Univerza v Mariboru

Point cloud quality metrics for Building Information Modelling

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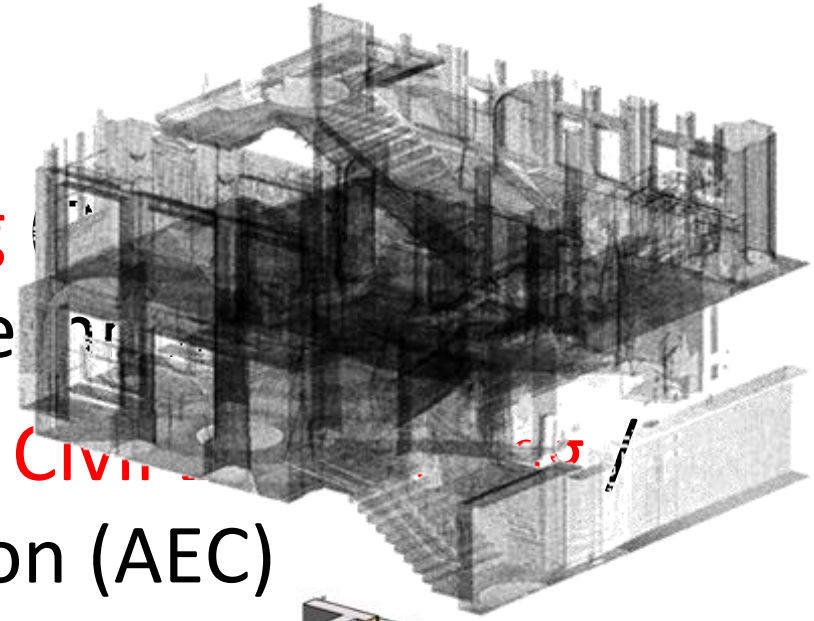
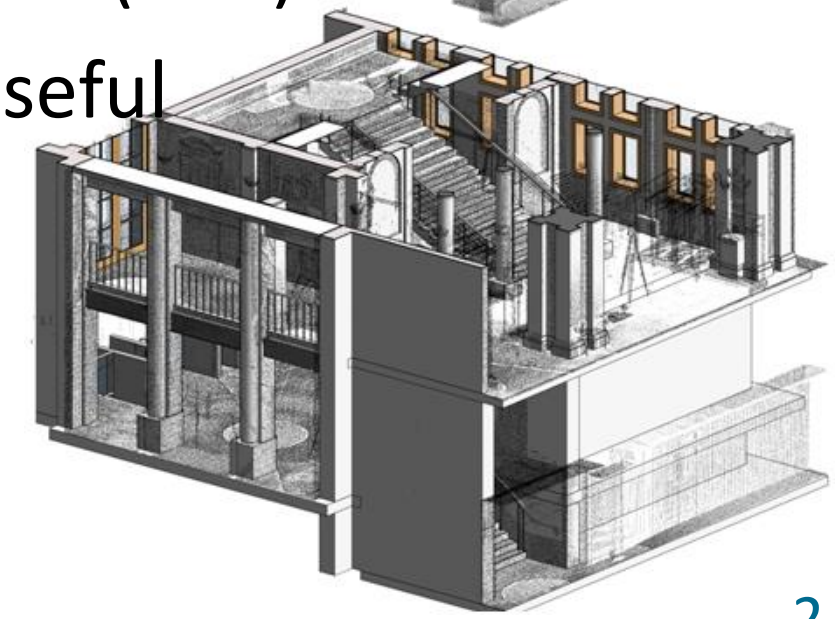
Introduction

- Building Information Models & Modelling (
  a mature and standardised (ISO 19650) te
- BIM is the fundament for digitalisation in Civ
  Architecture, Engineering and Construction (AEC)
- Point clouds are becoming increasingly useful
  - Construction progress Monitoring
    (Scan – vs – BIM)
  - Digitalisation of existing Buildings
    (Scan – to – BIM)

