SIMULATED ANNEALING-BASED FITTING OF CAD MODELS TO POINT CLOUDS OF MECHANICAL PARTS' ASSEMBLIES

GTMG: Journées du Groupe de Travail en Modélisation Géométrique

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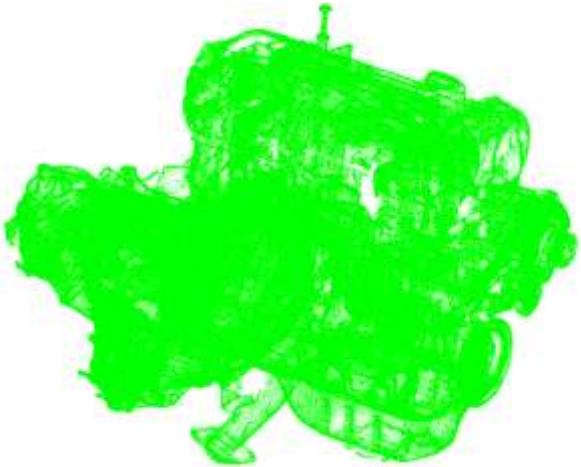
SUMMARY

1. Research question

How to reconstruct a CAD part/assembly by segmenting a point cloud of a mechanical assembly?

- To allow "as built" verifications of tolerances, without disassembly, etc.
- To reconstruct parametric CAD parts/assemblies without patch by patch fitting.



