Workshop

- Interactive!

- Copy the sample files from the USB thumb drive:

  ![USB Thumb Drive Content]

  - You can install CloudCompare 2.6.1 with the Windows or Mac OS X 10.9+ installers ("binaries"). Otherwise go to:

    [www.cloudcompare.org](http://www.cloudcompare.org)
Outline

- About the project

- Generalities
  - Level 1: GUI, display, manual editing, etc.

- Advanced stuff
  - Level 2: registration, distances, scalar fields, etc.

- And everything else…
2003: PhD for EDF R&D

- EDF
  - main French power utility
  - Over 150,000 employees worldwide
    - 2,000 @ R&D (< 2%)
    - 200 know about CloudCompare (< 0.2%)
  - Sales >75 Bn € (90 Bn $)
  - Over 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

- Initial goals: to compare freshly (*and big*) acquired point clouds to quickly assess for changes
  - either between a cloud and a mesh/CAD
  - or directly between two clouds (*the high density of TLS clouds is the key*)
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

- Moreover 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

- 2014: CloudCompare V2.6

- Works on:
  - Windows (XP / 7 / 8)
  - Mac OS (thanks to Andy Maloney)
  - Linux (thanks to Romain Janvier)

- Supports 3D mice (Windows only)
Open-source!

- Quickly evolving

- Goes where the users want…
  … goes there faster if the users are able to actively participate!

- Remains under strict supervision of the administrator ;-)

- Independent on any manufacturer

- Meant to survive: backed by strong companies and institutions (EDF, BRGM, CNRS, etc.)
Open-source!

- Free...

  ...but someone has to “pay” ;)
  - either by working on the project
  - or by paying someone to do so

- plugins are not necessarily public or free
Users

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

Developers

- Barely enough
  - few
  - none
  - none
  - none
  - none
  - none
Development cycle

Specs

core algorithm

“packaging” (GUI, details, etc.)

A simple message on the forum

The fun part

The less fun part

Developer’s hell

User’s hell ;)

stability

user feedback!

1st release

time
Worldwide users

> 1300 subscribers to the newsletter
Generalities
User interface overview

Menus + main toolbars

DB view

View toolbar

Selected entity properties

3D view(s)

Console
Input/Output

- Mainly point clouds (ASC/PTS, LAS/LAZ, E57, PTX, FLS/FWS, DP, etc.) and triangular meshes (PLY, OBJ, STL, OFF, FBX)

- Dedicated format: “BIN” (for projects)

- Other formats: calibrated photos (Bundler .OUT), CAD (Autocad DXF drawings, Aveva .PDMS scripts), GIS shapefiles

- To come:
  - RIEGL files
  - more manufacturer formats?
Clouds display

- Blank cloud
- Normals (slow 😞)
- RGB
- EDL (fast 😊)
PCV

- Global illumination / ambient occlusion
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

- Statistics can be computed

- Clouds can be processed based on those values
  - Segmentation (*Filter by value*)
  - Subsampling

- Values can be exported to a CSV file
  (Excel, Matlab, etc.)
Color scales

- Color Scale Editor: edit and create color scales
- Color scales can now be imported/exported as XML files
- When saving a « BIN » file, custom scales are automatically exported (and will be automatically imported when opening the file on another PC)
Manual editing

- Manual transformation
- Manual segmentation
- Cross Section
- Color / Normal editing
- Sub-sampling tool
- Scaling
- Cloning / Merging
Advanced
Registration

- Point-pair based alignment
- Automatic registration (ICP)

+ semi-automatic ball detection
Registration
Some considerations

What if my entities have some “structural differences”?

