



EUROPEAN UNION  
European Structural and Investment Funds  
Operational Programme Research,  
Development and Education



MINISTRY OF EDUCATION,  
YOUTH AND SPORTS

# AUTOMATED SEARCHING FOR DRAWING DOCUMENTATION OF AN UNKNOWN OBJECT – PART, COMPONENT..

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VŠB-Technical University of Ostrava  
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Research Platform focused on Industry 4.0 and Robotics in Ostrava Agglomeration project, project number CZ.02.1.01/0.0/0.0/17\_049/0008425 within the Operational Programme Research, Development and Education

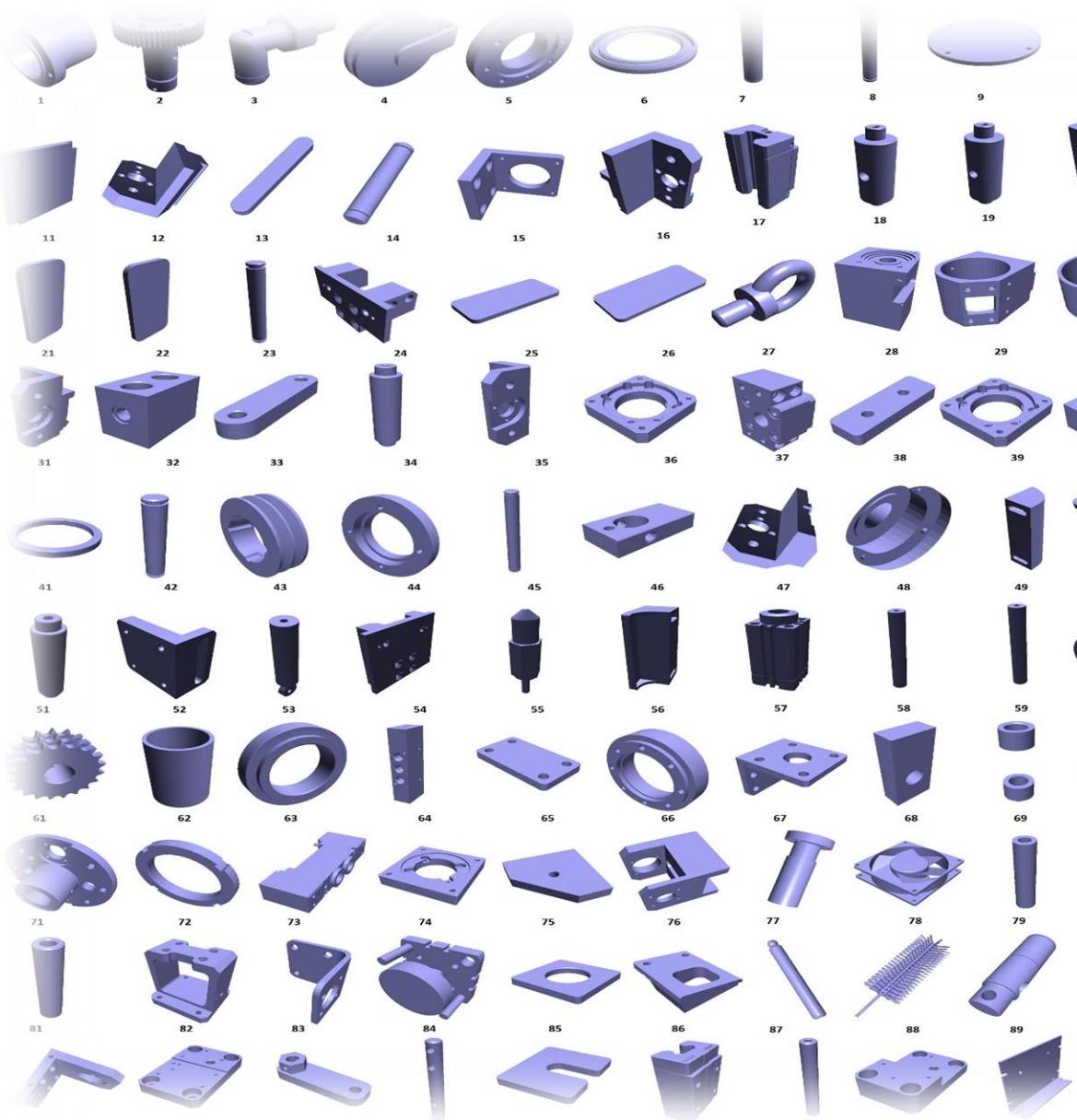
# Introduction

**The goal is to assign a 3D object (machine part) to its existing 3D model in the database.**

**And thus get a detailed description of it, without knowing its name, code designation, etc.**



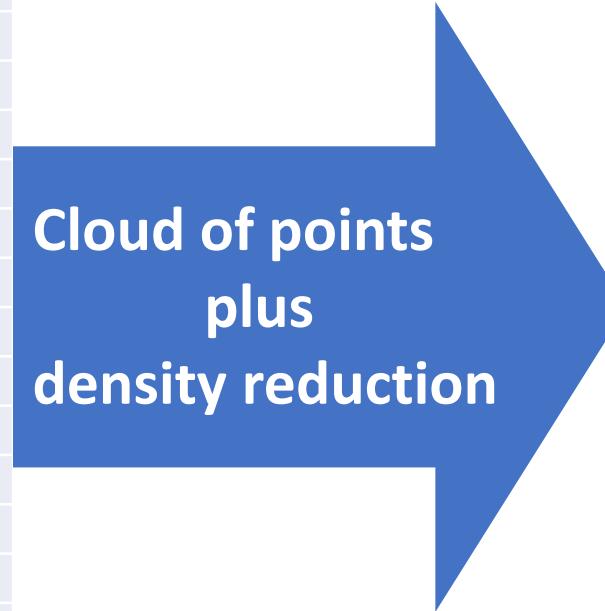
# Database of models in .stl format



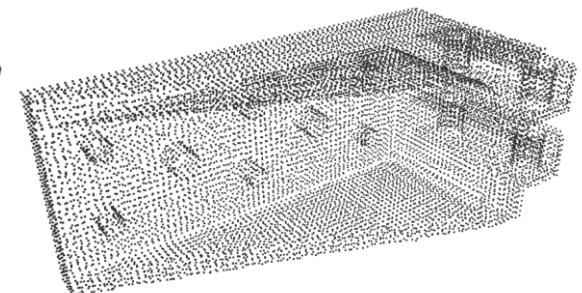
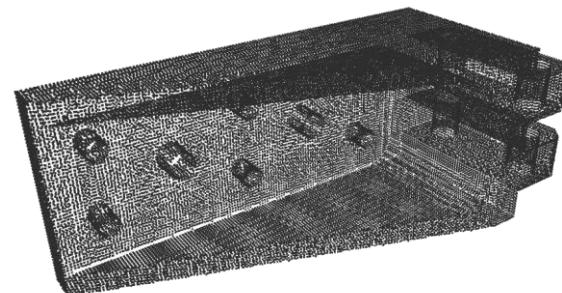
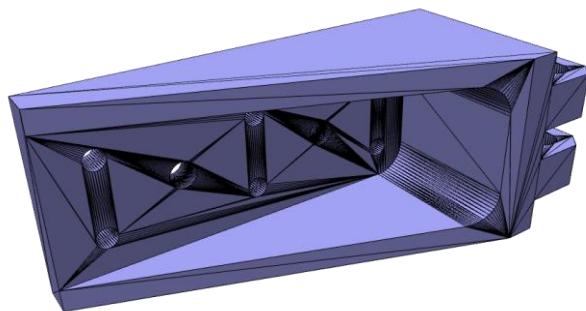
150927_zbh-9	.stl
191192_ysrw-5-8---_80_	.stl
_19216_dsnu-20-250-p---_a---0-	.stl
_19216_dsnu-20-250-p---_a---00-	.stl
196008_dsnu-50-250-p---_a---0	.stl
196008_dsnu-50-250-p---_a---00	.stl
210028_8_sxn_08_verzinkt_sl	.stl
_536288_adn-160-pps---_z_	.stl
_536288_adn-160-pps-a__ks_	.stl
536309_adn-80-pps---_z_	.stl
536309_adn-80-pps-a__ks_	.stl
559294_dsnu-25-500-pps---_a-35	.stl
559294_dsnu-25-500-pps---_a-47	.stl
_560210_hgpt-35-a-b---_0_g	.stl
6059_lbn-20_25---_l_	.stl