Point cloud

Mesh

2. Background

Reverse Engineering

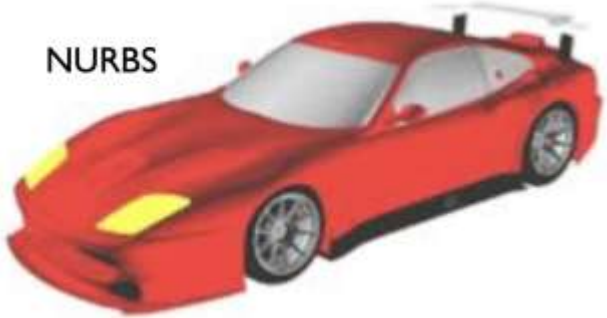
Ferrari 550 Maranello

Data acquisition

40 millions of points

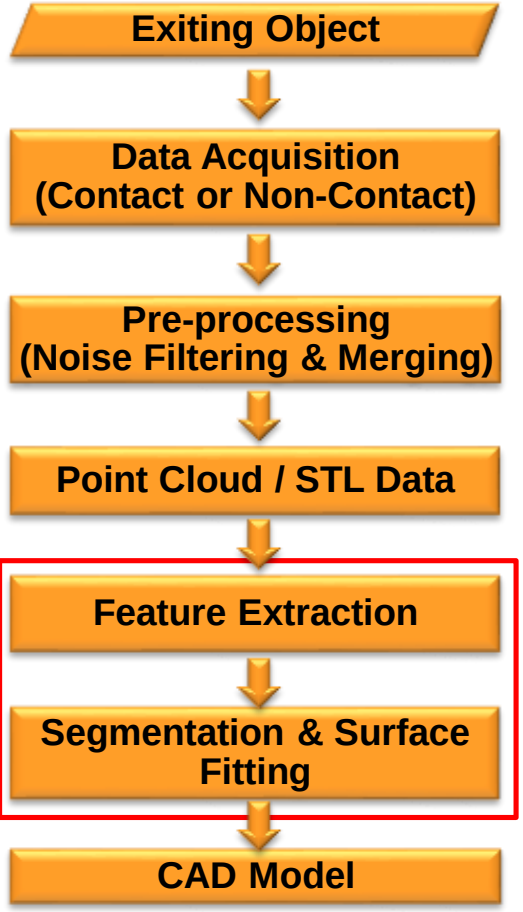
Data treatment

http://www.geomagic.com/fr/solutions/prodrive.php

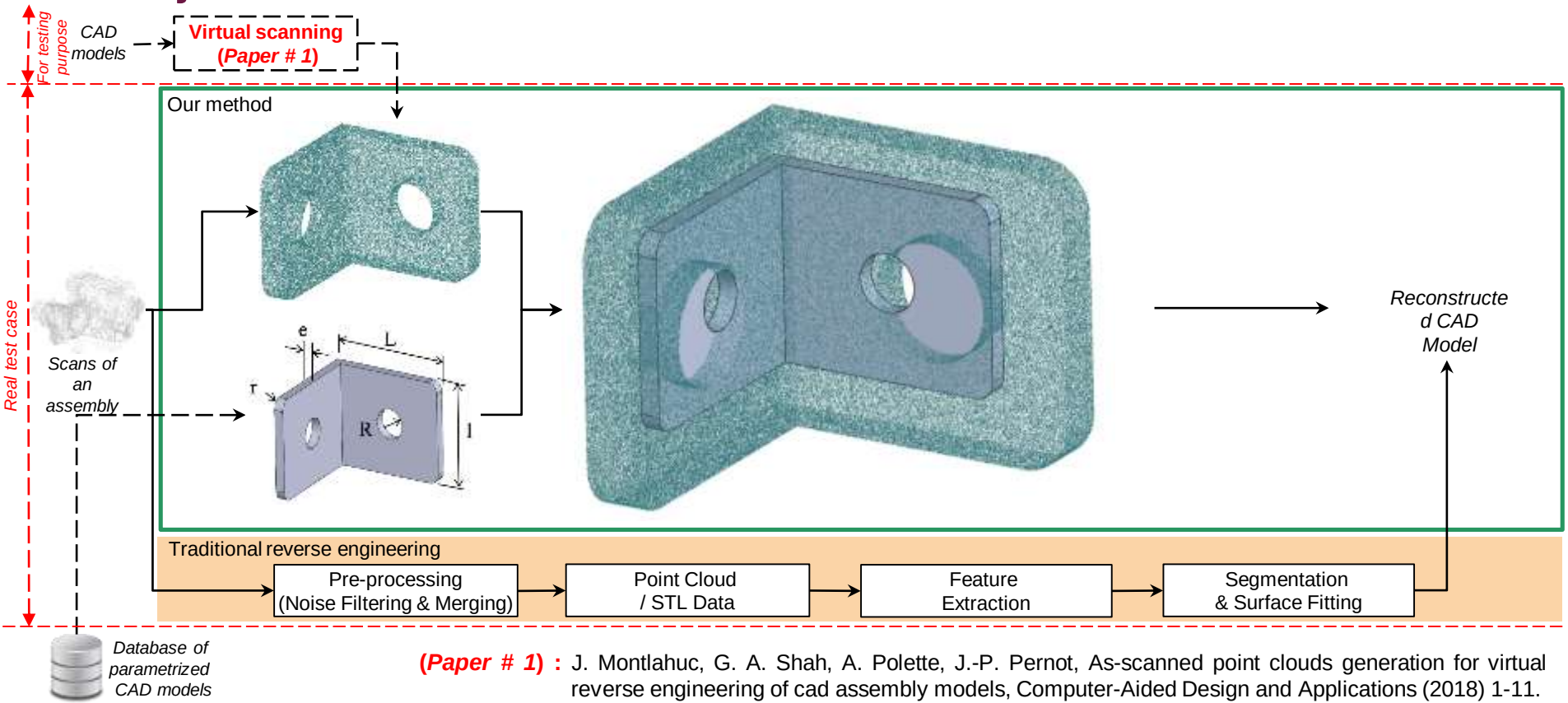


Surfaces reconstruction

- Time consuming
- Tedious
- Requires Skills
- Accuracy
- Patch by patch fitting issues
- Gaps filling
- Simpler parts