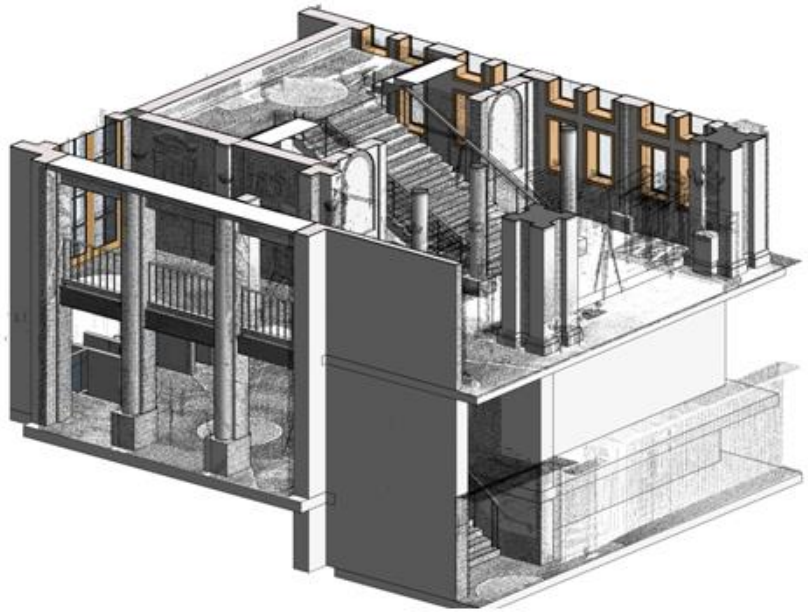




http://bimdesigning.com/

Purpose of our research

- To support Scan – vs – BIM processes by providing appropriate point cloud quality metrics
- which can help setup efficient scanning equipment and procedures (scanning plan)
- Existing point cloud quality definitions on parameters (Level od Details, Level of Acc
- that don‘t represent a useful input to det efficiency of Scan – vs – BIM



http://bimdesigning.com/

Methodology

1. Classification of building elements according to their size, (which also correspond to construction phases)
   - Large elements (L): Size $\geq$ 5 m2,
   - Medium elements (M): 1 m2 $\leq$ Size < 5 m2,
   - Small elements (S): 0.25 m2 $\leq$ Size < 1 m2
   - Very small elements (XS): Size < 0.25 m2

Methodology

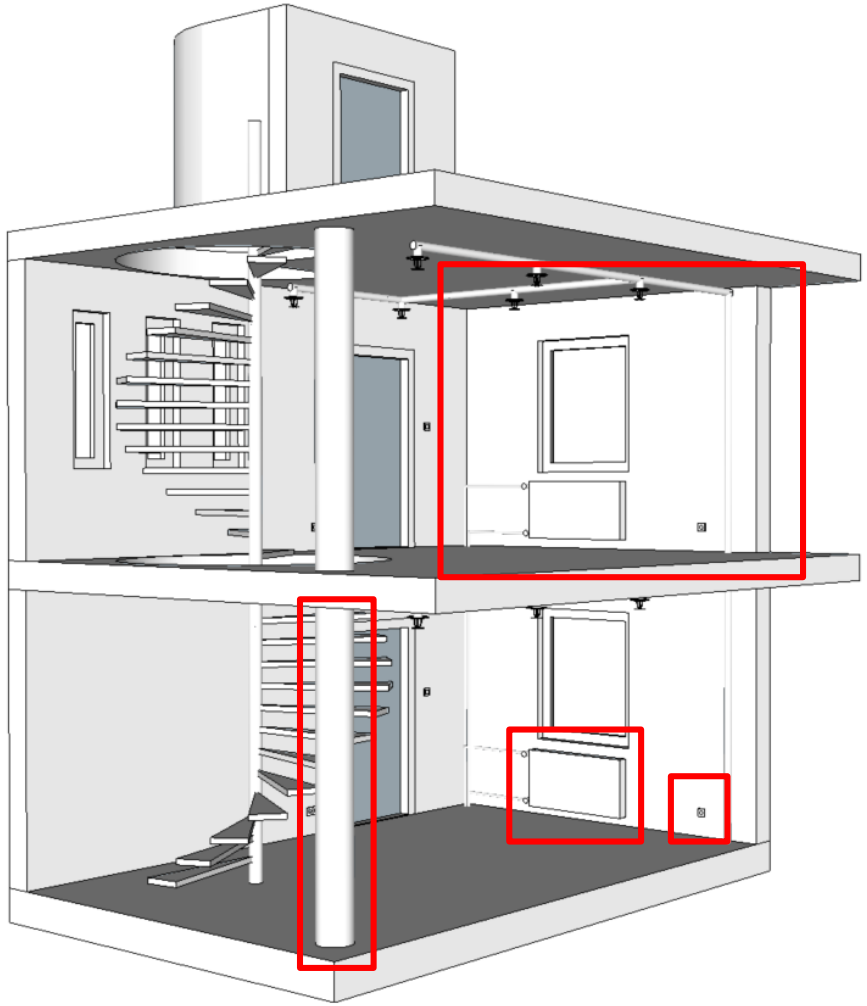
1. Classification of building elements according to their size
2. Definition of point cloud quality parameters
   that can be derived from the point cloud and related to the scanning methodology
   - Minimum local density [points / m2]
   - Minimum local accuracy [m]
   - Level of scatter [%]

