

# PONTFELHŐ FELDOLGOZÁSI LEHETŐSÉGEK CLOUDCOMPARE-BEN

*10. Nyílt forráskódú térinformatikai  
munkaértekezlet  
Foszforgézu Konferencia*



BUDAPESTI MŰSZAKI  
ÉS GAZDASÁGTUDOMÁNYI EGYETEM  
Építőmérnöki Kar - építőmérnöki képzés 1782 óta

Általános és Felsőgeodézia Tanszék

*Előadó: Hrutka Bence Péter*

**2023.06.09.**

# TARTALOM

- CloudCompare
- Elérhető funkciók
- Alkalmazások
- Programozás



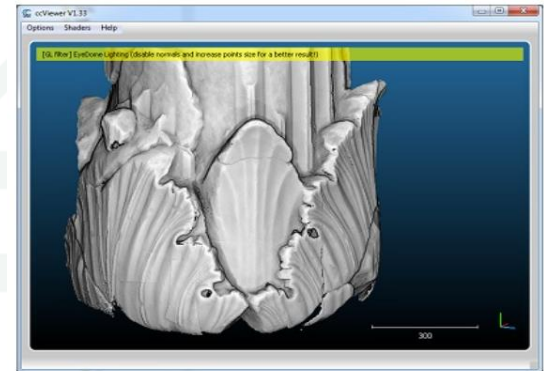
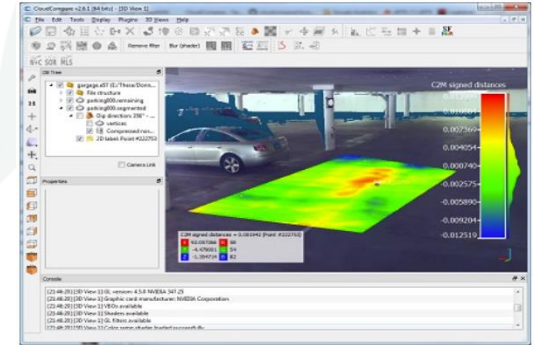
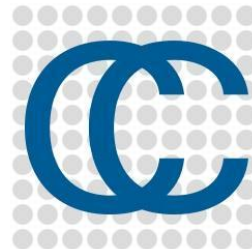
# CLOUDCOMPARE



## CloudCompare

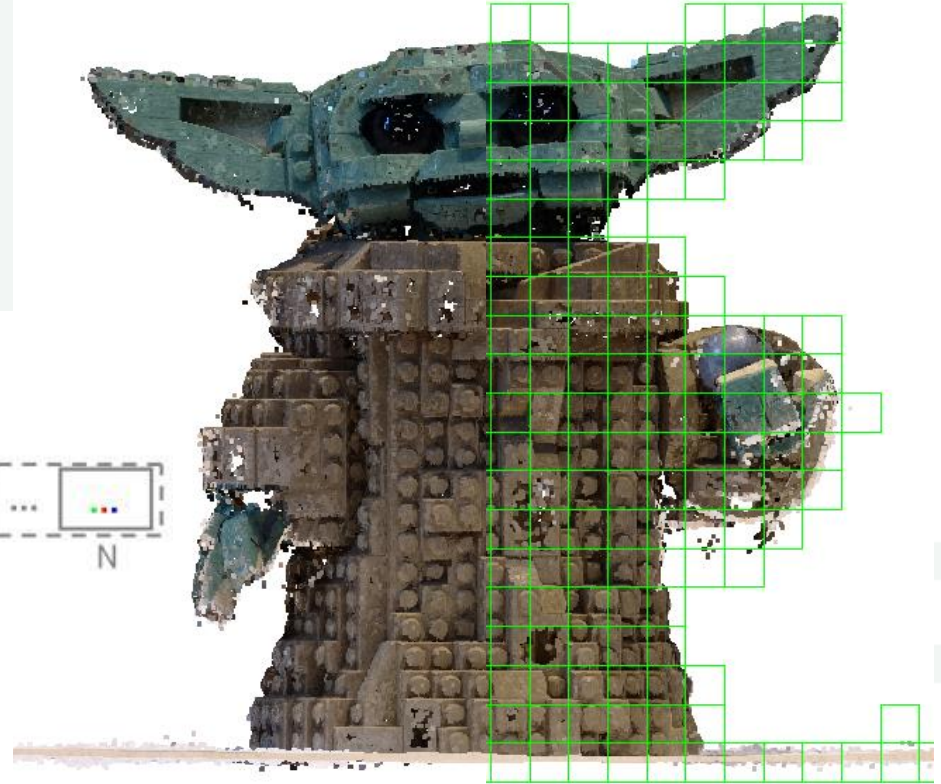
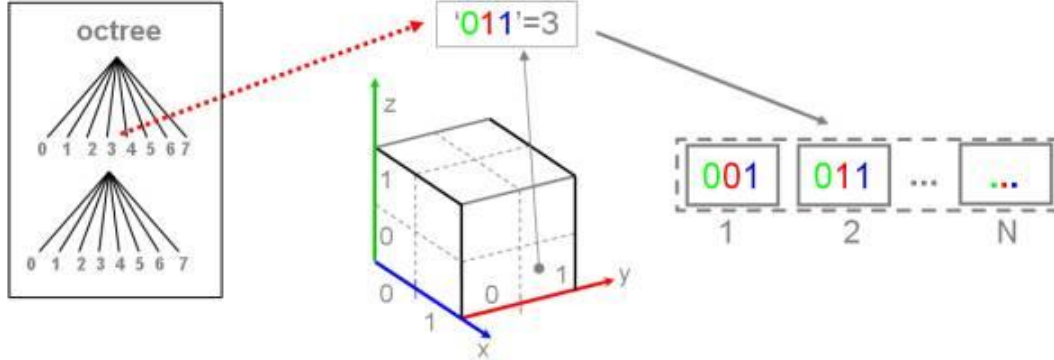
3D point cloud and mesh processing software  
Open Source Project

- C++
- 2003 óta fejlesztik
- Pontfelhő (+ háromszögháló) feldolgozás
- Eredetileg pontfelhők összehasonlítása
- Nyolcasfa (Octree) alapú



# NYOLCASFA STRUKTÚRA (OCTREE-BASED)

- Térbeli indexelés
- Alapja: a kocka
- Felosztás további kockákra



# TÁMOGATOTT FORMÁTUMOK

- Nyílt formátumok
- BIN (saját)
- Pontfelhő
  - *ASCII*
  - *LAS*
  - *E57*
  - *PLY*
  - *Stb.*