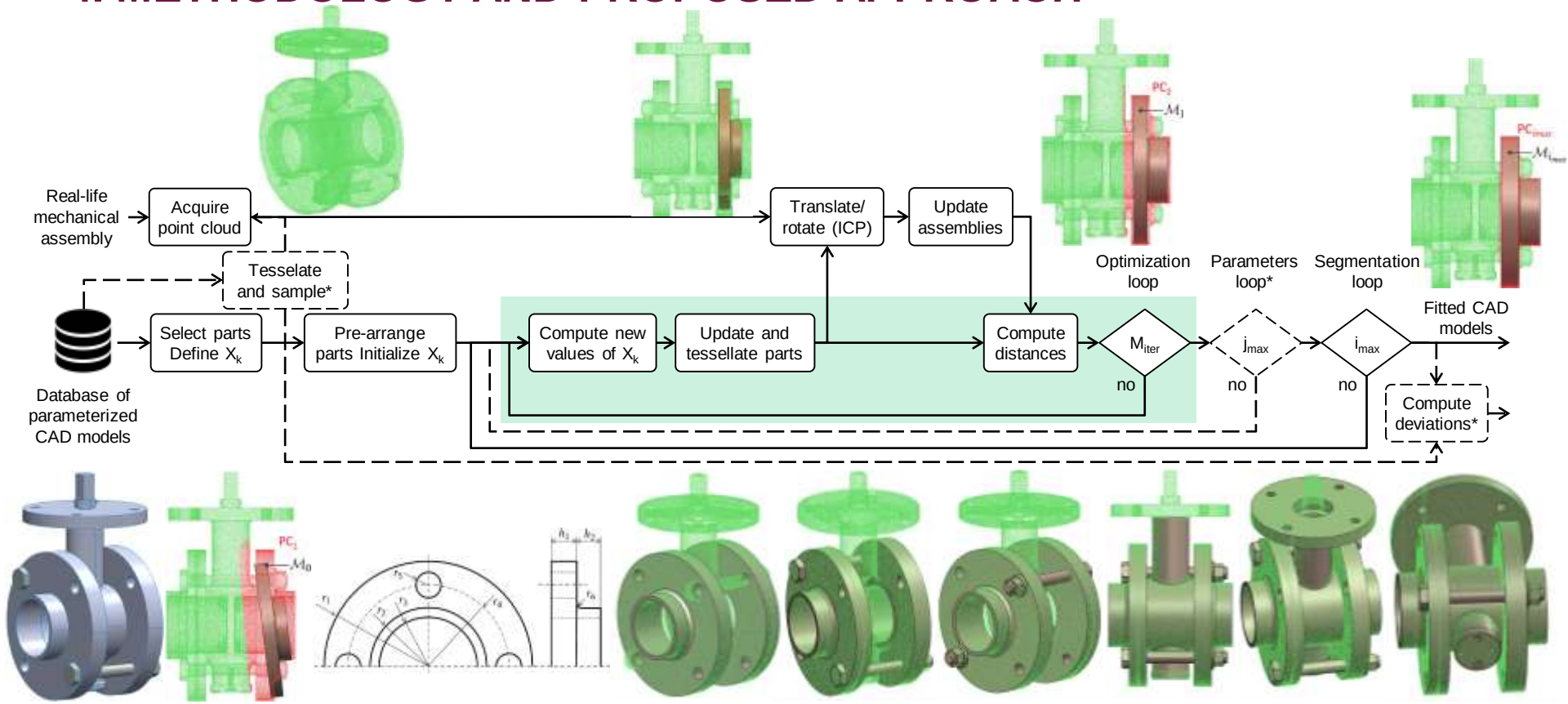
3. Objective



(Paper # 1) : J. Montlahuc, G. A. Shah, A. Polette, J.-P. Pernot, As-scanned point clouds generation for virtual reverse engineering of cad assembly models, Computer-Aided Design and Applications (2018) 1-11.

*optional modules

4. METHODOLOGY AND PROPOSED APPROACH



5. Results and Analysis (fitting)

Fitting of a Sonotrode (real scan)

- This example shows results of fitting of Sonotrode (approx. 257k) in real point cloud that has been obtained using a ROMER Absolute Arm 7520 SI (7 axis, 2m acquisition volume, absolute encoders, RSI laser sensor 30000pts/s) has been used to scan a Sonotrode.

