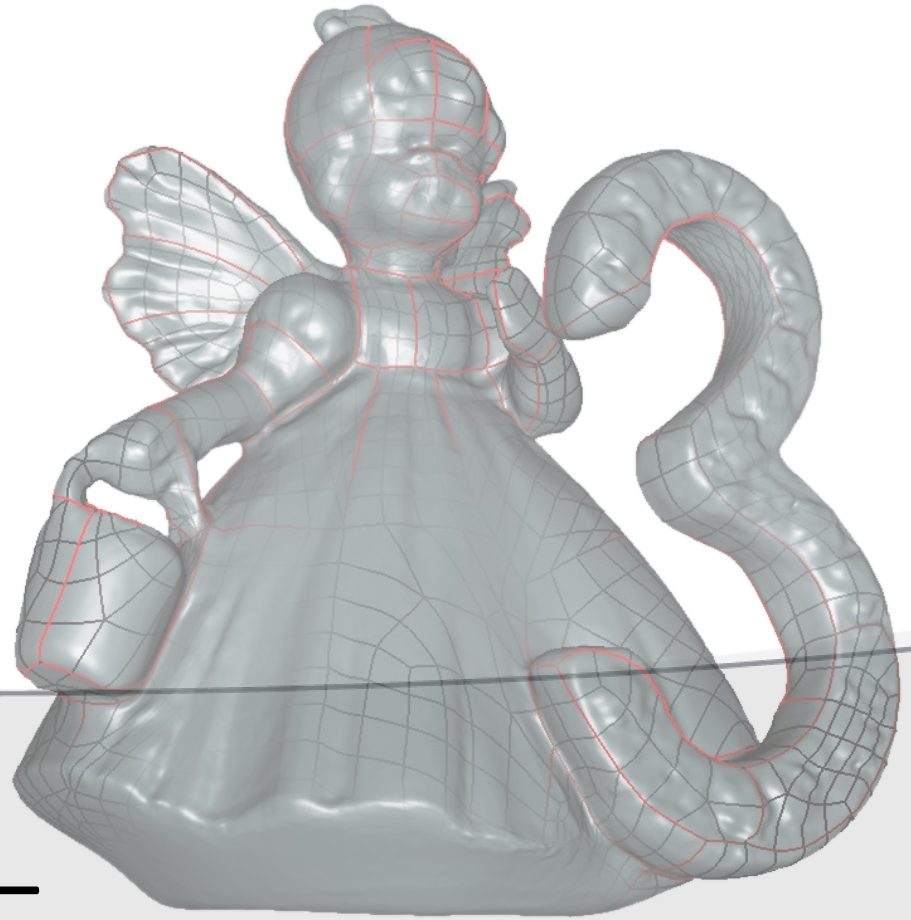

3D Vision UE

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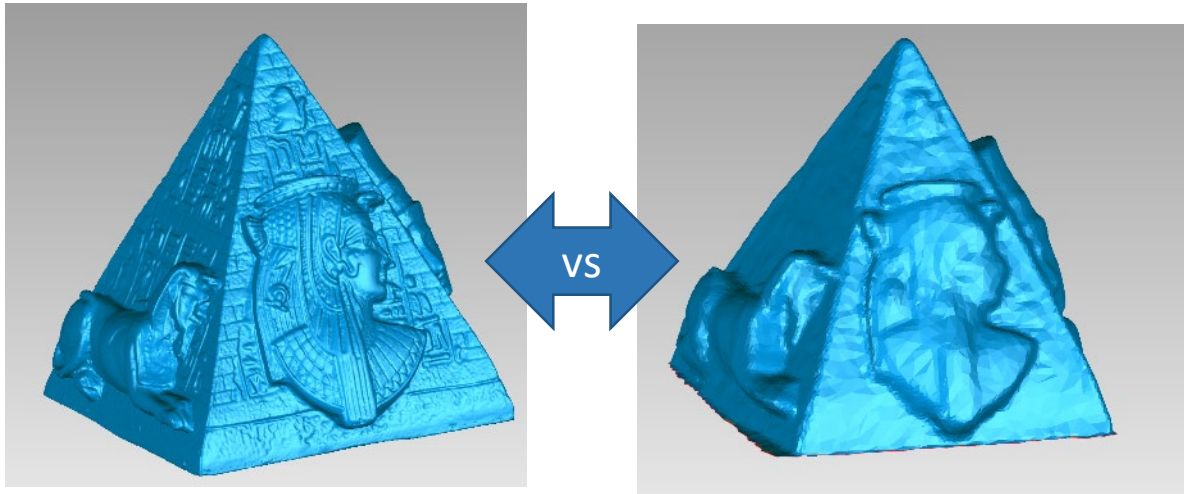
Tutors: Klement, Sonja; Nemeth, Peter

