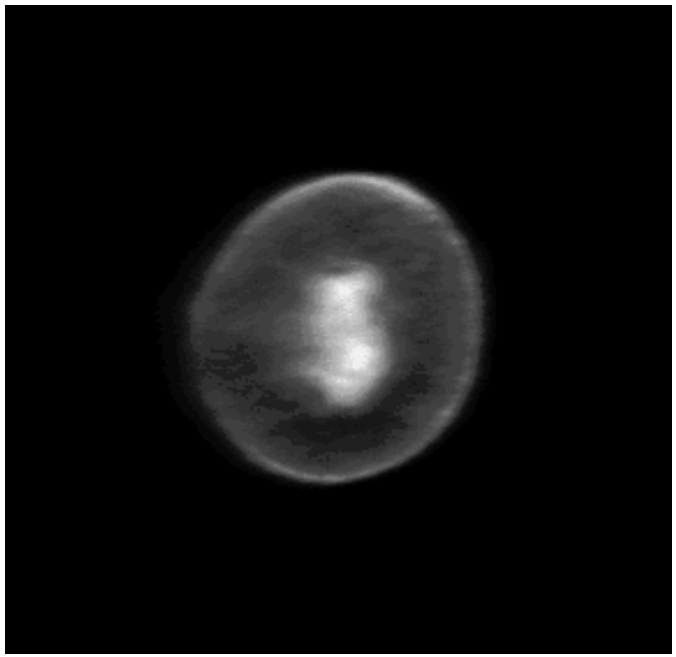
# Hazel pollen

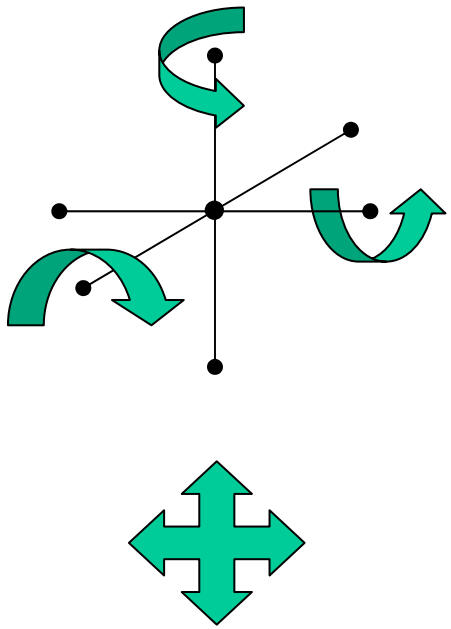


# Daisy pollen grain



# Taxus





Integration over the 3D Euclidian motion

# Reference Data Base Description

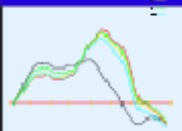
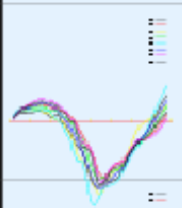
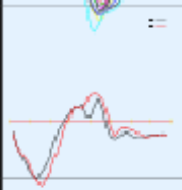
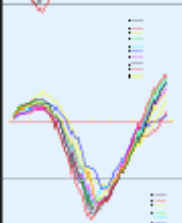
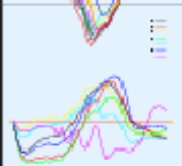
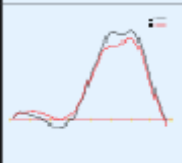
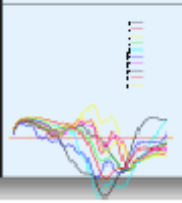
- 26 pollen species directly sampled from the plants
  - Correctly assigned species
  - Maybe less variation in size and shape compared to airborne pollen (no different sub-species, no regional variation)
  - No deformation or contamination or agglomeration

- Recording 3D volumes of about 15 samples of each species with a Confocal Laser Scanning Microscope
  - No distortions of the data due to imperfect imaging of a usual microscope

# Automated Pollen Recognition in Air Samples by Digital Microscopy

O. Ronneberger, U. Heimann, V. Dietze, E. Schultz

- **Motivation**
  - Time–consuming, but still inaccurate visual pollen counting
- **Demand**
  - Reliable pollen data for pollen forecast
- **Approach**
  - 3D fluorescence imaging (tomography) instead of 2D conventional translucent microscopy
  - Image recognition based on general »grey scale invariants«, instead of traditional object specific features
- **First results** (see table on the right)
  - »Grey scale invariants« have characteristic shapes for different pollen species
  - Recognition rate of 82% already in a first run
- **Outlook**
  - Employment of digital microscopy for automated particle analysis in general.

