# TIB GERMAN NATIONAL LIBRARY OF SCIENCE AND TECHNOLOGY

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**





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



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

## 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?



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



# 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:

- Selection: terms that correspond to a particular form a)
- <u>Mapping</u> of Archibase terms on AAT classes > 15 models / b) concept ما محمد اما : بيما

		-	buildir	ng elemen	t
seat	1049		•	fixtures	
table	933			-	fixtures.circulation fixtures
	555			_	fixtures.cleaning fixtures
chair	877			-	fixtures.culinary fixtures
easy chair	777			-	fixtures.general room and secondary spaces fixtures
couch	760			_	fixtures.sanitary fixtures
lamp	739		•	installati	ions
sofa	739			_	installations.electrical
furnituro	606			-	installations.lifts and escalators
Turmture	090		- /	-	installations.lighting
elbow chair	687			-	installations.lightning protection and conductors
armchair	682		$\neg$	-	installations.power
desk	637			-	installations.telecommunication
	624		•	primary	elements
luminaire	621			_	primary elements.building elements above roof
locker	607			_	primary elements.ceilings
rack	560			_	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

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# Descriptor calculation, classification and integration (Bonn University)

Step 2: Implementation of the shape descriptors

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

Step 4: Integration into PROBADO framework

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



#### • Shape variance within classes



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#### • Amount of training data in classes

Objects_Facet					
Dbject_Groupings_and_Systems-5495     escalators-5497     elevators-5498     prinfrastructuraLsystems-5499					
⊡ - Components-5501		Y	- Al		A CONTRACT OF
fasteners-5504	21338 - 1	21480 - 1	22076 - 1	18614 - 1	21537 - 1
- faucets-5505 - brackets-5506	jalousies	jalousies	jalousies	jalousies	jalousies
doorknobs 5507     doorknobs 5507     erchitectural_elements-5508     erchitectural_elements_and_structural_element_components-5509					
posts-5514	0000 1	11040 1			
openings_and_opening_components-5516     doors-5517     windows-5518     louvers-5519     skylights-5520     Islowise-5521     barriers_and_barrier_elements-5522     barriers-5523     balustrades-5524     balusters-5525     louvers-5526     barrier_elements-5527	jalousres	Jalousies			
fireplaces-5530     fireplaces-5532     cooling_heating_and_humidifying_components-5533         ⊕ cooling_heating_and_solution_components-5536         wenilation_system_components-5536         æ infrastructuraLelements-5537					
<ul> <li>⊨ plumbing_fixtures:5540</li> <li>— bathtubs:5541</li> <li>— bidiet:5542</li> <li>— drinking_fountains:5543</li> <li>— laundry_trays:5544</li> <li>— shower_baths:5545</li> <li>— airiks:5546</li> </ul>					
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#### • Suitability of descriptor



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## 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

(DOOK)SHEIVES	75,000	70,000	
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_candleh	86.000	73 000	
chandeliers (hanging	80,000	75,000	
lights)	85 000	85 000	
_lights)	83,000	68,000	
coffee tables	81 395	53 659	
columns	01,555 04 805	74 576	
consolo tablos	71 / 20	11 667	
couchos	69,000	41,007	
cuphoards	09,000 86 441	87,000 85 71 <i>4</i>	
cupboards	06,441	96,000	
dining tables	90,220	30,000 222 27	
divans	80,000	75,555	
doors	89,000 <b>92,000</b>	<b>87 620</b>	
double bods	92,000	88,029	
drossing tables	89,000	80,000	
asy chairs	74,000	80,000	
elbow chairs	81 000	86,000	
faucets	87,671	79 105	
fences	89 706	78 333	
floor Jamps	02,700	87 710	
hassocks	92,508 80.435	71 720	
lamnnosts	95 729	67 500	
lanterns	23,230 81 818	58 511	
lockers	81 000	70 000	
luctors	01,000 96 000	82 000	
IUSLEIS	00,000	00,000	

## Selection

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



## Integration into the PROBADO 3D portal

<ul> <li>Ranking by confidences</li> </ul>								
Suche Browsing Probado3D Labs Hilfe								
Kategorie Bereitsteller Sammlung Format								
KATEGORIEN								
	Test							
💿 Objekte	Treffer:7273							
▲ Objekte / Möbel								
▲ Objects Facet (AAT)		2 3 4 5 6 7 8	9 10 11 30.					
Furnishings and Equipment	0.979121	0.978936	0.977729					
> equipment	ModelInfoID17710	ModelInfoID21278	ModelInfoID2250					
⊿ furniture	Herunterladen: Yes (external)	Herunterladen: Yes (external)	Herunterladen: Ye					
✓ seating furniture	0.077601	0.07(281	0.075154					
b multiple-seating furniture	ModelInfoID22842	ModelInfoID17977	ModelInfoID2208					
✓ single seating furniture	Armchair	Chair	Chair					
⊿ chairs	Herunterladen: Yes (external)	Herunterladen: Yes (external)	Herunterladen: Ye					
▷ chairs by form	0.972381	0.971622	0.971326					
chairs by function	ModelInfoID8881	ModelInfoID22649	ModelInfoID2010					
chairs by location or context	Herunterladen: Yes (external)	Herunterladen: Yes (external)	Herunterladen: Ye					
> stools	0.971008	0.959014	0.967859					
sleeping and reclining furniture	ModelInfoID21575	ModelInfoID19122	ModelInfoID1685					
storage and display furniture	Chair Herusterladen (Asternal)	Chair Horusterladen Vez (external)	Chair					
> support turniture	Herunterladent, res (external)							
> screens	0.966476	0.963006	0.962801					
	Armchair	Chair	Armchair					
A Containers	Herunterladen: Yes (external)	Herunterladen: Yes (external)	Herunterladen: Ye					
washhowls	0.961925	0.961328	0.960486					
Vases	ModelInfoID18263	ModelInfoID17931	ModelInfoID1178					
boxes	Chair Herunterladen: Yes (external)	Chair Herunterladen:Yes (external)	Armchair Herunterladen: Ye					

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# 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

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### Thank you for your attention!

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