Groups	Parameters	Initial value (mm)	Obtained value (mm)
G1	D1	30	34.9872
	L1	40	47.6183
	L2	70	74.0385
	r1	7	11.4656
	r2	22	21.1645
	r3	12	20.0028
G2	D3	9	6.6348
	D4	4	7.9101
	L3	27	29.7042
G3	r4	0.5	0.8376

Table.1: Results for the global fitting of a Sonotrode to a real point cloud obtained by a laser scanner.

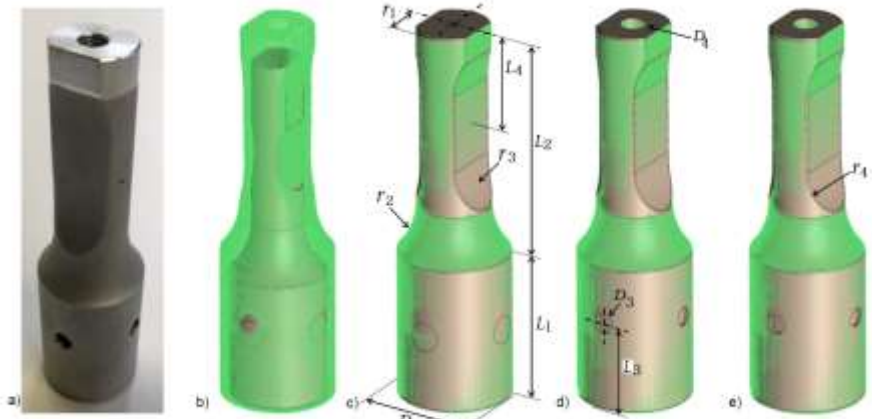


Fig.1: Global fitting of a Sonotrode to a real scanned point cloud following 3 optimization loops: (a) scanned Sonotrode; (b) coarse pre-arrangement in the initial point cloud; (c) loop on G1; (d) loop on G2; (e) final fitted part after a loop on G3.

5. Results and Analysis (fitting)

Fitting of robot arms (VS)

- To maintain the coherence between the physical system and its digital twin in the scope of the Industry 4.0

Groups	Parameters	Initial value (mm)	Target value (mm)	Obtained value (mm)	Deviation (mm)	Relative error
G1 Move-1	α_1	75	90	89.999	0.001	0.0000
	α_2	15	30	29.9946	0.0054	0.0002
	α_3	65	95	94.9968	0.0032	0.0000
G1 Move-2	α_1	89.999	115	114.9987	0.0013	0.0000
	α_2	29.9946	55	54.9954	0.0046	0.0001
	α_3	94.9968	120	119.9976	0.0024	0.0000
G1 Move-3	α_1	114.9987	140	139.9985	0.0015	0.0000
	α_2	54.9954	90	89.9935	0.0065	0.0001
	α_3	119.9976	170	170.0019	-0.0019	0.0000

Table.1: Results obtained when fitting three successive moves of robot arms parameterized by three rotation angles.