6140_fk-m10x1_25---_0bo_	.stl
6140_fk-m10x1_25---_bu_	.stl
6140_fk-m10x1_25---_ge_	.stl
6140_fk-m10x1_25---_kg_	.stl
6140_fk-m10x1_25---_mu_	.stl
_6141_fk-m12x1_25---_0bo_	.stl
_6141_fk-m12x1_25---_bu_	.stl
_6141_fk-m12x1_25---_ge_	.stl

# .stl model database – conversion to .pcd point clouds

_150927_zbh-9	.stl
_191192_ysrw-5-8---_80_	.stl
_19216_dsnu-20-250-p---_a----0-	.stl
_19216_dsnu-20-250-p---_a---00-	.stl
_196008_dsnu-50-250-p---_a----0	.stl
_196008_dsnu-50-250-p---_a---00	.stl
_210028_8_sxn_08_verzinkt_sl	.stl
536288_adn-160-pps---_z_	.stl
536288_adn-160-pps-a__ks_	.stl
536309_adn-80-pps---_z_	.stl
536309_adn-80-pps-a__ks_	.stl
559294_dsnu-25-500-pps---_a-35	.stl
559294_dsnu-25-500-pps---_a-47	.stl
560210_hgpt-35-a-b---_0_g	.stl
6059_lbn-20_25---_l_	.stl
6140_fk-m10x1_25---_Obo_	.stl
6140_fk-m10x1_25---_bu_	.stl
6140_fk-m10x1_25---_ge_	.stl
6140_fk-m10x1_25---_kg_	.stl



.pcd



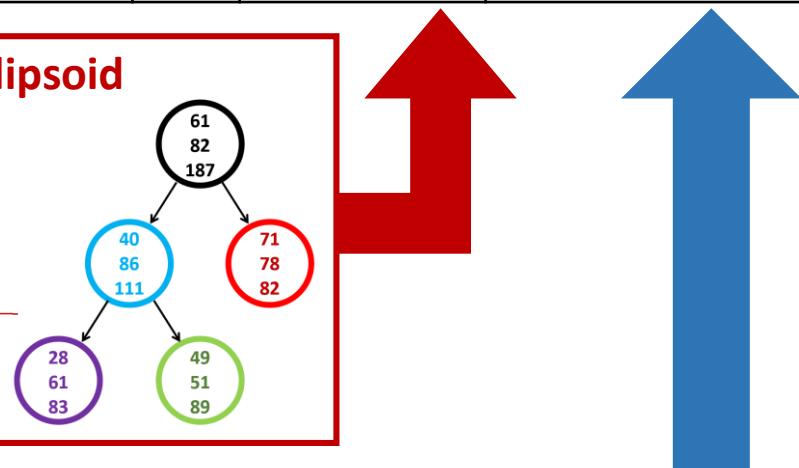
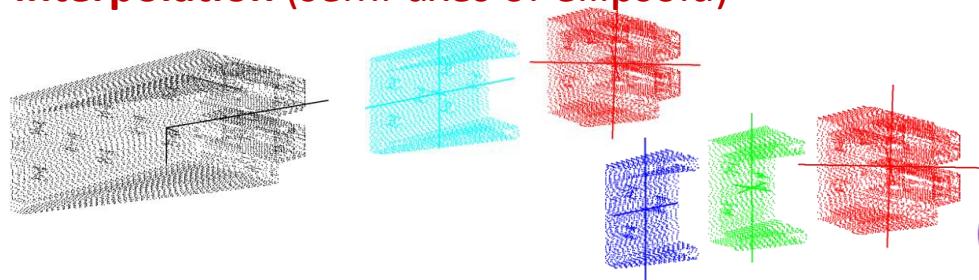
# Calculation of search parameters – for each model in the database

_150927_zb...	.pcd
_191192_ys...	.pcd
_19216_ds...	.pcd
_19216_dsn...	.pcd
_196008_dsk...	.pcd

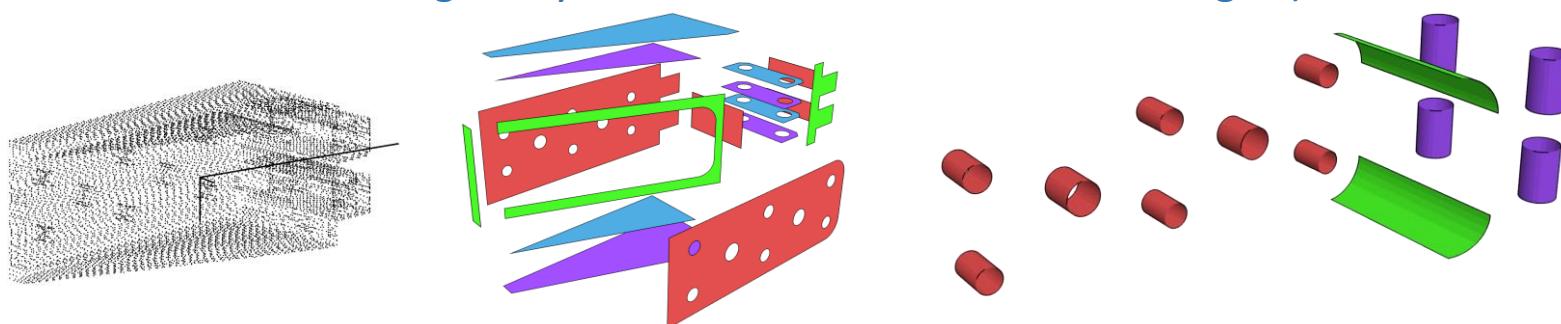
Calculation  
parameters

_150927_zb...	.pcd	<b>Ellipsoid tree</b>	<b>Geometric primitives</b>
_191192_ys...	.pcd	<b>Ellipsoid tree</b>	<b>Geometric primitives</b>
_19216_ds...	.pcd	<b>Ellipsoid tree</b>	<b>Geometric primitives</b>
_19216_dsn...	.pcd	<b>Ellipsoid tree</b>	<b>Geometric primitives</b>
_196008_dsk...	.pcd	<b>Ellipsoid tree</b>	<b>Geometric primitives</b>

