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Towards an automatic multi-label classification of 3D architectural models
TIB-project conducted with University of Bonn

Ina Blümel

**Workshop on Classification and Subject Indexing in Library and Information Science (LIS'2013)**
10.07.2013

German National Library of Science and Technology TIB – facts

- founded in 1959

- financed by Federal Government and all Federal States

- recently positively evaluated in 2011

- **Global literature supplier**

- > 6 mio media units

- Scientific and technical information
  - engineering, architecture, chemistry, information technology, mathematics and physics
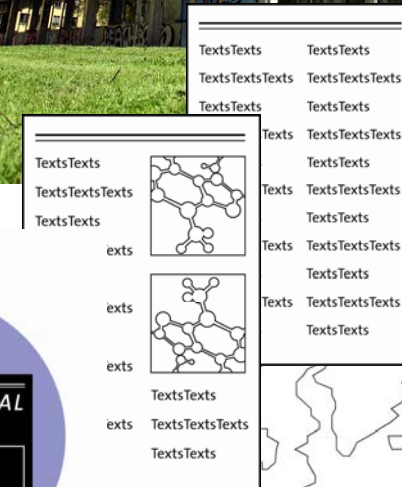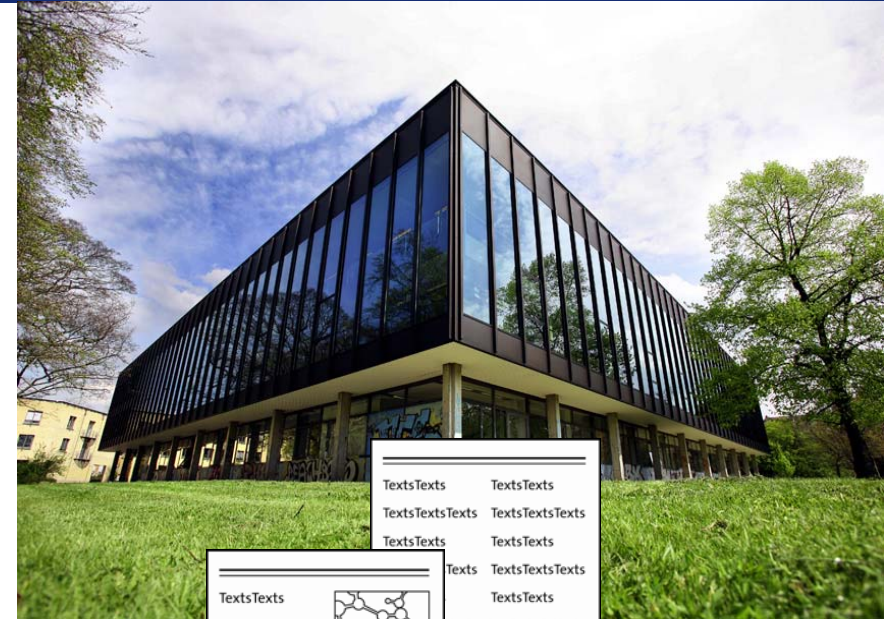
Traditional textual materials

Some current challenges for libraries…

- Increasing information volume

  10x larger in 2011 than in 2006*

- Extension of search space

  WWW instead catalog

- Structural aspects / Document models

  „Enhanced publications", increasingly hybrid

- New content / media formats

  increasing amount of **non textual information – e.g. 3D models**

* IDC Study 2008

TIB goals

- Scientific library services for non textual documents
- Integrating indexing and file processing into library workflow
- Innovative user interfaces for searching and visualisation

