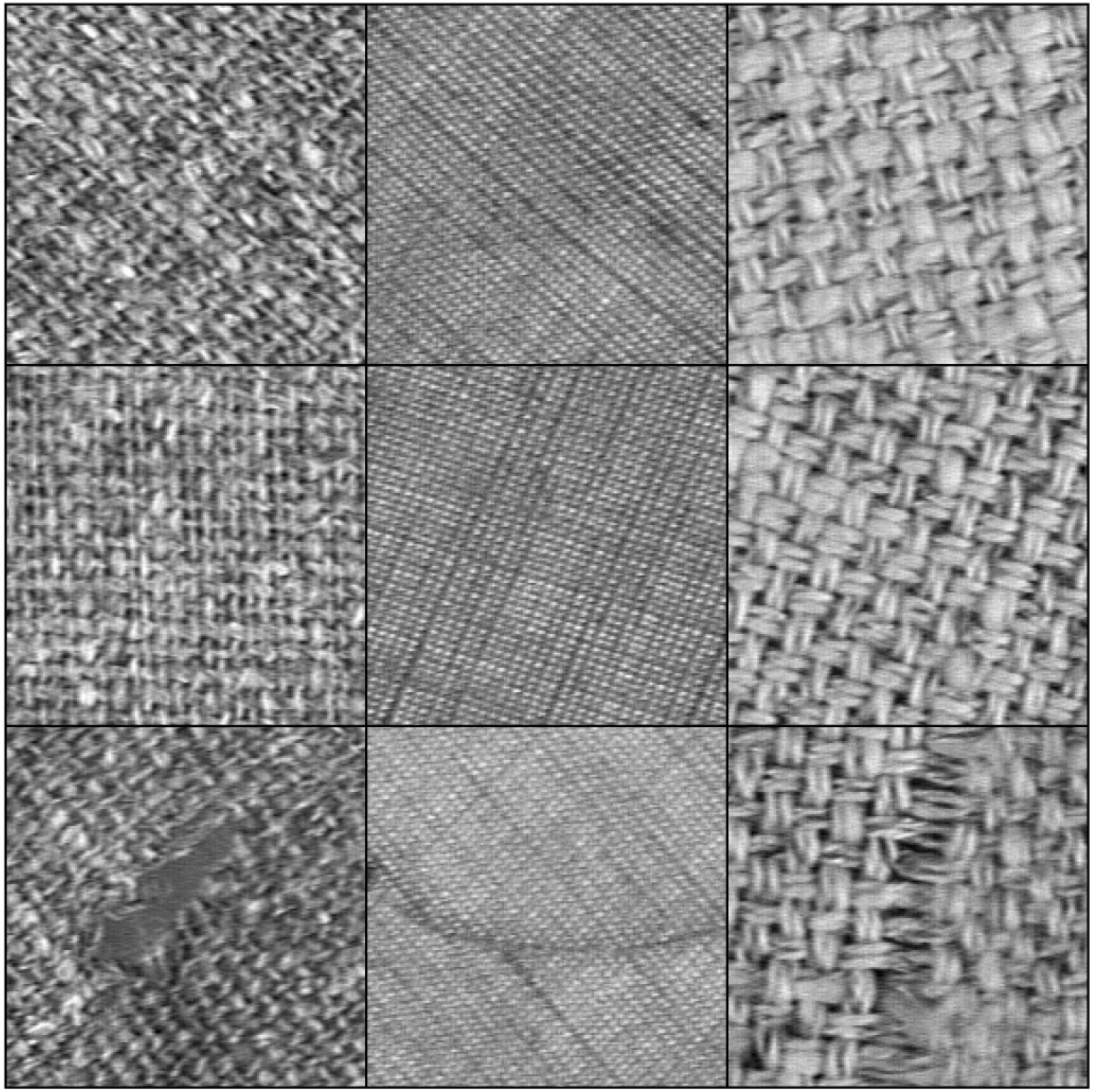
Kap. 5b
Anwendungen:
Invarianten über Gruppenmittel

- Sichtprüfungsaufgaben (Textilien)
- Bildsuchmaschinen (query by example) SIMBA und MICHELscope
- Automatische Klassifikation von Blütenpollen
- Suchen in Proteindatenbanken
- Suchen nach Wasserzeichen in alten Drucken

Complexity of Search tasks

- Finding an identical object (pixel by pixel) is trivial !
- Challenge for the future:
  Searching in Equivalence classes (up to a very high semantic level) can be very complex and demanding
- Data Bases without an intelligent access and retrieval mechanism is a graveyard for Bits and Bytes!