**Hierarchical cloud decomposition - ellipsoid / ellipsoid interpolation (semi-axes of ellipsoid)**



**Cloud decomposition into planar and cylindrical geometric primitives**  
(Planes - distances and angles, cylinders - distances of axes and angles)

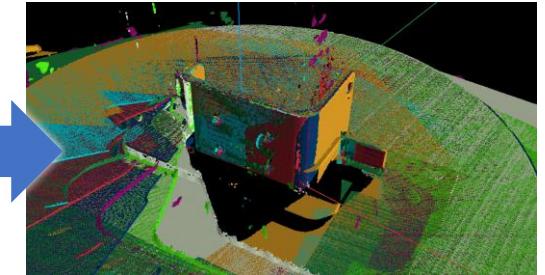
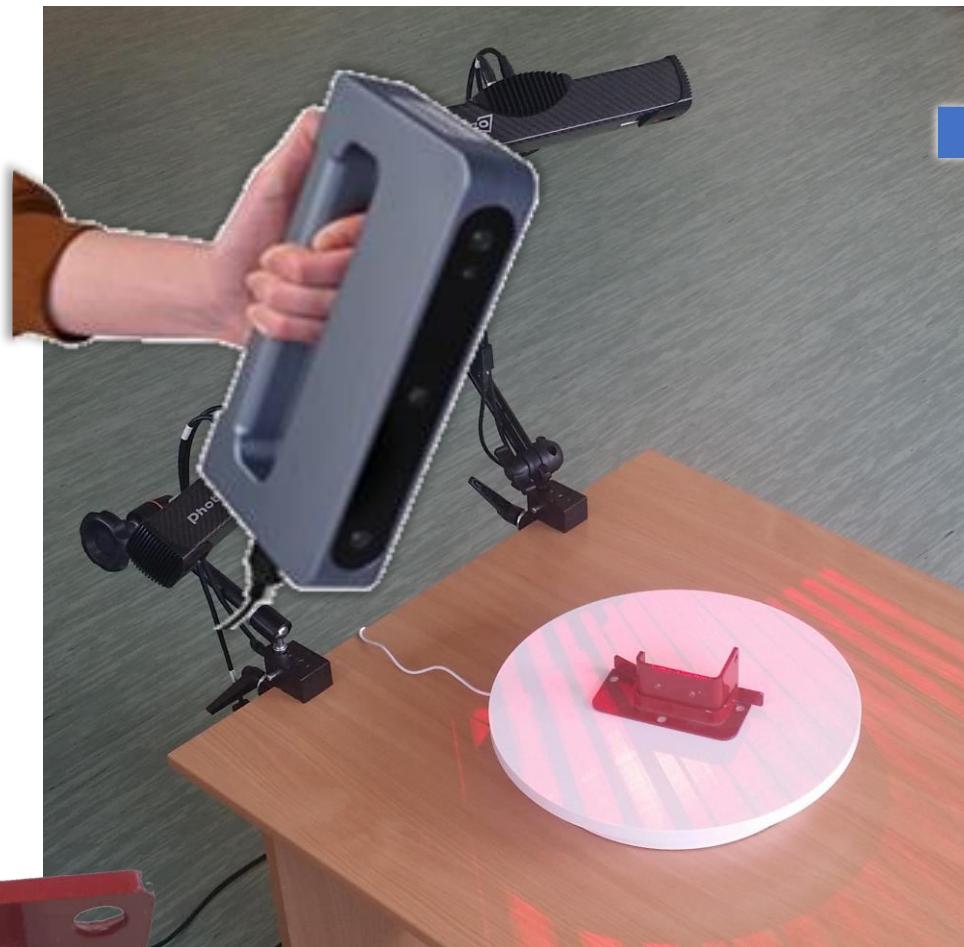


We have a real part – it is in the database,  
we do not know its assignment :-(

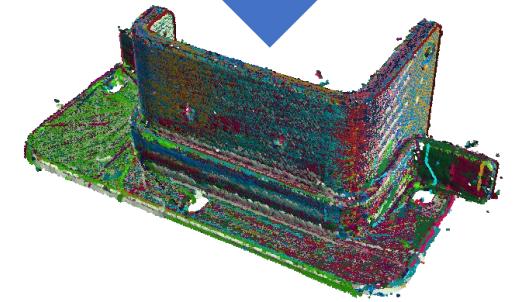


# 1. Creating a 3D scan of the real part – file in .stl format

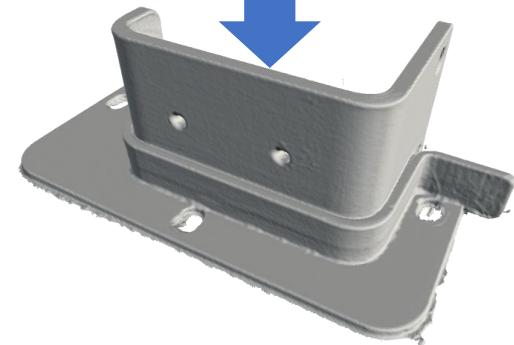
Commercial handheld 3D scanner can be used...



Unregistered scan



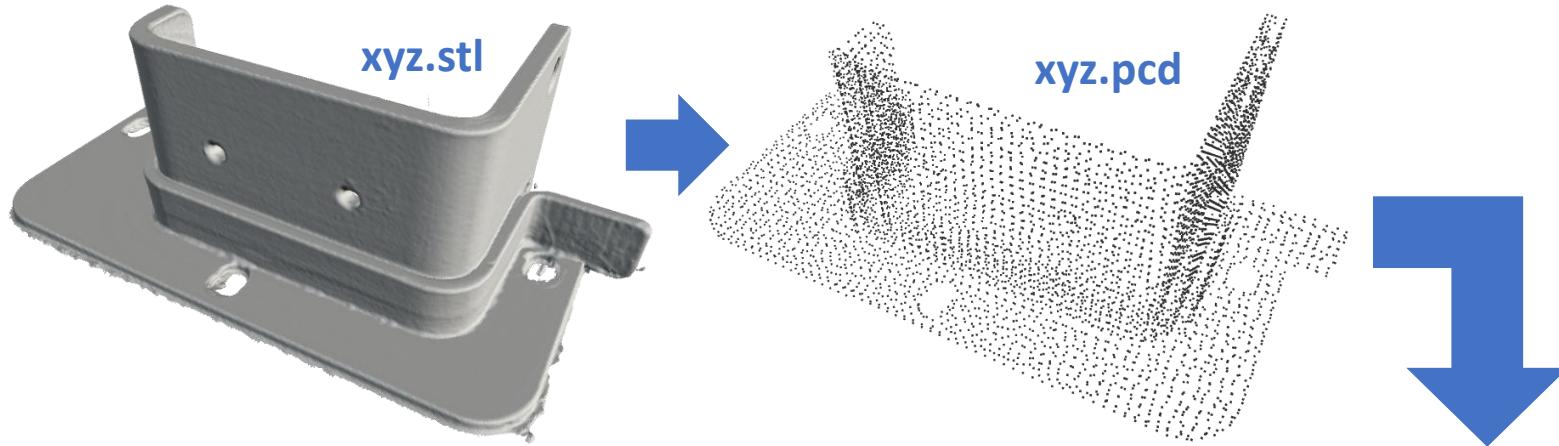
Raw scan



Resulting scan .stl

xyz.stl

## 2. xyz.stl to point cloud xyz.pcd, calculation of search parameters



**Hierarchical cloud decomposition - ellipsoid / ellipsoid interpolation  
(Semi-axes of ellipsoid)**

**Cloud decomposition into planar and cylindrical geometric primitives  
(Planes - distances and angles, cylinders - distances of axes and angles)**

**xyz.pcd**

**Ellipsoid tree**

**Geometric primitives**

We have parameters available for searching, we will search in the database  
what specific object it is...