VISUAL SEARCHING

CONTENT BASED
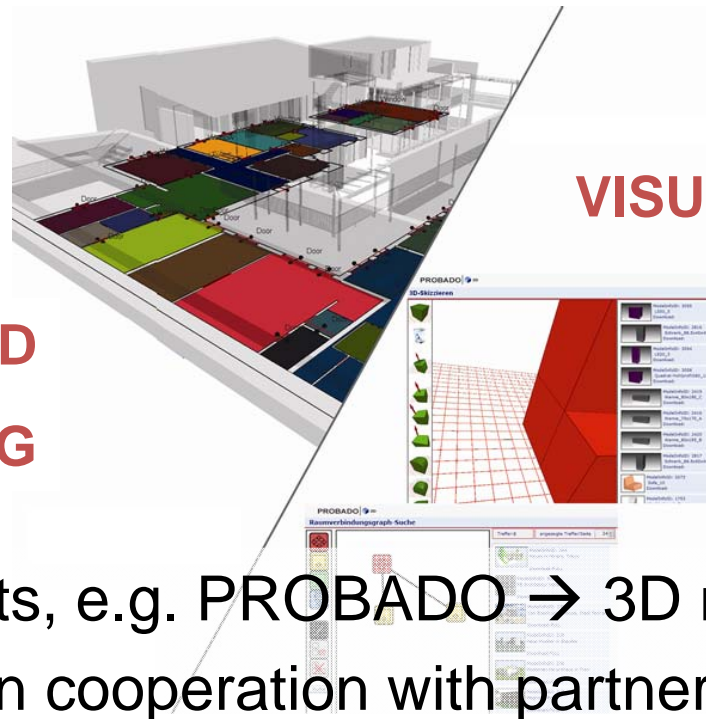
INDEXING

- several projects, e.g. PROBADO → 3D models of architecture
- development in cooperation with partners

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3D models in architecture
here: Computer aided design process

Architects are…

– creating 3D models when drafting

– gladly using existing models
- …as source for inspiration
- …for direct integration into
  own drafts

– searching for models
- WWW
- databases
- …
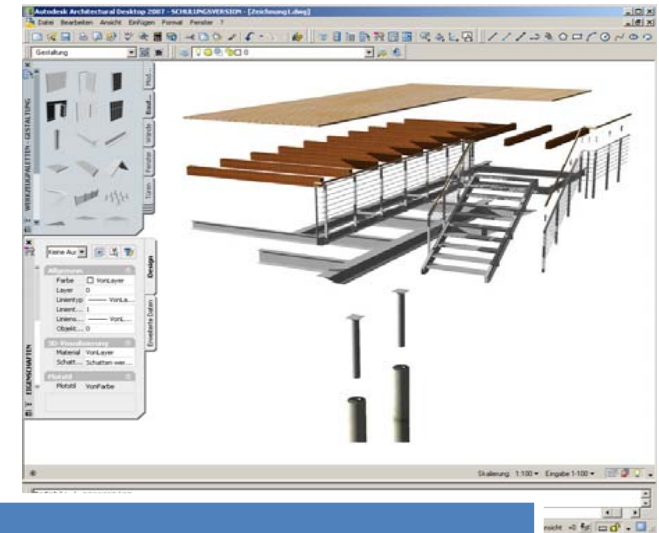
Survey among 58 architects*:
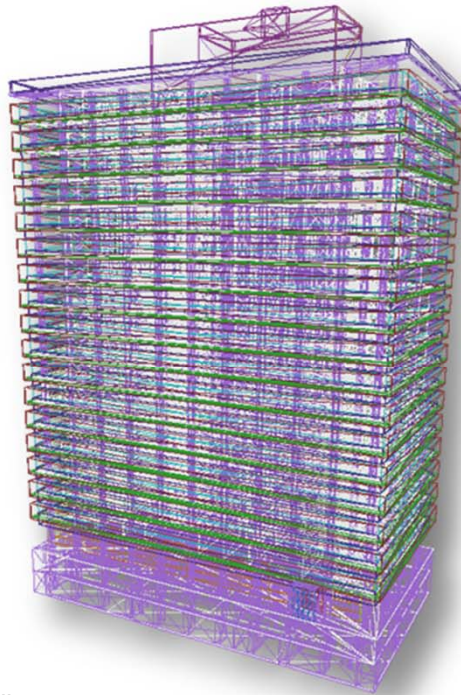71% use existing 3D models

Search methods most wanted:
Textual: 72,5%
Query-by-example: 27,5%

* conducted within PROBADO project 2006+

3D models – content?

opened in CAD editor…

Machine view: definition of vertices / faces, no semantics

- no explicitly available information (for e.g. full text search)
- poor metadata annotation available
- → Need for **indexing and classification algorithms**
  (tailored to architectural data and architect's requirements)