Visual inspection of textiles with anisotropic texture



Textildatenbank TILDA

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

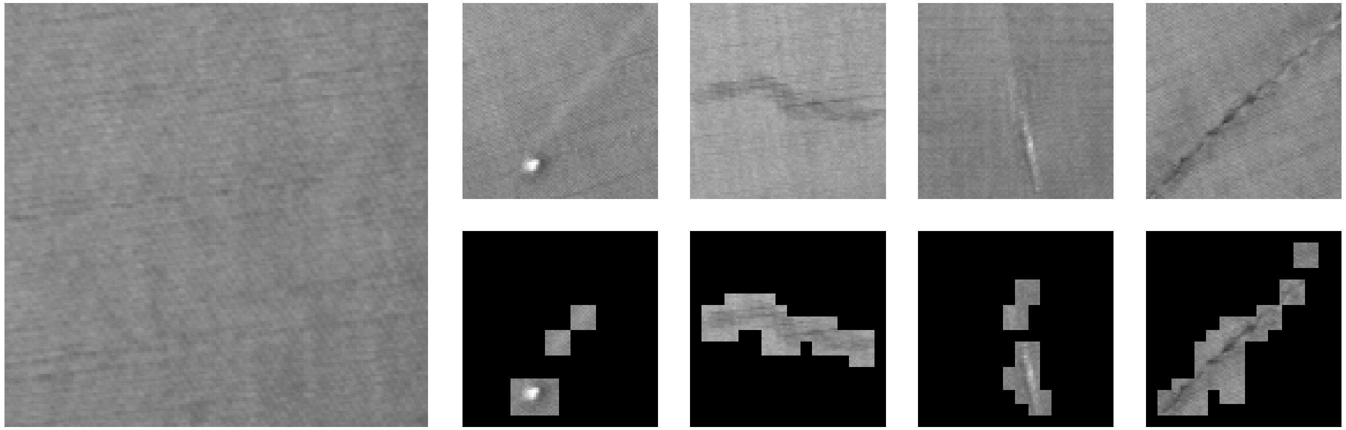
Texturdefektdetektion bei Textilstoffen

Segmentierung der Defekte

Texturklasse c1r1

Fehlerklassen

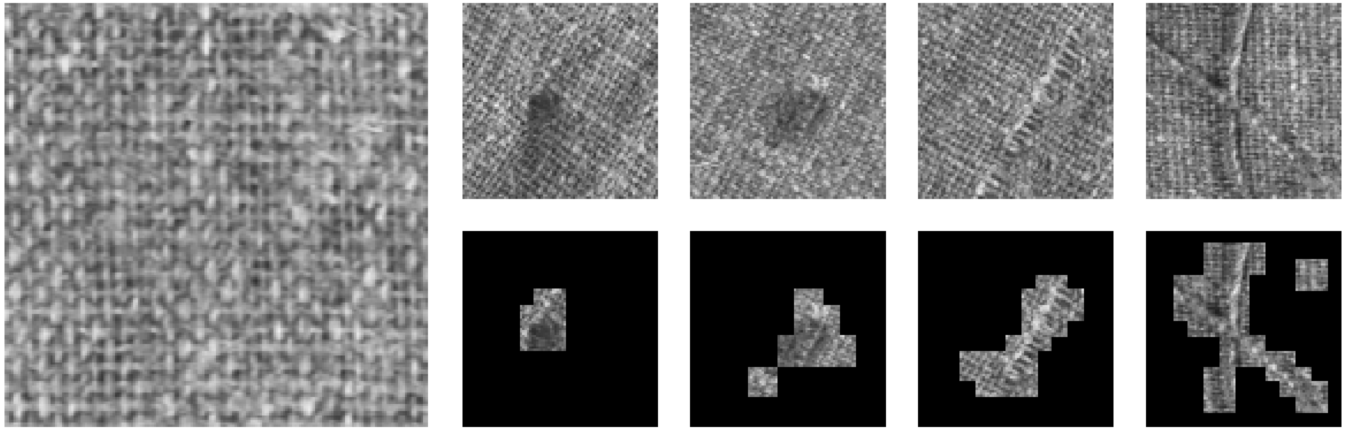
E1 E2 E3 E4



Texturklasse c2r2

Fehlerklassen

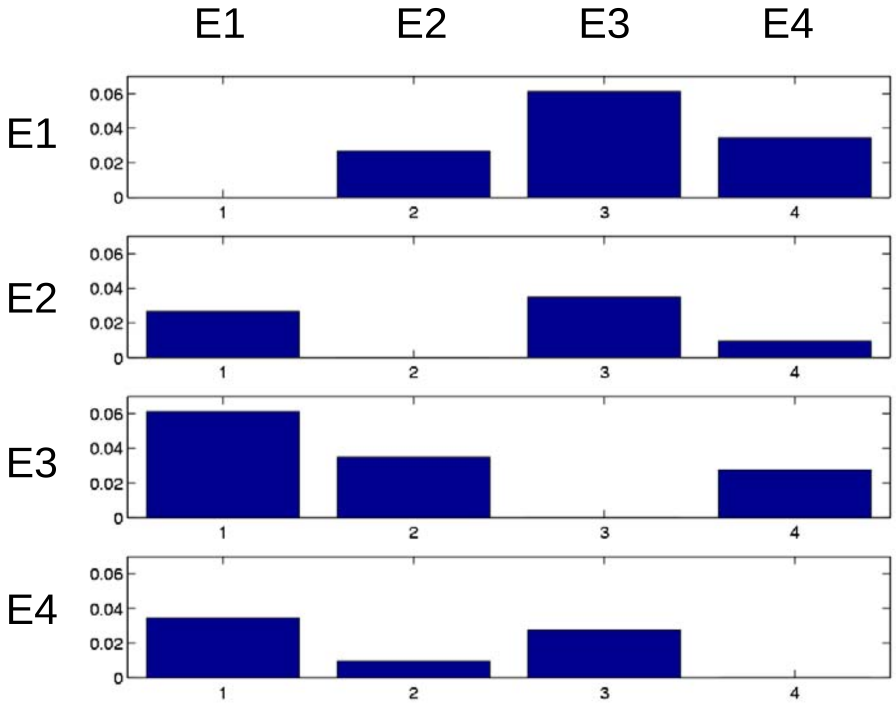
E1 E2 E3 E4



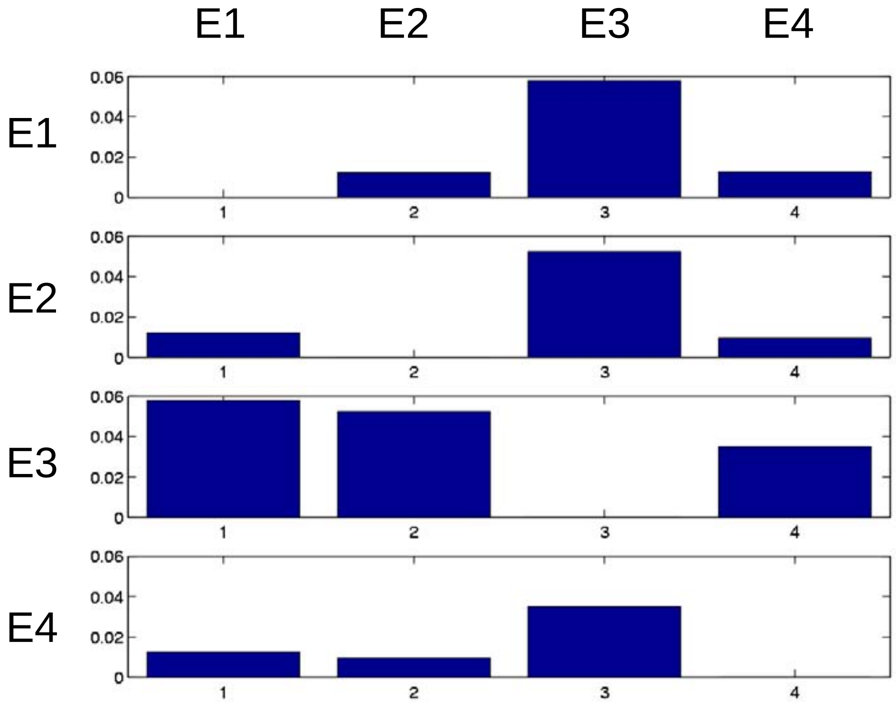
Texturdefektdetektion bei Textilstoffen

Diskriminierung der Defektklassen

Klassendistanzen Texturklasse c1r1

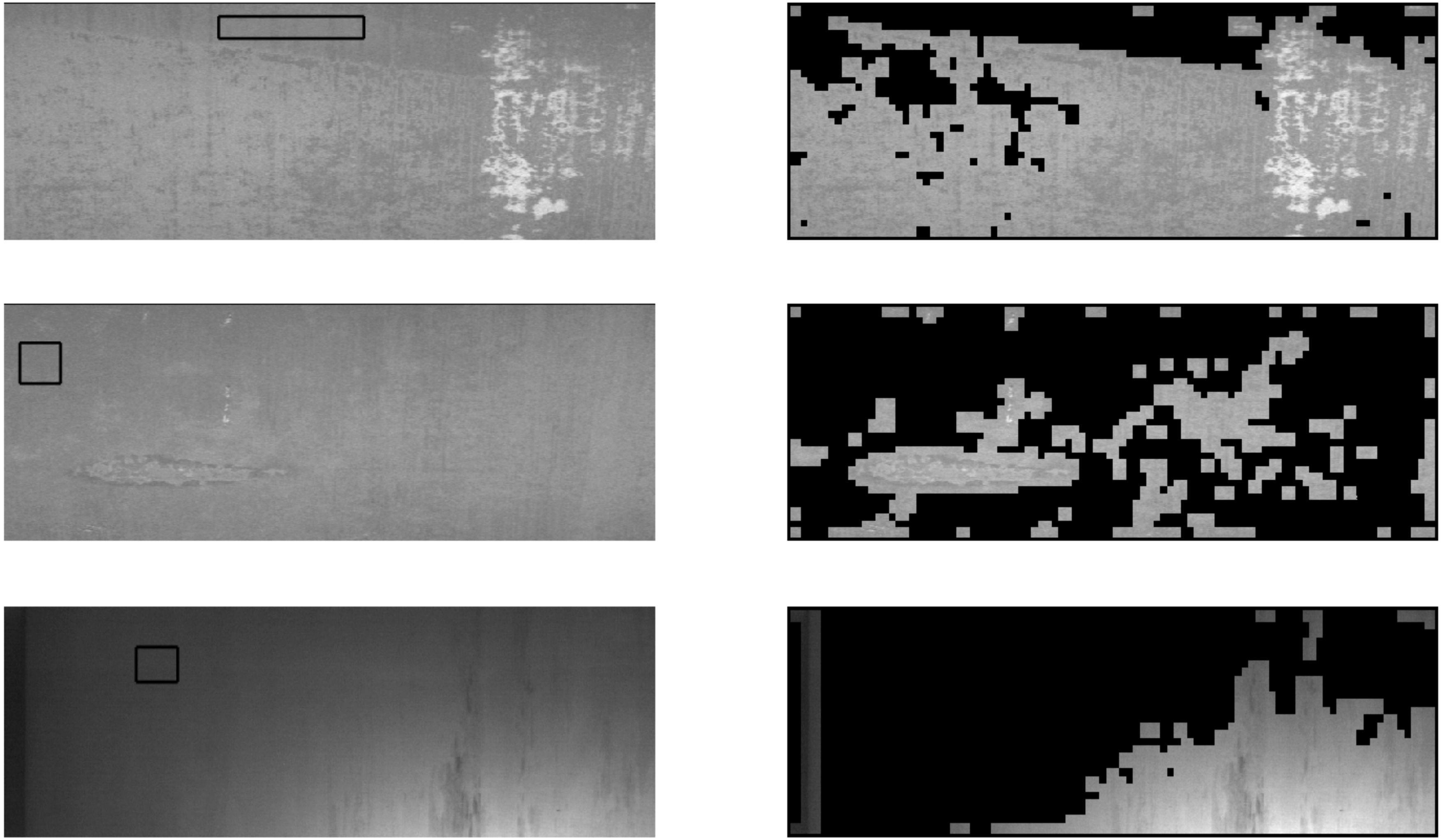


Klassendistanzen Texturklasse c2r2

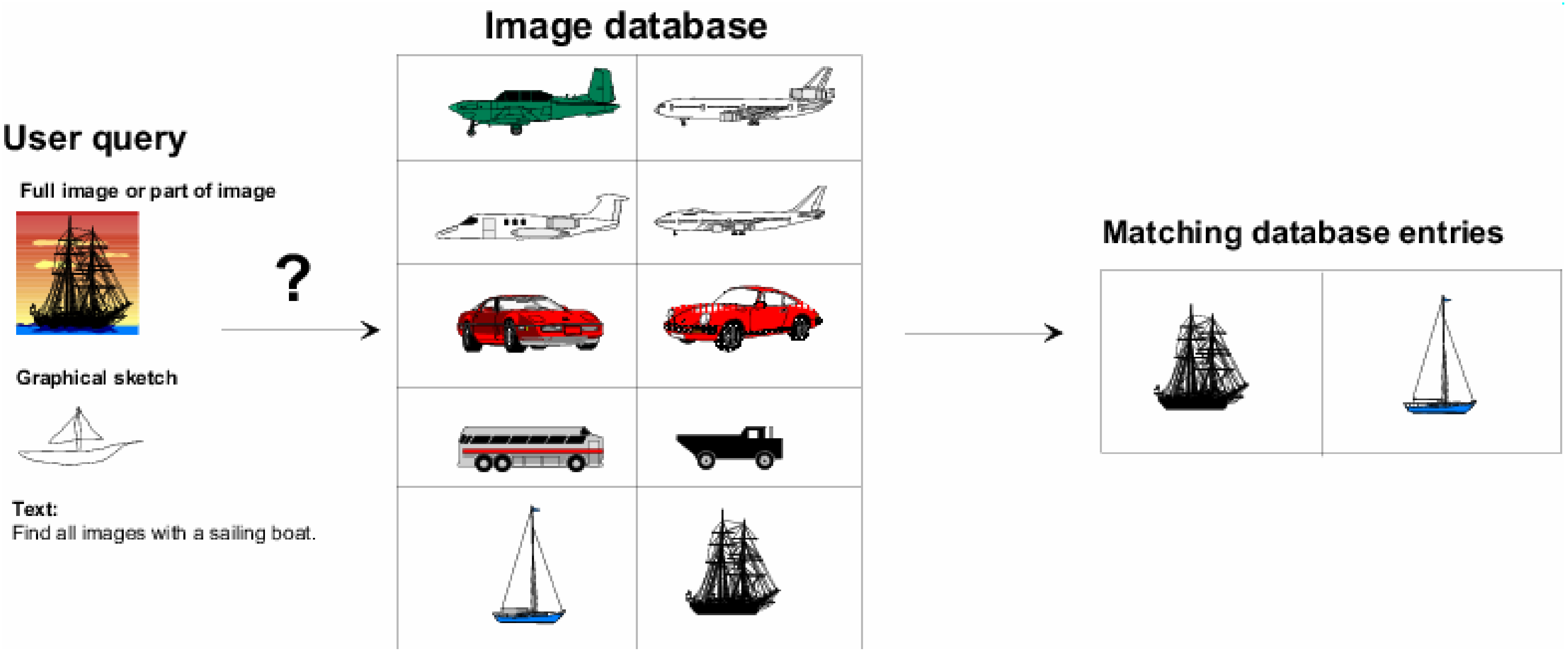


Texturdefektdetektion auf Stahloberflächen

Segmentierung der Defekte



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

x

0.65

+

0.65

?