Methodology

1. Classification of building elements according to their size
2. Definition of point cloud quality parameters
3. Experimental correlation of building element classes and quality parameters during a series of Scan – vs – BIM processes using point cloud simulation
4. Calculation of pont cloud quality criteria (treshold values of quality parameters) for successful element identification in a Scan – vs – BIM process

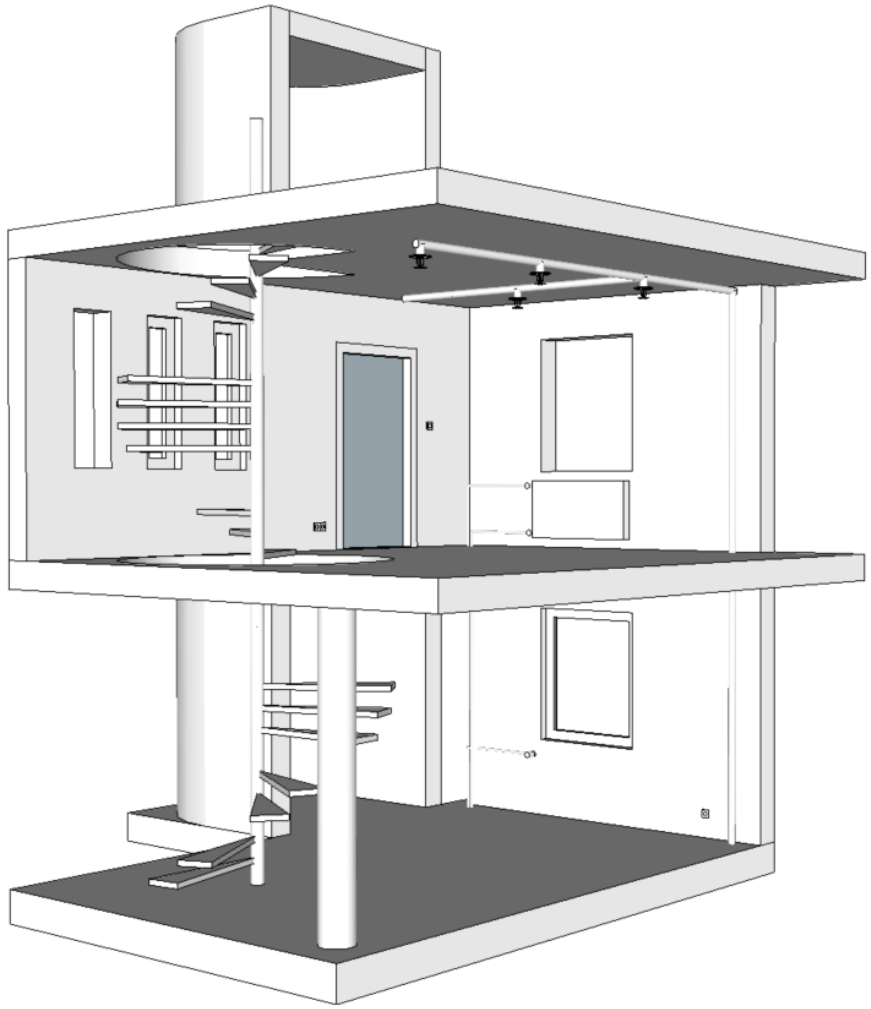
Experiment – Representative BIM model

- A BIM model was designed that includes all classes of elements (As-Designed model)
  - L (walls, slabs, shafts),
  - M (columns, doors, windows),
  - S (stairs, radiators) and
  - XL (pipes and valves, sprinkler system, outlets and switches)



