

#### CloudCompare Journée d'étude Big Data et données spatialisées





www.cloudcompare.org

@CloudCompareGPL



daniel.girardeau@gmail.com

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# The CloudCompare project



### 2003: PhD for EDF R&D

edf R®D

#### o EDF

- Main French power utility
- More than 165 000 employees worldwide 2 000 @ R&D (< 2%)</li>

200 know about CloudCompare (< 0.2%)

- Sales >69 B€
- > 400 dams + 56 nuclear reactors (19 plants)





# EDF and Laser Scanning

- EDF = former owner of Mensi (*now Trimble Laser Scanning*)
- Main scanning activity: *as-built* documentation



Scanning a single nuclear reactor building

- 2002: 3 days, 50 M. points
- 2014: 1.5 days, **50 Bn** points (+ high res. photos)



# EDF and Laser Scanning

- Other scanning activities:
  - Building monitoring (dams, cooling towers, etc.)
  - Landslide monitoring
  - Hydrology
  - Historical preservation (EDF Foundation)











#### o Change detection on 3D geometric data

- Application to Emergency Mapping
- Inspired by 9/11 post-attacks recovery efforts (see "Mapping Ground Zero" by J. Kern, Optech, Nov. 2001)



TLS was used for: visualization, optimal crane placement, measurements, monitoring the subsidence of the wreckage pile, slurry wall monitoring, etc.



**edf** 

**R®D** 

### CloudCompare V1

- o 2004-2006
- Aim: quickly detecting changes by comparing TLS point clouds...
  - with a CAD mesh
  - or with another (high density) cloud





# CloudCompare V2

- 2007: "Industrialization" of CloudCompare ... for internal use only!
- o Rationale:
  - idle reactor = 6 M€ / day
  - acquired data can be checked on-site → less missing or erroneous data → no need to come back later
  - checking the work of sub-contractors in charge of modeling became fast and accurate
  - the algorithms are also used for clash detection during virtual simulation of tricky maintenance operations → highly reduces the risk of issues or *bad surprises* during the actual maintenance operation

+ EDF is not a software company



#### The open-source path

- o 2009/2010: CloudCompare V2.1
  - Already a multi-purpose point cloud editing and processing software
- 2017: CloudCompare V2.8
- 2019: CloudCompare V2.11
- 2023: CloudCompare V2.13



Runs on: Windows Linux macOS (*sometimes*)

Support for 3D mouse & stereo displays



### **Open Source!**

- o Evolves quickly...
- ... in the direction users want (faster if users actively participate to the developments ☺)
- Remains under close supervision of its administrator
- Manufacturer independent
- Supported by various companies and public institutions (EDF, BRGM, CNRS, etc.)





o Free...



o ...however, someone still needs to pay ;)

- either by developping new functionnalities
- or by paying someone else to do it

o Plugins are not necessarily open source or free



Users

#### o Too many 😋 Academics: remote sensing geology archeology • etc. Surveyors none Forensic experts 1 Architects none MDs, dentists – none

- 3D designers none
- Artist?! none

o Barely enough 😂

Developers

a few PhD students and research engineers



### **SW** development cycle







#### Worldwide (6 months view)



Pays ?		Acquisition
		Utilisateurs ? 🗸
		<b>145957</b> % du total: 100,00 % (145957)
1.	China China	<b>22709</b> (15,42 %)
2.	United States	16792 (11,40 %)
3.	o] Japan	14101 (9,58%)
4.	📕 Italy	<b>10790</b> (7,33%)
5.	Germany	8019 (5,45%)
6.	France	<b>6142</b> (4,17%)
7.	📳 United Kingdom	<b>5056</b> (3,43%)
8.	Spain	4 444 (3,02 %)
9.	📲 Canada	3827 (2,60 %)
10.	🐑 South Korea	<b>3 474</b> (2,36 %)

> 108k downloads in 6 months (Windows version)> 5000 users registered to the newsletter



#### Citations in scientific articles



source: Google scholar

#### Quick overview



#### **(**, Interface



v

[18:34:29] [I/O] File 'E:/These/Donnees/3DArch2017/chambord.bin' saved successfully



#### Inputs / outputs

- o point clouds 🗆
  - ASCII, PLY, LAS, E57, PTX, PCD... + Faro, Riegl, DotProduct
- o triangular meshes 🚸
  - OBJ, PLY, STL, OFF, FBX
- o polylines 🞋
  - SHP, DXF, etc.
- o rasters 🔛
  - geotiff, etc. (*thanks to GDAL*)
- o calibrated pictures 🔊
  - Bundler OUT, Photoscan PSZ
- o sensors
- + dedicated format: BIN (for projects)



**NVIDIA** 

100M-500M

high-range

L.O.D. mechanism

Intel GRAPHICS

(intel

> 500 M. points?

- for now, use the command line mode 😉
- later: *out-of-core* support?