# Searching for a match in the Ellipsoid Tree parameter in the entire database using the PCA algorithm\* – returns 5\*\* results

xyz.pcd    Ellipsoid tree    Geometric primitives



3	150927_zb...	.pcd	Ellipsoid tree	Geometric primitives
1	191192_ys...	.pcd	Ellipsoid tree	Geometric primitives
2	19216_ds...	.pcd	Ellipsoid tree	Geometric primitives
5	19216_dsn...	.pcd	Ellipsoid tree	Geometric primitives
4	196008_dsk...	.pcd	Ellipsoid tree	Geometric primitives
	196008.ds...	.pcd	Ellipsoid tree	Geometric primitives
	150954_zb...	.pcd	Ellipsoid tree	Geometric primitives
	191ztr_ys...	.pcd	Ellipsoid tree	Geometric primitives
	192htr_ds...	.pcd	Ellipsoid tree	Geometric primitives
	192eez_dsn...	.pcd	Ellipsoid tree	Geometric primitives
	1960jg_dsk...	.pcd	Ellipsoid tree	Geometric primitives
	196bgt_ds...	.pcd	Ellipsoid tree	Geometric primitives
	1509kl_zb...	.pcd	Ellipsoid tree	Geometric primitives
	191mj4_ys...	.pcd	Ellipsoid tree	Geometric primitives
	19257_ds...	.pcd	Ellipsoid tree	Geometric primitives
	192li5_dsn...	.pcd	Ellipsoid tree	Geometric primitives
	115pz8_dsk...	.pcd	Ellipsoid tree	Geometric primitives
	476008.ds...	.pcd	Ellipsoid tree	Geometric primitives

\* - Principal Component Analysis

\*\* - can be chosen

# Search for a match in the Geometric primitives (DiP \*) parameter in the results of the previous step

xyz.pcd

Ellipsoid tree

Geometric primitives

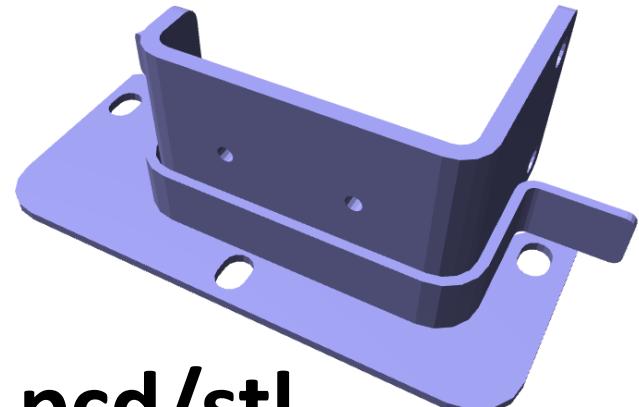


Winner

2  
3  
1  
1  
4  
5  
4

19216_ds...	.pcd	Ellipsoid tree	Geometric pri..
196008_dsk...	.pcd	Ellipsoid tree	Geometric pri..
1960jg_dsk...	.pcd	Ellipsoid tree	Geometric pri..
1509kl_zb...	.pcd	Ellipsoid tree	Geometric pri..
115pz8_dsk...	.pcd	Ellipsoid tree	Geometric pri..

Result - 3D model (stl),  
drawing documentation,  
description, ...



**xyz.pcd = \_1960jg.ds.pcd/stl**

\*- Decomposition into Geometric Primitives

# Summary:

Only once, time consuming...

We have a database of objects (parts, components) in **stl** format.

We convert each object in this database into a point cloud – **pcd**, calculate the search parameters – ellipsoids and geometric primitives.

**We have an object (part, component), it is in the database, we do not know which it is, we need its documentation (stl, drawings, ...).**

For each object...

1. We perform a 3D scan and get a file in stl and pcd. We calculate search parameters - ellipsoids and geometric primitives

**We start the search:**

2. Finding the best match in the ellipsoid parameter **in the whole database** – eg. 5 objects with the highest match    

3. Finding the best match in the **geometric primitives parameter** in the **results of the previous step**    

4. **Search result** – the searched object in the database corresponding to the scanned one. **We obtain its drawing documentation.**



Examples of  
searching for  
real  
components

# Examples of searching for real components



# Part 31



3D scan

Geometric primitives  
Ellipsoid tree

Rough sieve – PCA

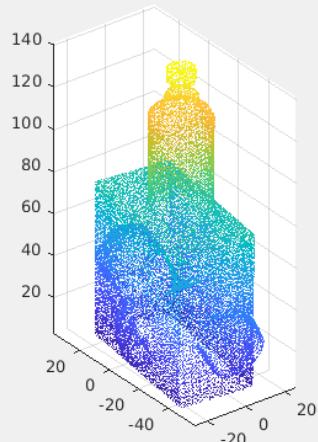
Fine sieve – DiP

Result

# Part „31“ – PCA, „Rough sieve“

Figure 3

View Insert Tools Desktop Window Help



Matching score = 21.3

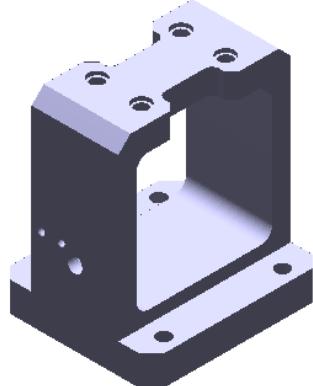


Figure 4

View Insert Tools Desktop Window Help

Matching score = 7.25

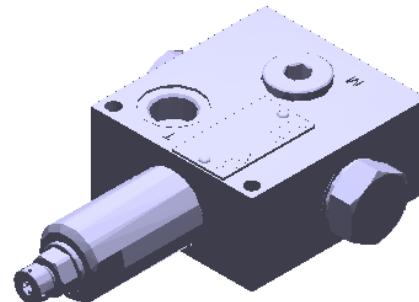
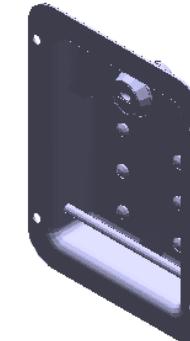