Type	Extension(s)	Description	Read	Write	Binary/ASCII	Point Cloud(s)	Mesh(es)	Other	Features
BIN	.bin	CloudCompare own format	X	X	binary	>1	>1	>1	Normals Colors (RGB) Scalar fields (>1) + Labels, viewports, display options, etc.
ASCII	.asc .txt .xyz .neu .pts	ASCII point cloud file (X,Y,Z,etc.)	X	X	ASCII	1			Normals Colors (RGB) Scalar fields (>1)
LAS	.las	ASPRS <sup>7</sup> lidar point clouds	X	X	binary	1			Colors (RGB) Various scalar fields (see LAS 1.4 specifications)
E57	.e57	ASTM E57 <sup>8</sup> file format	X	X	mixed	>1		Calibrated picture(s)	Normals Colors (RGB or I) Scalar field ( <i>intensity</i> )
PTX	.ptx	<a href="#">LEICA</a> point cloud export format	X		ascii	>1		Sensor(s)	<i>Robust normals can be computed at loading time</i>
FARO	.fls .fws	<a href="#">FARO</a> formats	X		binary	>1		Sensor(s)	Scalar field (reflection value)
DP	.dp	<a href="#">DotProduct</a> DPI-7 format	X		binary	>1		Sensor(s)	Colors (RGB) <i>Robust normals can be computed at loading time</i>
PCD	.pcd	<a href="#">Point Cloud Library</a> format	X	X	binary	>1			Colors (RGB) Normals Scalar fields (>1)

# TÁMOGATOTT FORMÁTUMOK

- Mesh
  - *PLY*
  - *OBJ*
  - *STL*
  - *Stb.*

PLY	.ply	Stanford 3D geometry format <sup>9</sup> (cloud or mesh)	X	X	both	1	1		Normals Colors (RGB or I) Scalar fields (all) Single texture
OBJ	.obj	Wavefront <sup>10</sup> mesh	X	X	ASCII	1	>1	Polyline(s)	Normals Materials and textures
VTK	.vtk	<a href="#">VTK</a> file format (triangular mesh or cloud only)	X	X	ASCII	1	1		Normals Colors (RGB) Scalar fields (>1)
STL	.stl	STereoLithography <sup>11</sup> file format (mesh)	X	X	ASCII		1		Normals
OFF	.off	Object File Format <sup>12</sup> (mesh)	X	X	ASCII		1		

# TÁMOGATOTT FORMÁTUMOK

- Vonal, vonallánc

- *DXF*

- *SHP*

- Kép

- *GeoTIFF*







- *JPG*





- *PNG*

- *Stb.*

FBX	.fbx	Autodesk (Filmbox) File format <sup>13</sup>	X	X	ASCII or binary	>1	>1		Normals Colors (RGB) Materials and texture
DXF	.dxf	Autocad DXF format <sup>14</sup>	X	X	ASCII	>1	>1	Polyline(s)	Normals Colors (RGB)
SHP	.shp	ESRI Shape file format <sup>15</sup>	X	X	binary	>1		Polyline(s) polygon(s) Contour plot(s) etc.	Scalar fields (1 per entity)
PDMS	.pdms .pdmsmac .mac	PDMS macros	X		ASCII		>1	Primitive(s)	
RASTER	.geotiff, etc.	Common raster formats (GDAL) <sup>16</sup>	X	X <sup>17</sup>	binary	1			Layers (as scalar fields)
OUT (Bundler)	.out	Bundler SfM output file <sup>18</sup>	X		ASCII	(1)		Calibrated picture(s) 3D keypoints	
2D images	.jpg *.png *.bmp etc.	Standard images			binary				








# FUNKCIÓK























Colors	▶
Normals	▶
Octree	▶
Grid	▶
Cloud	▶
Mesh	▶
Polyline	▶
Plane	▶
Sensors	▶
Scalar fields	▶
Waveform	▶
 Clone	
 Merge	
 Subsample	
Apply transformation	Ctrl+T
Multiply/Scale	
 Translate/Rotate	
 Segment	T
Crop	
Edit global shift and scale	
Toggle (recursive)	▶
 Delete	Del

Clean	▶
Projection	▶
Registration	▶
Distances	▶
Volume	▶
Statistics	▶
Segmentation	▶
Fit	▶
Batch export	▶
Other	▶
 Level	
 Point picking	
 Point list picking	
 Trace Polyline	Ctrl+P
Sand box (research)	▶

CloudCompare v2.12.4 (Kyiv) [64-bit] - [3D View 1]

File Edit Tools Display Plugins 3D Views Help

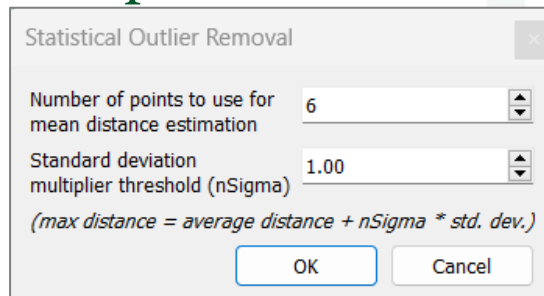
 Full screen	F9
 Full screen (3D view)	F11
 Refresh	F5
 Toggle Centered Perspective	F3
 Toggle Viewer Based Perspective	F4
Show cursor coordinates	
Lock rotation about an axis	L
Enter bubble-view mode	B
Camera link	
Render to File	
Display settings	
Camera settings	
Save viewport as object	Ctrl+V
Adjust zoom	
Test Frame Rate	
 Lights	▶
Shaders & Filters	▶
Active scalar field	▶
 Console	F8
Toolbars	▶
Language Translation	▶
Reset all GUI element positions	
Reset all VBOs	

 Animation	
 CEA Virtual Broom	
 CANUPO	▶
 Compass	
 Cork	
CSF Filter	
 Facet/fracture detection	▶
 Hough Normals Computation	
 Hidden Point Removal	
 M3C2 Distance	
 Mesh Boolean	
 PCL wrapper	▶
 PCV / ShadeVis	
 PoissonRecon	
 RANSAC Shape Detection	
 Surface of Revolution Analysis	▶
 AutoSeg	
 Cloud layers	
 Colorimetric Segmenter	▶
 Ellipse marking	
 Json RPC (Standard Plugin)	
 ManualSeg	
 MPlane	