Automatic multi-label classification of 3D models

project for the development of a prototype
TIB and University of Bonn

Given: A set of 3D models
without any textual annotation

Objective: Multi-label classification
of the models in order to allow
textual search for these models

tables
column tables

sideboards

sofas

couches

seating furniture

armatures

mirrors
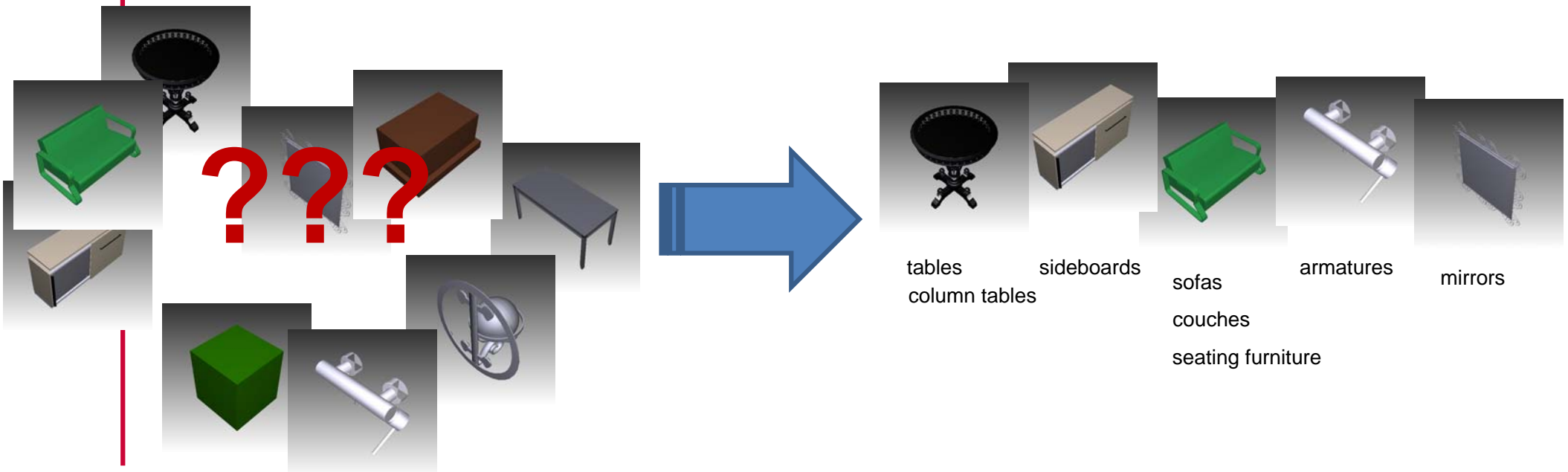
Training data

- We want to have as little work with any manual labeling for training purposes
- We want to have multiple labeling

We chose:

- Archibase portal, about 16.000 object models
- manually annotated with keywords

Training data and preliminary work (TIB)

Step 1:

a) Selection: terms that correspond to a particular form

b) <u>Mapping</u> of Archibase terms on AAT classes > 15 models / concept

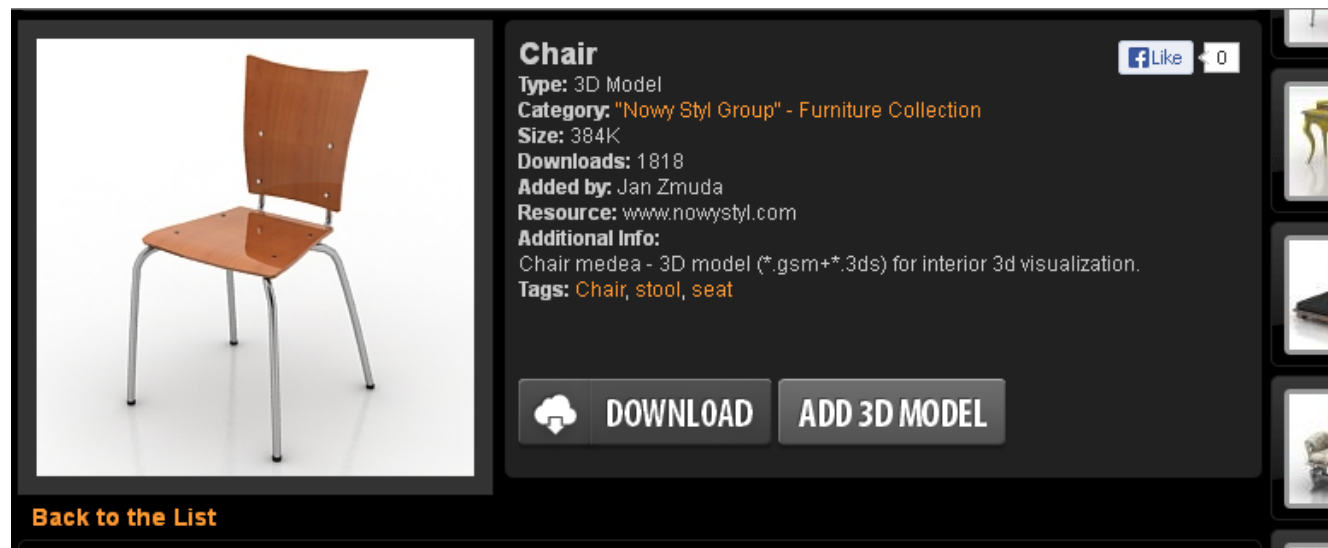|	
seat	1049
table	933
chair	877
easy chair	777
couch	760
lamp	739
sofa	739
furniture	696
elbow chair	687
armchair	682
desk	637
luminaire	621
locker	607
rack	560