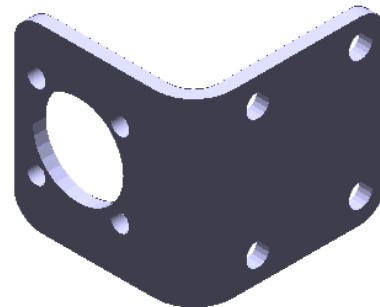
Figure 5

File Edit View Insert Tools Desktop Window Help

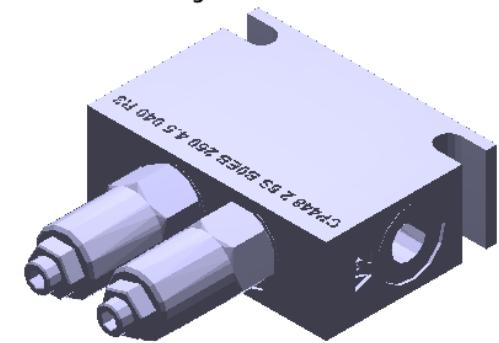
Matching score = 19.4



Matching score = 23

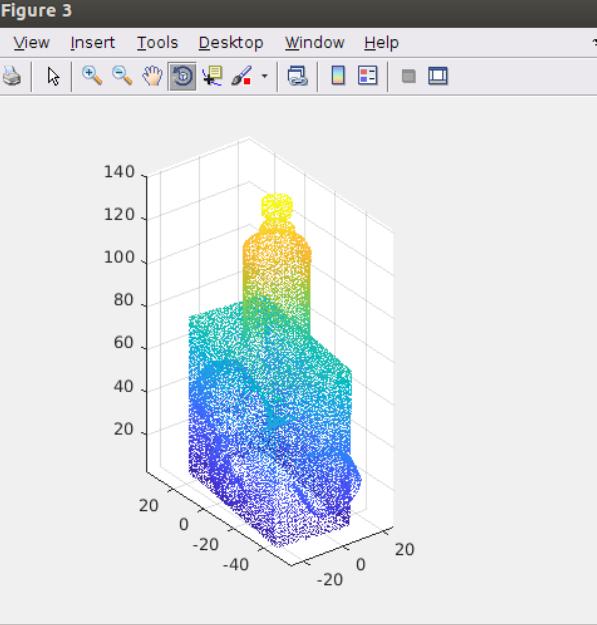


Matching score = 26.5

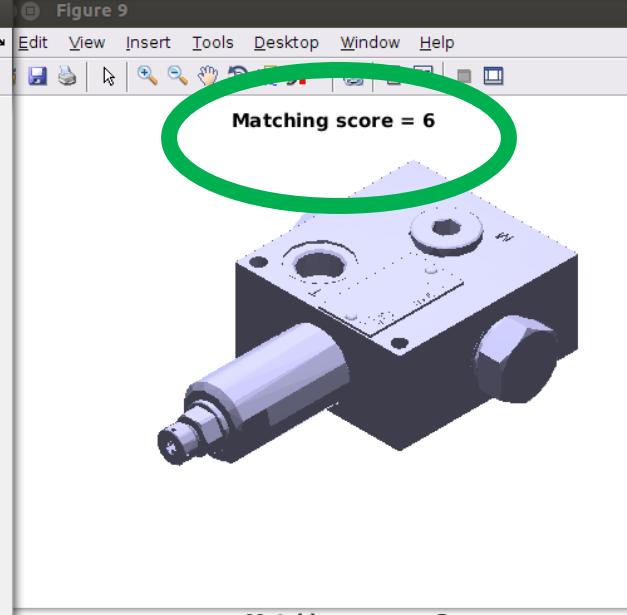


...These components are found in the database

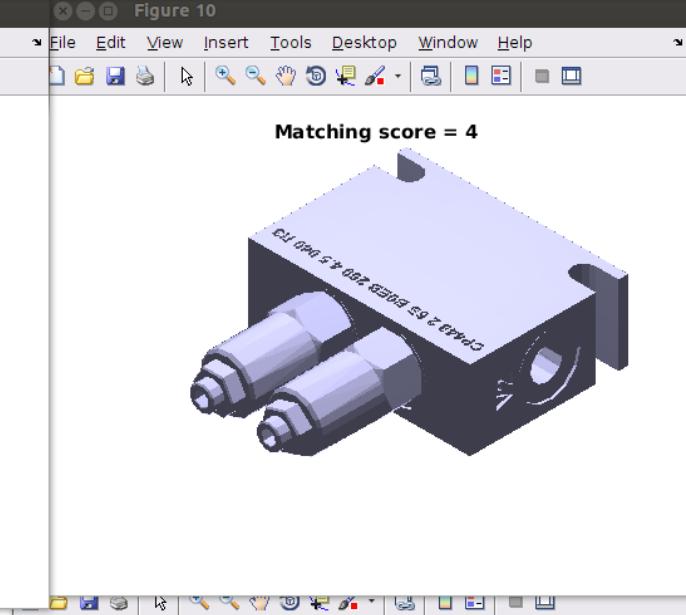
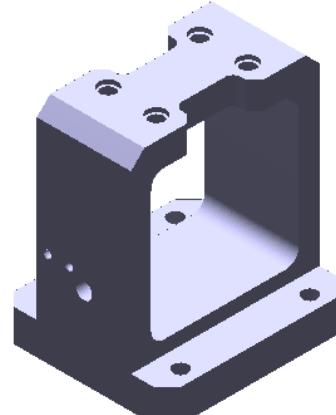
# Part „31“ – DiP, „Fine sieve“