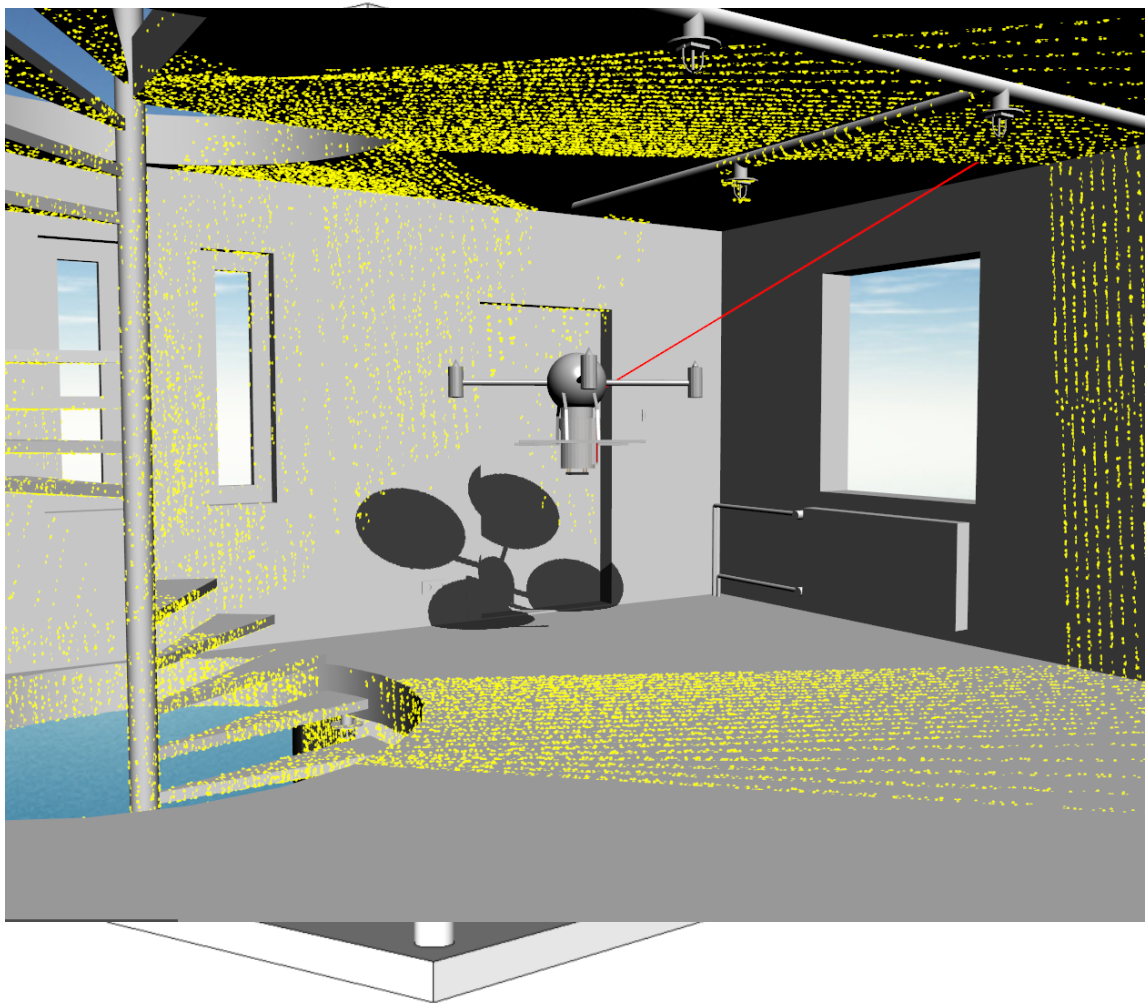
Experiment – Point cloud simulation

- To determine treshold values of quality parameters an As-Built model was designed, missing some elements of each class



Experiment – Point cloud simulation

- 108 different As-Built point clouds were simulated by combining scanner parameters (depth accuracy, beam divergence, and frequency)
- Simulation was performed using a multi-purpose laser scanning simulation framework HeliOS



Experiment – Criteria calculation

- Scan – vs – BIM was performed using each point cloud
- treshold parameters were determined for limits of correct identification