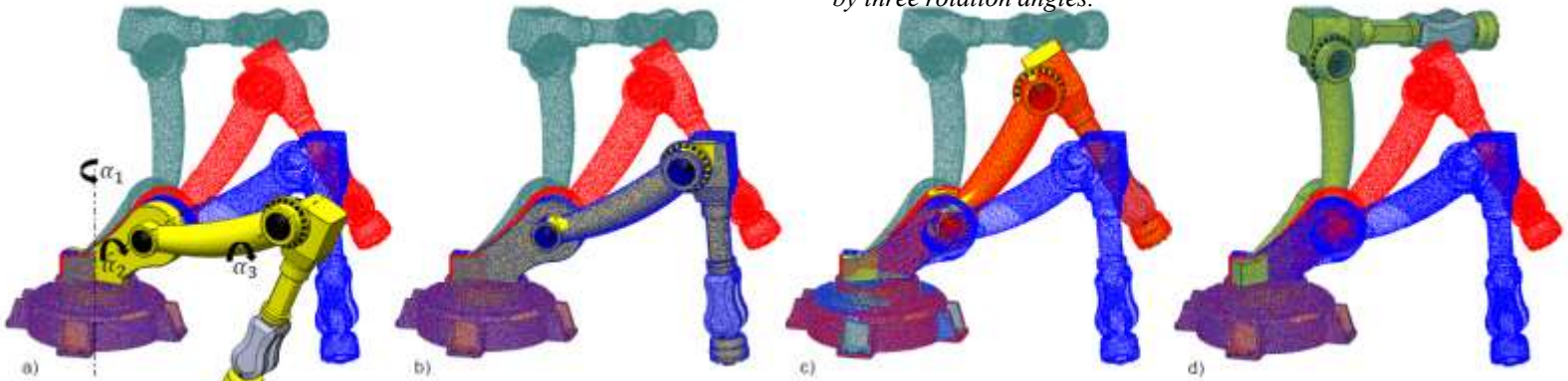
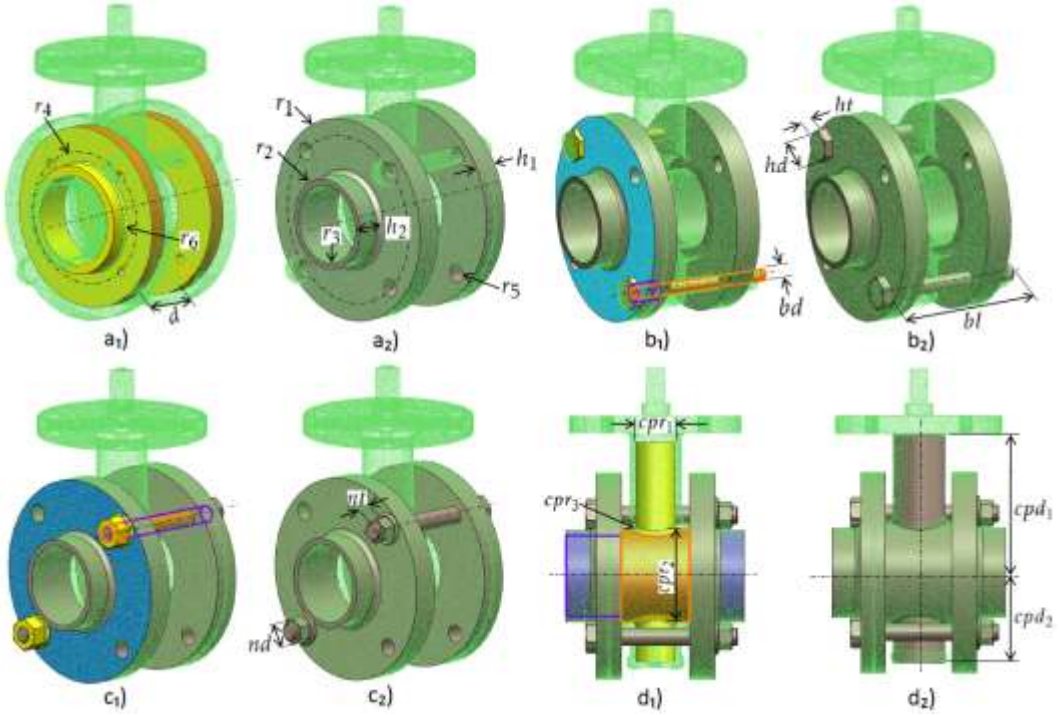


Fig.1: Fitting of robot arms constrained with assembly constraints and parameterized by 3 rotation angles: (a) initial configuration; (b,c,d) final configurations fitting respectively the first, second and third robot moves.