- building element
  - fixtures
    - fixtures.circulation fixtures
    - fixtures.cleaning fixtures
    - fixtures.culinary fixtures
    - fixtures.general room and secondary spaces fixtures
    - fixtures.sanitary fixtures
  - installations
    - installations.electrical
    - installations.lifts and escalators
    - installations.lighting
    - installations.lightning protection and conductors
    - installations.power
    - installations.telecommunication
  - primary elements
    - primary elements.building elements above roof
    - primary elements.ceilings
    - primary elements.external walls
    - primary elements.external walls.curtain walling
    - primary elements.external walls.loadbearing walls
    - primary elements.external walls.non-loadbearing walls
    - primary elements.flat roofs and terraces
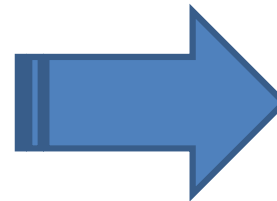
Descriptor calculation, classification and integration (Bonn University)

Step 2:
Implementation of the shape descriptors

Step 3:
Application on test set
Evaluation → feedback → adaptation of the algorithm, various iterations

Step 4:
Integration into PROBADO framework

Challenges #1

- Training data: inconsistencies in keyword assignment, no real "ground truth"

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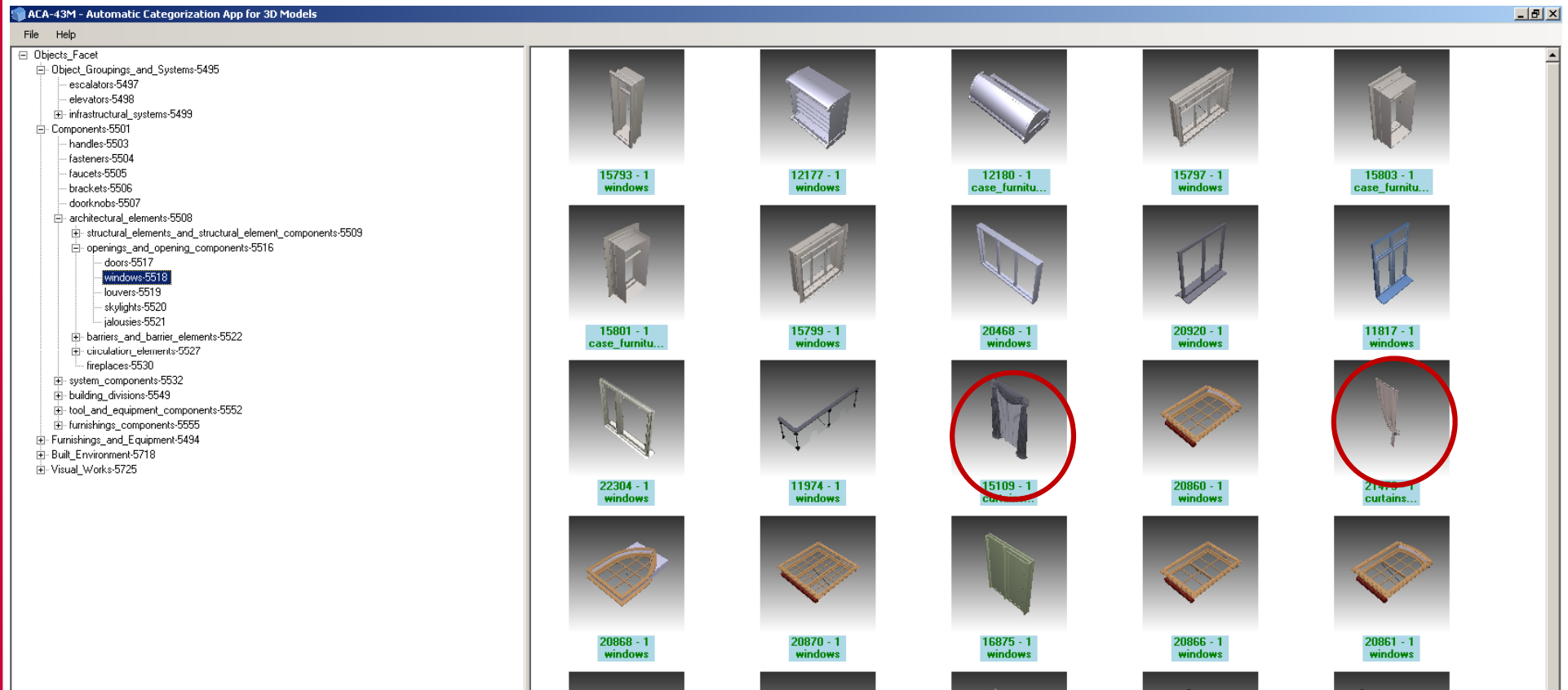
Challenges #2