| Pollen species | Grey Scale Invariants | No | Mis-classifications |
|---|---|---|---|
| Maple |  | 5 | 1 | (l) –> Goose. |
| Birch |  | 8 | 3 | (r1) –> Alder<br>(r3) –> Alder<br>(s1) –> Alder |
| Yew |  | 2 | – | |
| Alder |  | 10 | 2 | (u3) –> Birch<br>(v3) –> Birch |
| Goosefoot |  | 7 | – | |
| Horn beam |  | 2 | – | |
| Hazel |  | 10 | 2 | (p2) –> Goose.<br>(p4) –> Alder |

Collaborating institutions

Deutscher Wetter Dienst

MeteoSchweiz

ALBERT-LUDWIGS-UNIVERSITY OF FREIBURG

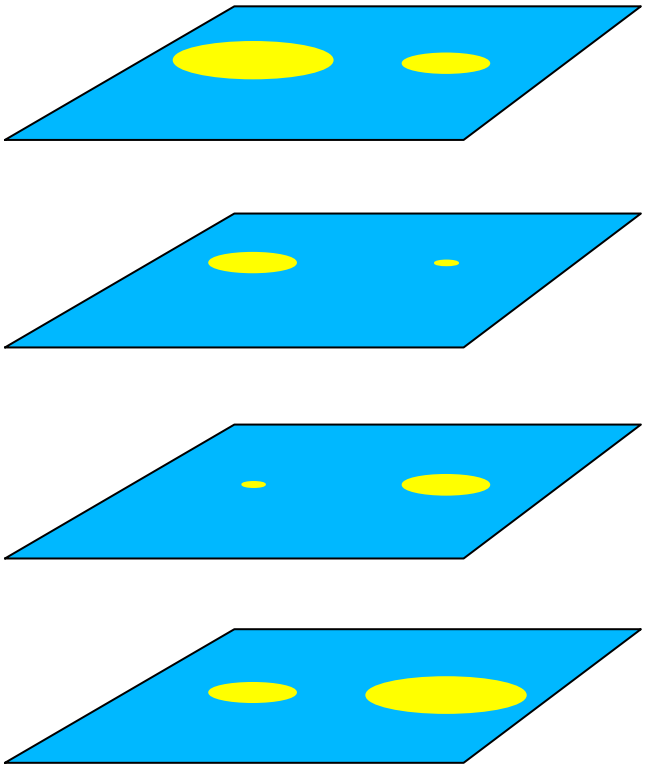
# Classification Results using 3D LSM Data

(leave-one-out Classification)

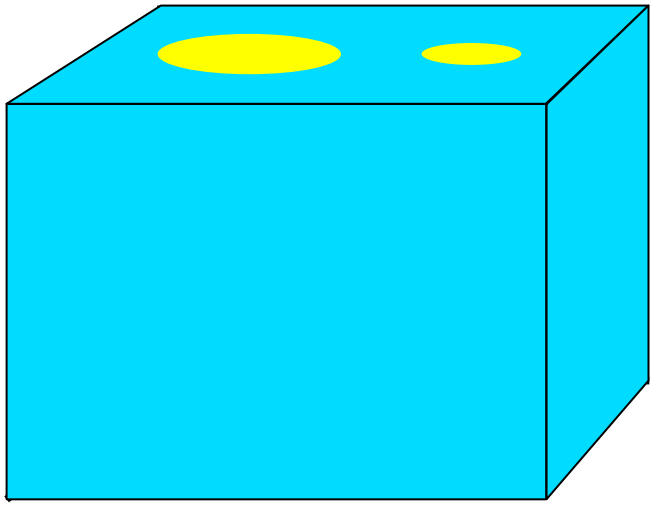
| | Correct | Wrong classifications |
|---|---|---|
| *Artemisia:* | 13 | 1 -> *Compositae*, 1 -> *Platanus* |
| *Alnus:* | 15 | - |
| *Alnus viridis:* | 12 | - |
| *Betula:* | 13 | 2 -> *Plantago* |
| *Corylus:* | 13 | 1 -> *Alnus* |
| *Gramineae/Poaceae:* | 15 | - |
| *Secale:* | 11 | 3 -> *Fagus*, 1 -> *Tilia* |
| Allergolocial irrelevant*: | 282 | 2 -> *Gramineae* |
| Total: | 97.4% | 2.6% |

