Terrestrial Laser Scanning

2. Lecture

Measuring and processing procedure

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Reconnaissance – what precedes

- Contract
- Familiarization with the terms and conditions of the contract
  - What should be scanned:
    - Dimension of the object
    - Accessibility
    - Safety restrictions
    - Vegetation
    - Level of scanning detail
  - What should be the result
  - Coordinate systems
  - Time conditions
  - Safety conditions
  - Other risks and restrictions
  - Instrument selection
  - Price

Reconnaissance

- Personal familiarization with the area/object
- How to register - identical points, overlapping territory
- Layout of sites and number of sites
- Location of identical points
  - Spherical targets
  - Black and white targets
  - Suitable parts of the object to be targeted - corners, edges, ...
  - Necessary number of points between two positions (it is better to have more)
    - Scanner is not levelled– 3 points
    - Scanner is levelled– 2 points
  - Determining coordinates by another method - for transformation, for not deforming the model (especially linear)
- Overlap - large enough, preferably in all axes (overlap on flat or linear objects may not work)

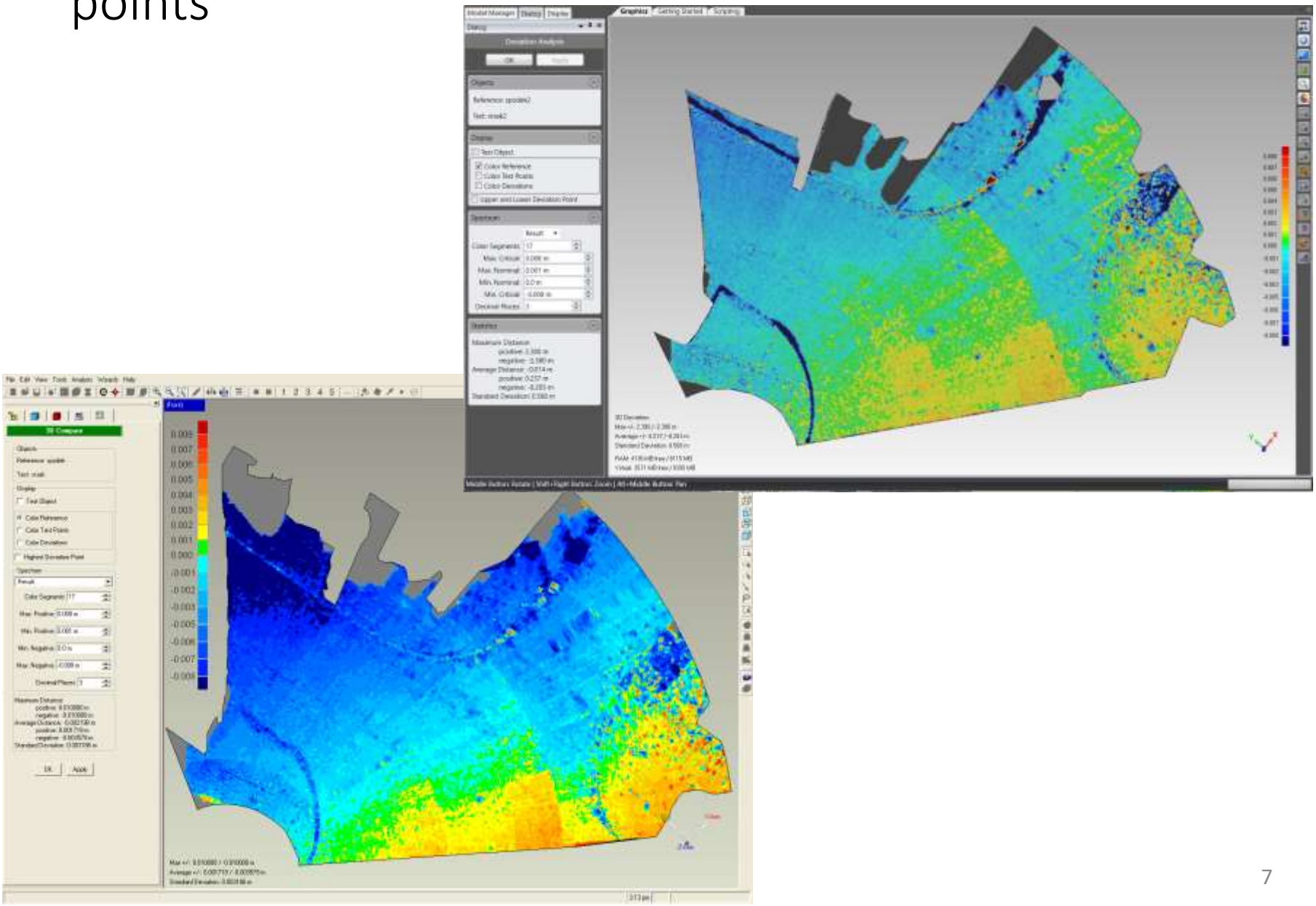
Measuring

- Po příchodu na stanovisko skener postavíme
- Necháme temperovat, zapneme
- Podle typu skeneru založíme zakázku nebo rovnou nastavíme parametry skenování. Nastavuje se (záleží na typu skeneru):
  - **Hustota skenování** – obecně je definována jako příčný rozestup bodů na určitou vzdálenost. Čím hustší, tím víc bodů, lepší rozlišení, delší doba měření
  - **Kvalita skenování** – vyšší kvalita znamená nižší rychlost a nižší délkový šum – řiďte se doporučením výrobce a vlastní zkušeností
  - **Dosah** – delší dosah snižuje rychlost skenování, někdy skenery při prodlouženém dosahu neměří kratší délky – nutno měřit dvakrát
  - **Teplota, tlak** – záleží na skeneru, pro krátké vzdálenosti (malý objekt) nemá velký význam
  - Zda se budou při skenování pořizovat **snímky** – prodlužuje dobu skenování, nastavují se parametry snímkování
  - **Redukce z nadmořské výšky a ze zobrazení** – obvykle se nenastavují

Measuring

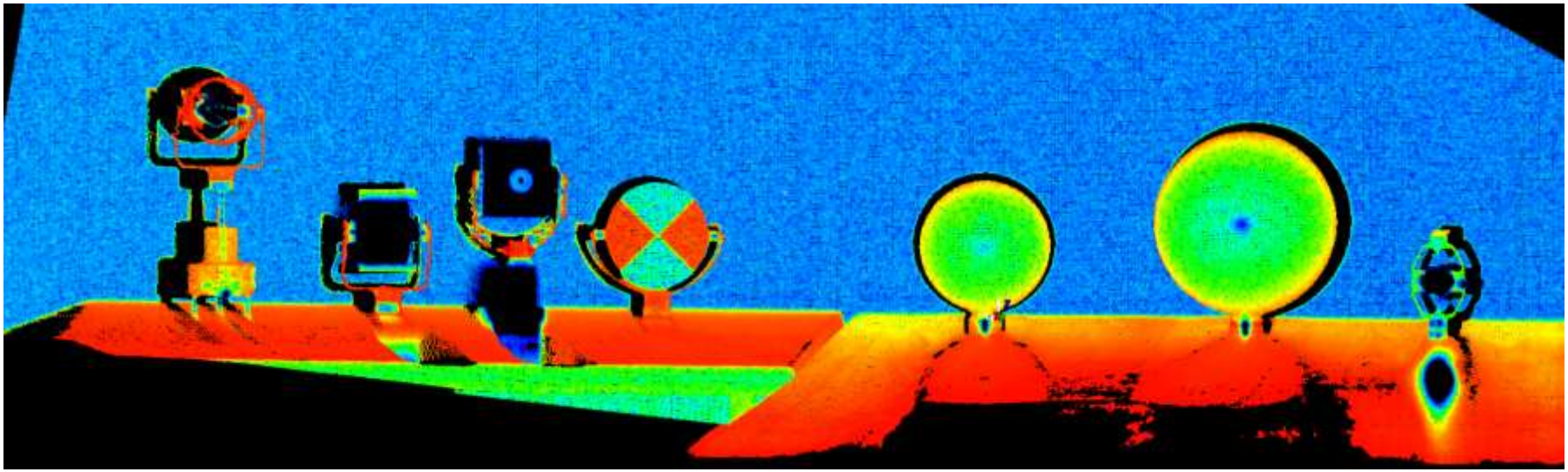
- Place identical points around the scanner
- We follow the large-to-small principle
- Regular spacing, local irregularities are appropriate
- Distance of identical points from the scanner
  - Greater than the distance of the object to be surveyed (the part that is important for this position)
  - Within the recommended scanning distance - the distance for which the scanning accuracy is defined
  - When using spherical targets or black-and-white targets without a special scanning process, take care to ensure a sufficient density of points on the target!
- Checking that we can see a sufficient number of identical targets from neighboring positions