11.03.2024

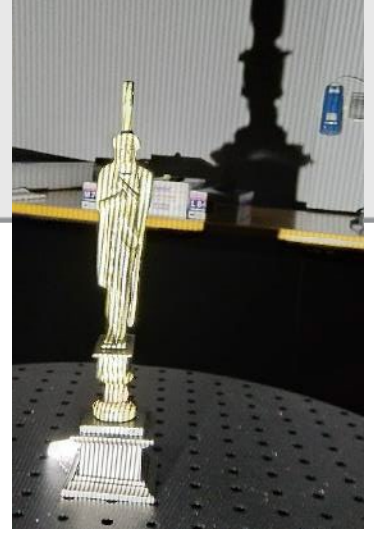
Course overview

- Tasks:
  1. Scan an object of your choice with our Structured Light Scanner
  2. Create a Structure from Motion (SfM) model of the **same** object
  3. Evaluate / compare the results
- Team size:
  - 2-3 students
  - **1 object per student**



Part 1: structured light scanning

Structured Light Scanning overview



- Scanning sessions in our lab
  - group appointments
  - Supervised by tutor
  - You have **one job**: bring a suitable object
    - 1 object **per student**
- Post-Processing
  - Use 3D processing software (recommended: Geomagic Wrap)
  - Noise/background removal, registration, merging, filling holes
  - Expected result: clean, closed („waterproof“) 3D Model

Choosing the Object

- Choose an object which you can access througout the whole term
- Size: apple – pineapple
- Ideally a waterproof object (for volume measurements)
- Matte surface, moderately textured
- Avoid:
  - Uniform colored surfaces → hard for SfM
  - Black surfaces → bad signal/noise ratio
  - Specular / transparent / translucent surfaces → nope.

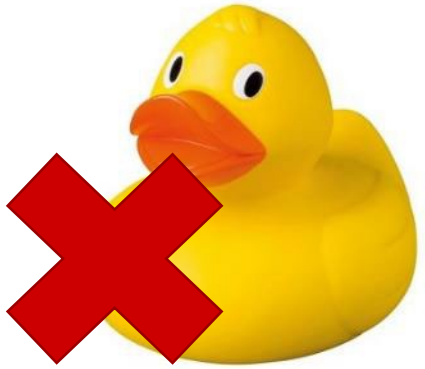
Good objects

Bad objects

shiny

Transparent /translucent

High contrast texture



No texture

Too complex

Too simple / symmetric

deformable

No texture AND black

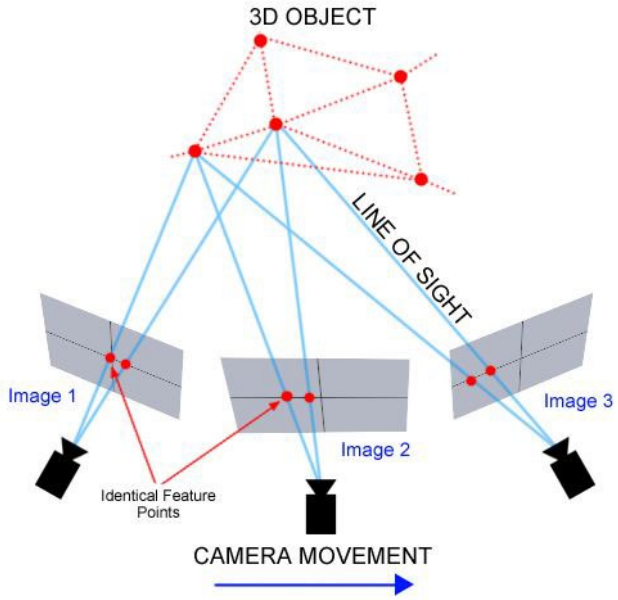
Geomagic Wrap – professional post processing tool

- Use at home (Windows only ☹):
  - Download latest installer: https://support.3dsystems.com/s/article/Geomagic-Wrap (accessed 2024-03-10)
  - Activate 14 days full trial (should be enough for completing the exercise, with proper planning)
- Use at the lab:
  - Installed on 8 workspaces in **Pong Lab** (Favoritenstraße 9, ground floor)
  - From the start of the tutorial sessions until end of semester (see TISS)
  - Lab access outside of tutorial sessions: TBD (InfLab policies…)
- Documentation:
  - See additional slides at the end
  - Also here: https://support.3dsystems.com/s/article/Geomagic-Wrap

