Outline

- About the project
- Quick overview of the software capabilities
- Point cloud processing with CloudCompare
The project
2003: PhD for EDF R&D

- EDF
  - Main French power utility
  - More than 150,000 employees worldwide
    - 2,000 @ R&D (< 2%)
    - 200 know about CloudCompare (< 0.2%)
  - Sales >75 B€
  - > 200 dams + 58 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)
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.
CloudCompare V1

- 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!

- 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

- 2009/2010: CloudCompare V2.1
  - Already a multi-purpose point cloud editing and processing software

- 2017: CloudCompare V2.8

- 2019: CloudCompare V2.11

Runs on:
- Windows (XP / 7 / 8 / 10)
- Mac OS (Andy Maloney)
- Linux (Romain Janvier)

Support for 3D mouse & stereo displays
Open Source!

- 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.)
Open Source!

- Free...

- ...however, someone still needs to pay ;)
  - either by developing new functionalities
  - or by paying someone else to do it

- Plugins are not necessarily open source or free
Users

- Too many 😊
  - Academics:
    - remote sensing
    - geology
    - archeology
    - etc.
  - Surveyors
  - Forensic experts
  - Architects
  - MDs, dentists
  - 3D designers
  - Artist?! 😅

Developers

- Barely enough 😁
  - a few PhD students and research engineers
  - none
  - 1
  - none
  - none
  - none
  - none
CloudCompare Event 2020

Event Timing: March 11-13, 2020

Developers training course: March 11-12 (20 ⬃) FULL!
Users workshop: March 13 (100 ⬃)

Event information and registration

REGISTER NOW ➤  FREE
Worldwide

Sessions (November)

> 3300 users registered to the newsletter
Citations in scientific articles

source: Google scholar
Quick overview
Interface
Inputs / outputs

- point clouds
  - ASCII, PLY, LAS, E57, PTX, PCD… + Faro, Riegl, DotProduct
- triangular meshes
  - OBJ, PLY, STL, OFF, FBX
- polylines
  - SHP, DXF, etc.
- rasters
  - geotiff, etc. (thanks to GDAL)
- calibrated pictures
  - Bundler OUT, Photoscan PSZ
- sensors
  - TLS or projective cameras

+ dedicated format: BIN (for projects)
Display capabilities

- 0-20M points
- 20M-100M: mid-range
- 100M-500M: high-range

> 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.)

- Values can be (dynamically) color-coded
Scalar fields

- 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

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

- **Mesh operations**
  - create (2.5D Delaunay), sample points, smooth, etc.
  - → *see Meshlab for more*

- **Scalar fields operations**
  - filter points by value, convert, smooth, gradient, etc.

- **Point picking,**
  Distance / angle measurements

- **Others**
  - Subsample, merge, scale, etc.
Main tools

- Registration
  - point-pair-based alignment, ICP

- Distances
  - Cloud-to-cloud (C2C), Cloud-to-mesh (C2M), Cloud-to-primitive (C2P), Robust cloud-to-cloud (M3C2)
Main tools

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

- Segmentation
  - connected components, profile extraction, etc.

- Fitting
  - plane, sphere, quadric, etc.
Main tools

- Roughness, curvature, density and other geometric features computation

Features: "Contour detection in unstructured 3D point clouds", Hackel et al, 2016
Advanced point cloud processing
Built-in support

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

- Plugins
- Command line mode
M3C2

- Robust + signed C2C distances
  - Search correspondances along surface normal
  - Multi-scale approach
  - Uncertainty estimation based on local surface roughness
“3D uncertainty-based topographic change detection with SfM photogrammetry: precision maps for ground control and directly georeferenced surveys” by M. James et al.
Canupo

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

Cloth Simulation Filter (CSF)

- 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
Compass

- Structural geology toolbox for the interpretation and analysis of virtual outcrop models
  - Delineation of geological units
  - Measurement of orientations and thicknesses

- Tracing and automated path ‘following’

"Rapid, semi-automatic fracture and contact mapping for point clouds, images and geophysical data", S. Thiele et al., 2017
Other plugins

- Automatic shape detection (Ransac Shape Detection)
- Geological facet extraction (Facets)
- Global illumination of clouds and meshes (PCV)
- 3D surface reconstruction (PoissonRecon)
- Animation rendering (Animation)
- Surface of Revolution Analysis (SRA)
- Planar surfaces cleaning (Virtual Broom)
- Hidden Points Removal (HPR)
- etc.
Creating your own plugin...

- ... 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
Thanks for your attention!

CloudCompare
3D point cloud and mesh processing software
Open Source Project

Welcome to the official website of the CloudCompare project.
Want to know when a new release comes out? Subscribe to the newsletter

You can now follow us on twitter

CloudCompare 2020 Developers training & Workshop: March 11-13 2020
Visit the event page

CloudCompare (view, edit and process)  ccViewer (light viewer only)

www.cloudcompare.org