						A	[mm]	5	20	50	100	150	200	5	20	50	100	150	200
Form			Calc			BD	[deg]	1	1	1	1	1	1	5	5	5	5	5	5
						F	[KHz]	30	30	30	30	30	30	30	30	30	30	30	30
				min ↓	max ↓	LOS→		99,0%	66,2%	29,7%	16,1%	11,2%	8,8%	99,0%	66,2%	29,7%	16,1%	11,2%	8,7%
Sprinkler_pi	0,455	S	28	0	1			1	1	1	1	1	1	1	1	1	1	1	1
EX	D			8,2254	10109	180,96		1505,4	951,7	635,41	442,11	306,4	261,16	1429,2	1022	596,34	472,96	326,96	234,42
	C			0,0323	0,9987	0,5004		0,7334	0,7404	0,8016	0,7575	0,6529	0,6011	0,7231	0,7523	0,7661	0,7498	0,6774	0,5689
	A			5	200	50		5	20	50	100	150	200	5	20	50	100	150	200
Pipe_12_2	0,381	S	29	0	1			1	1	1	0	0	0	1	1	1	0	0	0
EX	D			2,6281	6168,2	386,33		835,74	691,2	386,33	244,42	183,97	136,66	917,21	691,2	465,18	260,18	215,51	157,69
	C			0,0088	0,8228	0,5341		0,6658	0,6648	0,5341	0,4439	0,3701	0,3096	0,6561	0,6481	0,5825	0,4228	0,4149	0,3263
	A			5	200	50		5	20	50	100	150	200	5	20	50	100	150	200
Pipe_12_1	0,337	S	30	0	1			1	1	1	0	0	0	1	1	1	0	0	0
EX	D			0	6243,7	317,98		876,67	630,01	395,25	237,74	211	166,42	814,26	695,39	404,16	211	234,77	172,36
	C			0	0,8556	0,5519		0,7084	0,6981	0,5982	0,4917	0,4623	0,347	0,6817	0,6931	0,5928	0,4228	0,4808	0,3459
	A			5	200	5		5	20	50	100	150	200	5	20	50	100	150	200