Part 2: Structure from motion

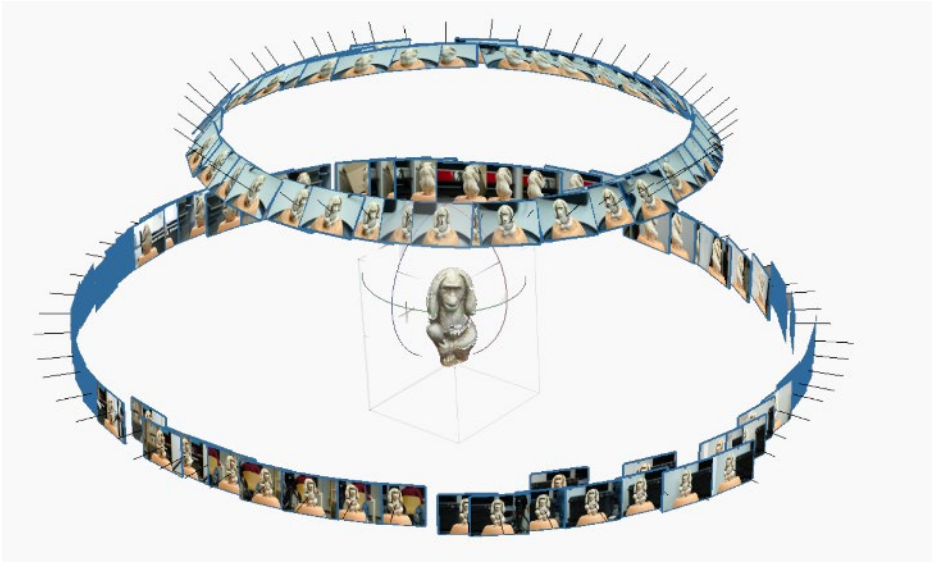
Structure from Motion overview

- Take **good** pictures
- Create 3D model with SfM software, e.g:
  - **Agisoft Metashape Professional**: commercial, lots of handy features, 30 days full trial available
  - Meshroom: open source, standard pipeline works very well
  - VisualSFM: open source, very basic
  - Regard3D
  - …
- Export model and refine it (e.g. in Geomagic Wrap; noise removal etc)
- Compare output to scanned object



Recommended approach for taking pictures

- **Move the camera around the object**
  - at a constant height & distance
  - in ~10°-steps;
  - do several rounds from different heights
- **Do not move the object!**
  - Changing the relation between object and background leads to contradictions
  - Moving the object can lead to different shadows and thus different local appearance
  - Exception: if you need to turn around the object to scan it from the bottom:
    - Create separate models for each object pose (different „chunks“ in Metashape)
    - Merge them afterwards



(Alternative Approach)

- Stationary camera, object is rotated
- Rotate the object in small increments (~10°)
- be sure to capture from all sides
- Avoid shadows:
  - two light sources, symmetric to the camera axis
  - Preferably area lights → "soft“
- Background removal recommended
  - Metashape has tools for that

DIY solution from a previous semester

Taking pictures – camera settings

- Use constant camera settings!
- Preferably: “real” camera (DSLR, mirrorless)
- Manual mode
  - Fixed aperture, shutter speed and ISO
  - Fixed focal length → if you have a zoom lens, don’t touch it during imaging
- When using a mobile phone camera:
  - Use a camera app that allows manual settings → same rules as above
  - No fancy image enhancements (background blur, color enhancements, etc..)

For DSLRs: use a small aperture

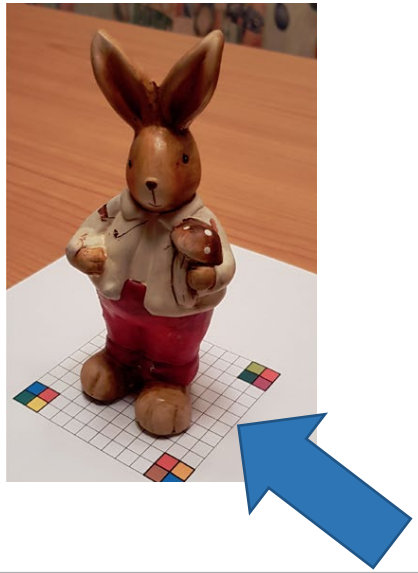
- Most of your object should be sharp in your image
- Small aperture (=high f-number) → large Depth of field
- This leads to longer exposure times → Use a tripod!