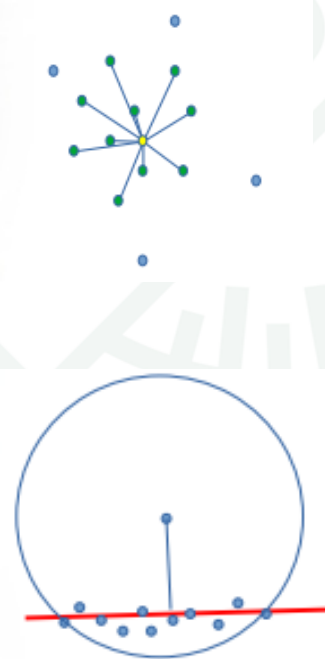
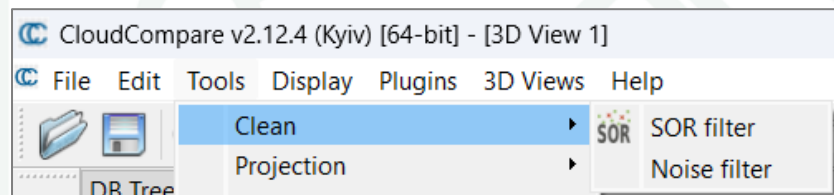
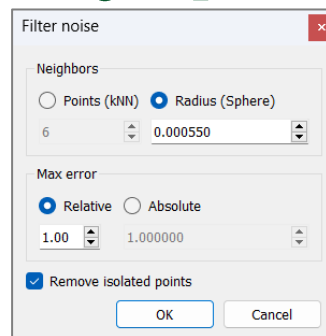


# ZAJSZŰRÉS

- Statisztikai alapú (SOR)