Measuring - inappropriate placement of identical points

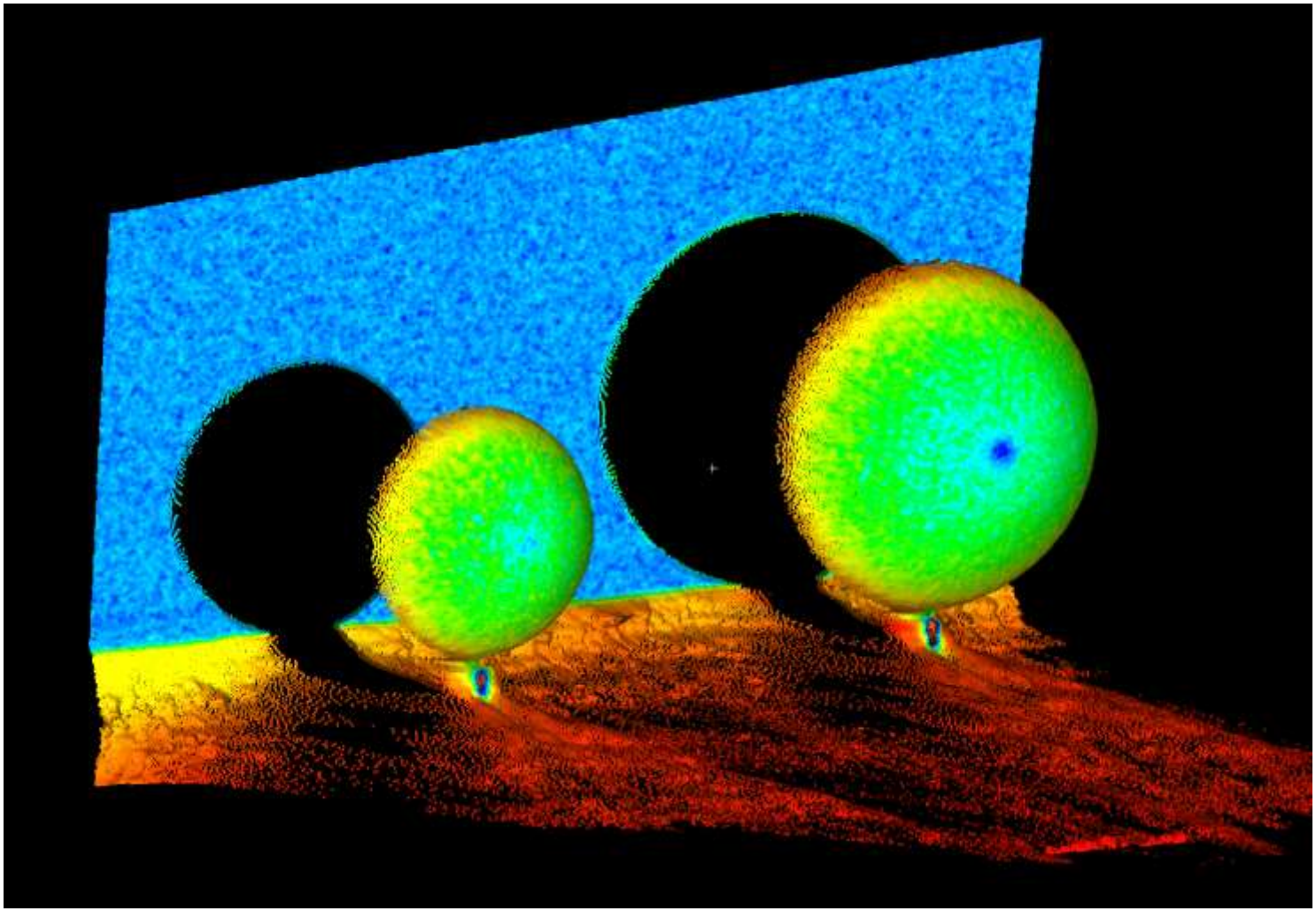


Identical points

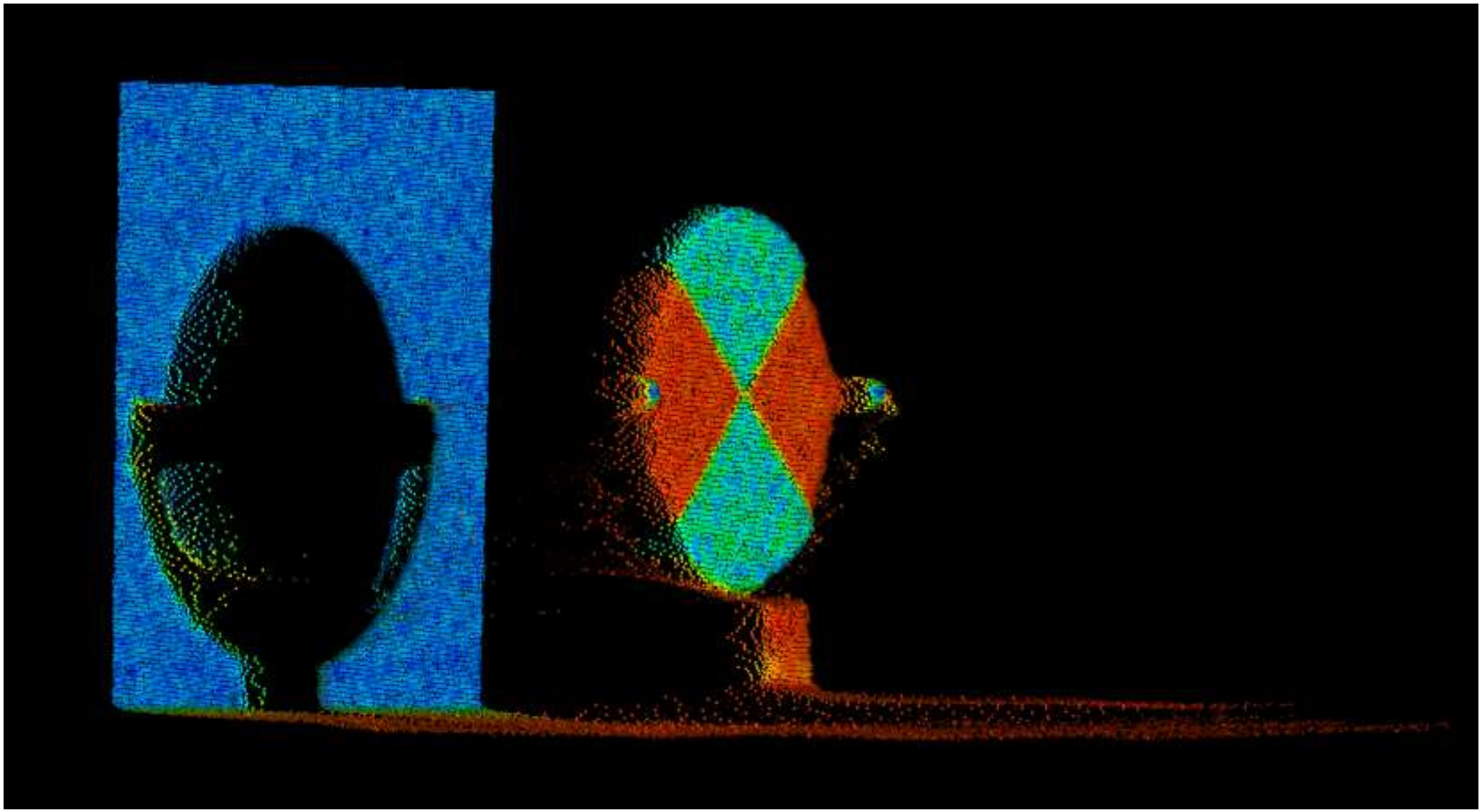
- An example of identical points - not everyone is suitable for scanning and total station