0.63

+

Query image

0.98

0.80

0.78

0.74

0.70

0.60

0.59

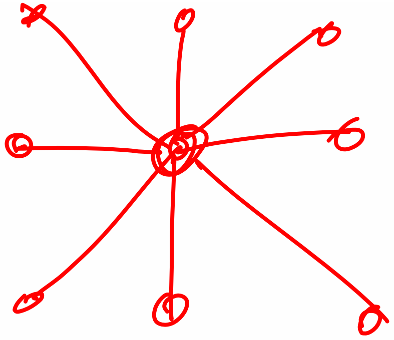
0.57

SIMBA – Search IMages By Appearance

COLOR only

relationale Kerne


Search template




96827


63939.4


62383.7


60840.3


59997.4


59316.6


59061


58323.8

SIMBA – Search IMages By Appearance

RELATIONAL only

Search template

87948.7

85491.7

85163

84896.4

84603.2

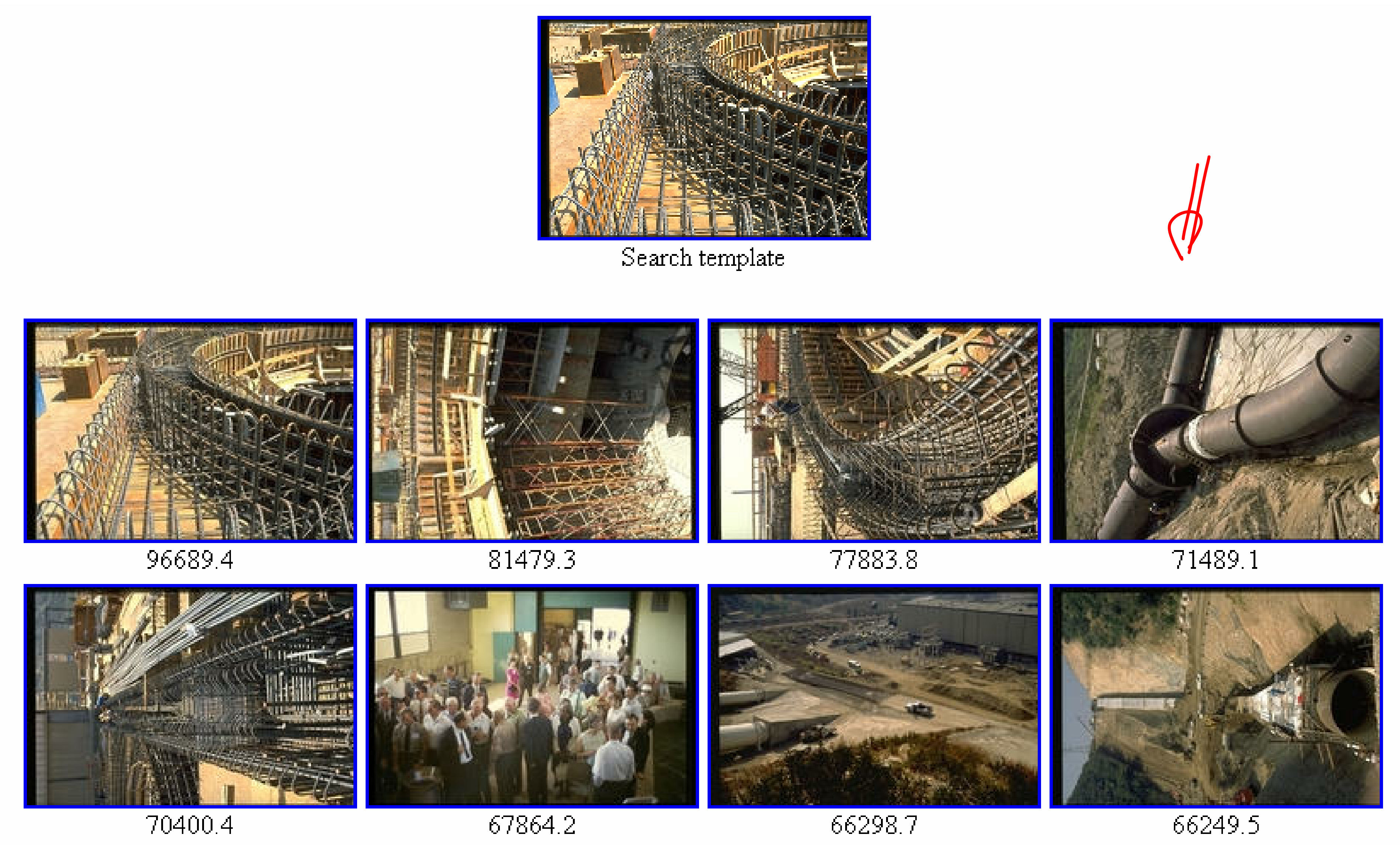
84379.5

84065.4

83475.7

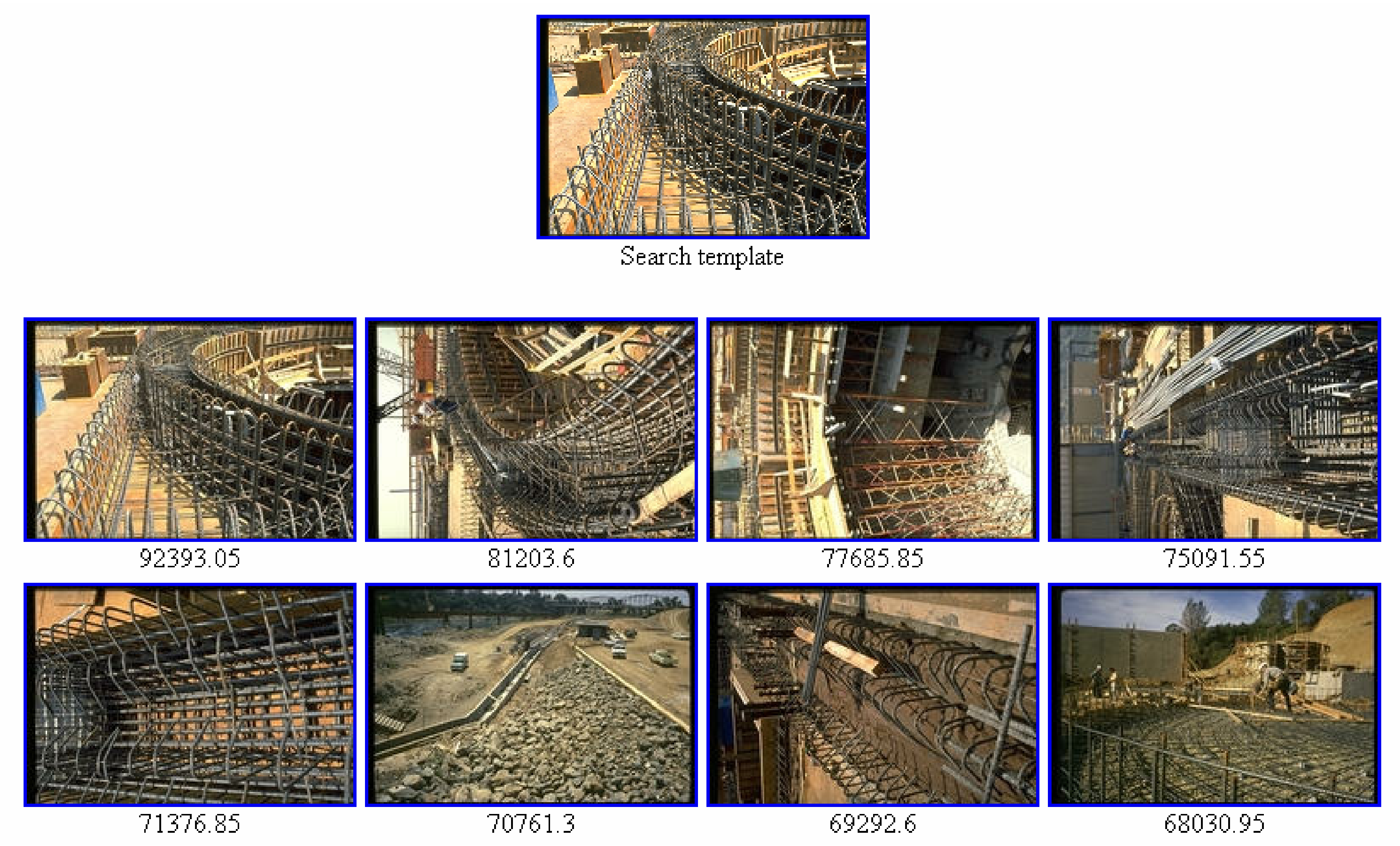
SIMBA – Search IMages By Appearance

COLOR only



SIMBA – Search IMages By Appearance

COLOR+RELATIONAL



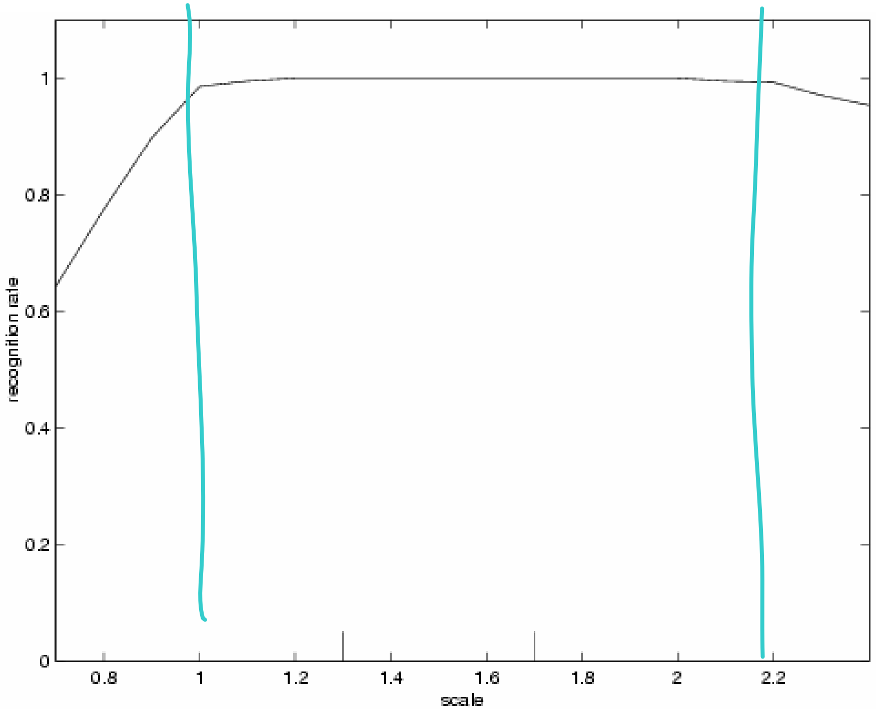
Search template

92393.05
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



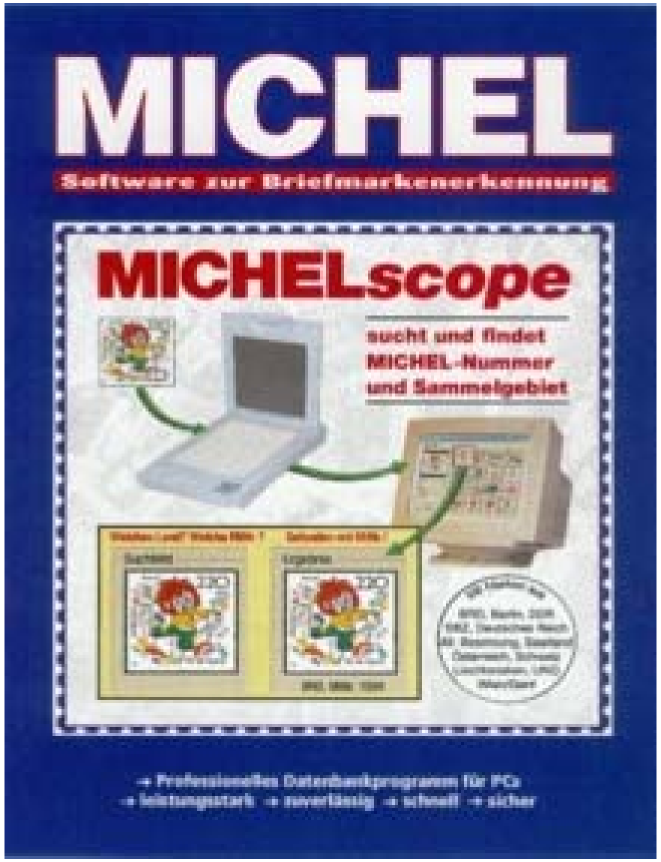
→ Good recognition from scale 1 to 2.2, i.e. scale 4.8 in area