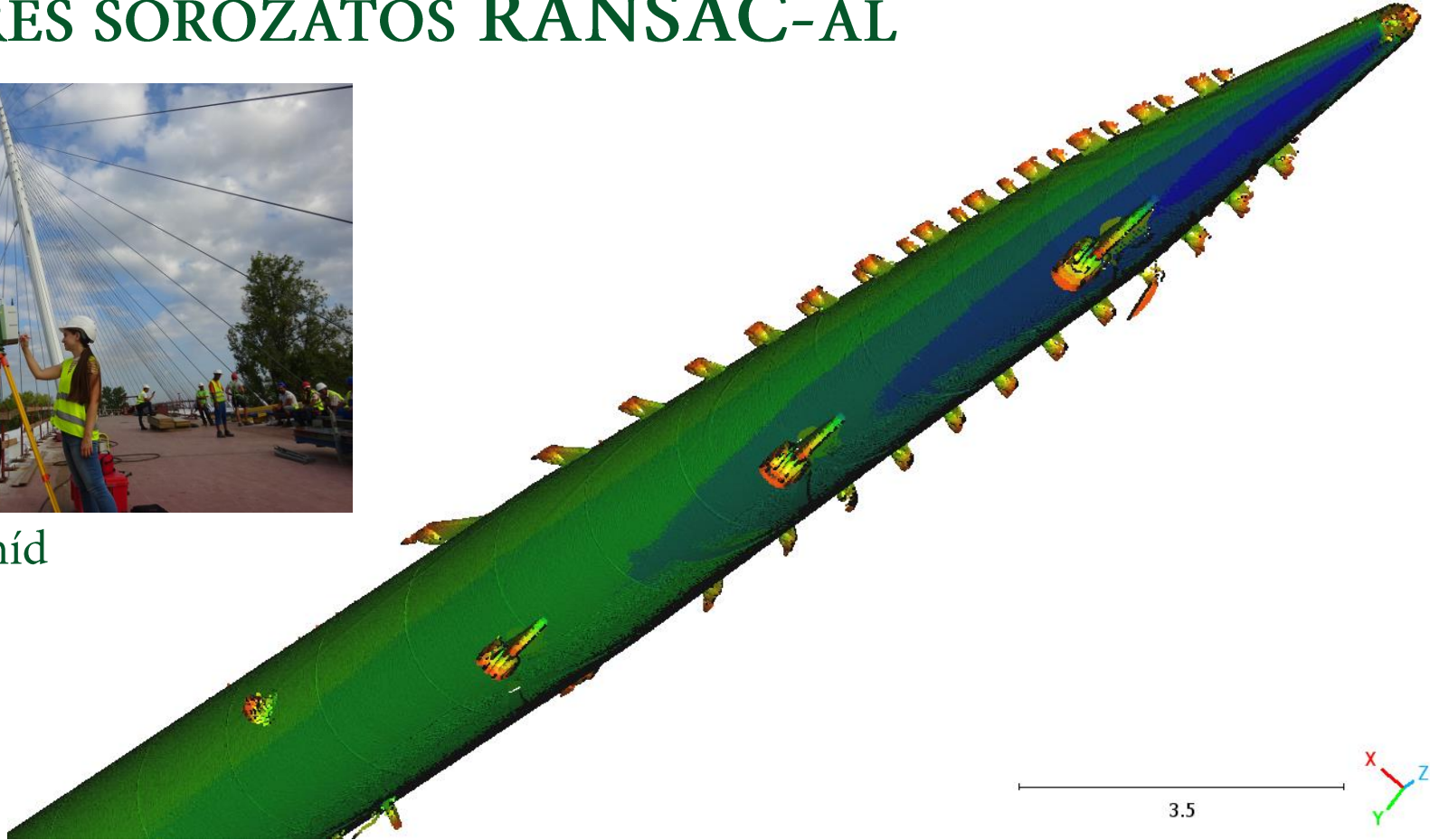
- Környezetből kiugró pontok



# SZŰRÉS SOROZATOS RANSAC-AL



Robinson híd

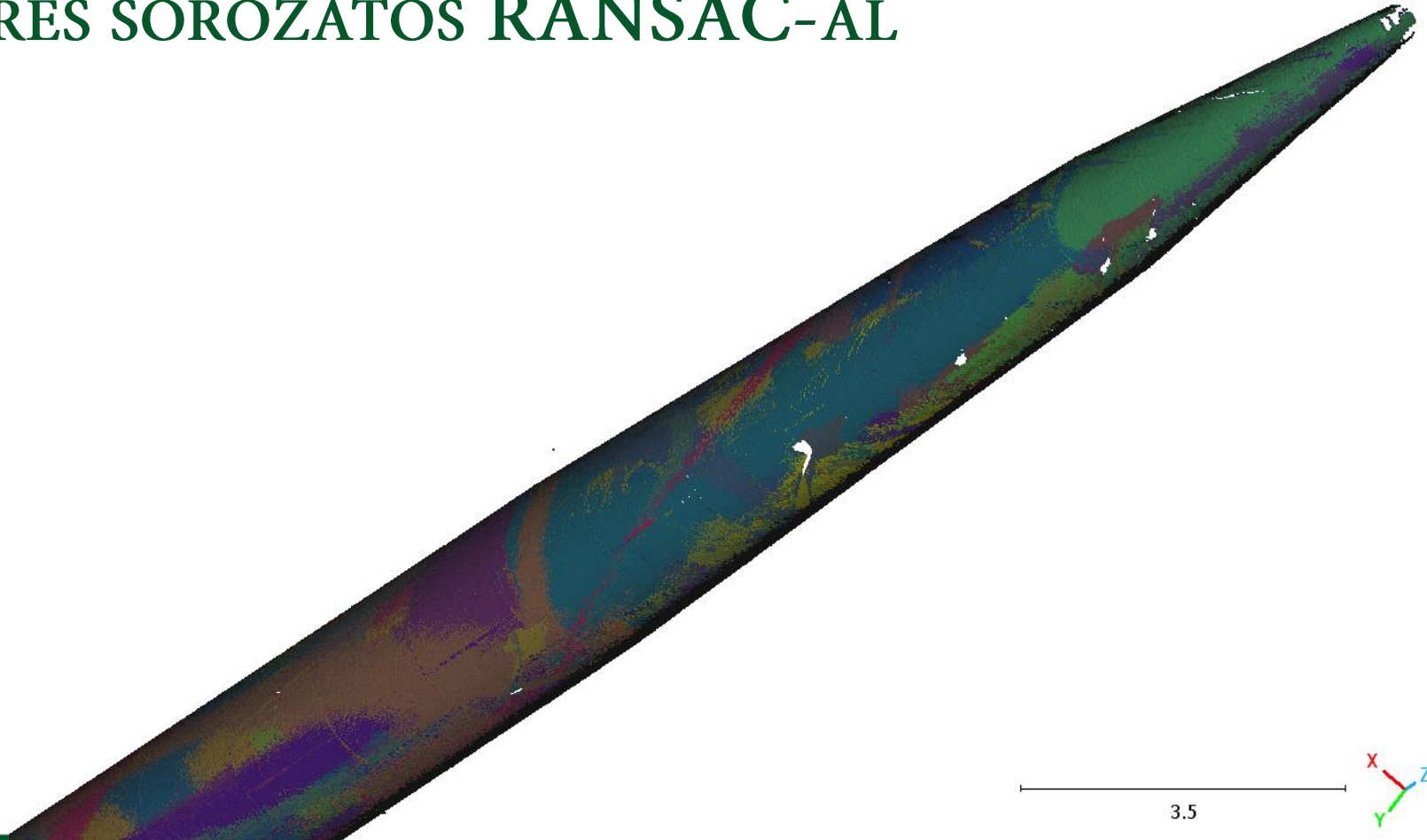


# SZŰRÉS SOROZATOS RANSAC-AL

- Geometriai alakzatok keresése (sík, gömb, henger stb.)
- RANSAC Shape Detection (plugin)



# SZŰRÉS SOROZATOS RANSAC-AL



# ÚJ RAMINTAVÉTELEZÉS

- Random
  - *Mennyi pont maradjon?*
- Távolság
  - *Min. pont távolság?*
- Nyolcasfa
  - *Milyen nyolcasfa szintig?*

Cloud sub sampling

Sampling parameters

method Space

large

min. space between points 0.0000

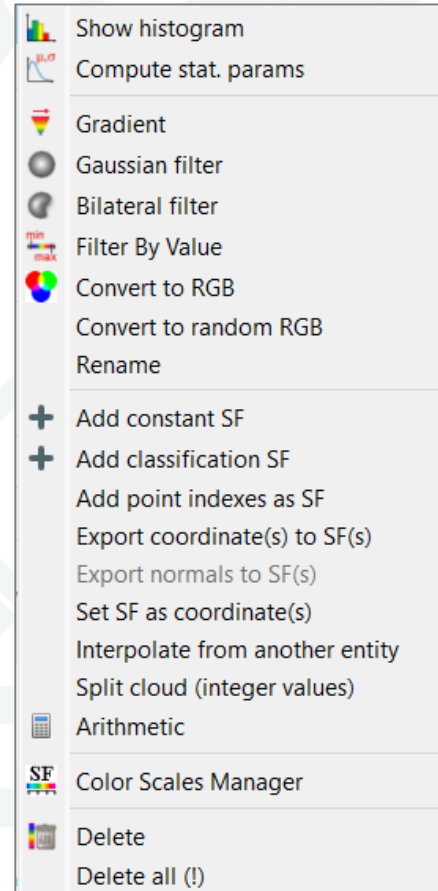
☐ Use active SF

SF value	Spacing value
min 1	0.000000
max 1	0.477730

OK Cancel

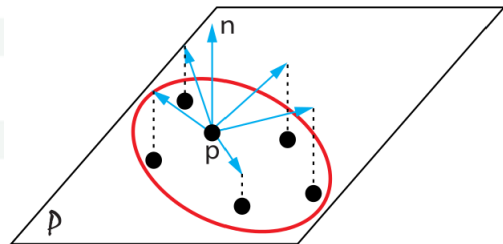
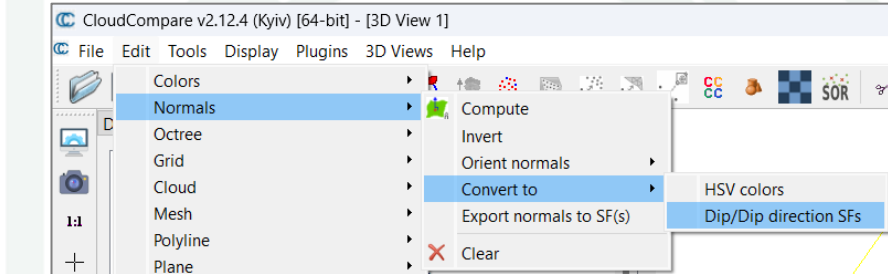
# SKALÁRMEZŐ