- Shape variance within classes

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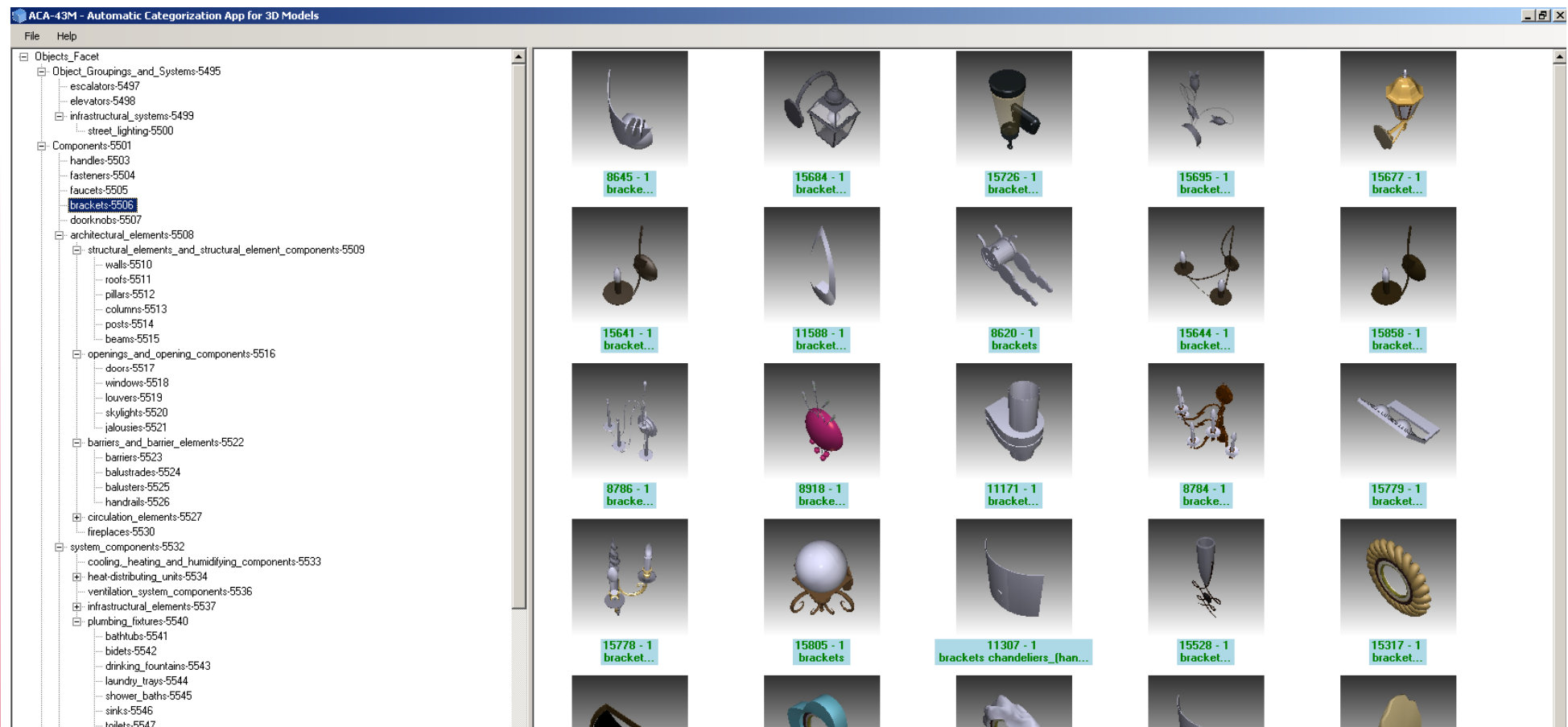
Challenges #3