- Small local differences:
  - ICP: ‘Enable farthest points removal’ checkbox

- Different scales:
  - Point-pairs based alignment: uncheck the ‘Fixed scale’ checkbox
  - ICP: check the ‘Free scale parameters’ checkbox

- Major differences:
  - Prefer the “point-pairs based alignment” tool!
Registration
Some (more) considerations

*What if one of the entity is a mesh?*

- Almost the same workflow

- Sometimes you may have to
  - sample points on the mesh first (*Edit > Mesh > Sample points*)
  - then apply the resulting transformation on the original mesh (*Edit > Apply Transformation*)

- For the ICP process (*fine registration*) the mesh should always be the ‘reference’
  - generally less holes and/or noise
Distances computation

- Distances are computed between each point of a ‘compared’ cloud and its nearest point or triangle in a ‘reference’ entity.

- Process is not symmetrical.
Distances computation

Two (or three) cases

1. Comparison of two clouds

2. Comparison of a cloud and a mesh

3. Comparison of two meshes: *the only way to do this in CloudCompare is to sample points on the ‘compared’ mesh → back to case 2*
Cloud-cloud distances

- **Main idea:** if the ‘reference’ cloud is dense enough, then the nearest neighbor distance will be (almost) as accurate as the true distance to the underlying surface
  - Error is bounded
  - Error depends on the reference cloud density only

- **Consequences:**
  - Use the denser cloud as reference (if possible)
  - The reference cloud extents must be at least as large as the compared ones (*avoid non overlapping areas!*)

\[ \varepsilon^2 = \frac{1}{\sqrt{\lambda \pi}} \]

N.N. distances in a random Poisson process
Poor or irregular density?
Local meshing strategy

Local modeling: 2 to 5 times slower
Cloud-cloud distances

- Select both entities
- Tools > Distances > Cloud/Cloud dist.
Robust C2C distances with M3C2

Cloud-mesh distances

- Tools > Distances > Cloud/Mesh dist.

- In this mode, the distance is computed between each point of the ‘compared’ cloud and its nearest triangle in the ‘reference’ mesh.

- If the mesh quality is good, this is generally faster and more accurate... but getting a clean mesh can be hard!

- Regarding the output, the only difference with the cloud/cloud case is that the distances are signed (*we use the triangle normal*)
Cloud-mesh distances
Classification with CANUPO

Cleaning

Various methods to remove isolated parts, outliers, non-overlapping areas, etc.:

- Manual editing

- Remove isolated parts with the “Label Connected Components” tool

- Remove isolated points / noise with:
  - Tools > Clean > Noise filter

- Other option: scalar-field based segmentation
Contour/profile extraction
Rasterize & contour plots
Other
Working with SfM data

- Support for Bundler files
- Handling of calibrated pictures and camera sensors
Sensors

- TLS ("GBL") Sensors
- Camera sensors
Meshing

- Meshing tool (to cope with holes mainly)
  - Delaunay 2D for \textquote{2D\textsc{½} } clouds
  - Or the \texttt{qPoissonRecon} plugin for closed shapes

\textbf{Warning: CloudCompare is not a \textquote{meshing} tool}
(remember that the initial aim was to avoid meshes ;-)

It only provides simple approaches for convenience

Consider using \textquote{true} meshing tools
(Meshlab, VR mesh, Geomagic, etc.)
If you need accurate meshes
Presenting & sharing results

- **Analysis**
  - Histogram
  - Local Statistical Testing tool
  - Export to Matlab®/Excel®/etc. (ASCII ~ CSV format)

- **Display**
  - create labels, save viewports, etc.
  - Save the whole project in a “BIN” file

- **Share**
  - ccViewer (lightweight, for load & display only)
Misc.

- Plane and sphere fitting
- Unroll feature (on a cylinder or a cone)
- Plugins
- Command line mode
In preparation

- Near future:
  - Oculus Rift plugin
  - Animation
  - Volume calculation

- TODO list:
  - [https://github.com/cloudcompare/trunk/blob/master/qCC/TODO.txt](https://github.com/cloudcompare/trunk/blob/master/qCC/TODO.txt)
Next workshops

- 2nd international conference of the IAFSM (San Diego, Nov. 2015)

- ISPRS International Conference (Prague, Jul. 2016)
Thanks for your attention!

www.cloudcompare.org