- Pont(ok)hoz rendelhető érték
- Egyszerre több is lehet
- Különböző műveletek



# SKALÁRMEZŐ ÉRTÉKEK

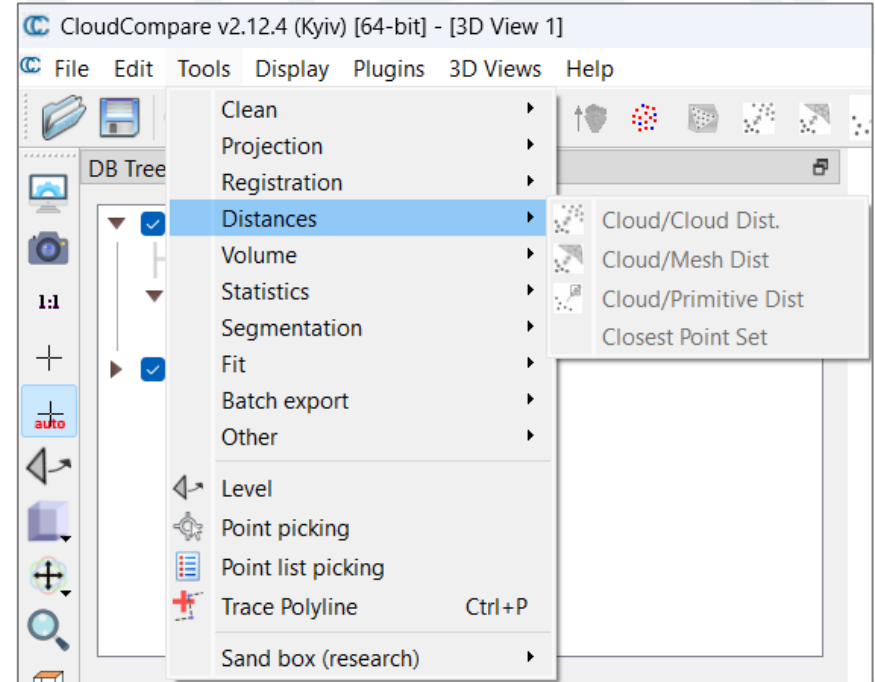
- Normálisok





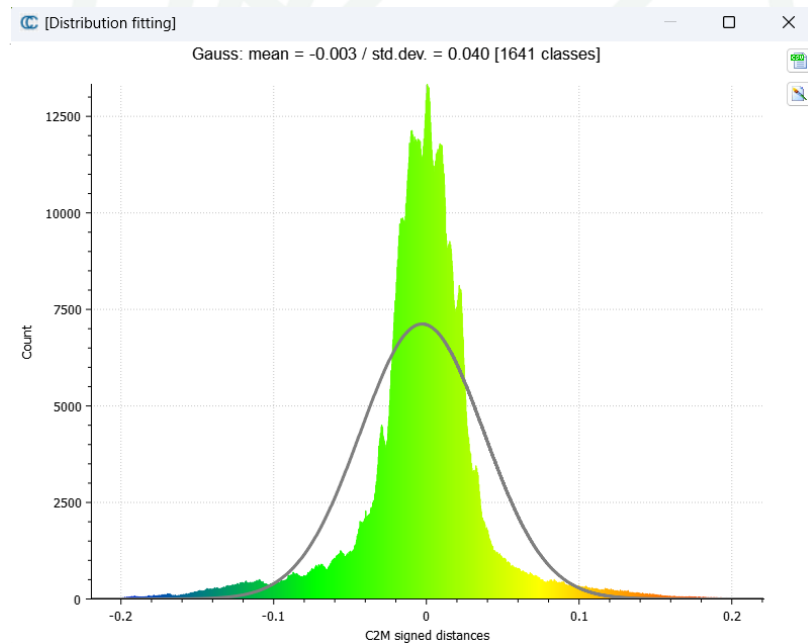
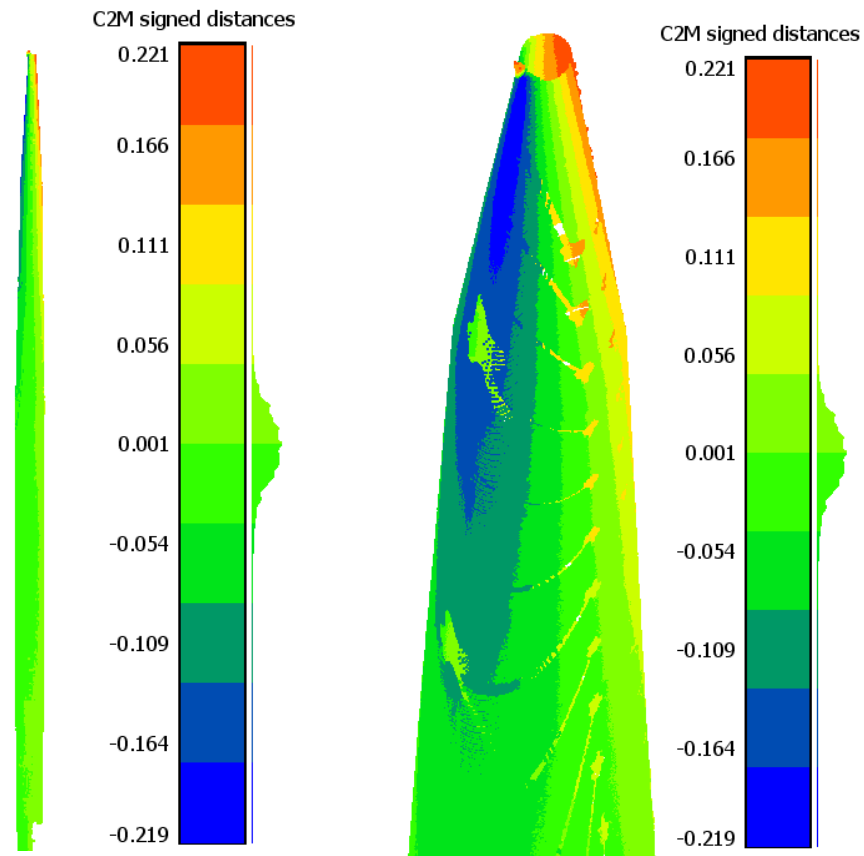
# SKALÁRMEZŐ ÉRTÉKEK