#### Scalar fields

- One value per point
- The value can be anything (distance, intensity, density, roughness, confidence, curvature, temperature, time, etc.)
- o Values can be (dynamically) color-coded

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#### Scalar fields

- o Values can be
  - mixed (+,-,/,x)
  - transformed (cos, log, etc.)
  - filtered (spatial smoothing, spatial gradient, etc.)
  - imported or exported as a coordinate dimension
  - merged with colors
  - transferred to another entity (+ interpolated)
- Statistics can be computed
- Clouds can be processed based on those values
  - Segmentation ("*Filter by value*")
  - Subsampling



#### Main features

- o Interactive tools
  - transformation, segmentation, cross section
- o Colors
  - create, convert, level, etc.
- o Normals
  - create, convert, orient





#### Main features

- o Mesh operations
  - create (2.5D Delaunay), sample points, smooth, etc.
  - $\rightarrow$  see Meshlab for more
- o Scalar fields operations
  - filter points by value, convert, smooth, gradient, etc.
- Point picking,
   Distance / angle measurements
- o Others
  - Subsample, merge, scale, etc.





#### Main tools

- o Registration
  - point-pair-based alignment, ICP
- o Distances
  - Cloud-to-cloud (C2C), Cloud-to-mesh (C2M), Cloud-toprimitive (C2P), Robust cloud-to-cloud (M3C2)





#### Main tools

- o Cleaning
  - SOR, etc.
- o Rasterize
  - + contour plot
- o 2.5D volume estimation





#### Main tools

- o Segmentation
  - connected components, profile extraction, etc.
- o Fitting
  - plane, sphere, quadric, etc.







• Roughness, curvature, density and other geometric features computation

Geometric features	< Comparison of the second sec	
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Features: "Contour detection in unstructured 3D point clouds", Hackel et al, 2016

#### Advanced LIDAR point cloud processing



## Built-in support

- o Octree structure (fast construction, fast kNN)
- Sensors (TLS or Camera)
- Scan grids (structured point clouds)
- o Full waveform



- o Plugins
- Command line mode





- Robust + signed C2C distances
  - Search correspondances along surface normal
  - Multi-scale approach
  - Uncertainty estimation based on local surface roughness





- Point cloud classification
  - Multi-scale local dimensionality feature
  - SVM based training



"3D Terrestrial lidar data classification of complex natural scenes using a multi-scale dimensionality criterion: applications in geomorphology", N. Brodu, D. Lague, 2012





- o Advanced point cloud classification
  - https://lidar.univ-rennes.fr/en/3dmasc
  - Multiple Attributes, Scales and Clouds
  - Designed to classify bi-temporal or bi-spectral surveys
  - Fully configurable (mix any number of scalar fields, geometric features, colors, etc.)



- intermediate vegetation (Ain) (high) vegetation vegetated ground

surf zone (Fréhel) water underwater sand underwater rock (Fréhel)

ground rock (Fréhel) pebble (Fréhel) buildings artificial ground power lines vehicles

3DMASC: Accessible, explainable 3D point clouds classification. Application to Bi-Spectral Topo-Bathymetric lidar data, M. Letard et al, 2023



# Cloth Simulation Filter (CSF)

o Ground points extraction from LiDAR point clouds



"An Easy-to-Use Airborne LiDAR Data Filtering Method Based on Cloth Simulation", W. Zhang et al., 2016



#### Cloud Layers

- o Manual (re)labelling of point clouds
- o Works with any scalar field
- (developed in Ukraine )





### Other plugins



- o Automatic shape detection (Ransac Shape Detection)
- Structural geology toolbox for the interpretation and analysis of virtual outcrop models (Compass)
- Geological facet extraction (Facets)
- o Global illumination of clouds and meshes (PCV)
- o 3D surface reconstruction (PoissonRecon)
- Animation rendering (Animation)
- o Surface of Revolution Analysis (SRA)
- Planar surfaces cleaning (Virtual Broom)
- Hidden Points Removal (HPR)
- o etc.



# Creating your own plugin...

- o ... is easy:
  - copy the 'dummy' plugin folder
  - replace the word 'dummy' in all files by your plugin name
  - and add the code for your plugin 'action' at the right place
- Plenty of examples
  - simply mimic another plugin that has the same workflow
- Ask questions on the forum (*or send me an email*)
- Development in C++ with Qt



#### Next steps

- o CloudCompare V2.13 (about to be released)
- o Long term
  - Out-of-core support?

#### • And always the ever-growing TODO list...

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#### Thanks for your attention!



CloudCompare

3D point cloud and mesh processing software Open Source Project



Home - Presentation - Download - Github - Tutorials - Documentation - Forum - Declare a bug

Welcome to the official website of the CloudCompare project.

This is a Free project. Just as people and countries should be and remain.



CloudCompare (view, edit and process)

ccViewer (light viewer only)

Download the "CloudCompare 2020 Developers course" material here

Download the short course presentations of the Virtual Geoscience Conference 2021 (*in English*) here CloudCompare home - cloudcompare.org - EDF R&D - contact