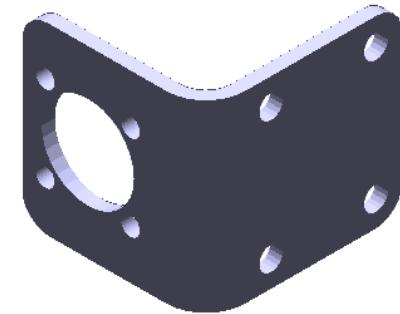
Matching score = 3



Matching score = 3



Matching score = 0



... Winner found in PCA results

# Part 36



3D scan

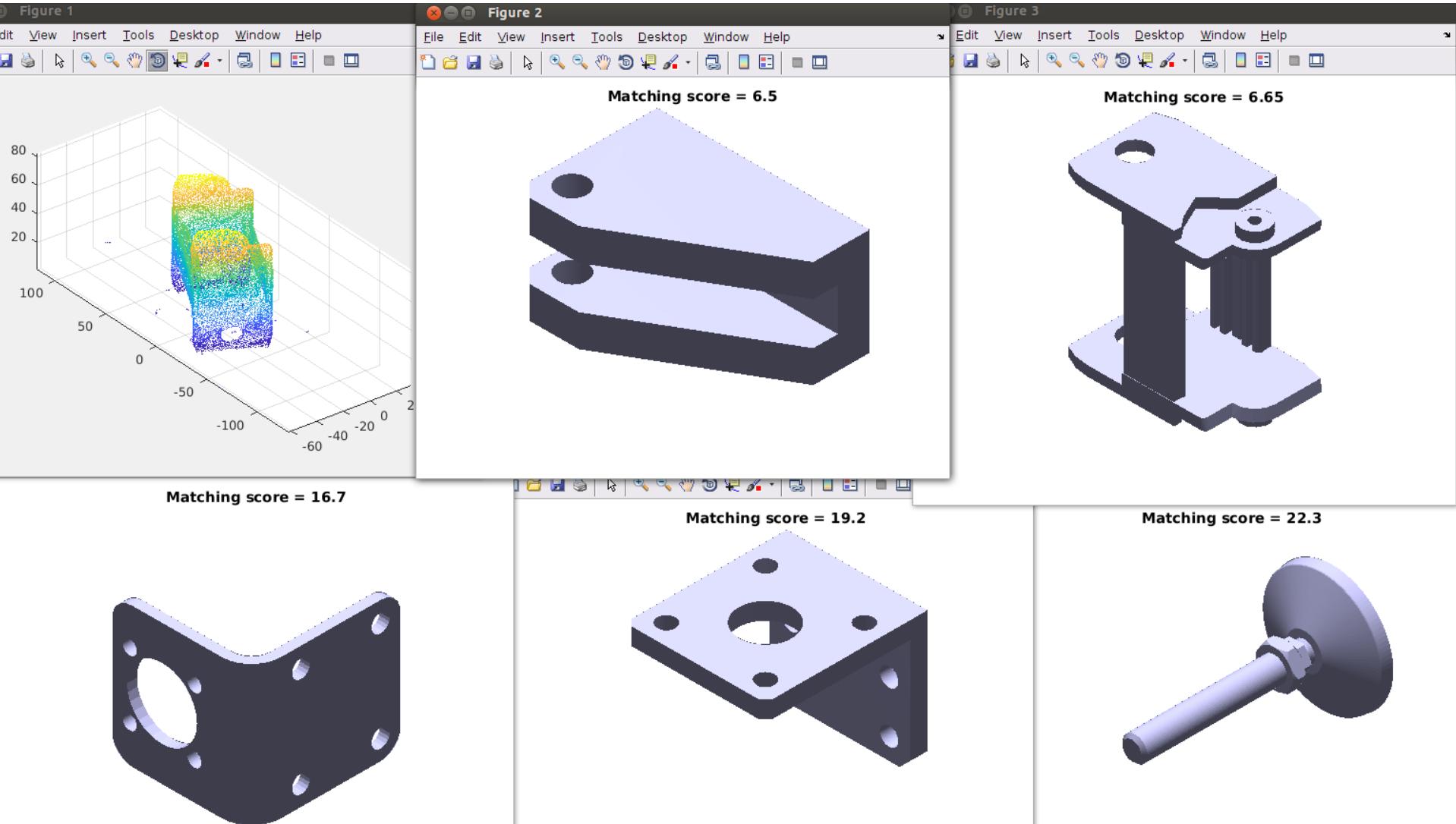
Geometric primitives  
Ellipsoid tree

Rough sieve – PCA

Fine sieve – DiP

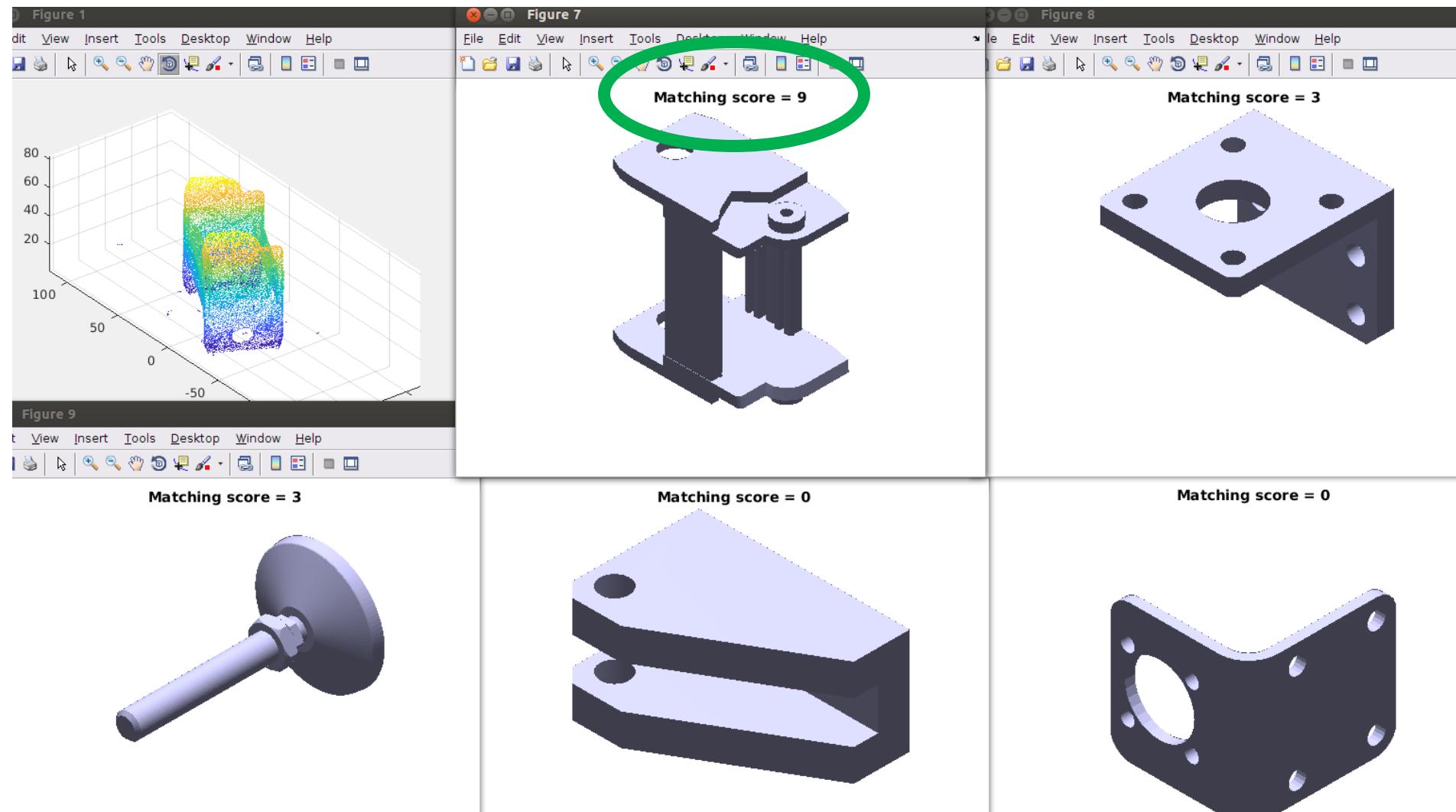
Result

# Part „36“ – PCA, „Rough sieve“



...These components are found in the database