SIMBA
Searching Images by Appearance

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

MICHELscope

A search engine for philatelists



Suchbild

Suchmethode

Farbe — Textur

☑ Motiv

☑ Größe

☑ Seitenverhältnis

Datenbank: BRD

Brd0644 Brd0638 Brd0732 Brd0689

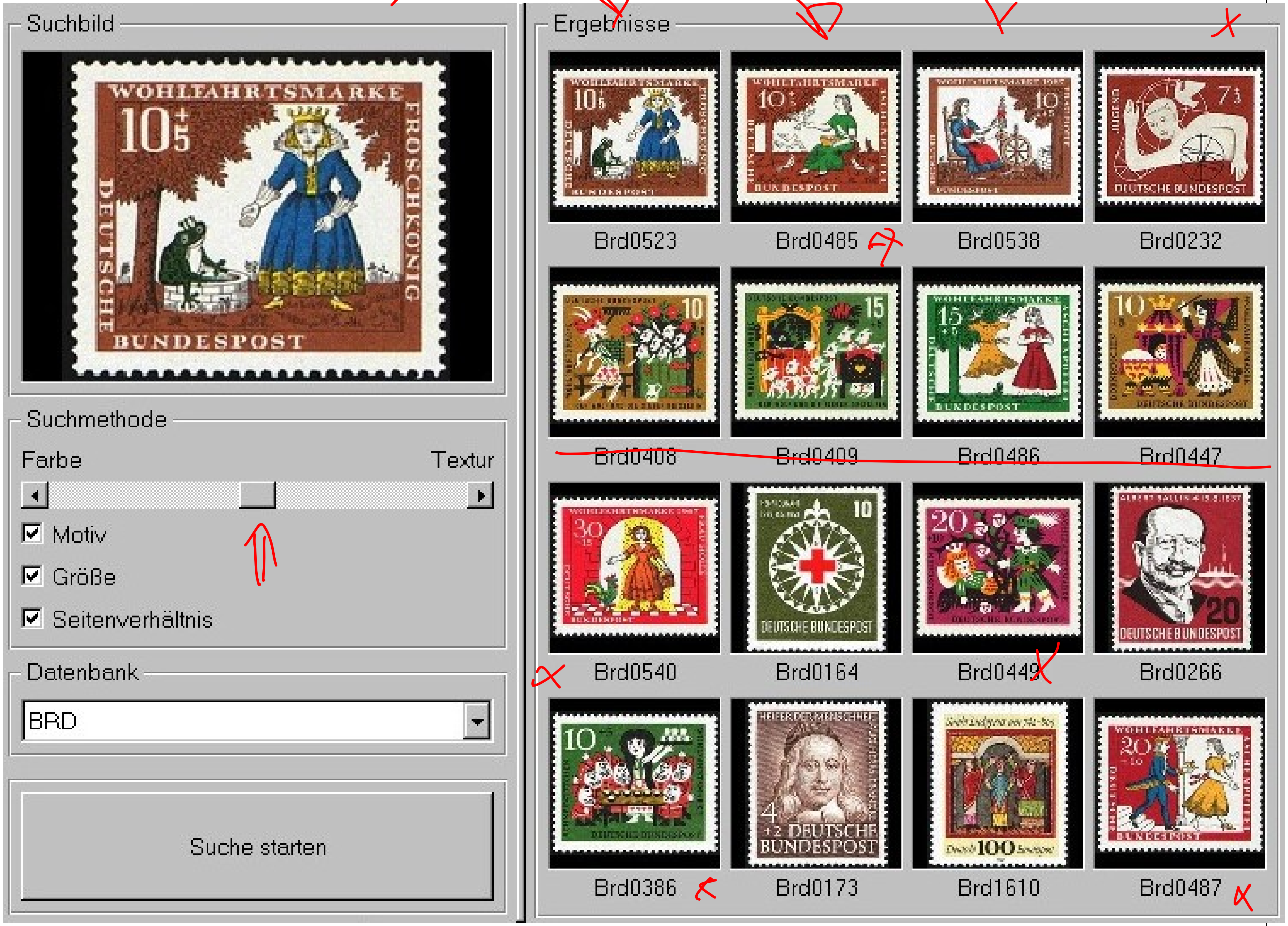
Brd0729 Brd0636 Brd0727 Brd0637

Brd0645 Brd0640 Brd0642 Brd0635

Brd0691 Brd0730 Brd0639 Brd0643

☑ Motiv
☑ Größe
☑ Seitenverhältnis

Datenbank: BRD



Suchmethode

Farbe — Textur

☑ Motiv

☑ Größe

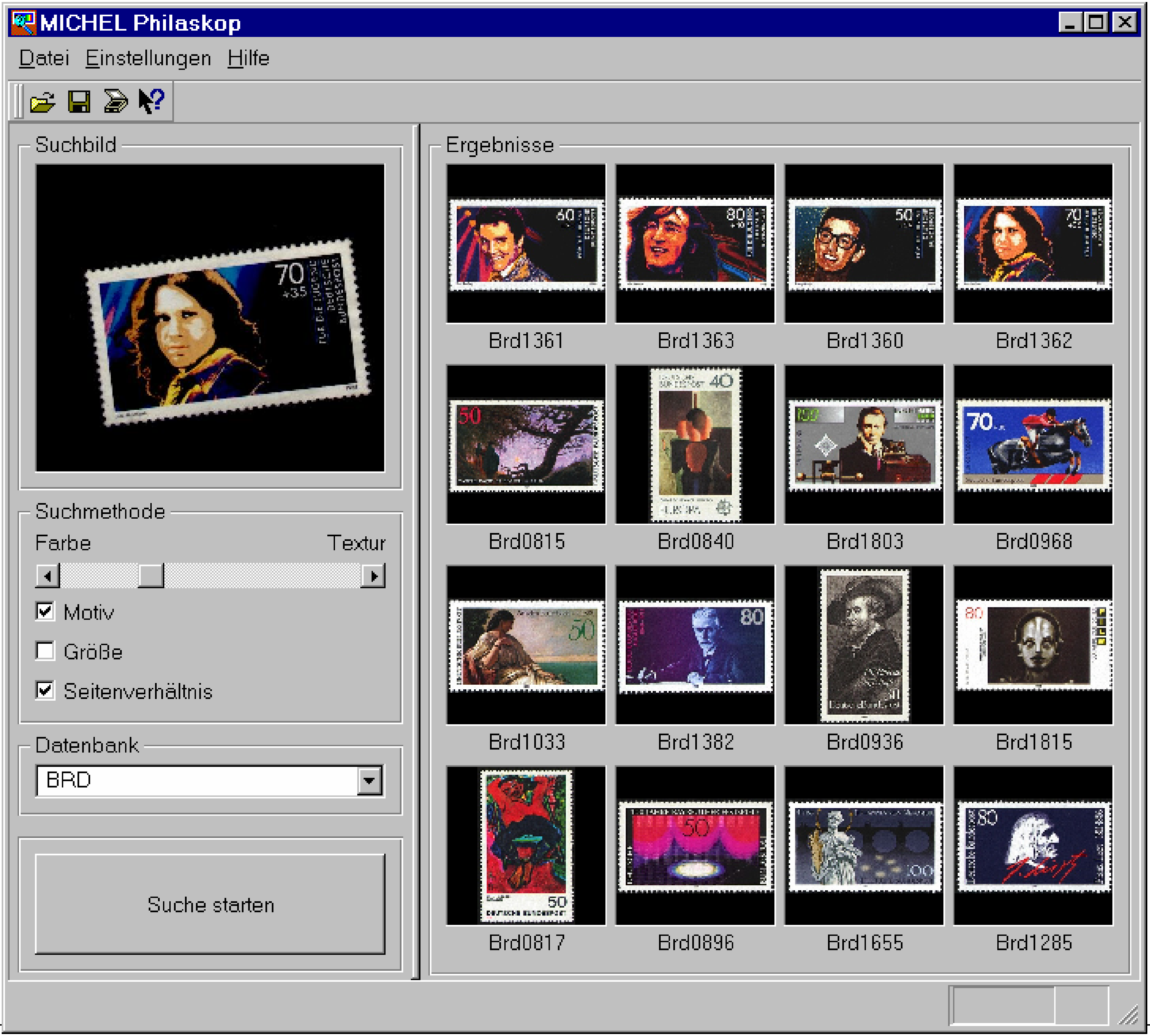
☑ Seitenverhältnis

Datenbank: BRD

Suche starten

Ergebnisse

Brd0523	Brd0485	Brd0538	Brd0232
Brd0408	Brd0409	Brd0486	Brd0447
Brd0540	Brd0164	Brd0449	Brd0266
Brd0386	Brd0173	Brd1610	Brd0487