***** *Acer, Carpinus, Chenopodium, Compositae, Cruciferae, Fagus, Quercus, Aesculus, Juglans, Fraxinus, Plantago, Platanus, Rumex, Populus, Salix, Taxus, Tilia, Ulmus, Urtica*

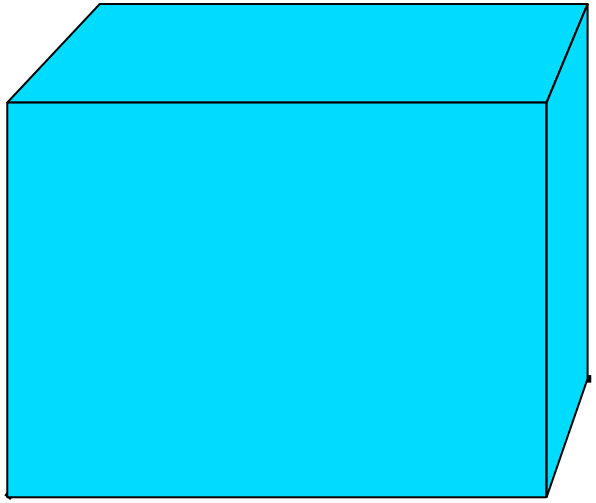
# Retrieving tomographical 3D data with a regular Fluoreszenz microscope



Recording a stack of images with a regular microscope



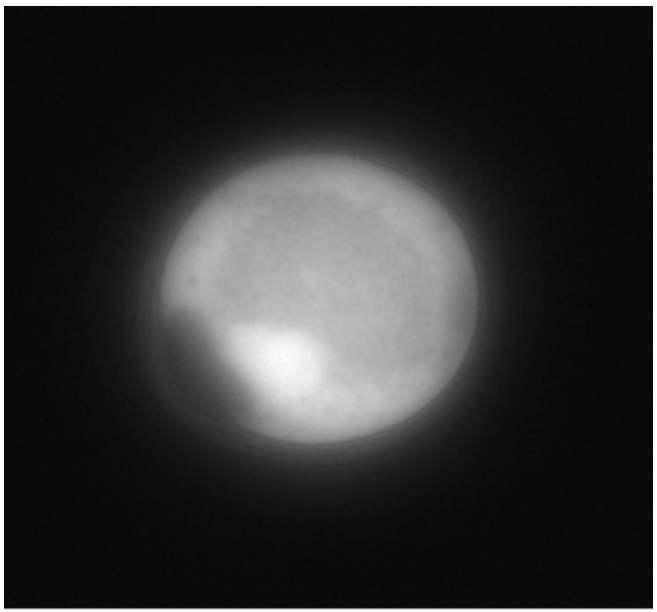
assembling the images to obtain volume information



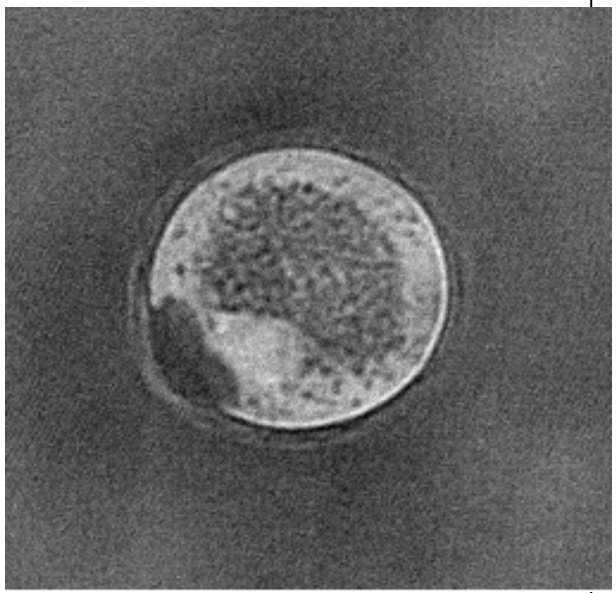
by deconvolution with Punktbildfunktion all fuzzy areas are removec

# Deconvolution of a Pollen (hazel/Corylus)

point-spread function



volume



deconvolved volume

# Video
# “Licht ins Dunkel”