# Part „36“ – DiP, „Fine sieve“



... Winner found in PCA results

# Part 38



3D scan

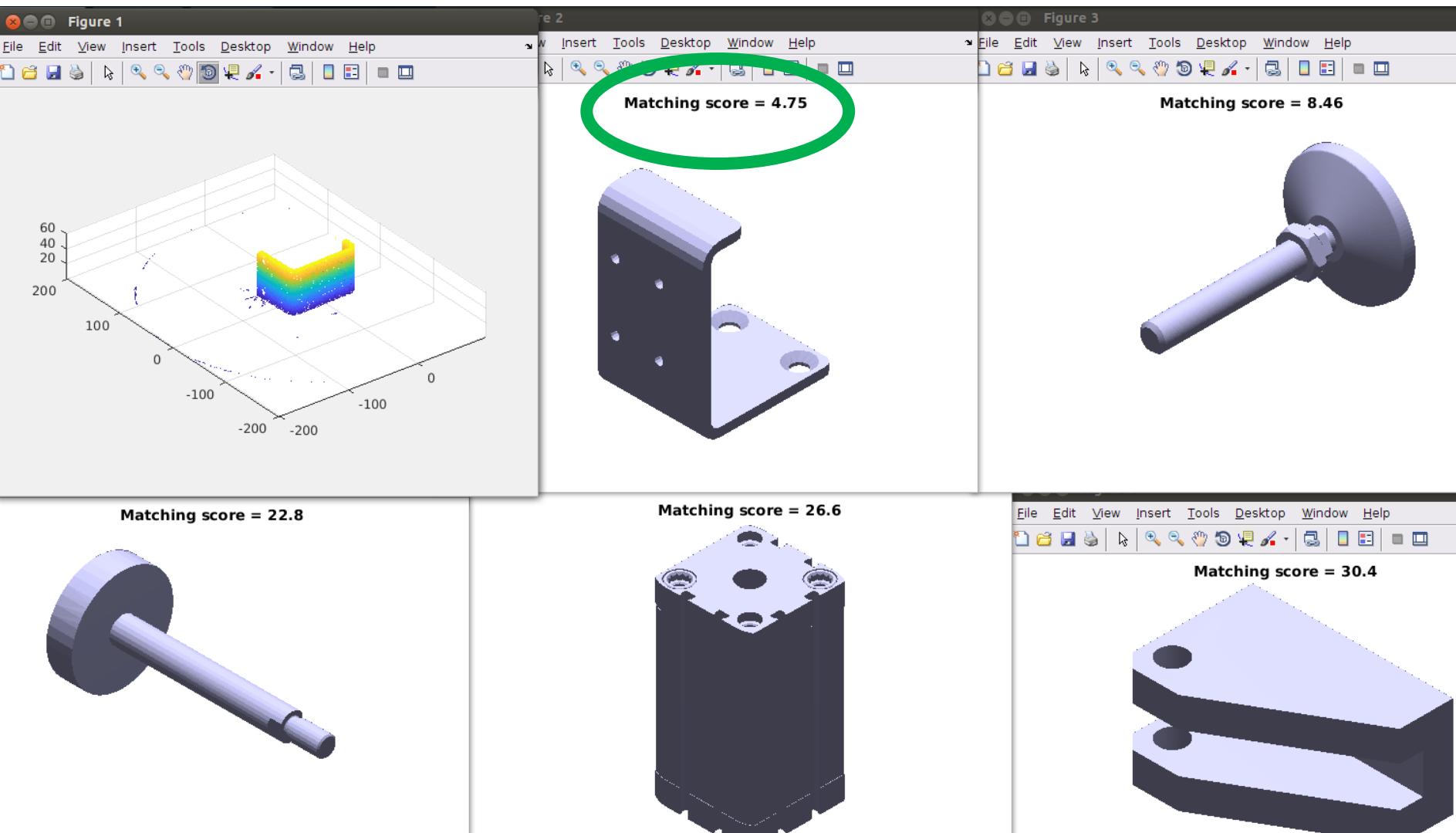
Geometric primitives  
Ellipsoid tree

Rough sieve – PCA

Fine sieve – DiP

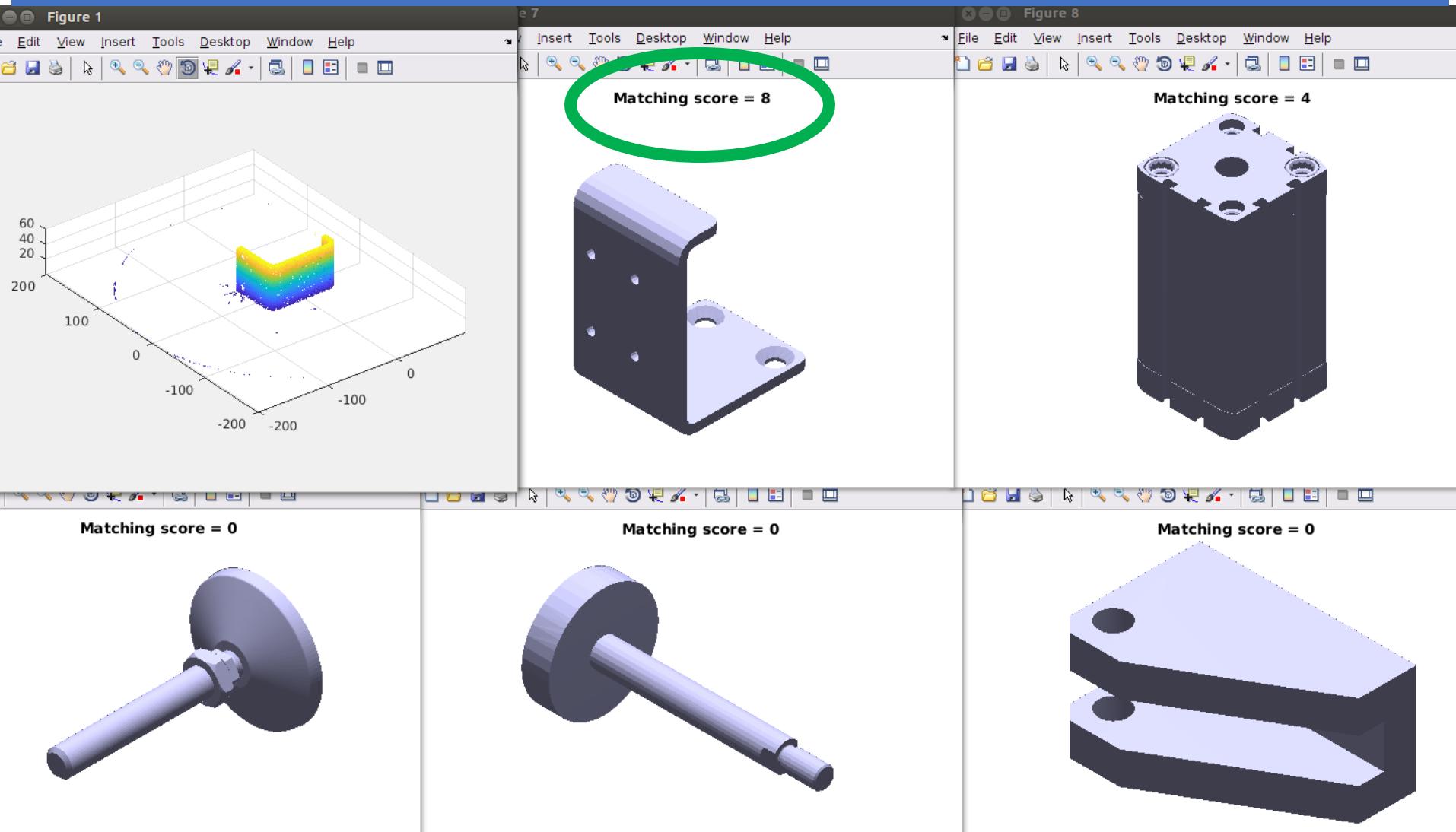
Result

# Part „38“ – PCA, „Rough sieve“



...These components are found in the database