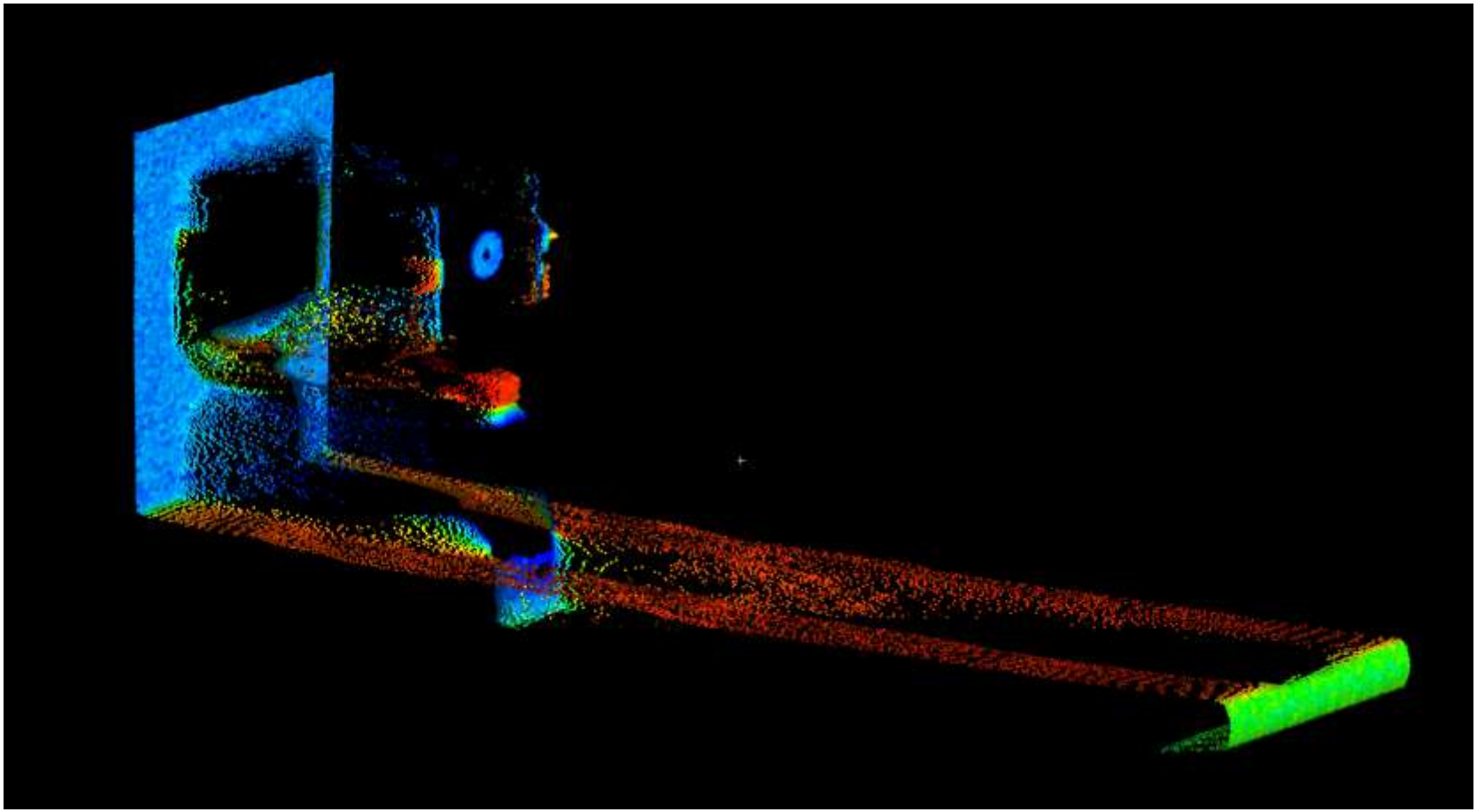
Identical points– detail –spherical targets



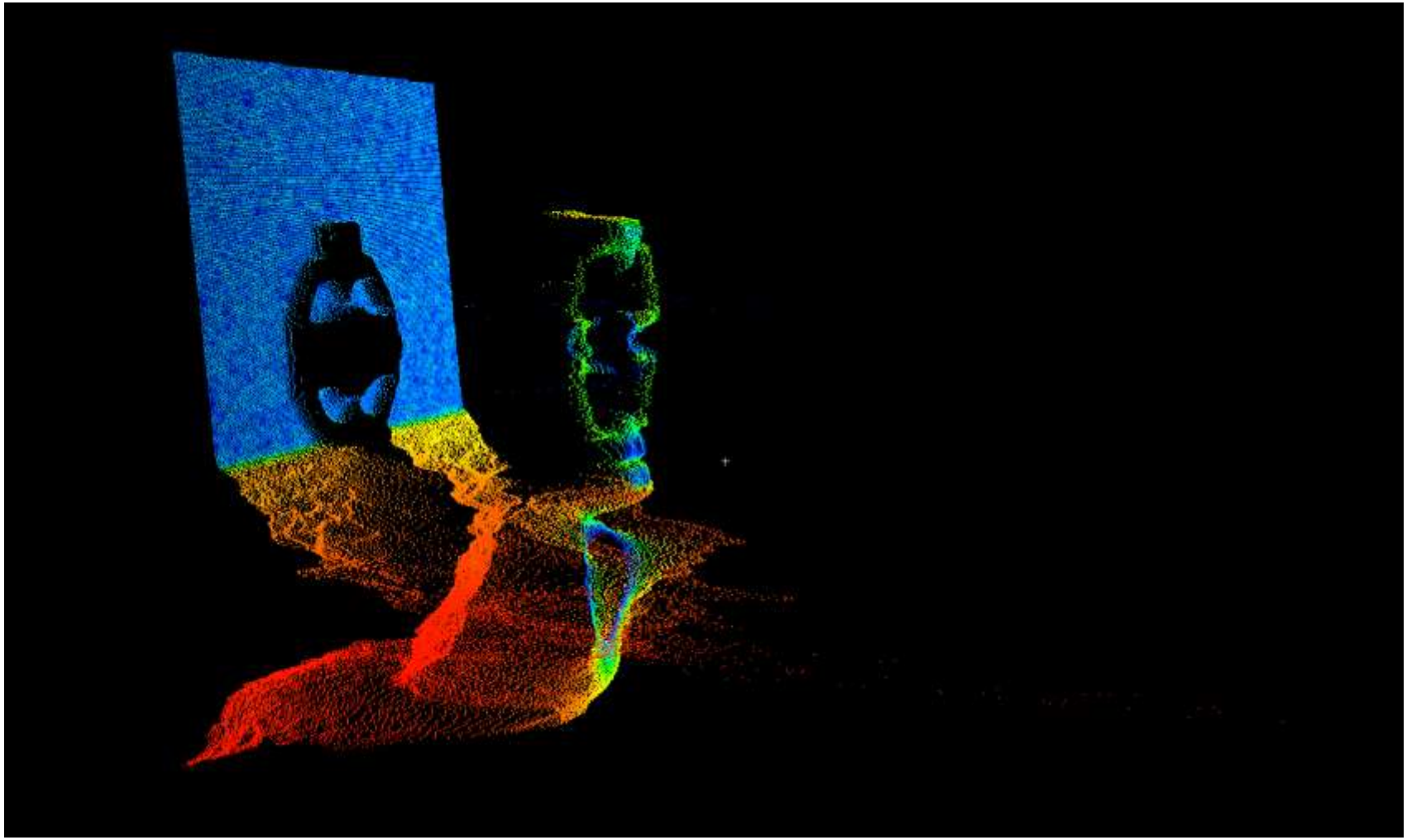
Identical points– detail – black and white targets



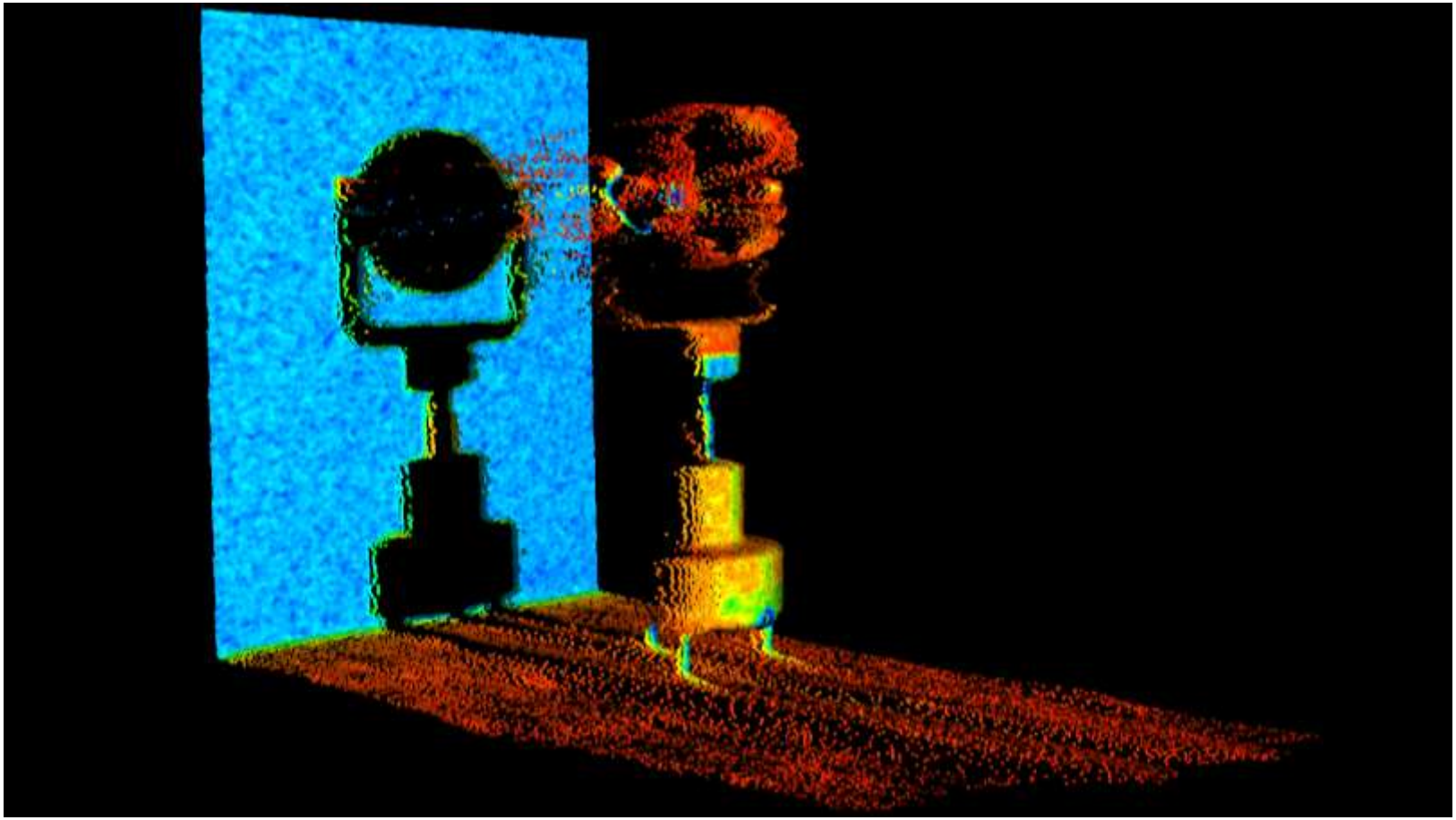
Identical points– detail – blue and white target HDS3000