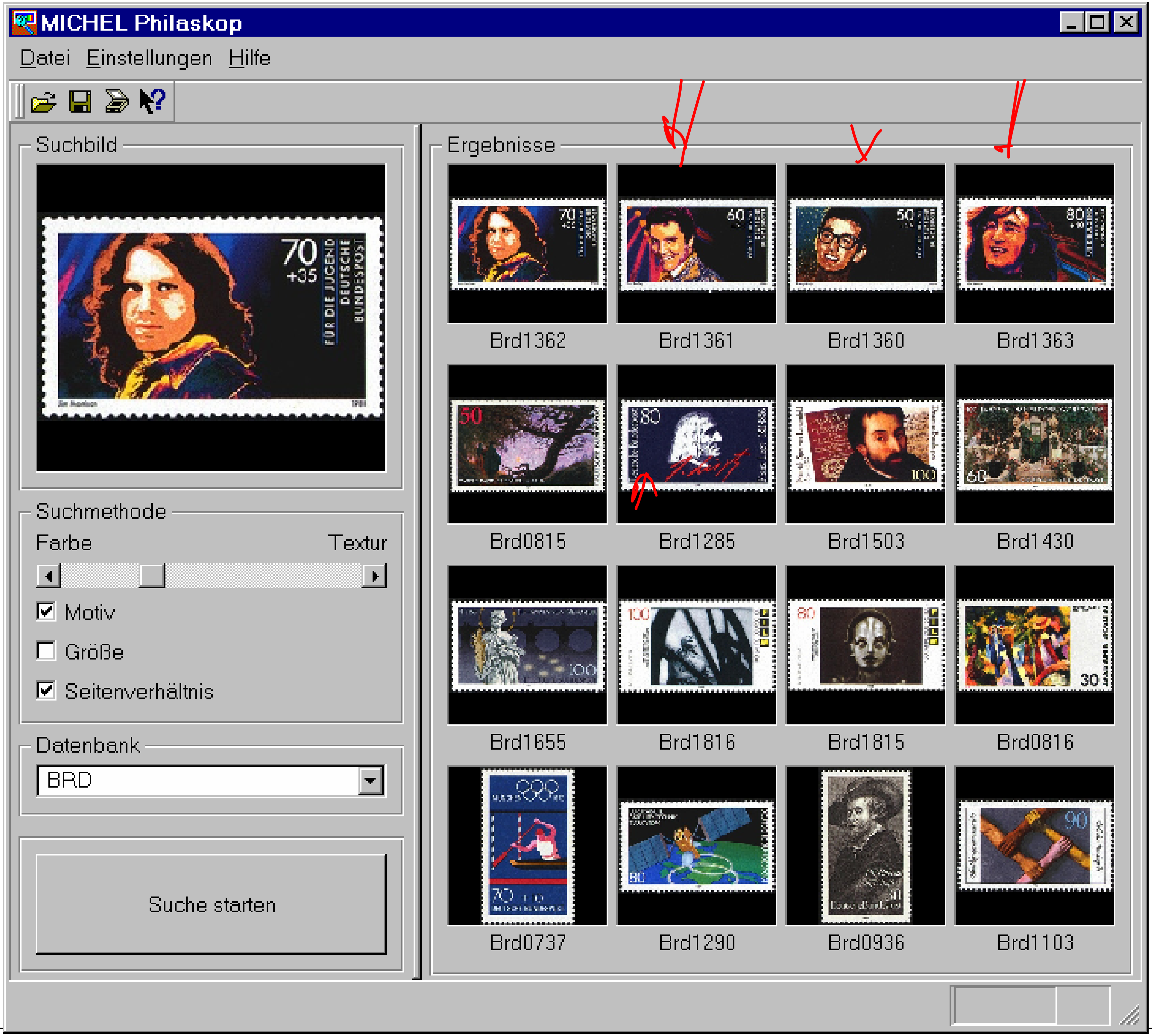


☑ Motiv

☐ Größe

☑ Seitenverhältnis

Datenbank: BRD



Suchmethode

Farbe — Textur

☑ Motiv

☐ Größe

☑ Seitenverhältnis

Datenbank: BRD

Ergebnisse

Brd1362 Brd1361 Brd1360 Brd1363

Brd0815 Brd1285 Brd1503 Brd1430

Brd1655 Brd1816 Brd1815 Brd0816

Brd0737 Brd1290 Brd0936 Brd1103

Suchbild

Suchmethode

Farbe — Textur

☑ Motiv

☑ Größe

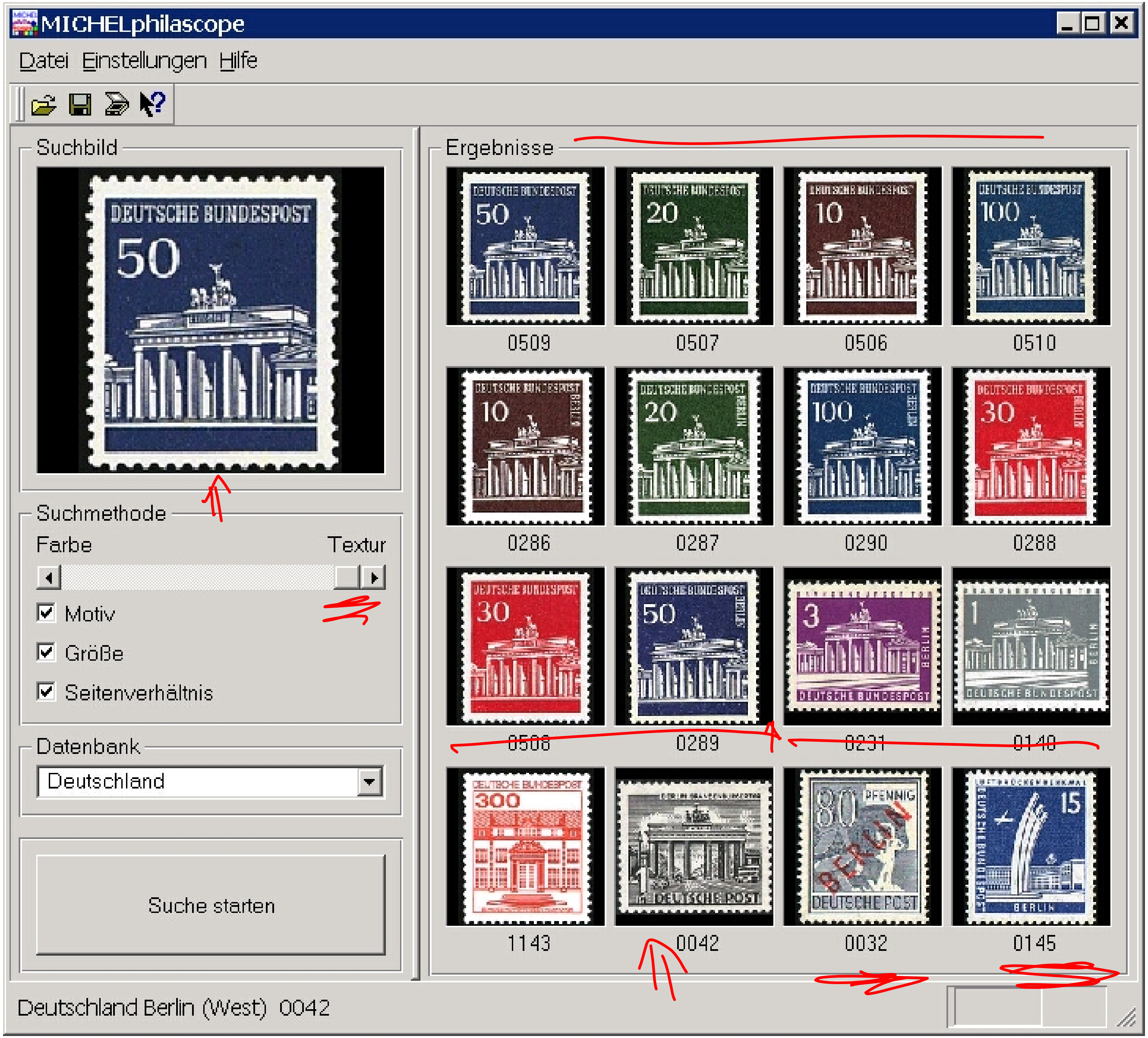
☑ Seitenverhältnis

Datenbank: BRD

Suche starten

Ergebnisse

Brd0700	Brd0694	Brd0697	Brd0773
Brd0703	Brd0702	Brd0698	Brd0696
Brd0701	Brd1623	Brd1140	Brd0695
Brd1379	Brd1137	Brd0699	Brd1038



☑ Motiv

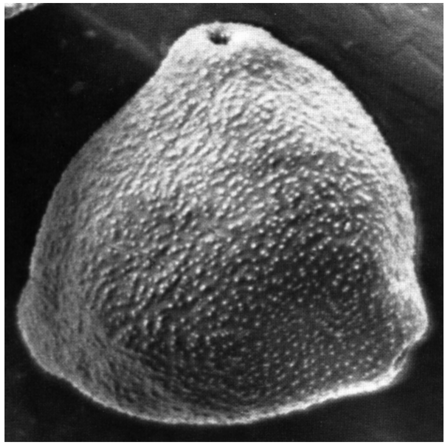
☑ Größe

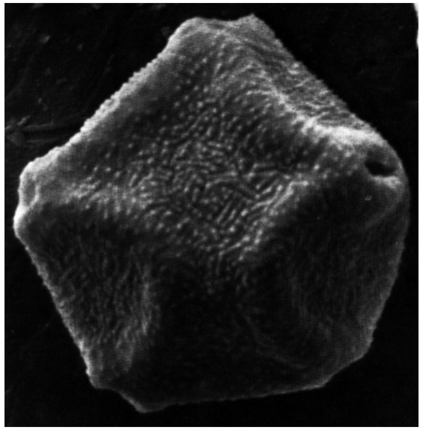
☑ Seitenverhältnis

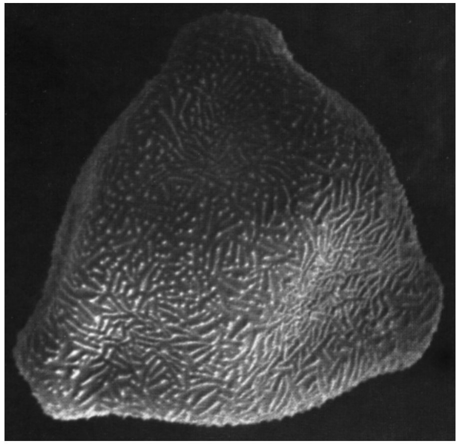
Datenbank: Deutschland

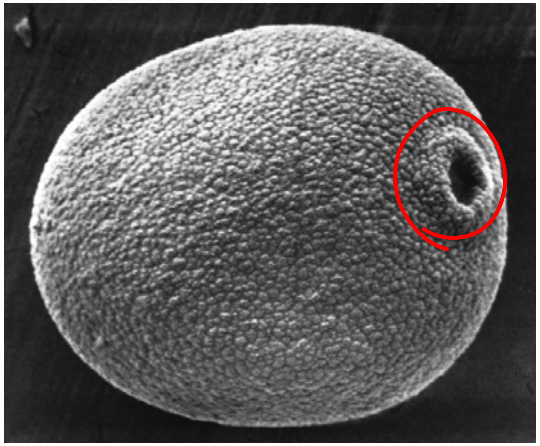
Deutschland Berlin (West) 0042

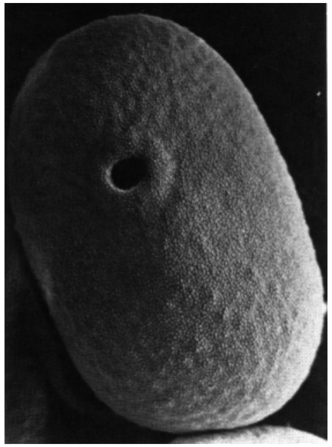
Projekt zur automatischen Erkennung von Blütenpollen - Elektronenmikroskopische Aufnahmen von Pollen