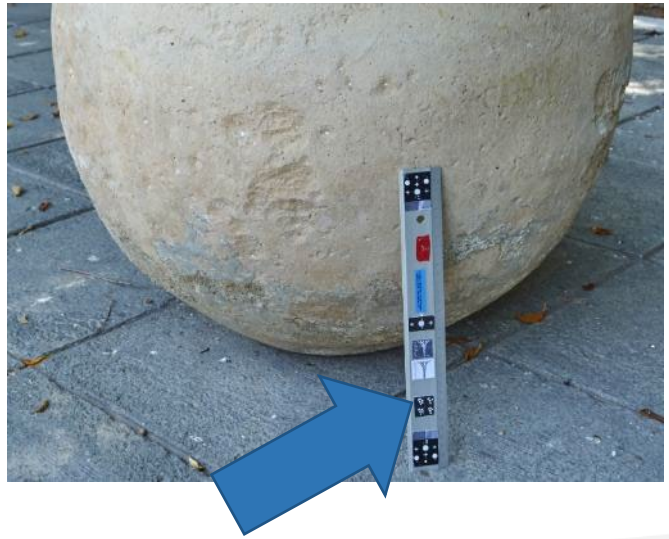
Life hack

- Shoot outdoors on a cloudy day
  - Enough light
  - Soft shadows
  - Fresh air ☺

Use a reference scale

- Necessary to correctly scale your model
  - Grid, Ruler
- How?
  - In Metashape (recommended): Create markers & scalebars, update scale
  - In Wrap: measure same distance in real world & in the model, scale model accordingly

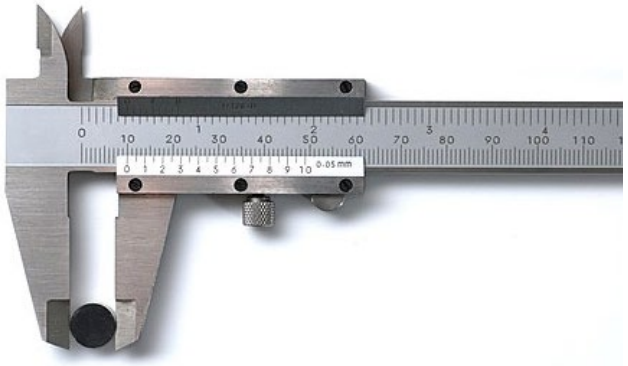


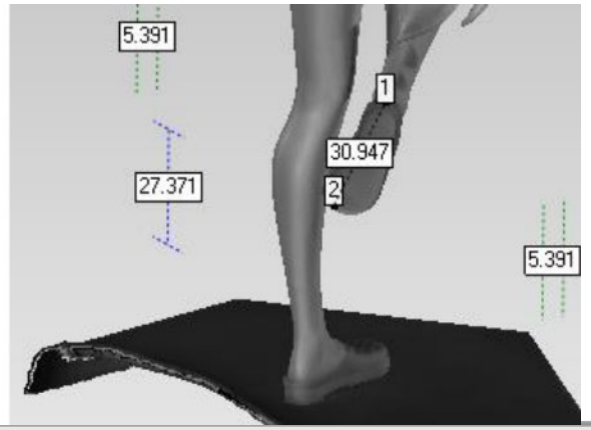


Part 3: Evaluation, Documentation, Presentation

Evaluation

- Give a quantitative evaluation (measure accuracy)
- Measure the same quantities for real object, structured light model and SfM model
- ≥ 3 lengths
  - Real object: caliper (recommended) or ruler
  - Models: Geomagic Wrap
- volume (if possible)
  - Real object: water/sand displacement
  - Models: Geomagic Wrap
- Document what you have measured (screenshots or photos)





Documentation

- 2-4 pages per student
- Describe / document your workflow (especially for SfM)
- Show your results
  - Structured light and SfM
  - Compare results qualitatively
- Give a quantitative evaluation
  - measure **≥ 3 lengths & volume**
  - compare in a table: real object / scanner / photogrammetry
  - Document the lenghts measured with images
- Write about the lessons learned when scanning & editing your object
- (Do not explain how scanning methods work…)