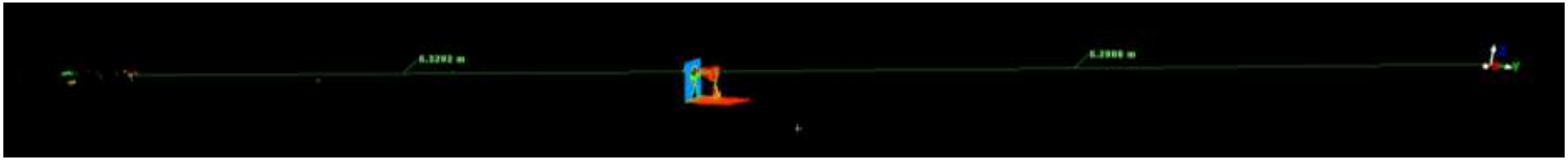


Identical points– detail – mini prism Leica

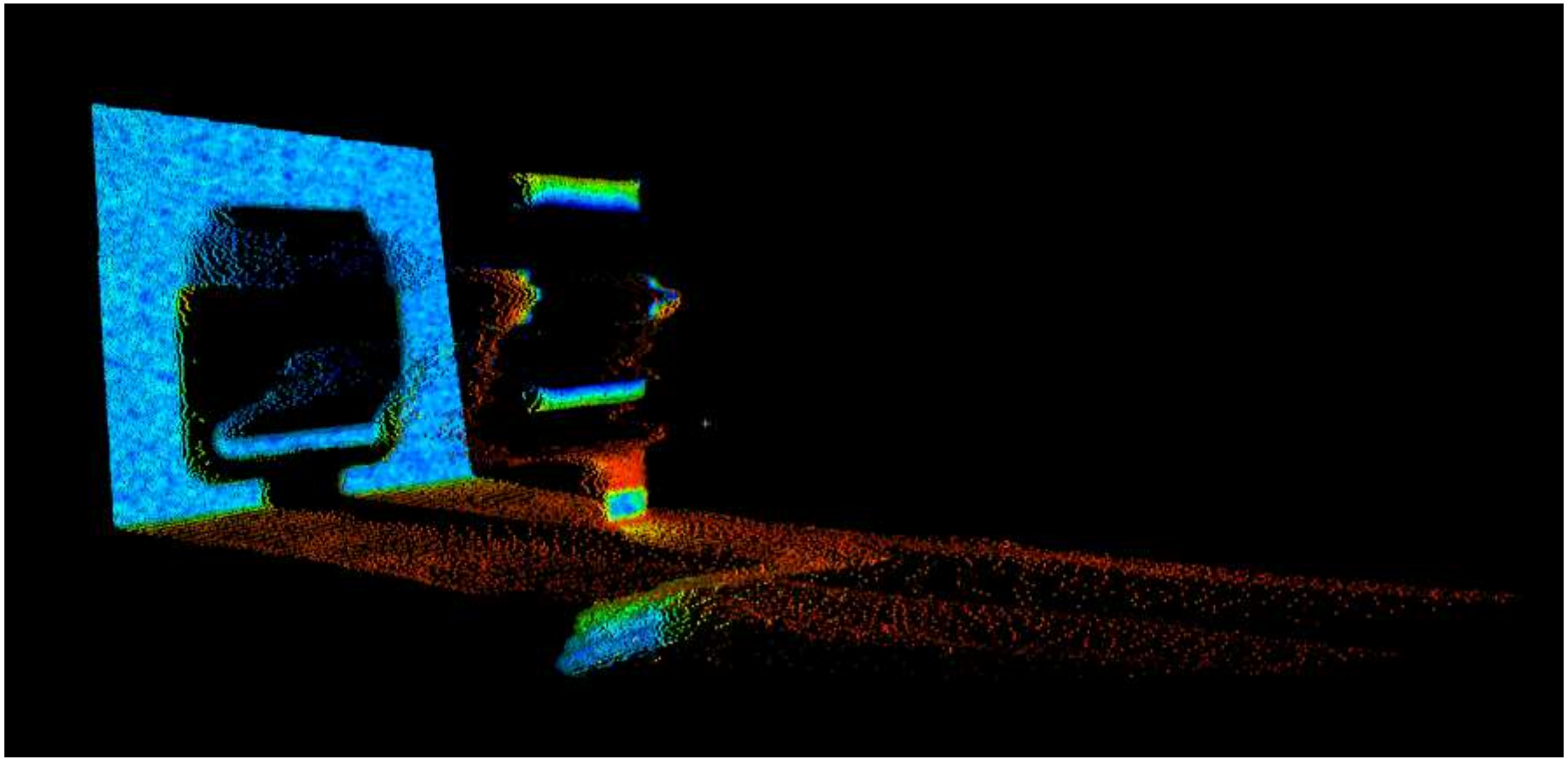


Identical points– detail – prism Leica





Identical points– detail – reflective foil



Processing - export

- The measured data needs to be exported from the scanner
- The directly exported data is not always readable → It is necessary to have software that allows us to export to several common formats used in scanning.
- Standard point cloud formats (basic selection):
  - *.txt *.xyz *.csv *.pts
  - *.ptx
  - *.las / *.laz
  - *.e57

Processing – data preparation for registration

- After the export, we have point clouds from the different positions
- In the case of large data, it is advisable to perform a point reduction - it is not enough to reduce the points to a certain percentage of the original cloud, but it is necessary to use an intelligent reduction, at least one that preserves the desired point density.
- Cleaning the point cloud of "noise" - wrongly measured points, moving objects in the area, people, vehicles, etc.
- Modelling of spherical targets and their numbering - manual / semi-automatic / automatic (with checking)

Processing - registration

- The process of connecting individual point clouds into a single entity and transforming them into final coordinate systems (local/global)
- Identical points
- Overlap
- Automatic registration