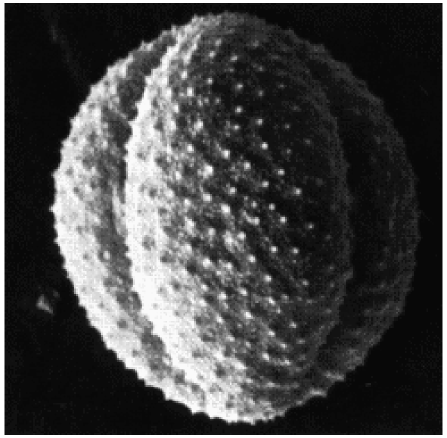

Hasel


Erle


Birke

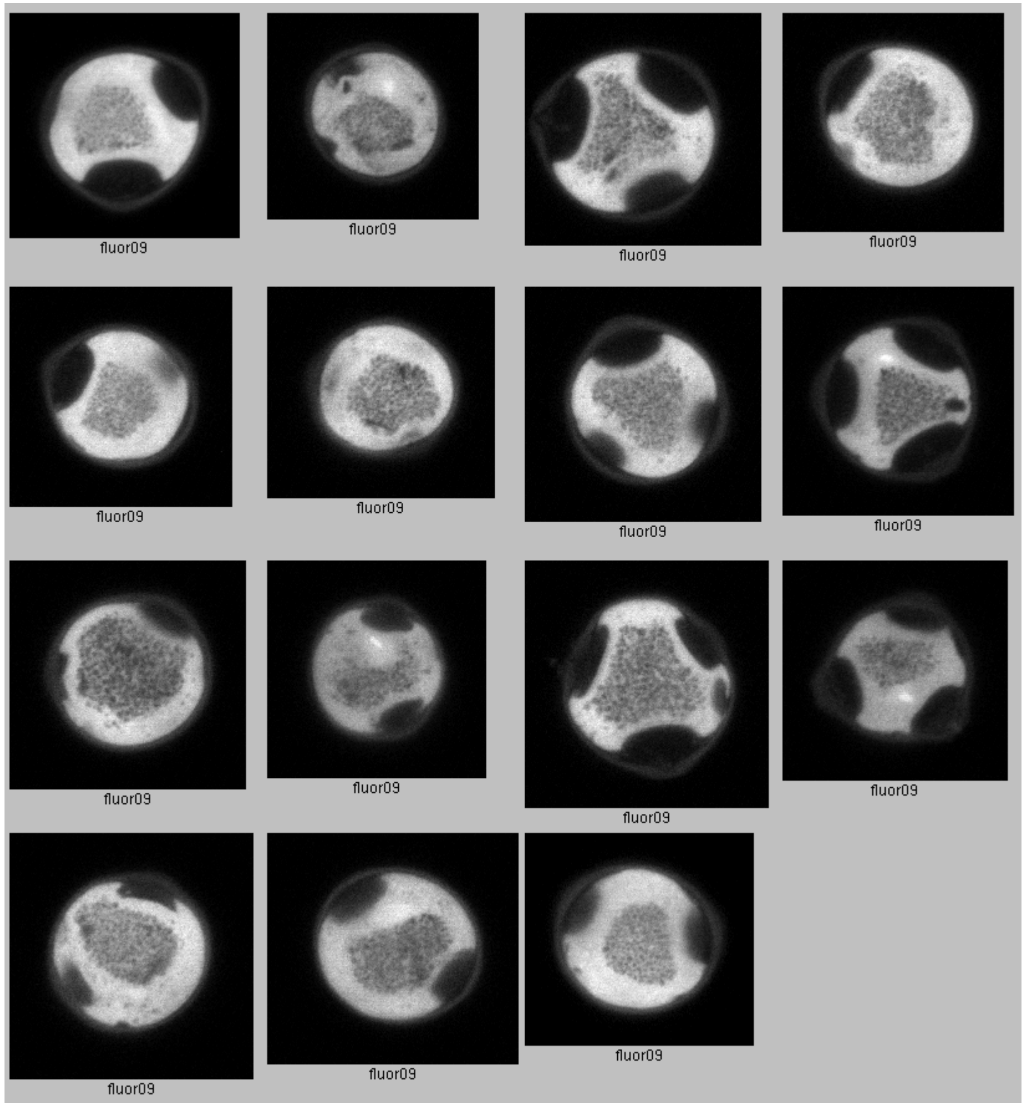

Gräser


Roggen

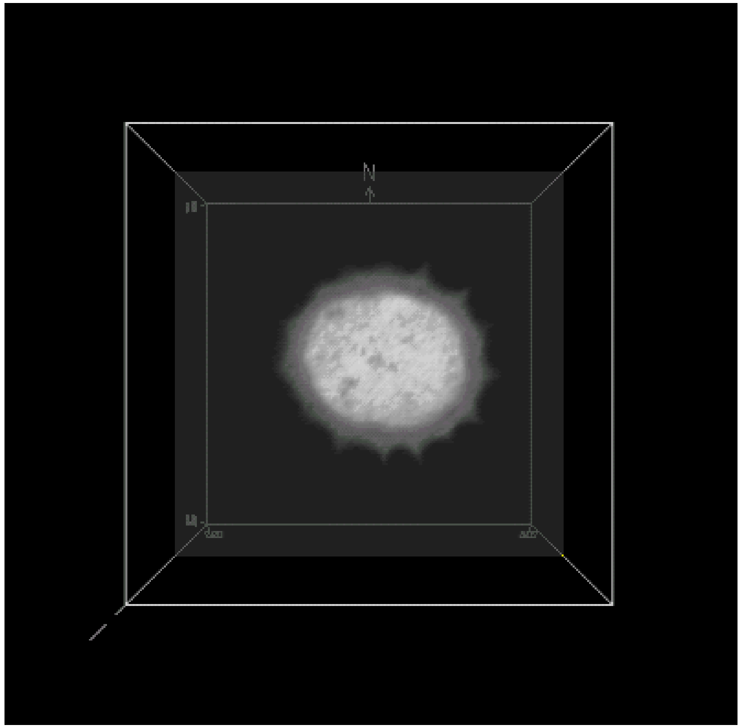

Beifuß

+ 33 further species (not relevant for allergies)

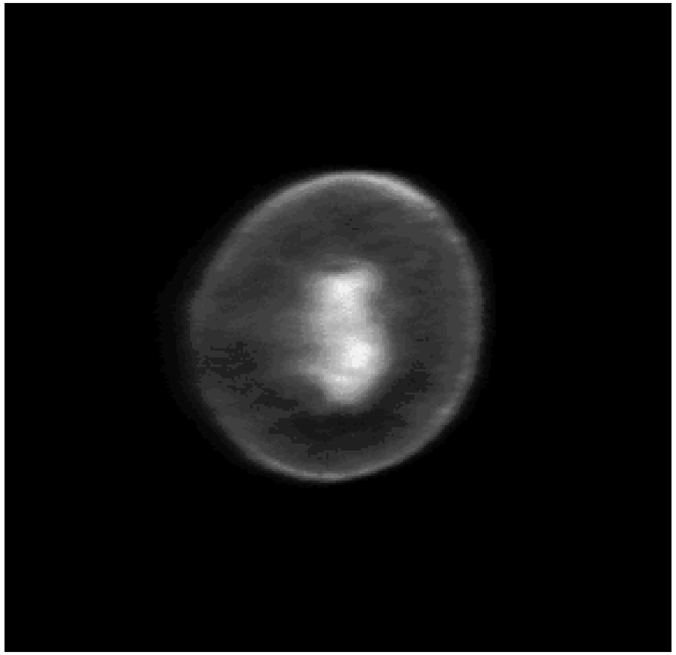
Haselpollen

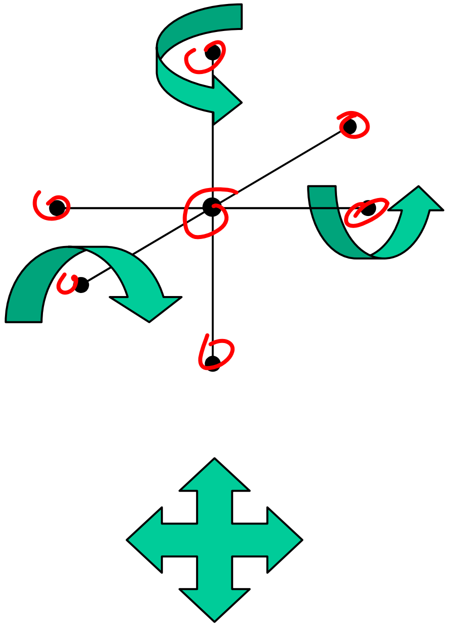


Gänseblümchen/daisy pollen grain



Eibe/Taxus





Integriere über die 3D Euklidsche Bewegung

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.

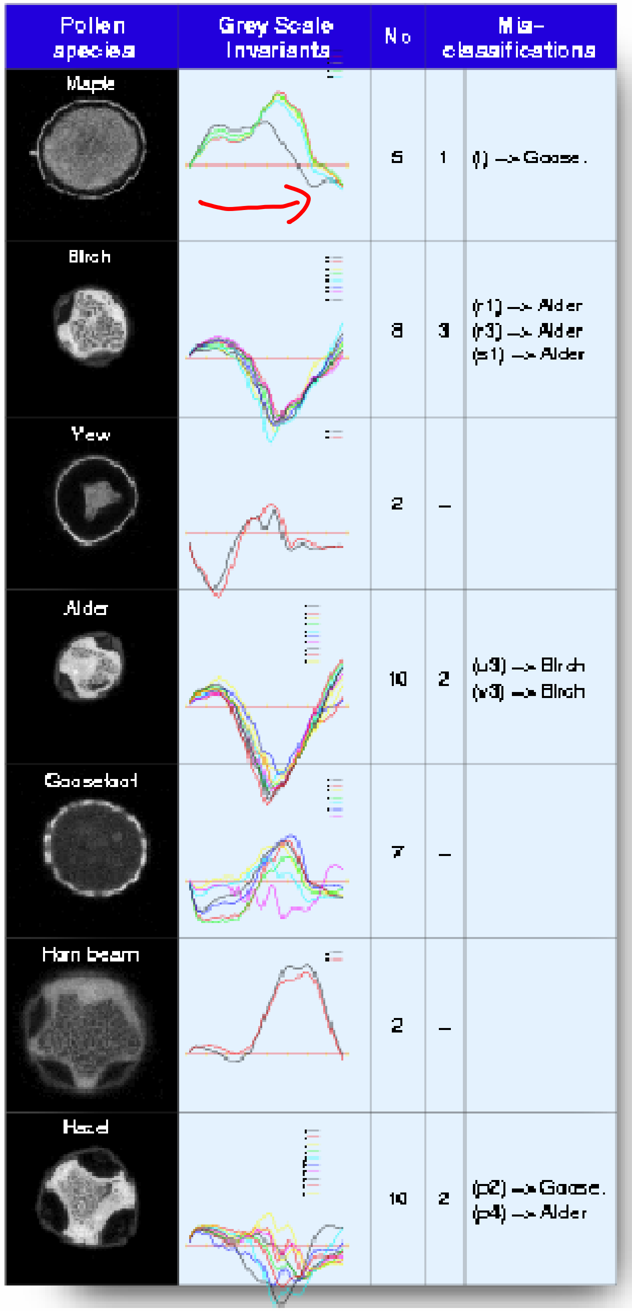
Collaborating institutions

Deutscher Wetter Dienst

SMA ISM SMI

MeteoSchweiz

ALBERT-LUDWIGS-UNIVERSITÄT FREIBURG



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

Classification Results using 3D LSM Data

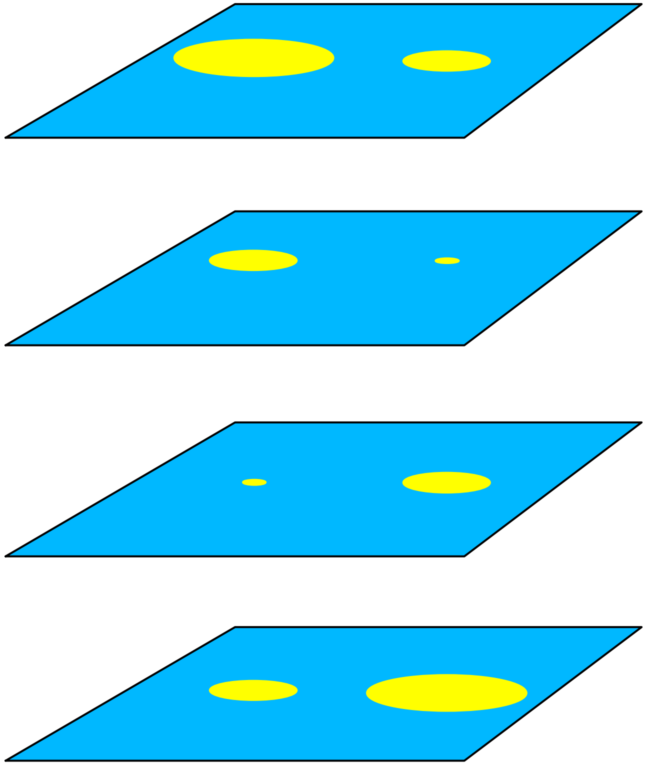
(leave-one-out Classification)