Final Presentation

- Length
  - 5-7 minutes **per group**
  - Max. 12 slides **per group**
- Content
  - Summary of your report
  - Anything that could be interesting for the audience

Grading Scheme

- Max. achievable points: 100
  - Structured Light model: 30p
    - 9p creation of one single connected surface model (baseline)
    - 7p watertightness (absence of holes)
    - 7p quality of geometry (are there non-manifolds, self-intersections, noise, etc.)
    - 7p truthfulness to original (were parts omitted/added, excessively smoothed, etc.. the more complex the object, the more generous we are)
  - SfM model: 30p
    - 9p creating a 3d model from photographs (baseline)
    - 7p correct scaling
    - 7p quality of geometry (are there multiple disconnected parts, reversed surface orientations, self-intersections, etc.)
    - 7p truthfulness to original
    - for certain kinds of surfaces, bad SfM results must be expected - we are generous here, **if the problems are discussed in the report**
  - Report: 30p
    - 10p documentation of the workflow (especially for photogrammetry)
    - 10p documentation of results
    - 10p evaluation
  - Presentation: 10p
    - presentation of workflow & results
    - answers to questions

Points	Grade
87-100	1
75-86	2
63-74	3
51-62	4
0-50	5

Schedule

- 3D scanning: March / April (see TUWEL for slots)
  - At the institute (HA 0420, Favoritenstraße 9)
- Supervised lab sessions: May / June (see TISS for dates)
  - Pong Room (HG EG15, Favoritenstraße 9)
  - Mainly for post-processing
  - Attendance **not** mandatory
  - You can work on your models, ask a tutor for help, etc.
  - Only 8 workplaces with Wrap installed – first come, first serve
  - No SfM software installed
- Deadlines
  - Final Model & Documentation: **June 12**
  - Presentations: **June 17/18**

Registration is now open. Please register for the groups / scanning slots via TUWEL.

Questions?

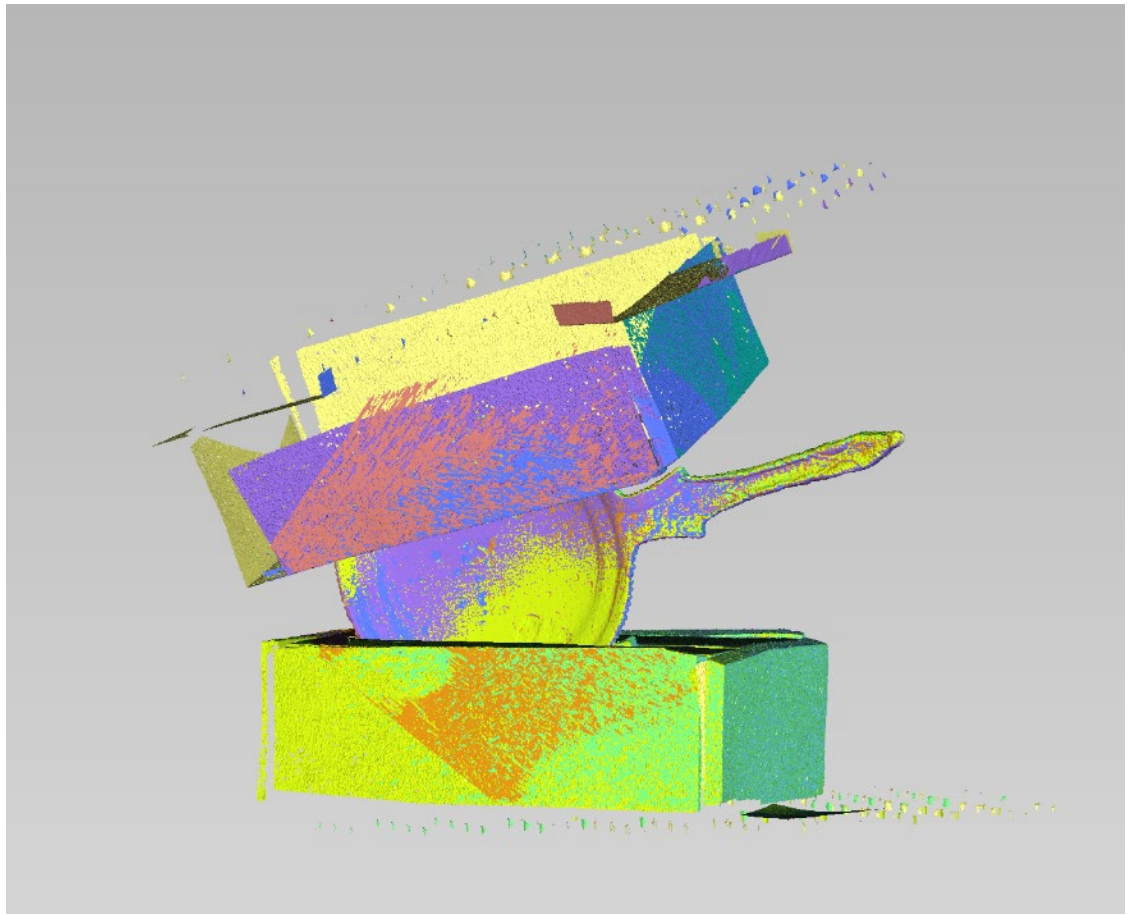
Geomagic Wrap – professional post processing tool