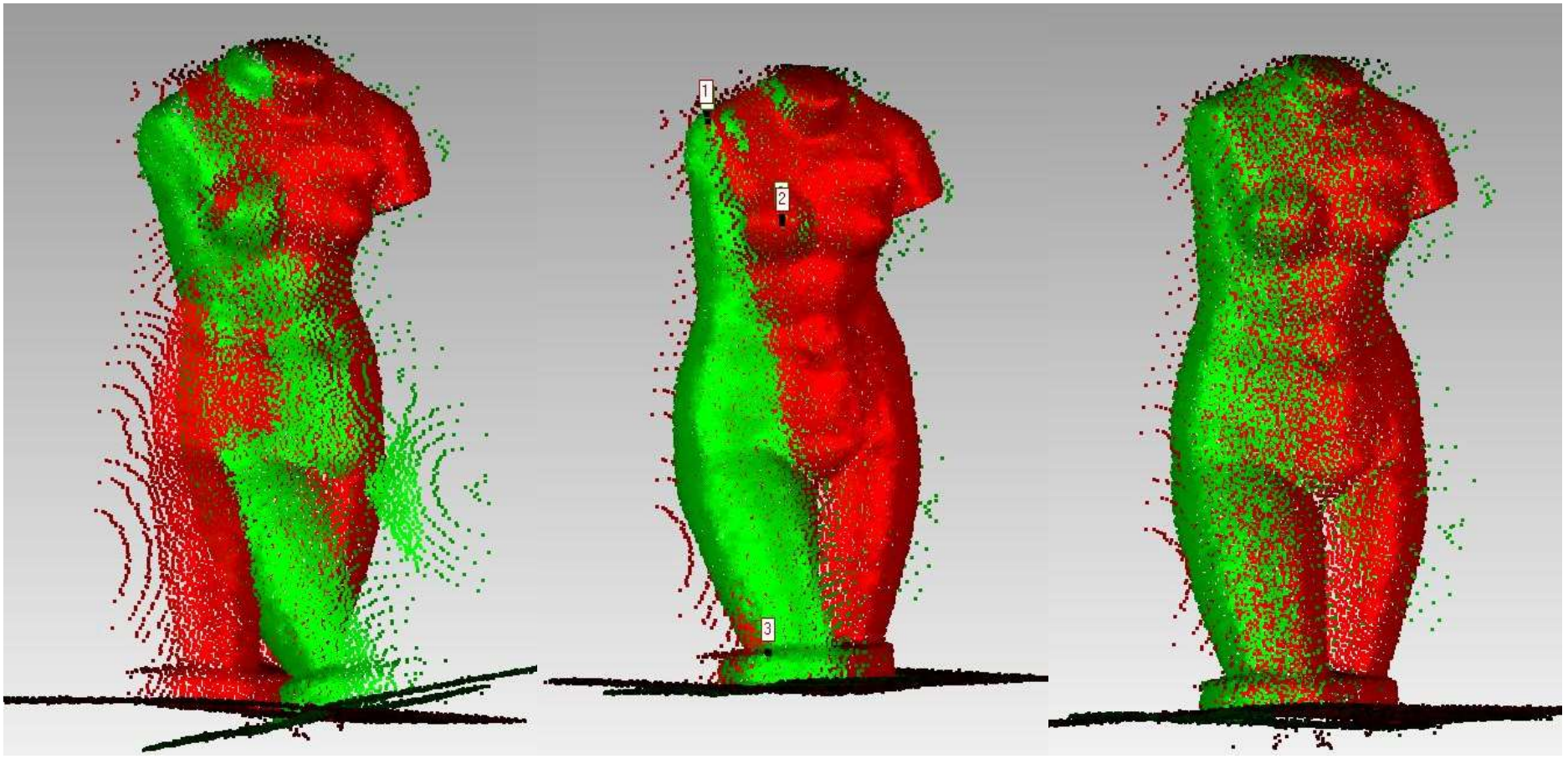
Processing - registration

- Overlap - Iterative Closest Point (ICP) algorithm - minimizes the distance between two points clouds based on the least squares method. The distance between selected points in the overlapping part of both clouds is minimized. The algorithm iteratively revises the transformation needed to minimize the observed error parameter (usually the distance between the points of the two clouds - the sum of the squares of the differences between the lengths of the paired points).

- This is a process whose outcome is somewhat random. It is influenced by the approximate values and the choice of points.

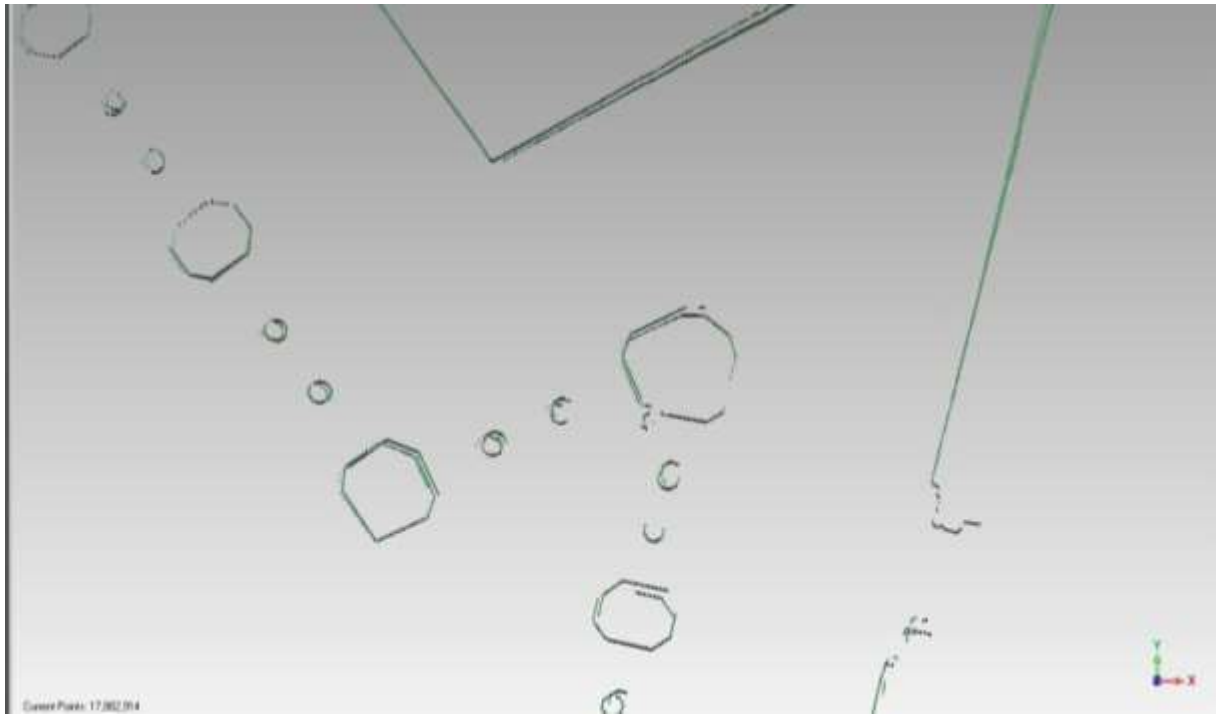
- Manual x global ICP

Processing - registration- overlap



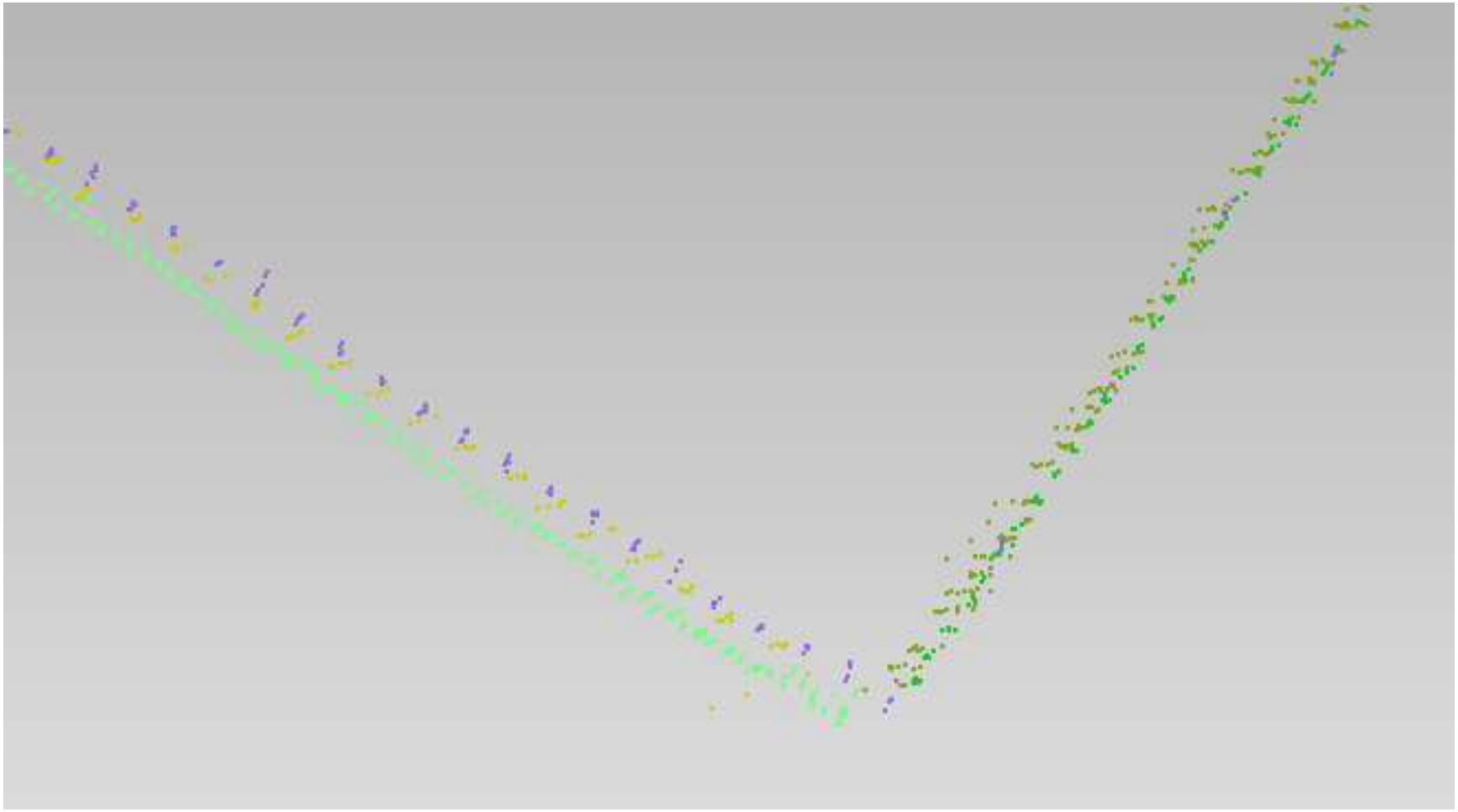
Processing - checking registration

- After the registration, the resulting cloud must be inspected and the quality of the cloud connections on the overlapping areas checked by thin sections in all three axes.
- This check must always be done! Even if the resulting registration logs show sufficient accuracy.
- Example of an incorrect registration:



Processing - checking registration

- Example of an incorrect registration:



Processing - data preparation for modelling

- The registered point cloud must be prepared before modelling:
- Point reduction
- Cleaning the point cloud of any unwanted objects
- Transformation into a local system suitable for modelling
- Splitting the point cloud into logical parts

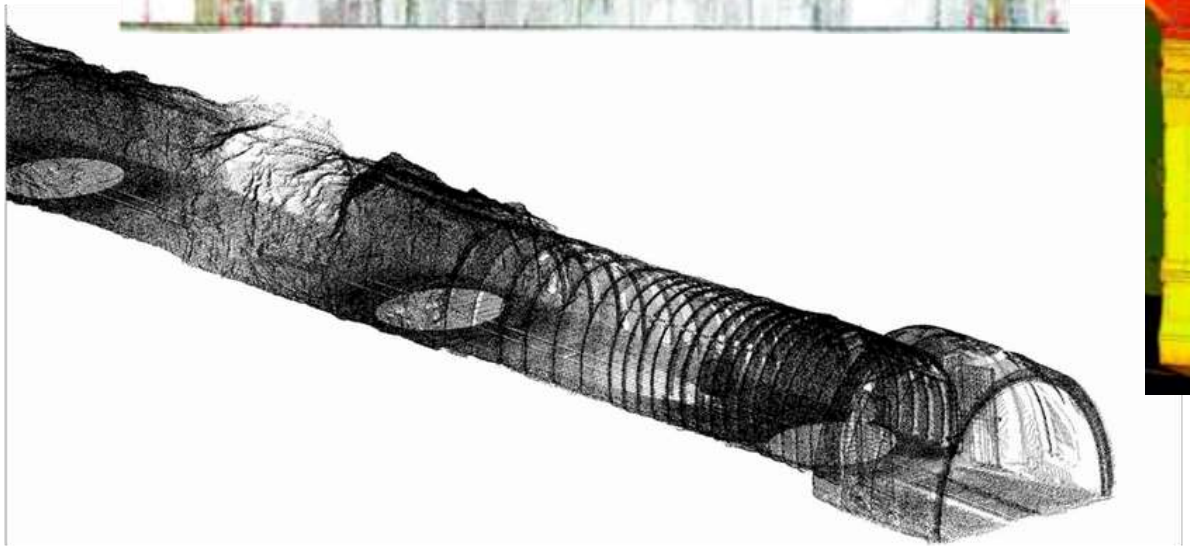
Processing - modelling

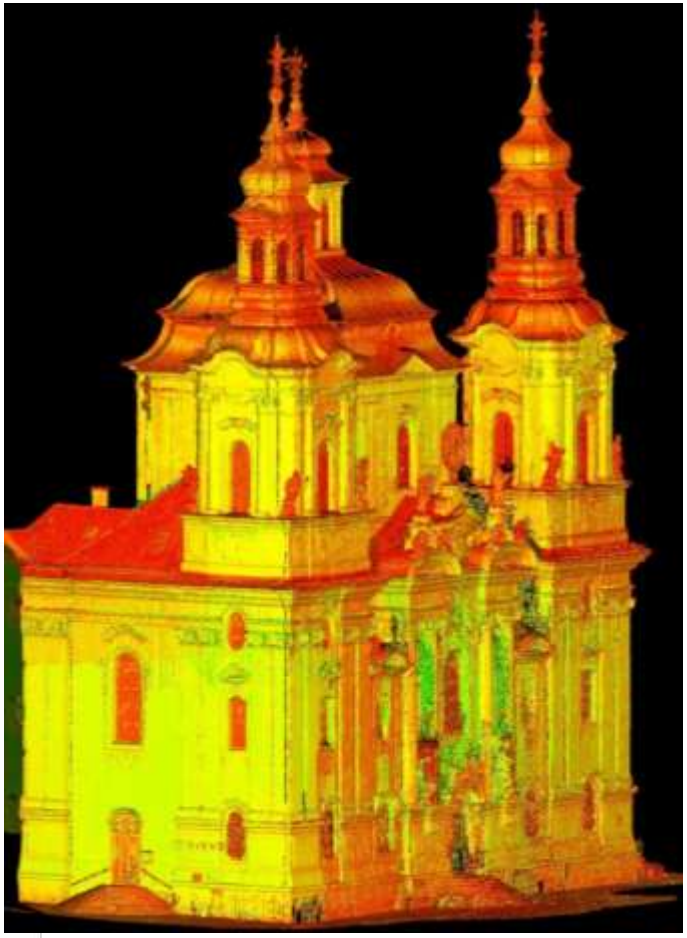
- Processing a point cloud into a final model is usually time, software and hardware consuming

- There are several forms of processing a point cloud into a final model:
  - A merged and modified point cloud.
  - A 3D model where the point cloud is replaced by geometric primitives (CAD model).
    - Wireframe model
    - Surface model
  - A 3D model where the point cloud is replaced by a Triangular Irregular Network (TIN).
  - 3D model where the point cloud is replaced by surfaces with variable curvature (e.g. B-spline).

Processing - modelling

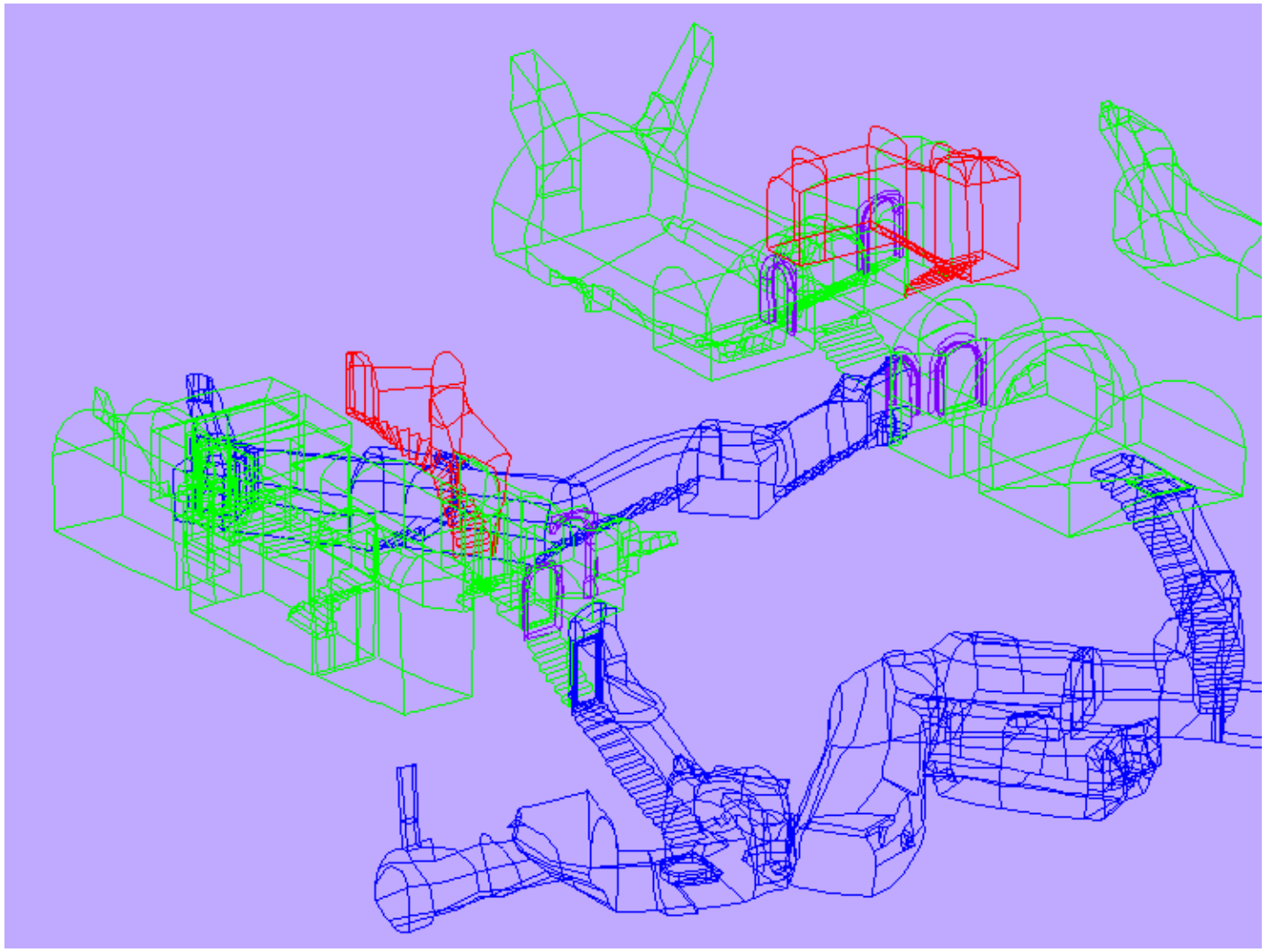
- the point cloud on which it can be directly measured, it is often transformed into a suitable local coordinate system