- Távolság
  - *Pontfelhő-pontfelhő*
  - *Pontfelhő-felület*

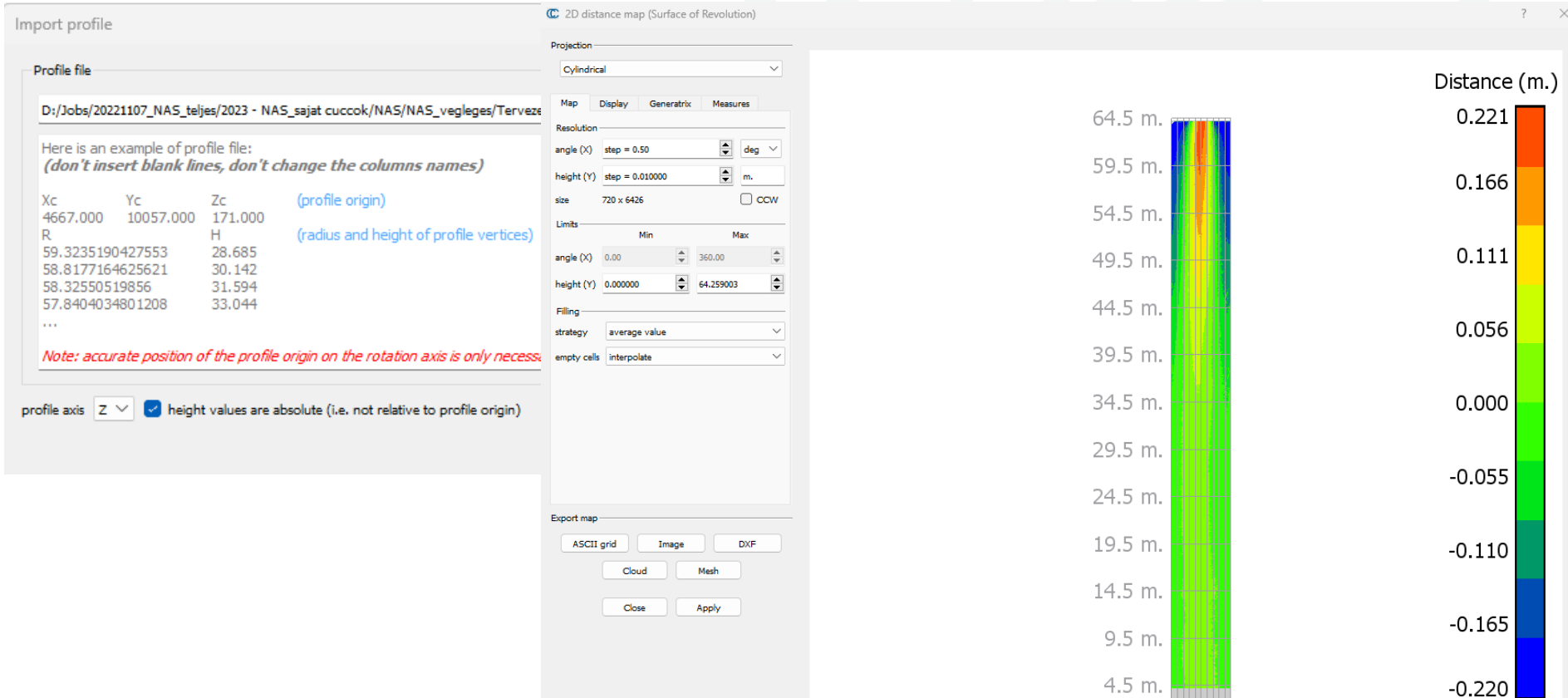




# PONTFELHŐ-FELÜLET TÁVOLSÁG



# SURFACE OF REVOLUTION ANALYSIS (PLUGIN)



# SURFACE OF REVOLUTION ANALYSIS (PLUGIN)

2D distance map (Surface of Revolution)

Projection: Cylindrical

Map Display Generatrix Measures

Resolution

angle (X) step = 0.50 deg

height (Y) step = 0.010000 m

size 720 x 6426 ☐ CCW

Limits

	Min	Max
angle (X)	0.00	360.00
height (Y)	0.000000	64.259003

Filling

strategy average value

empty cells interpolate

Export map

ASCII grid Image DXF

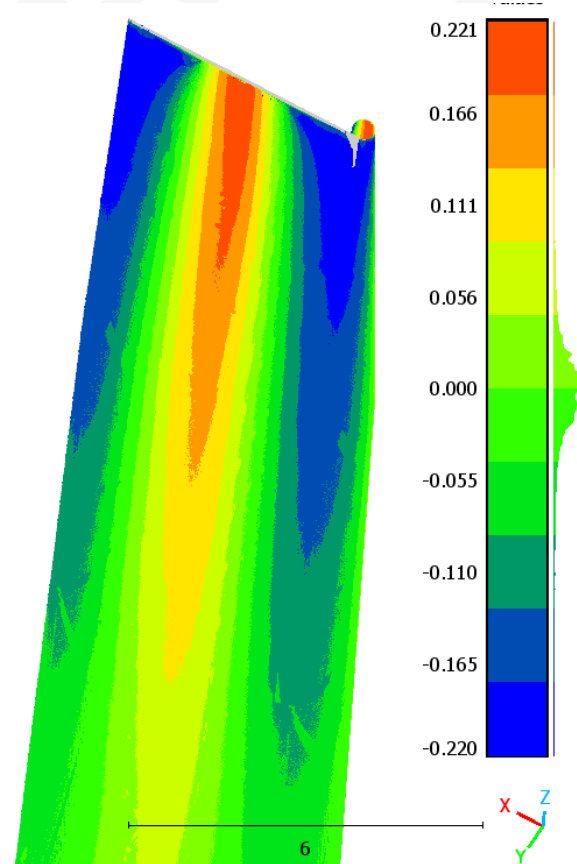
Cloud Mesh

Close Apply

64.5 m.  
59.5 m.  
54.5 m.  
49.5 m.  
44.5 m.  
39.5 m.  
34.5 m.  
29.5 m.  
24.5 m.  
19.5 m.  
14.5 m.  
9.5 m.  
4.5 m.

Distance (m.)