Geomagic Wrap: processing structured light scans

1. Import .bre files
2. Background removal
3. If necessary: registration / alignment
4. Merging / Meshing
5. Cleanup
6. Close holes

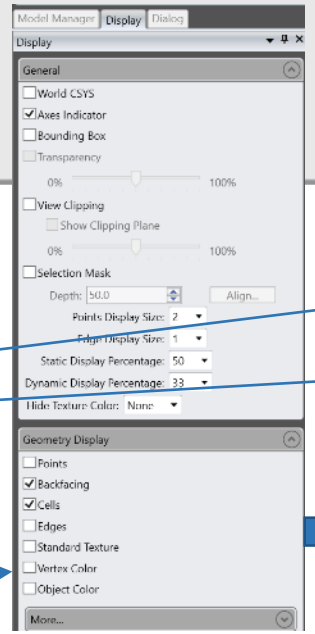
Import .bre files

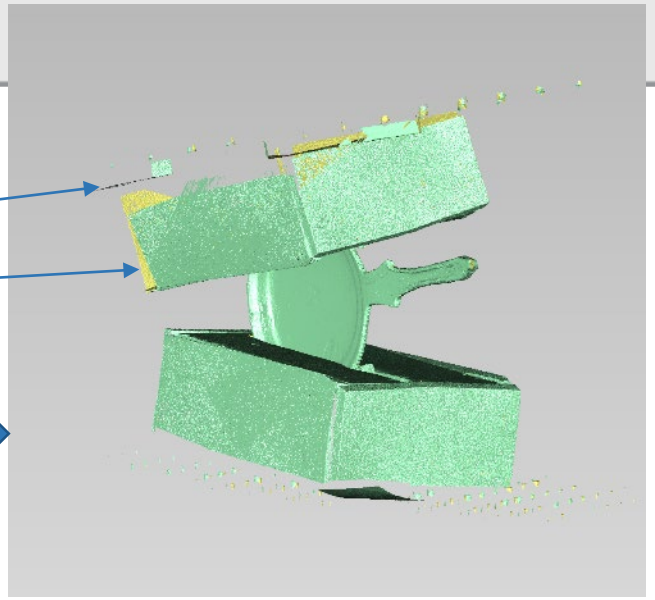
- ordered point clouds
- one file per scan direction
- Unit: mm

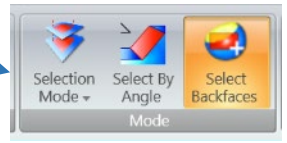


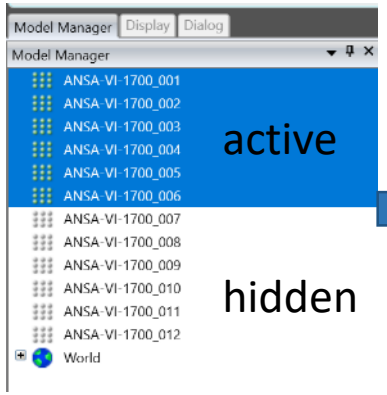
Background removal

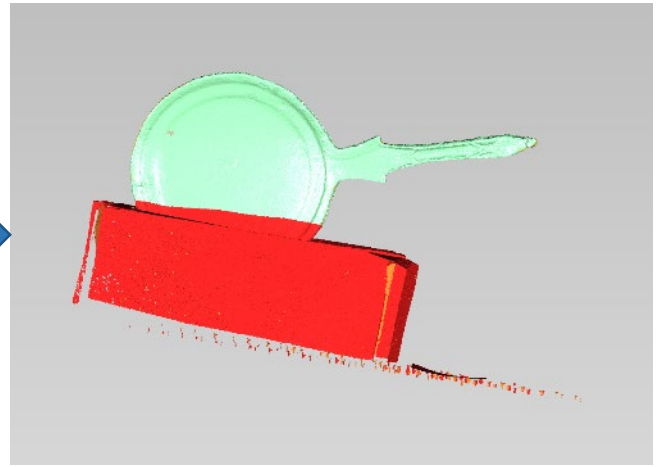
- Remove artifacts from turntable / positioning aids
- Tips:
  - Disable all coloring
  - Pay attention to selection mode
  - Treat each object position individually
  - Clear selection: crtl+c