	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%

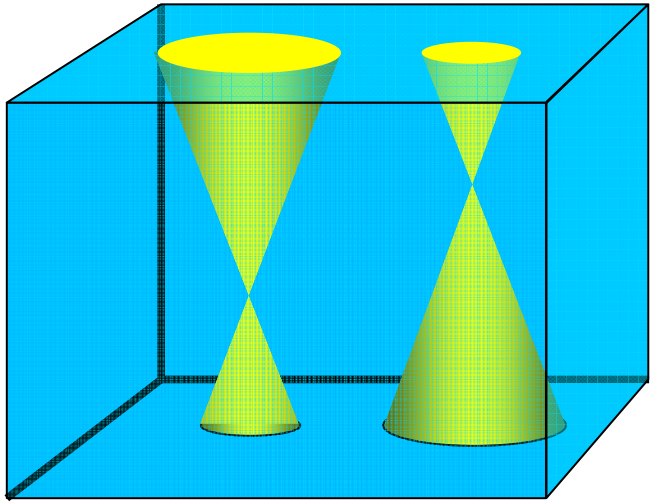
98,7%

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

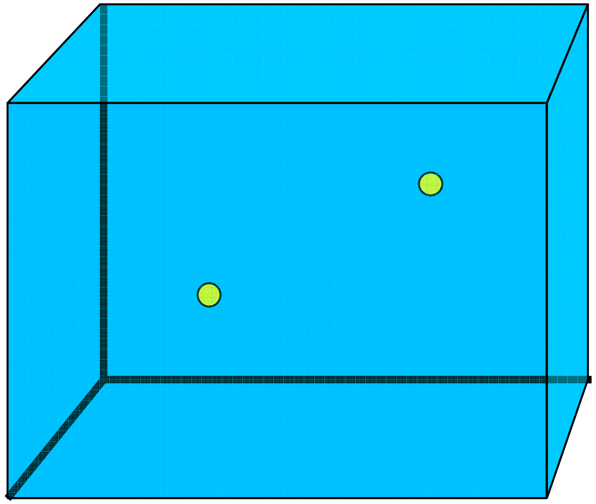
Gewinnung von tomographischen 3D-Daten mit einem normalen Fluoreszenz-Mikroskop



Aufnahme eines Bildstapels mit einem normalen Mikroskop



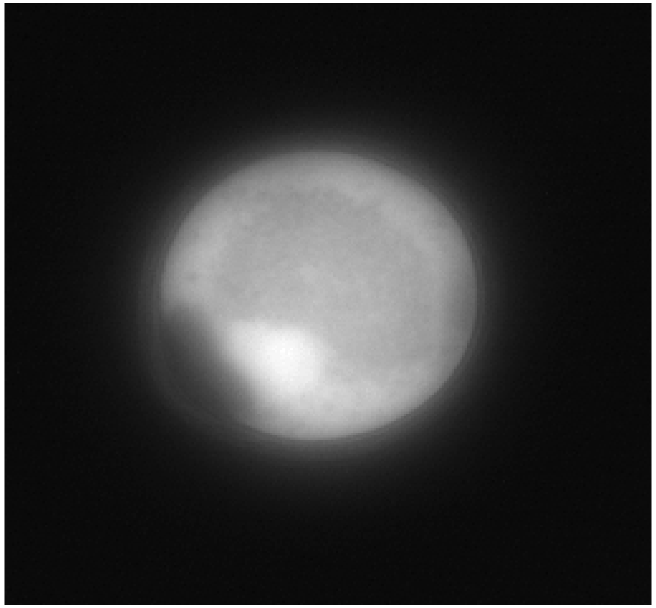
Zusammensetzen der Bilder im Computer zu einem Volumen



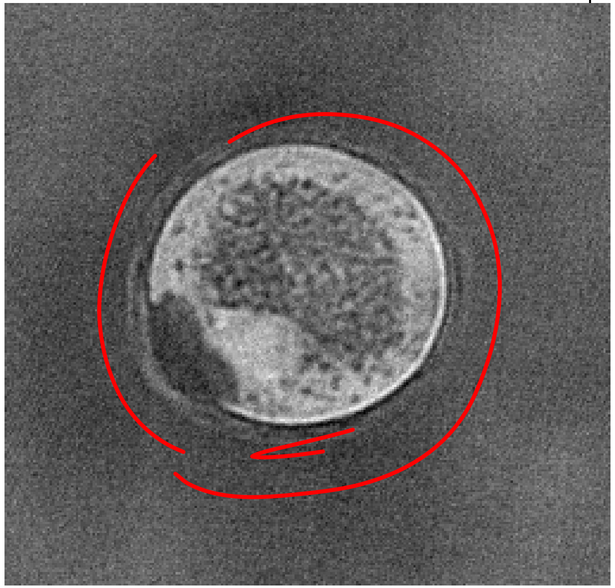
Nach Entfaltung mit der Punktbildfunktion sind alle unscharfen Bereiche entfernt

Deconvolution of a Pollen (Hasel/Corylus)

point-spread function



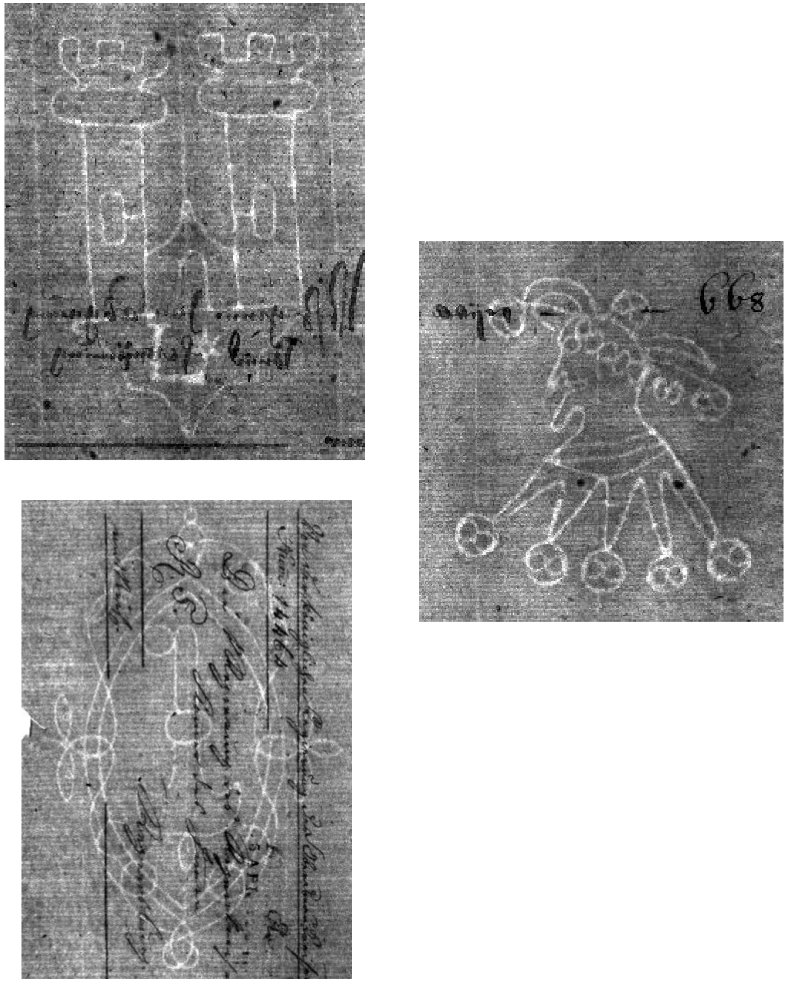
volume



deconvolved volume

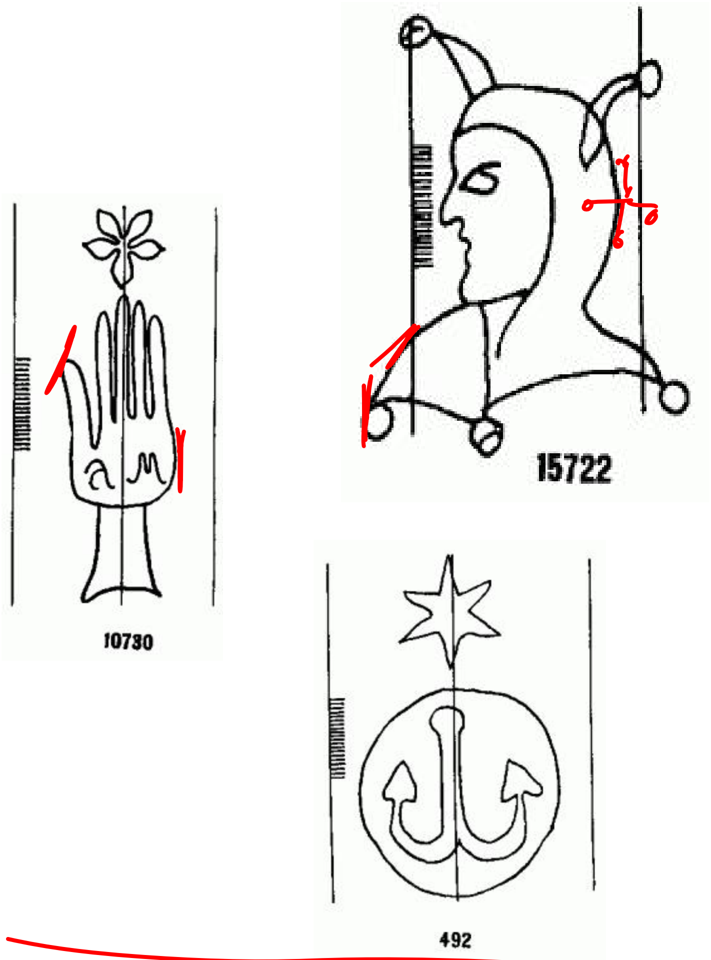
Search Engine for Watermarks in old paper prints
(Joint project with Basel Paper Mill, Swiss Museum for Paper, Writing and Printing)

Scanned watermark images
(samples)

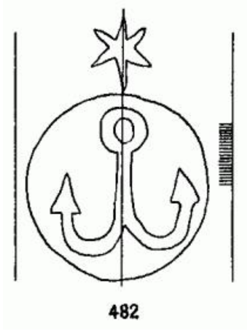


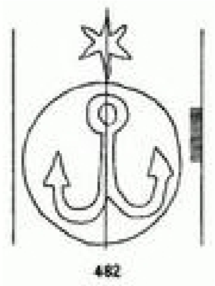
After preprocessing

(sample images)



Query Image





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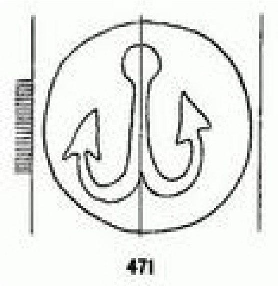
0.98229



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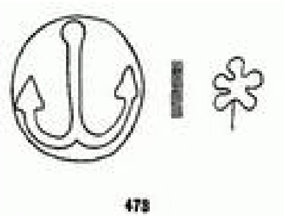
0.97986