# Part „38“ – DiP, „Fine sieve“



... Winner found in PCA results

# Part 40



3D scan

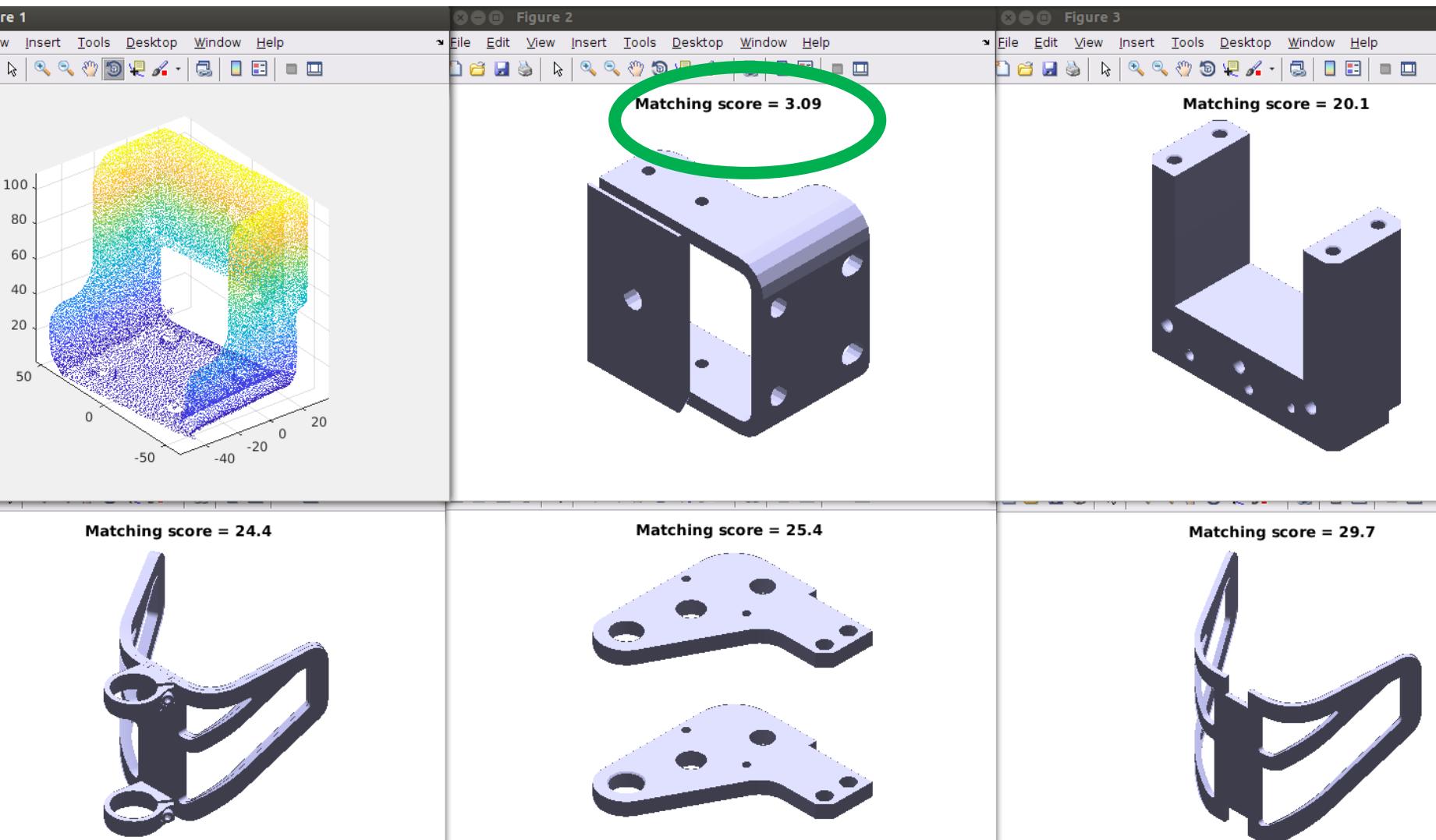
Geometric primitives  
Ellipsoid tree

Rough sieve – PCA

Fine sieve – DiP

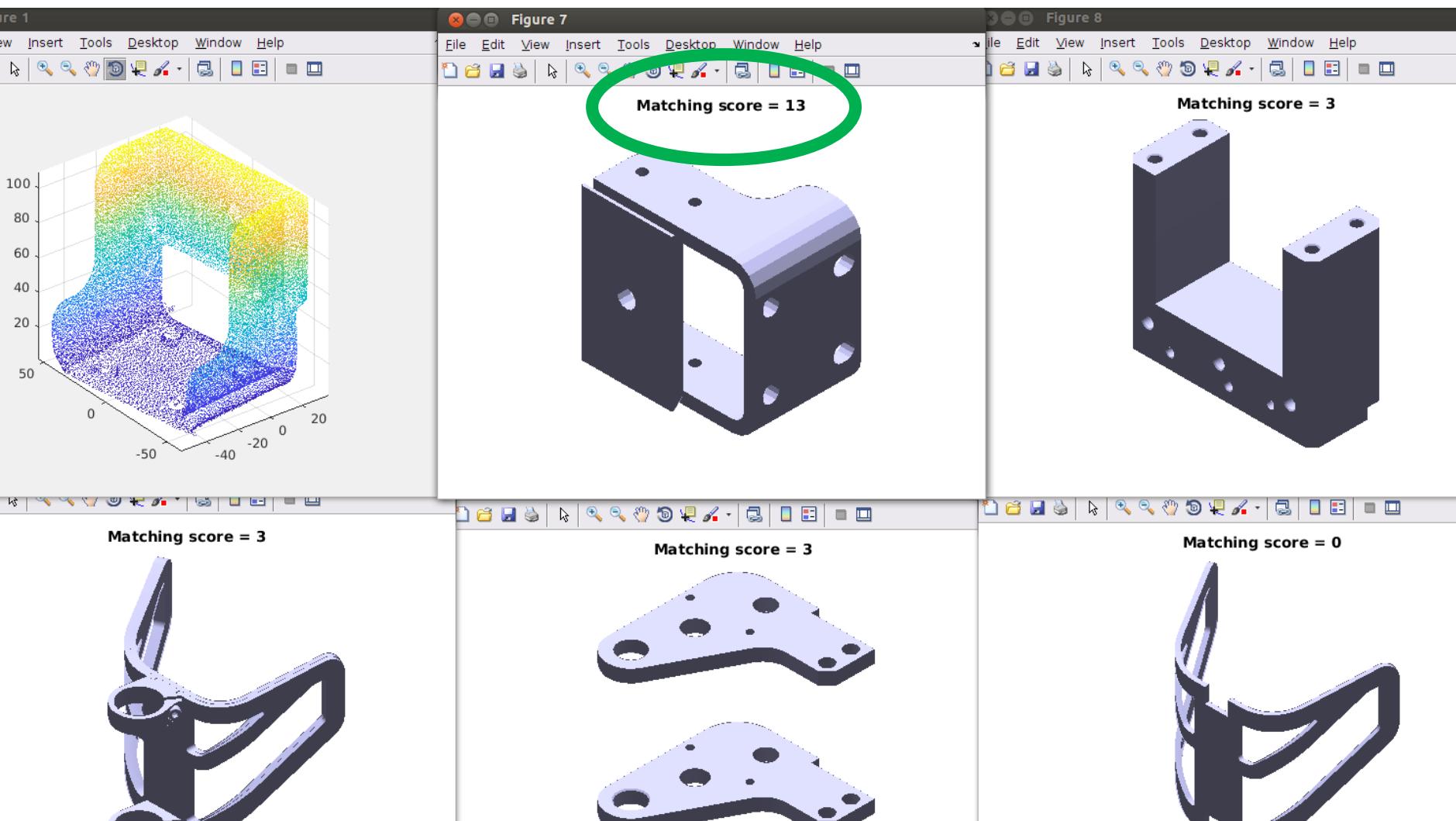
Result

# Part „40“ – PCA, „Rough sieve“



...These components are found in the database

# Part „31“ – DiP, „Fine sieve“



... Winner found in PCA results