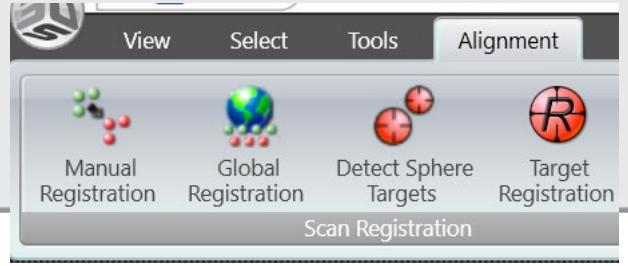




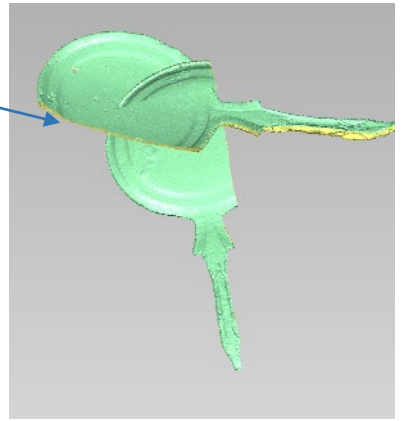


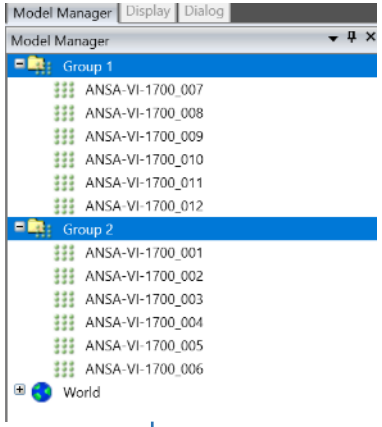


If necessary: registration / alignment

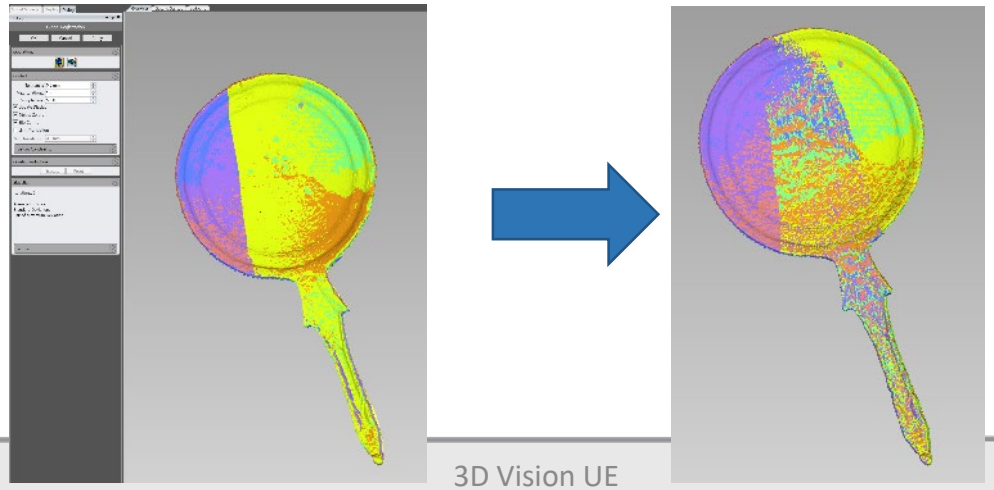


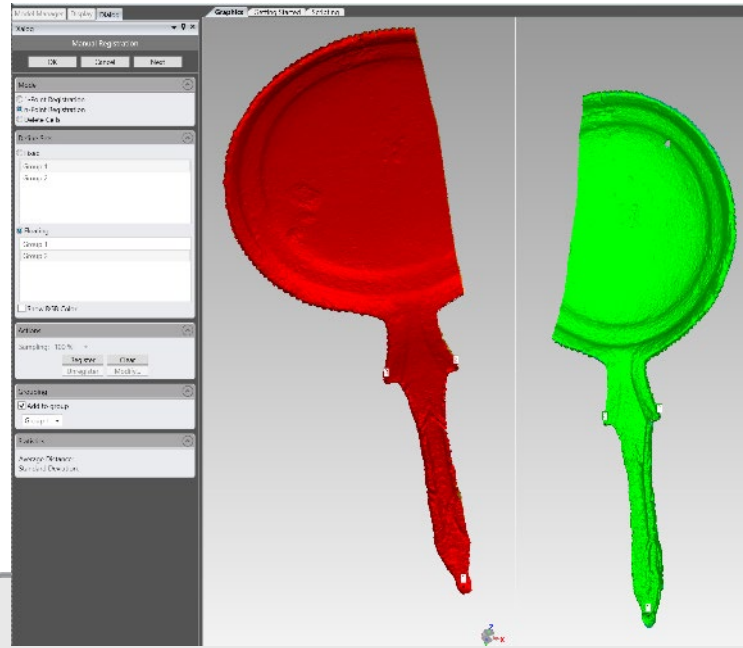
- „Manual Registration“: for large displacements (perhaps a mistake during scanning)
  - Put misaligned parts in groups
  - Start manual registration with 2 groups selected
  - Choose n-point registration, select matching points





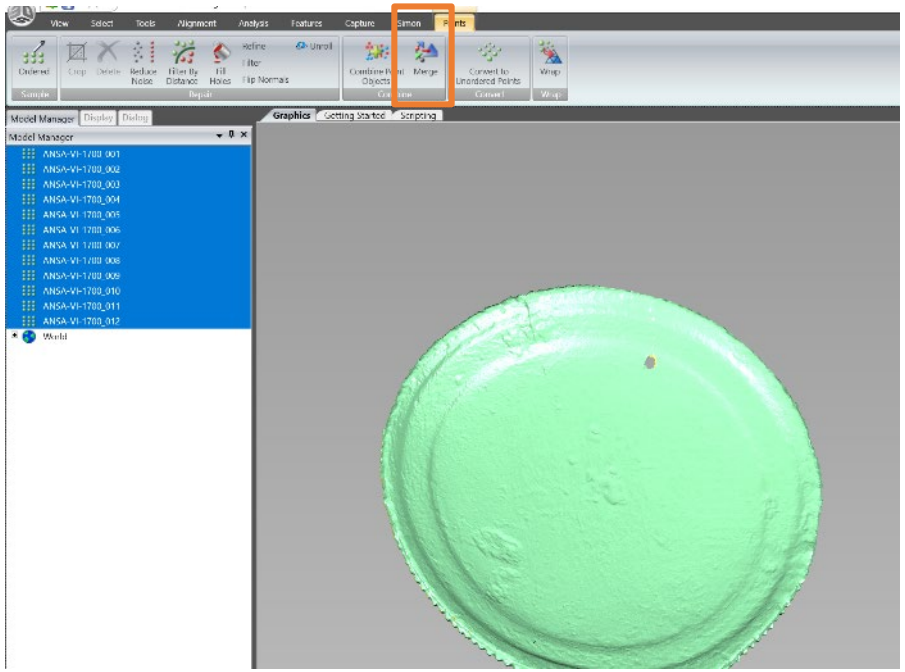
- „Global Registration“: for small displacements, optimizes distances between overlapping parts





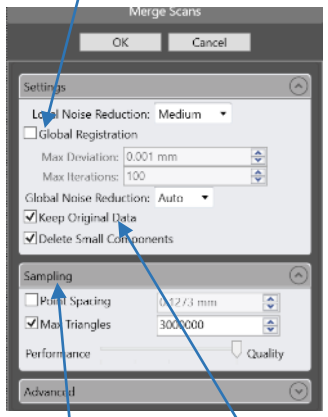
Merging & meshing

- Merge parts and create surface model from point cloud
- „Merge“ tool does both at once



Multiple point clouds

No global registration necessary, if parts are already aligned nicely



Keep original data for easy undo

Sampling: up to you

Single mesh / surface model

Cleanup and hole filling

- Cleanup:
  - a palette of tools available, just try them
  - „Mesh doctor“: removes most of the nasty stuff
- Hole filling:
  - Use „Fill Single“, treat holes individually
  - Different continuity options
  - Use partial fill or bridges when filling large holes with irregular borders, for more control