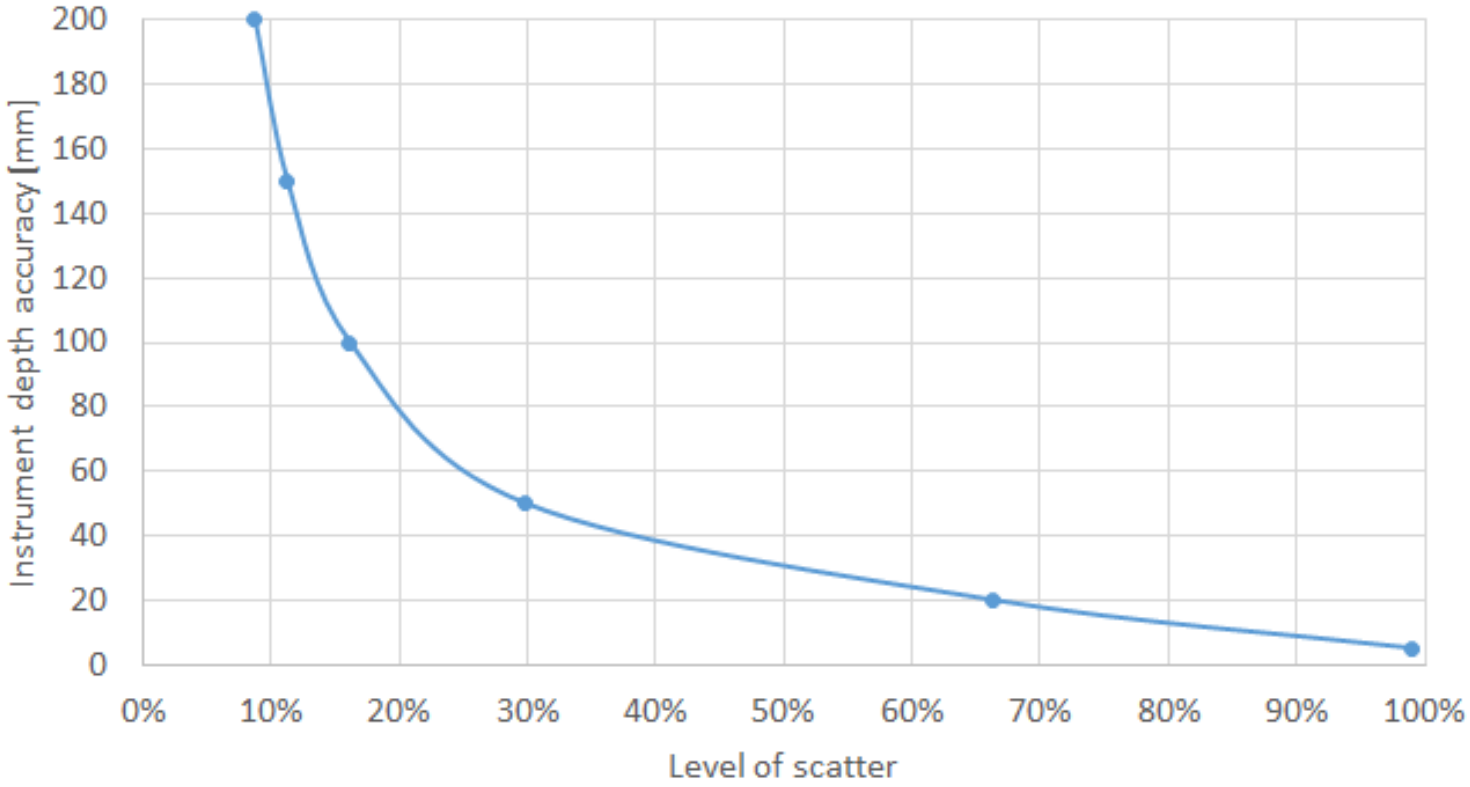
Experiment – Criteria calculation

- Criteria values of point cloud quality parameters for correct Scan-vs-BIM element identification were calculated

Class	Size (surface area)	D_c	A_c	C_c
L	$\geq 5\ m^2$	≥ 14	$<min(side)_E/2$	> 0.5 for existing elements ≤ 0.5 for missing elements
M	$1\ m^2 \leq Size < 5\ m^2$	≥ 70		
S	$0.25\ m^2 \leq Size < 1\ m^2$	≥ 530		
XS	$Size < 0.25\ m^2$	≥ 4500		

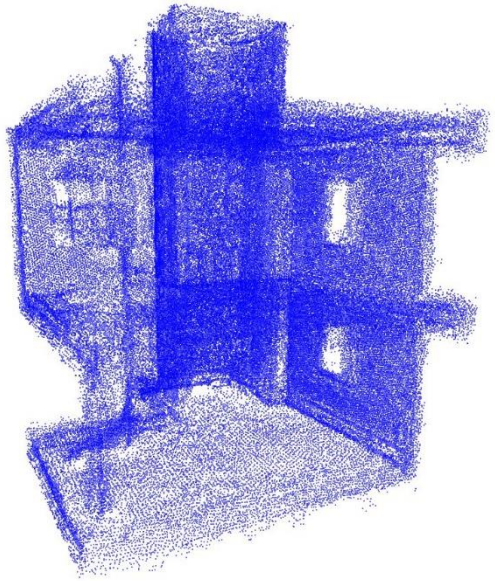
Experiment – Criteria calculation

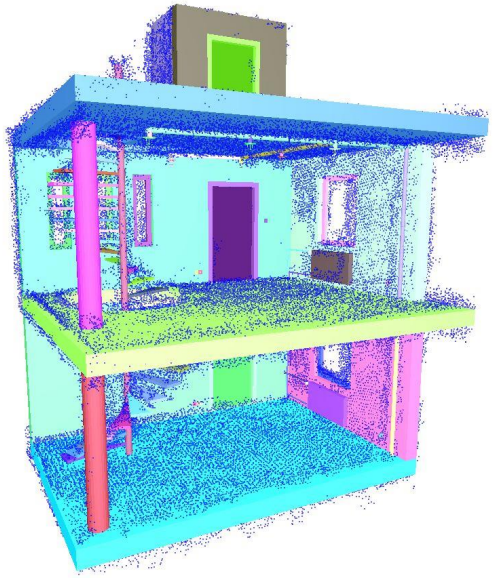
- Correlation between the Level of scatter (LOS) and the simulated scanner depth accuracy (A) was calculated



Validation of quality parameters

- 3 validation experiments, including:
  - Videogrammetry and
  - Scanning with Kinect
- confirmed the developed metrics
- The defined criteria represent useful guidelines for scan planning





Further development of PC quality metrics

- We are curently developing a method to explicitly define the quality of a point cloud with independent parameters
- using an algorhitm that is able to assign each point to the corresponding element and calculate the Local Level of Scatter.