- similar classes (considering their shape) both at Archibase and AAT

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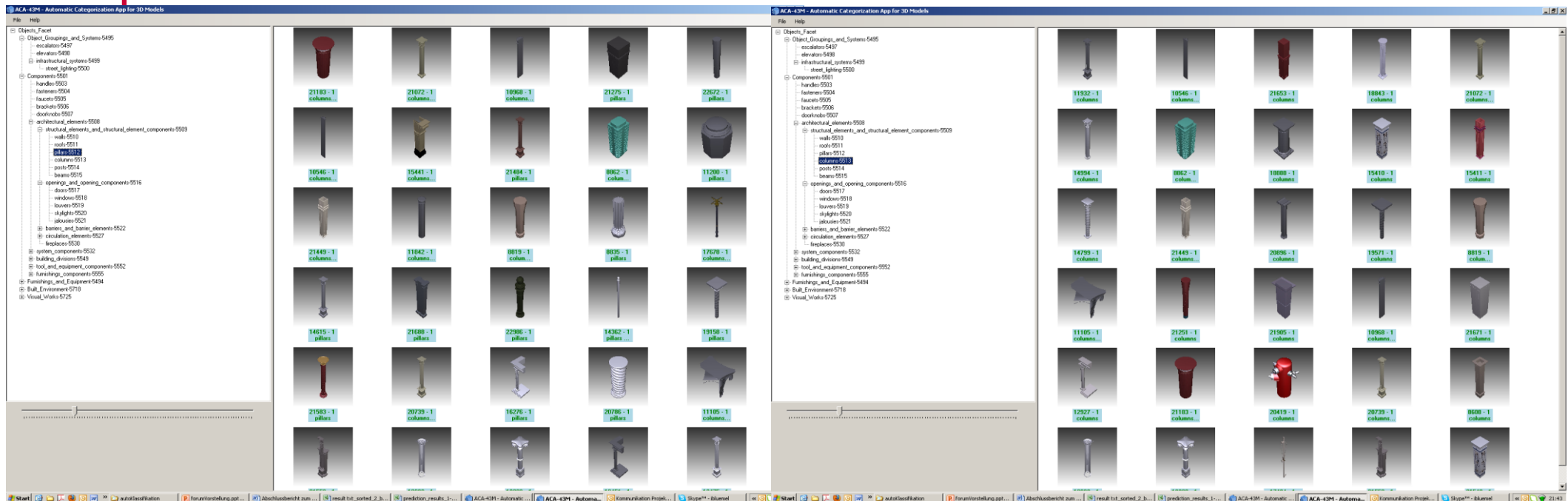
Challenges #4