5. Results and Analysis (fitting)

Fitting part by part valve assembly (VS)

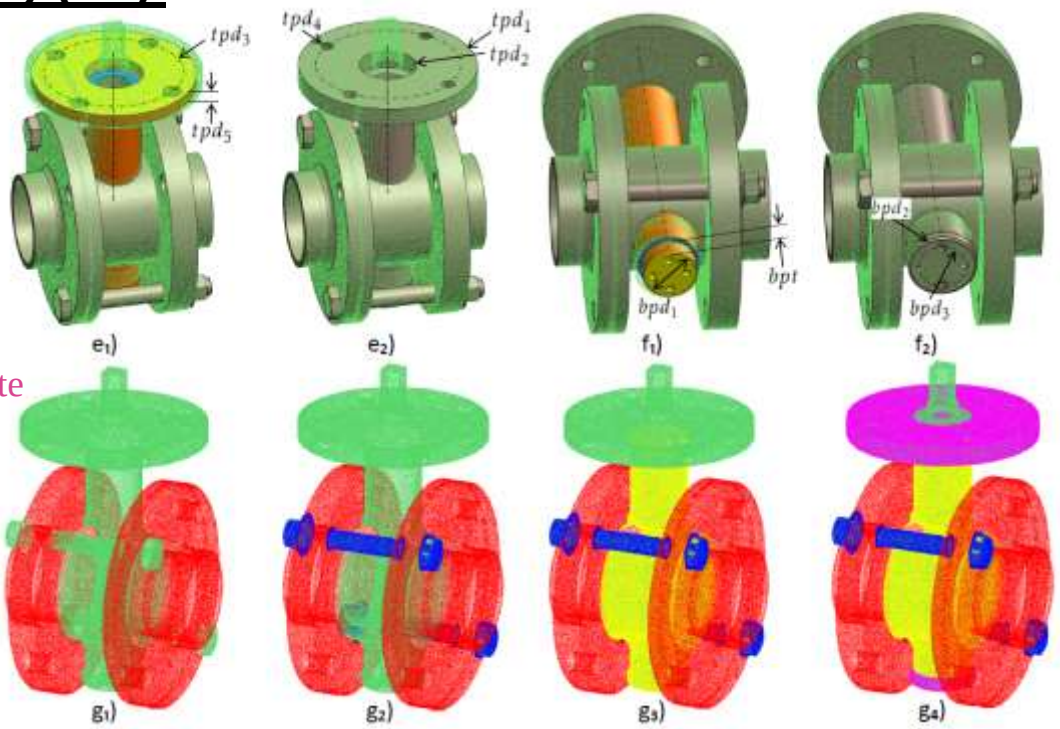
- Fig.a_1 shows pre-arranged flanges
- Fig.a_2 shows fitted flanges
- Fig.b_1 shows pre-arranged screws
- Fig.b_2 shows fitted screws
- Fig.c_1 shows pre-arranged nuts
- Fig.c_2 shows fitted nuts
- Fig.d_1 shows pre-arranged central part
- Fig.d_2 shows fitted central part



5. Results and Analysis (fitting)

Fitting part by part valve assembly (VS)

- Fig.e_1 shows pre-arranged top plate
- Fig.e_2 shows fitted top plate
- Fig.f_1 shows pre-arranged bottom plate
- Fig.f_2 shows fitted bottom plate
- Fig.g_1 shows segmented PC for flanges
- Fig.g_2 shows segmented PC for nuts & screw
- Fig.g_3 shows segmented PC for central part
- Fig.g_4 shows segmented PC for top/bottom plate



6. Conclusions and Future works

- Fitting simultaneously several parameterized CAD models
- Resulting CAD models are editable
- Bypasses data manipulation
- Proposed approach can be used for global and local fitting
- Proposed approach is modular and each module can still be improved

Future works

- Energy minimization by putting weight functions to small features.
- Initialization of initial temperature for the simulated annealing.
- Sensitivity analysis of parameters.
- 2D /3D fitting techniques using normal and distance-based filters for segmentation.

THANK YOU

Q&A