0.221  
0.166  
0.111  
0.056  
0.000  
-0.055  
-0.110  
-0.165  
-0.220



# SKALÁRMEZŐ

- Geometriai jellemzők
  - *Pontsűrűség*
  - *Görbület*
  - *Szomszédos pontok száma*
- Spektrális jellemzők
  - *RGB*
  - *Intenzitás*
- Sajátértékeken alapuló jellemzők

Geometric features

Local neighborhood radius 0.050000

**Roughness**

☐ Roughness

☐ Up direction

X=0.00 Y=0.00 Z=1.00

**Curvature**

☐ Mean

☐ Gaussian

☐ Normal change rate

**Density**

☐ Number of neighbors

☐ Surface density

☐ Volume density

**Moment**

☐ 1st order moment

**Features**

☐ Sum of eigenvalues

☐ Ominvariance

☐ Eigenentropy

☐ Anisotropy

☐ Planarity

☐ Linearity

☐ PCA1

☐ PCA2

☐ Surface variation

☐ Sphericity

☐ Verticality

☐ 1st eigenvalue

☐ 2nd eigenvalue

☐ 3rd eigenvalue

# SAJÁTÉRTÉKEKEN ALAPULÓ JELLEMZŐK

- „R” sugarú gömbbe eső pontok
  - $R = 0.5 \text{ m}$
- Kovariancia mtx.
- Sajátértékek
  - $\lambda_1 \geq \lambda_2 \geq \lambda_3$  a sajátértékek csökkenő sorrendben
  - Síklapúság (planarity) alapján szűrés
    - $p = \frac{(\lambda_2 - \lambda_3)}{\lambda_1}$

Forrás: Feng et al. 2018.