- Amount of training data in classes

Challenges #5

- Suitability of descriptor
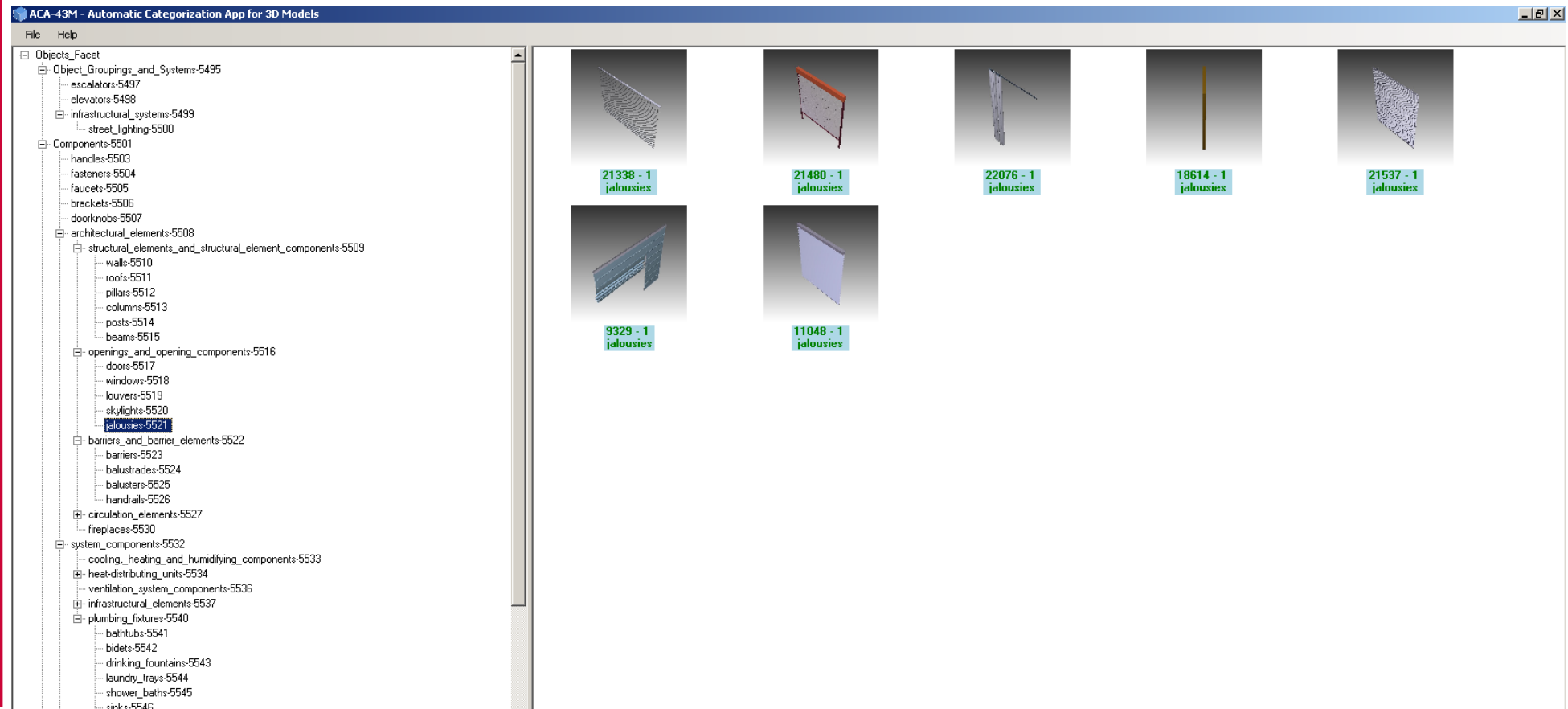
Results

- Training with different parameter settings

- about 6 out of 10 models was tagged correctly, about every 9 tagged incorrectly

- Optimization algorithm, such that low false positive rate occurs

|		
(book)shelves	73,000	76,000
balusters	92,857	83,333
balustrades	85,714	60,000
barriers	90,196	78,049
bathtubs	90,909	52,577
benches	79,070	65,714
bidets	75,000	91,667
bookcases	83,333	73,684
boxes	84,000	64,000
brackets	72,000	68,000
cabinets	74,000	79,000
candles_and_candleholders	86,000	73,000
chandeliers_(hanging_lights)	85,000	85,000
chests_of_drawers	84,000	68,000
coffee_tables	81,395	53,659
columns	94,805	74,576
console_tables	71,429	41,667
couches	69,000	87,000
cupboards	86,441	85,714
curtains	96,226	96,000
dining_tables	83,333	73,333
divans	89,000	75,000
doors	**92,000**	**87,629**
double_beds	89,000	88,000
dressing_tables	81,250	80,000
easy_chairs	74,000	84,000
elbow_chairs	81,000	86,000
faucets	87,671	79,105
fences	89,706	78,333
floor_lamps	92,308	87,719
hassocks	80,435	71,739
lampposts	95,238	67,500
lanterns	81,818	58,511
lockers	81,000	70,000
lusters	86,000	83,000

Selection

- Visualization Tool for selection of classes that are to be accepted
- 37 of classes 83 integrated