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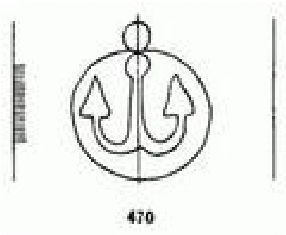

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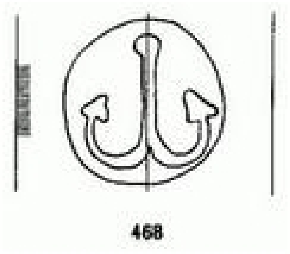

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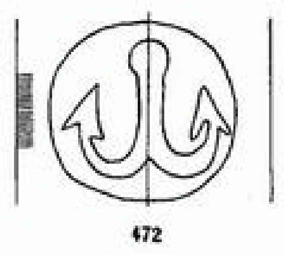

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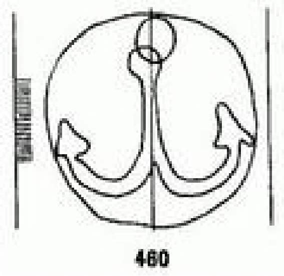
0.97565



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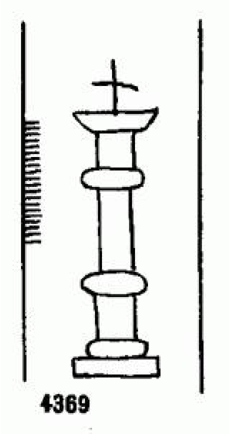
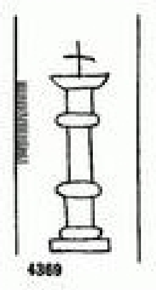
Query Image

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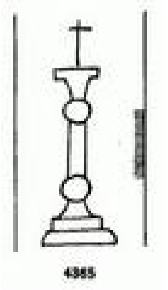
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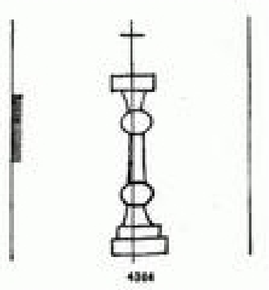
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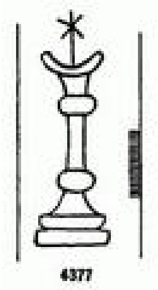
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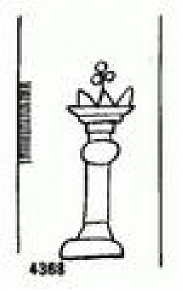
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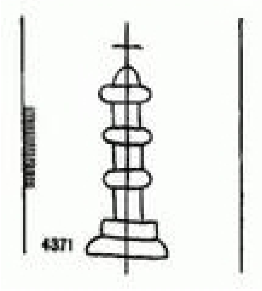
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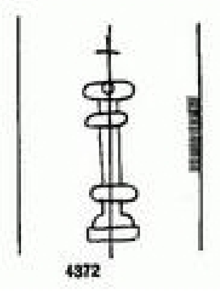
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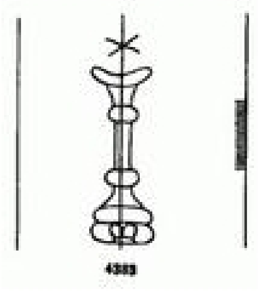
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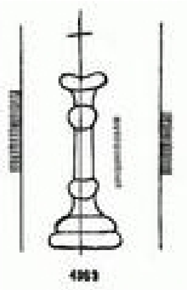
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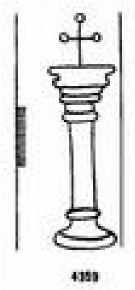
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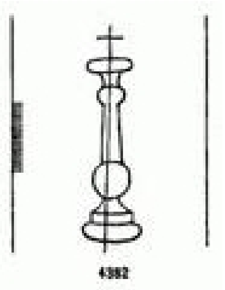
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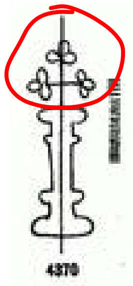
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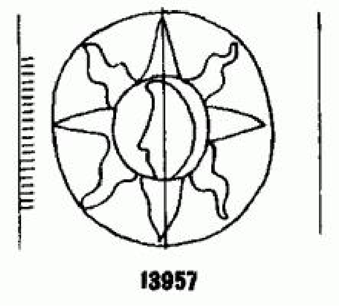
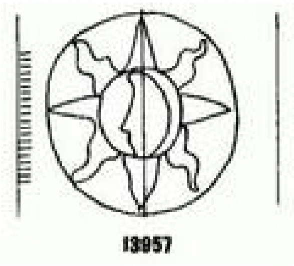
Query Image





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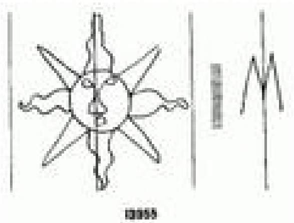

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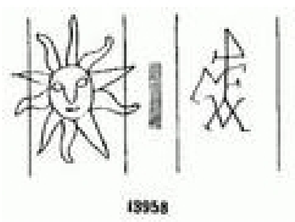

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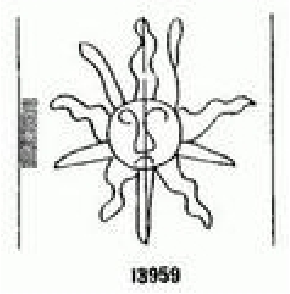

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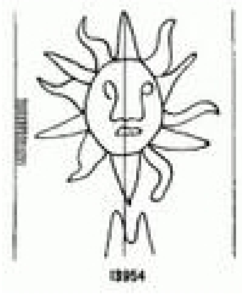

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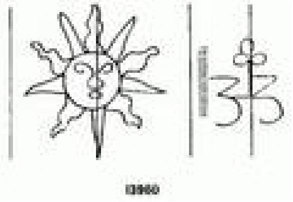

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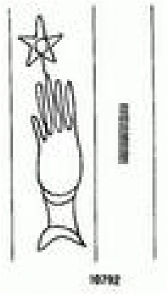

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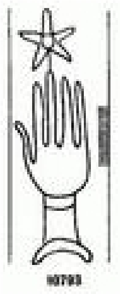

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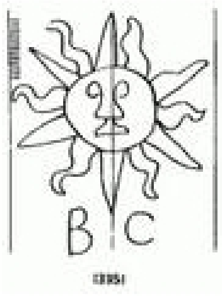

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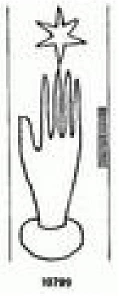


0.75896

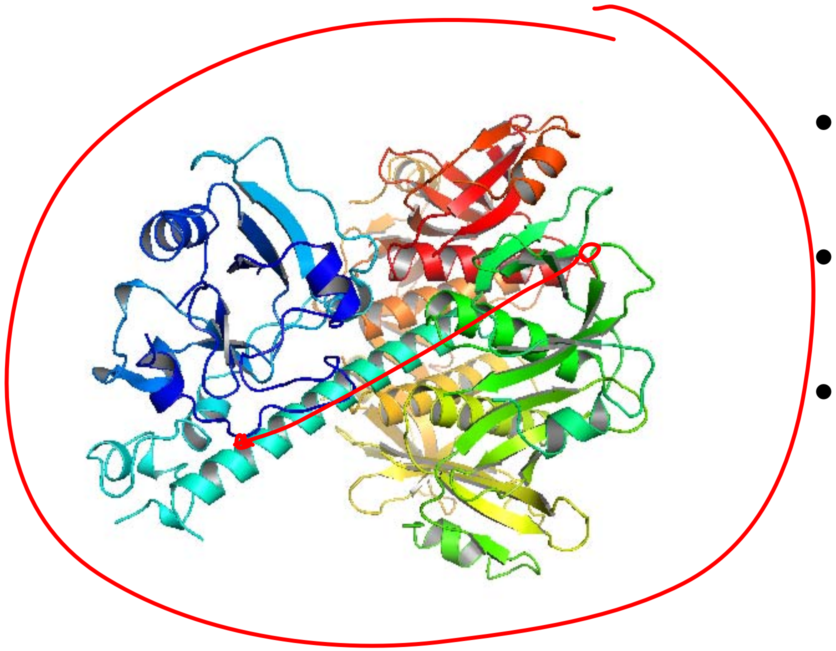
USED FEATURES:

- We encode inter-relational structure knowledge from feature vectors.
- Line segments are grouped by hierarchical clustering.
- Relative spatial arrangements of the grouped line segments are captured in histograms.
- The resulting histogram is robust against illumination changes, rotation, translation and scaling.

Development of a Search Engine for Protein Databases

- There is no canonical way of describing the folding structure of proteins
- This search engines develops space-invariant descriptors for the folding structure of proteins which can be used as index for searching in databases

A Search Engine for Protein Databases based on 3D Folding-Structure



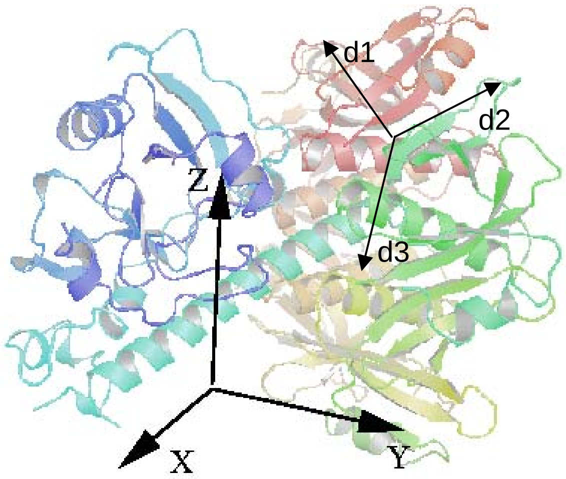
- A Protein is a highly structured 3D object consisting of amino acid chains
- Typical number of amino acids: 100-1000
  → several thousands of atoms
- In the past proteins were compared solely by its amino acid sequence, but
  different sequence → same 3D-
  structure →
  3D-structure functional behavior

- Growing amount of 3D-macromolecular structural data (currently > 32000 in Brookhaven‘s PDB)
- need for efficent search and retrieval techniques
  - drug design
  - evolutionary link detection
- current structural search techniques rely on alignment algorithms
  → slow (retrieval times >hour or >day)

A Search Engine for Protein Databases based on 3D Folding-Structure

- Methods known from Content-Based 3D-Shape/Image Retrieval offer numerous fast algorithms
- Search and Classification is feature-based. The features are invariant to the 3D-pose and the numbering of the amino acids.
- *Invariant Protein Features* are numerical quantities that describe global properties of the Protein, for example

F1 = „How often occur two atoms of the Protein within some distance d“
F2 = „Percentage of atoms which are part of a alpha-Helix structure“



80%

Preliminary Results:

Classification Accuracy:
- for SCOP-‘class‘ granularity: **99.8%**
- for SCOP-‘fold‘ (class alpha): **97.6%**

Retrieval times: less than a second in DB with
more than 32000 proteins (>65000 chains)

Video
“Licht ins Dunkel”

Licht ins Dunkel\VTS_01_1.avi