# BEMENŐ PONTFELHŐ



50



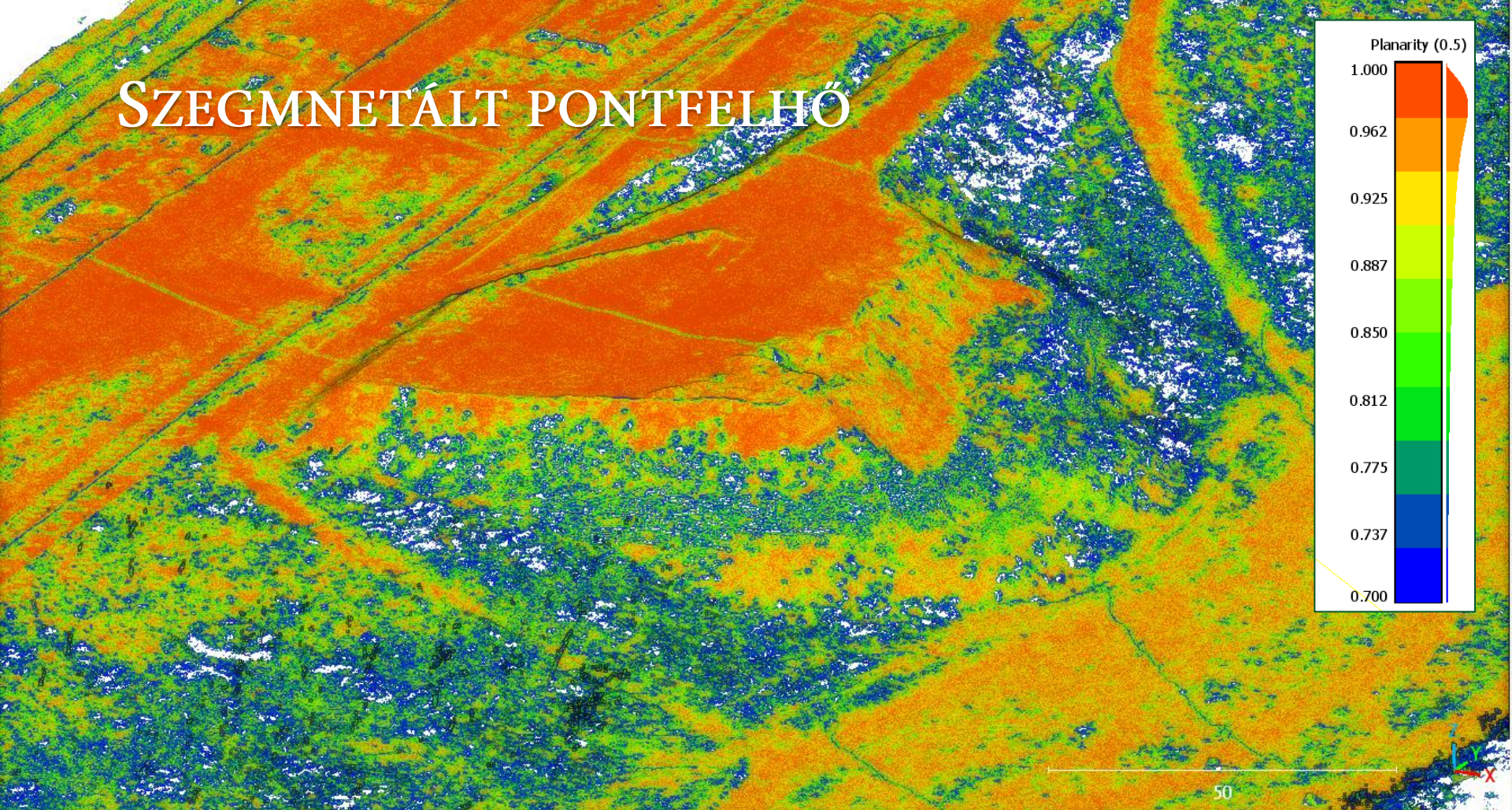


# HAMISSZÍNES PONTFELHŐ





# SZEGMNETÁLT PONTFELHŐ

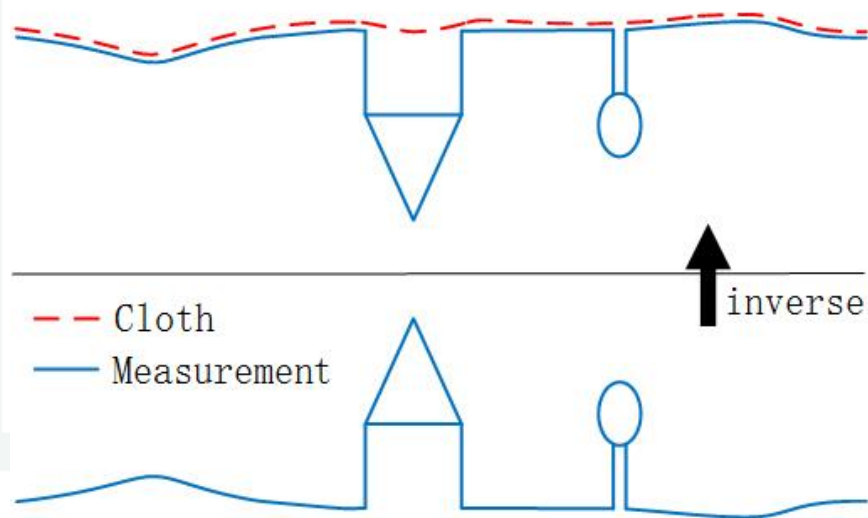
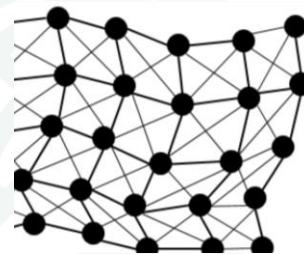




# TALAJ, NEM-TALAJ OSZTÁLYOZÁS

- Cloth Simulation Filtering (CSF)

- *plugin*
- *Pontfelhő invertálás*
- „lepedő” ejtése
  - GRID definiálja
  - Felbontás
- *Felület-pontfelhő távolság*
  - Iteráció, küszöbérték
  - Talaj pontok
  - Nem-talaj pontok



# TALAJPONTOK



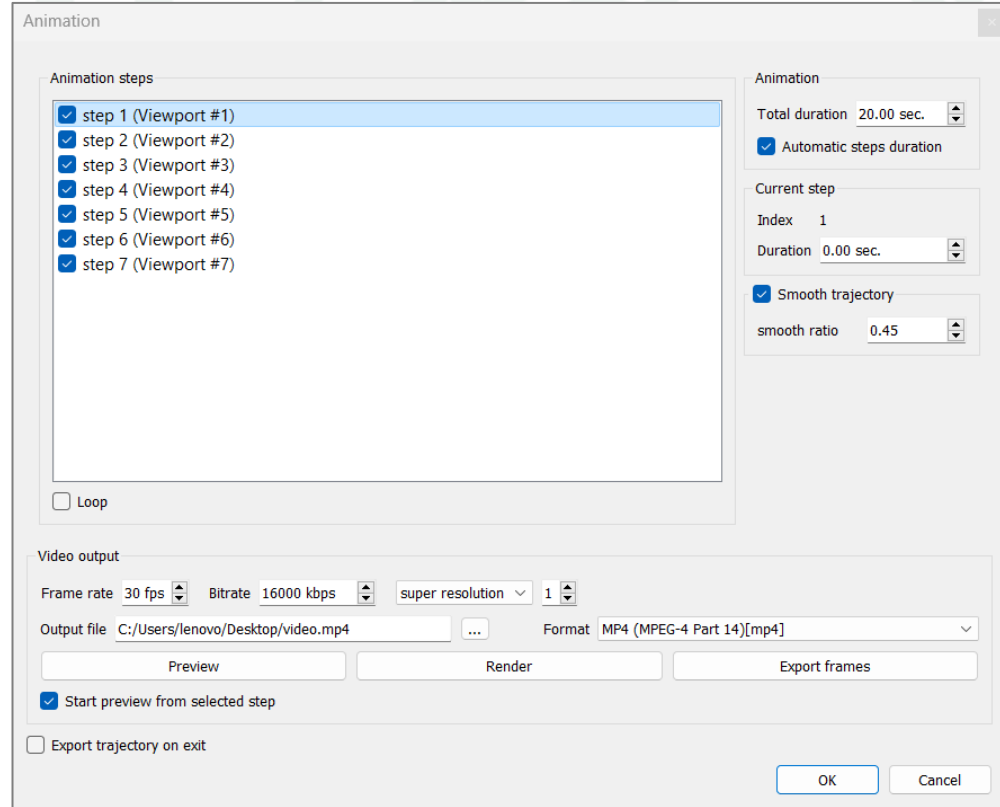


# TALAJPONTOKRA ILLESZTETT POLIGONHÁLÓ (MESH)



# ANIMÁCIÓ KÉSZÍTÉS

- Animation plugin
- Viewport
  - *Display* → *Save viewport*
  - *CTRL+ V*
- Blender







# PARANCSSOR

- Dokumentáció
- Példák
- `CloudCompare -O myhugecloud.bin -SS SPATIAL 0.1`
- `CloudCompare -SILENT -AUTO_SAVE OFF -O lidar.txt -C_EXPORT_FMT ASC -PREC 3 -Crop 548025.89:5128996.49:1099:550424.10:512929 3.08:1101 -SAVE_CLOUDS FILE lidar_hz_section.asc`

# PARANCSSOR + PYTHON



- pyCloudCompare modul
  - *pip install pyCloudCompareCLI*

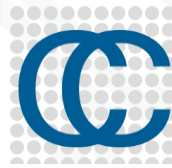
```
import pyCloudCompare as cc
cli = cc.CloudCompareCLI()
cmd = cli.new_command()
cmd.silent() # Disable console
cmd.open("pointcloud.ply") # Read file
cmd.cloud_export_format(cc.CLOUD_EXPORT_FORMAT.ASCII, extension="xyz")
cmd.save_clouds("newPointcloud.xyz")
print(cmd)
cmd.execute()
```

# PYTHON



## CloudCompare

3D point cloud and mesh processing software  
Open Source Project



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## [New] Python wrappers for CloudCompare



Thanks to our great contributors, CloudCompare offers now several options to be used with Python in a more integrated way (more than the command line ;)

Mind that these 2 projects are still work in progress. Constructive feedback is welcome: **please declare bugs or ask questions on their respective github pages.**

**CloudCompy**, by Paul Rasclé

This project allows one to load clouds and access their internal data as numpy arrays, call some of CloudCompare's algorithms, apply your own processes, and save the result.

- the reference documentation can be found [here](#)
- the latest available Windows binary can be found [here](#)
- you'll also find in the [readme.md](#) file most of the directions to build it on Linux and Windows, as well as an example of how it can be used

The tests are good examples of how it can be used (click to expand)



**CloudCompare Python Plugin** by Thomas Montaigu







KÖSZÖNÖM A FIGYELMET!