Integration into the PROBADO 3D portal

- Ranking by confidences
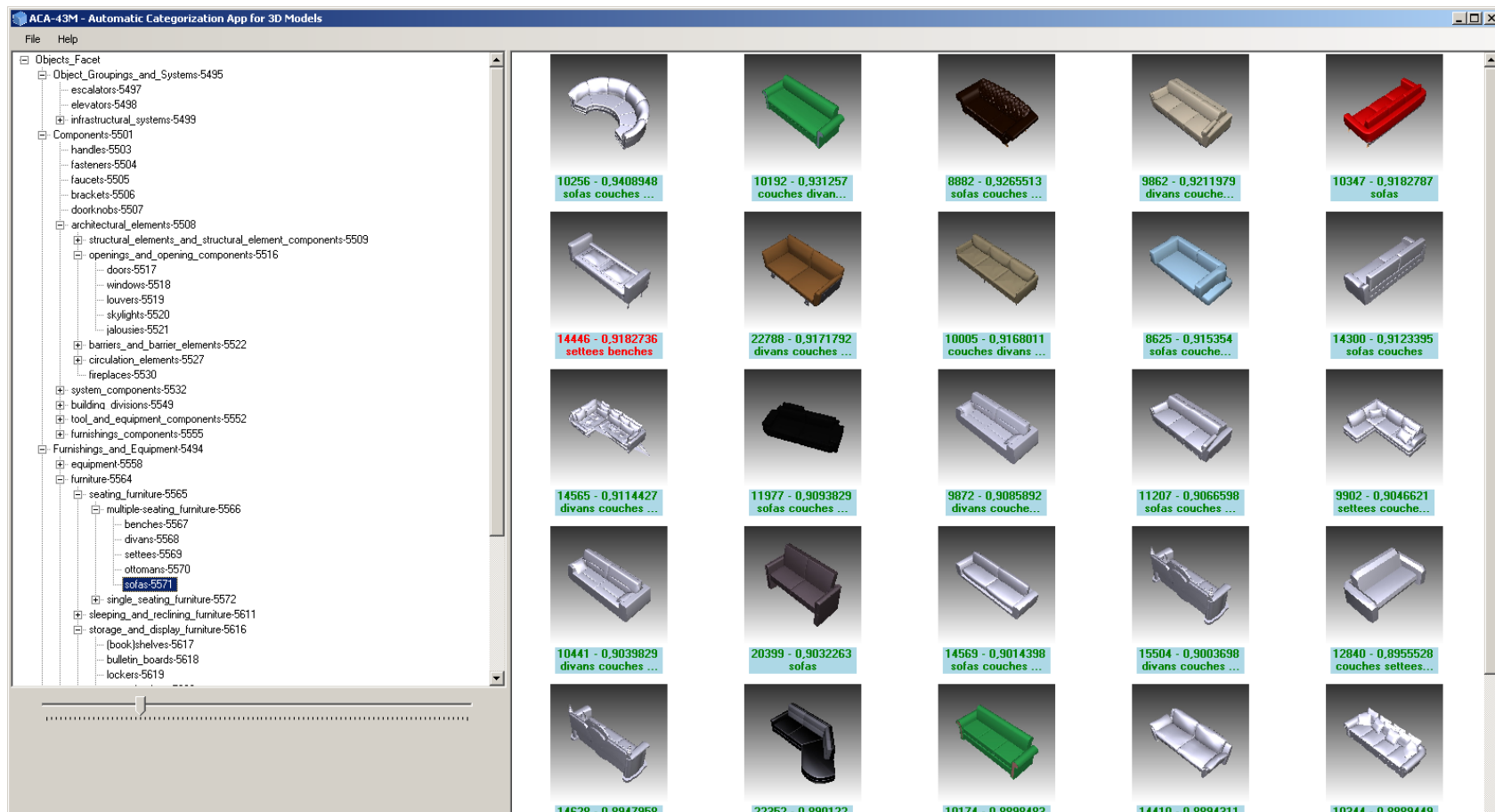
Publications (selection)

- **Metadatenbasierte Kontextualisierung architektonischer 3D-Modelle**
  Ina Blümel
  Dissertation, HU Berlin 2013

- **3D @Technische Informationsbibliothek (TIB)**
  Ina Blümel, Irina Sens
  in *Unimagazin, Ausgabe 1|2-2012 "WebScience"*, Präsidium der LUH (Hrsg.), Juni 2012, Seiten 16ff

- **Efficient Retrieval of 3D Building Models Using Embeddings of Attributed Subgraphs**
  Raoul Wessel, Sebastian Ochmann, Richard Vock, Ina Blümel, Reinhard Klein
  Proceedings of the *20th ACM Conference on Information and Knowledge Management (CIKM 2011)* : Glasgow, UK, Okt. 2011

- **Supporting Planning through Content-Based Indexing and 3D Shape Retrieval**
  Ina Blümel, René Berndt, Sebastian Ochmann, Richard Vock and Raoul Wessel
  Proceedings of *10th International Conference on Design & Decision Support Systems in Architecture und Urban Planning (DDSS)*, July, 2010

- **A 3D Shape Benchmark for Retrieval and Automatic Classification of Architectural Data**
  R. Wessel, I. Blümel and R. Klein
  EUROGRAPHICS 2009 Workshop on 3D Object Retrieval, March 2009

- **The Room Connectivity Graph: Shape Retrieval in the Architectural Domain**
  R. Wessel, I. Blümel and R. Klein
  Proceedings of *The 16-th International Conference in Central Europe on Computer Graphics, Visualization und Computer Vision'2008*, ISBN 978-80-86943-15-2, February 2008

Thank you for your attention!

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