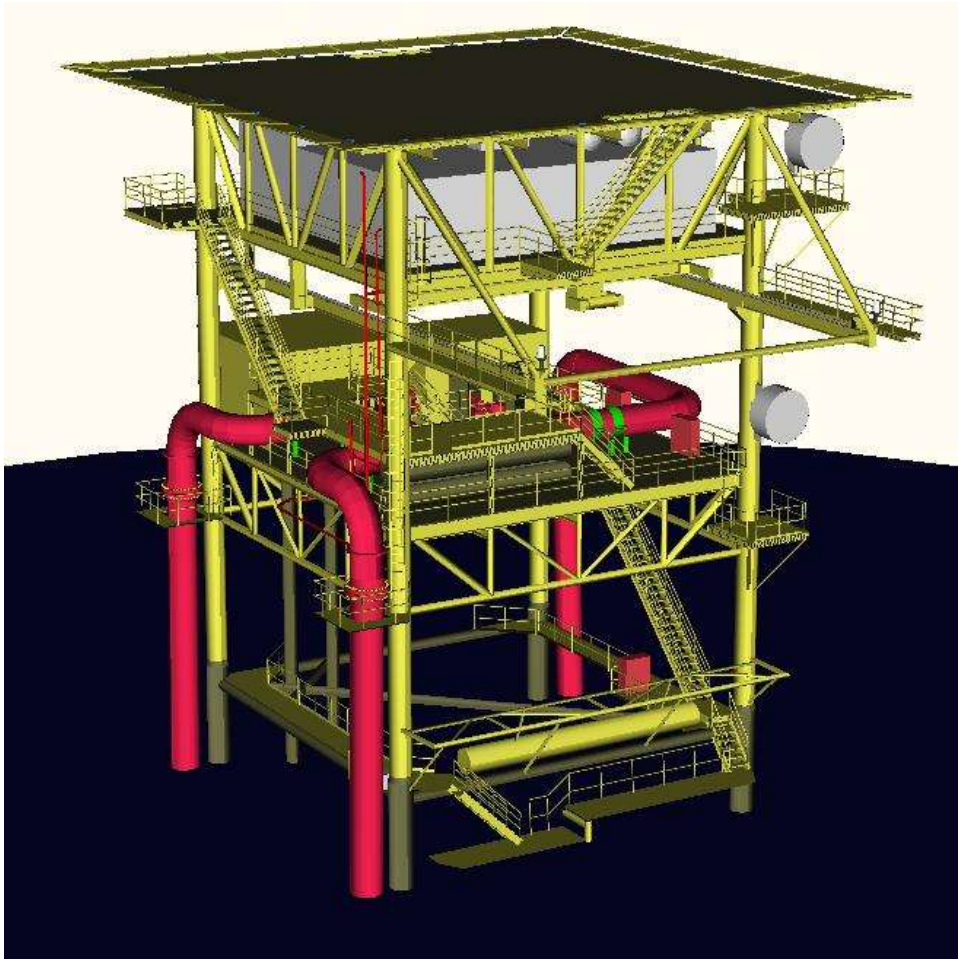
Processing - modelling

- wire model



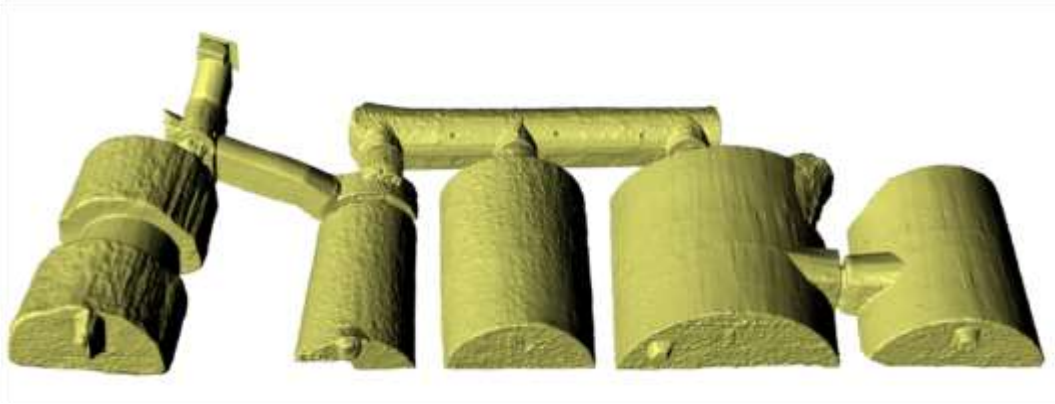
Processing - modelling

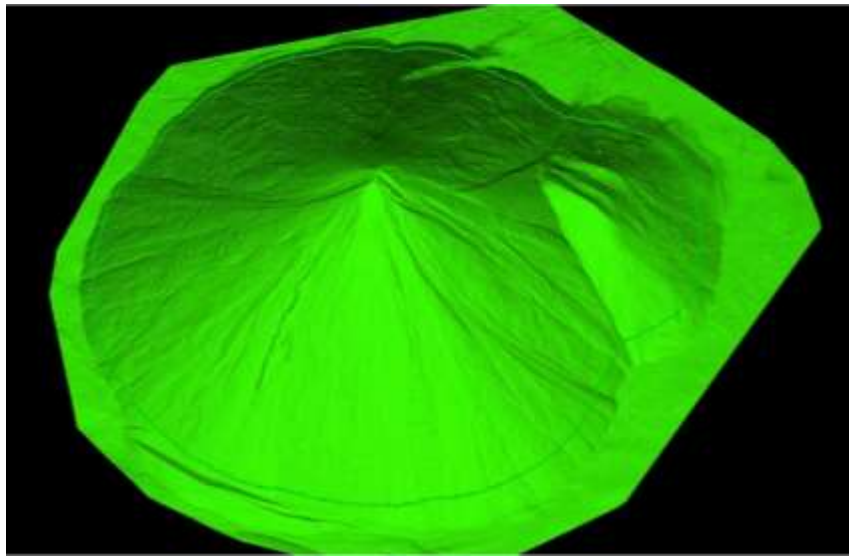
- Surface model



Processing - modelling

- Triangulated network/ mesh



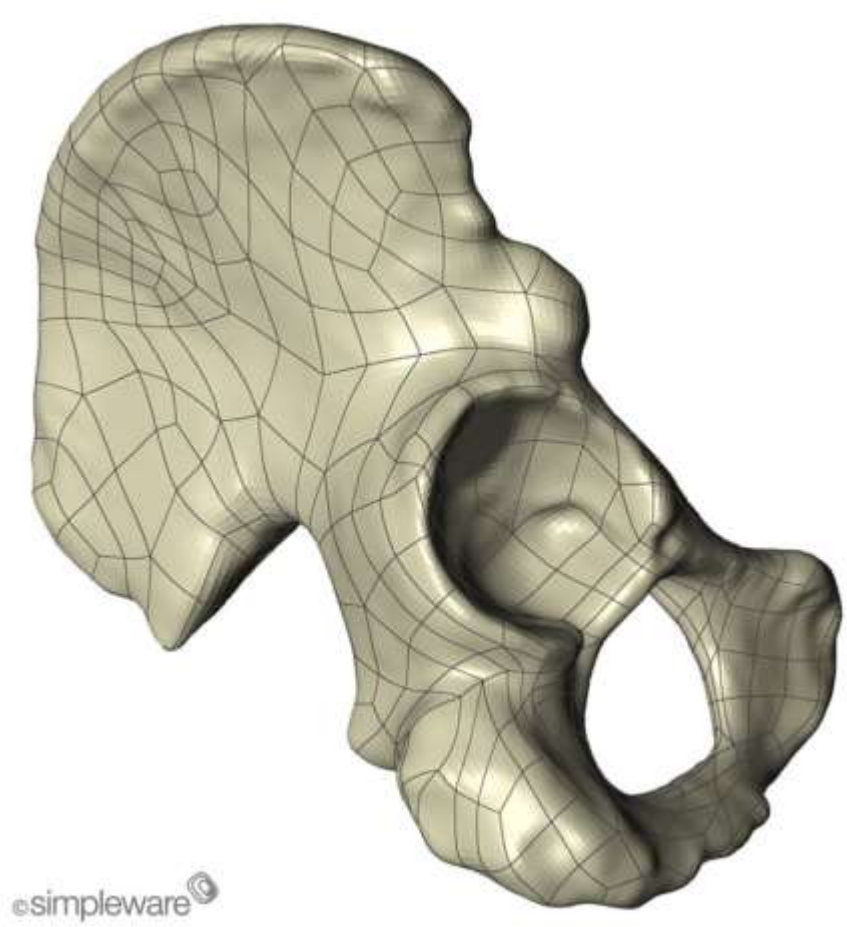


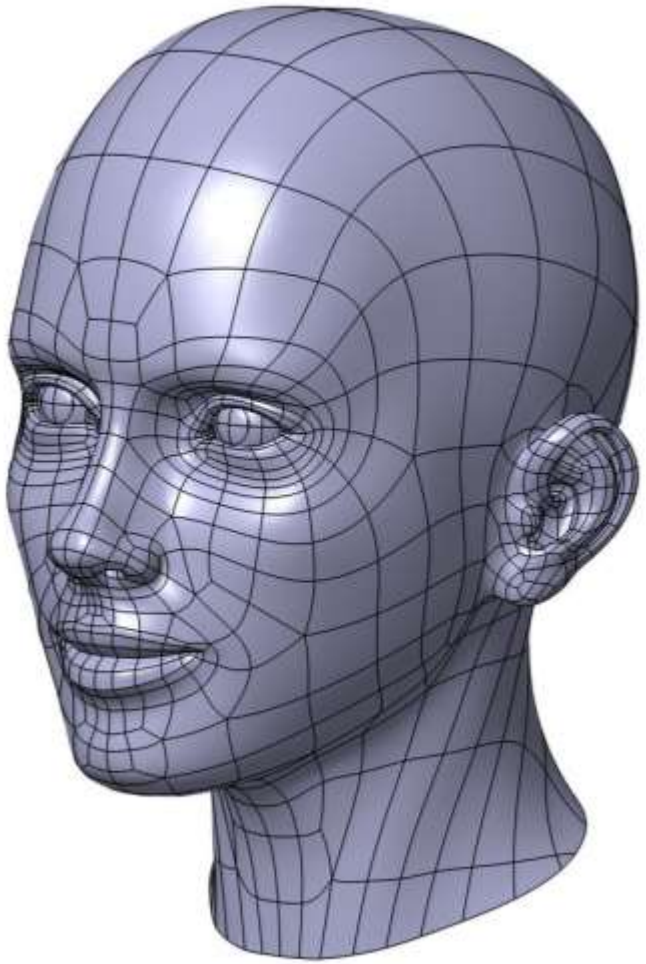
Processing - modelling

- Combination of procedures

Processing - modelling

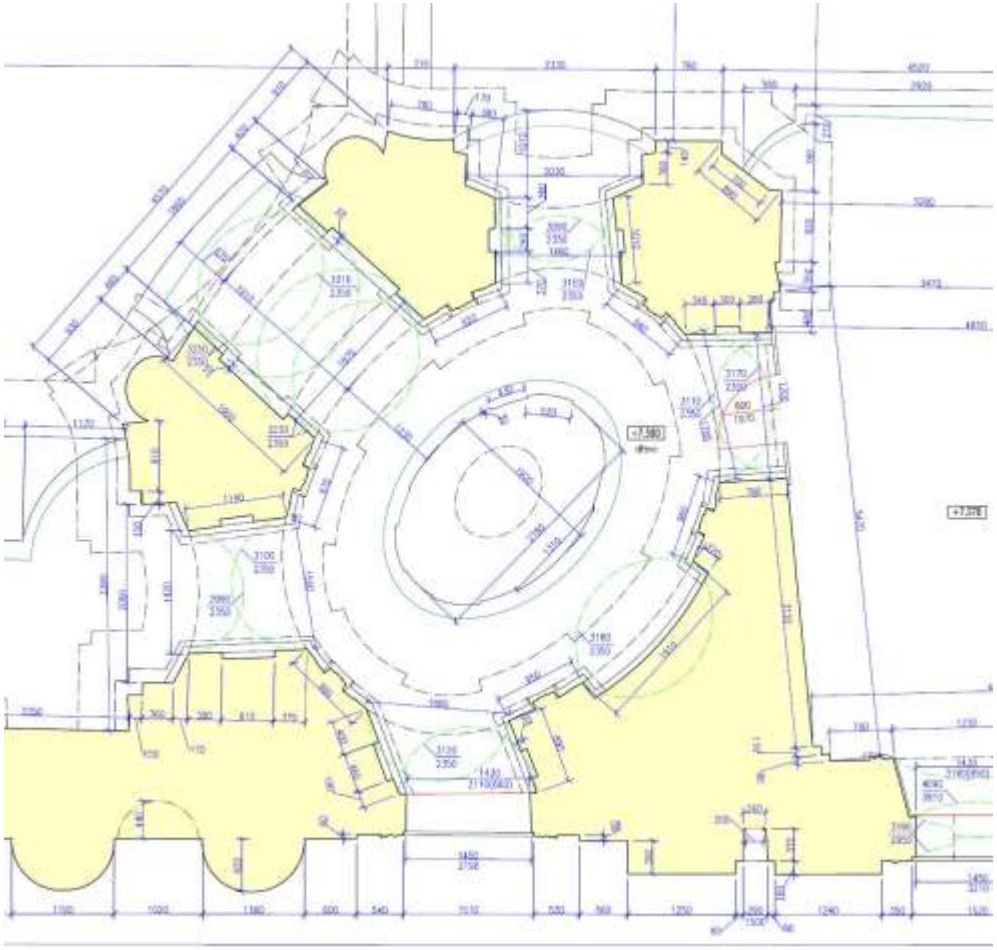
- B-spline surfaces

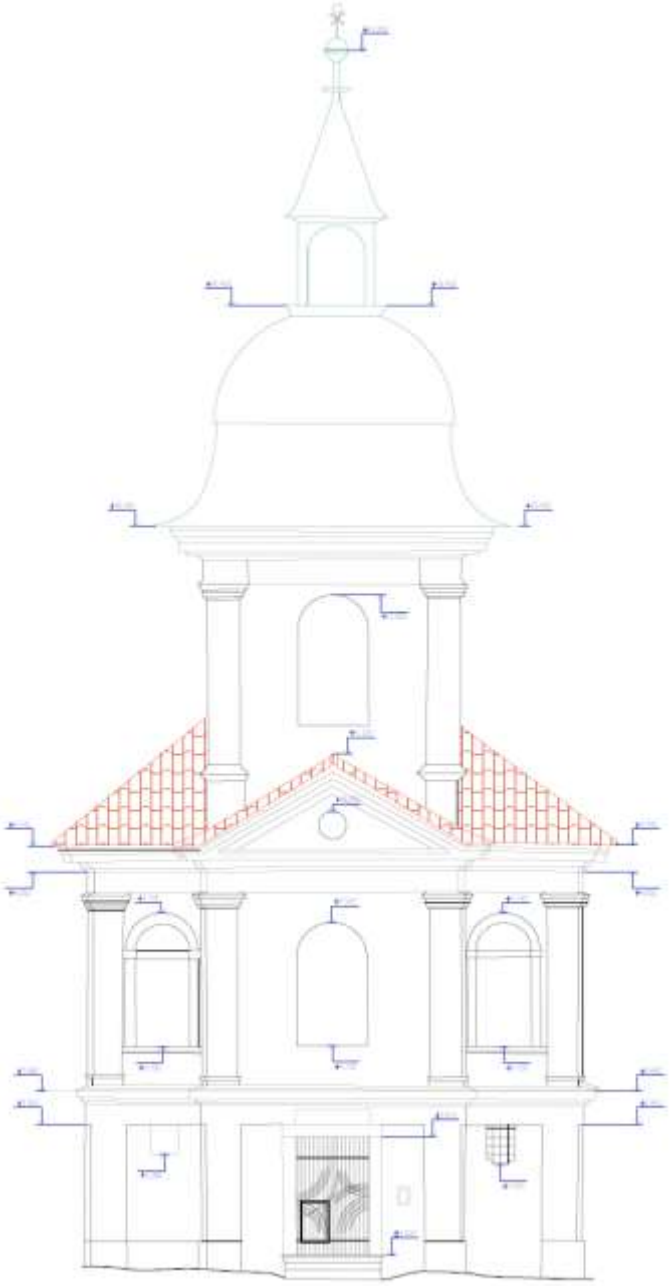




Processing - modelling

- 2D output - drawings, views, sections, ...





Presentation of the results

- Depends on the type of result
- The customer wants to see the result and present it to their business partners
- Scan results are spatial/planar, detailed, different view scales can be used, They are big data and hardware and software intensive
- Need to provide the customer with viewing software and basic processing tools (coordinate reading, length measurement, generation of sections, ...)
- Create images, videos, various visualizations to present the results, ...

Thank you for your attention!