Outline

- About the project
- Quick overview of the software capabilities
- Some success stories
- Future
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

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

Support for 3D mouse and NVidia Stereo glasses (Windows only)
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
Worldwide

Windows version downloads (January)

> 2400 users registered to the newsletter
Citations in scientific articles

source: Google scholar
Quick overview
Interface
One or several 3D views
Interface

Data-base
Interface

Properties (colors, normals, S.F., etc.)
Interface

Lots of icons tools and plugins
Interface

A antiquated good old console
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
  - Bunder OUT, Photoscan PSZ (+ PSX to come)

- sensors
  - TLS or projective cameras

+ dedicated format: **BIN** (for projects)
Display capabilities

- 0-20M points (mid-range)
- 20M-100M points
- 100M-500M points (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

- 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), M3C2 (plugin)
Main tools

- **Cleaning**
  - SOR, etc.

- **Rasterize**
  - + contour plot

- **2.5D volume estimation**
Main tools

- Segmentation
  - connected components, profile extraction, etc.

- Fitting
  - plane, sphere, quadric

- Other
  - density, curvature, roughness, etc.
Plugins

- Robust + signed C2C distances (M3C2)
- Classification (CANUPO)
- Automatic shape detection (RANSAC S.D.)
- Global illumination of clouds and meshes (PCV)
- 3D surface reconstruction (PoissonRecon)
- Animation rendering (Animation)
- Surface of Revolution Analysis (SRA)
- Planar surfaces cleaning (Virtual Broom)
- Geological facet extraction (Facets)
- Hidden Points Removal
- 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++
Success stories
The Dancers column of Delphi

- Virtual reconstruction of the column
  - More than 260 marble fragments
  - More than 14 m. high

A Point-Based Approach for Capture, Display and Illustration of Very Complex Archeological Artefacts
The Dancers column of Delphi

- acquisition: > 1 week, 2200 scans, 600 M. points (in 2004)
- cleaning + segmentation (removal of plaster parts) $\rightarrow$ 220 M. points remaining
- 600h of intensive 2D/3D virtual “puzzling”
- lots of discussion + specific tools development (3 labs)
The Dancers column of Delphi

CloudCompare part:
- unrolling
- mesh quality assessment
- global illumination of clouds (Shadevis / “PCV”)
- visualization

mesh (\textit{normals})  mesh (PCV)  photograph
The Dancers column of Delphi

- Unrolling (Omphalos)
The Dancers column of Delphi

Drum 2

Capital
The Dancers column of Delphi
Classification of China's terracotta warriors ears (1)

Photogrammetry  
Segmentation  
Pair-wise comparison  
Classification

(1) Computer vision, archaeological classification and China's terracotta warriors, A. Bevan et al. 2014
Analysis of construction work for a court case
Comparison of scans in a cave

- Cramped environment, few options for positioning the scanner → lots of occlusions
Comparison of scans in a cave

→ lots of false detections
Comparison of scans in a cave

- Comparison
  - real change area
  - Area hidden at $T_1$
    - (high distances but no change in reality)
Comparison of scans in a cave
Comparison of scans in a cave
Chambord Castle

- Full documentation of the castle with:
  - TLS scans
  - Photogrammetry (ground-based + UAV)
  - Panoramic images
  - Traditional survey points acquisition for georeferencing

broadcasted on French TV ;)

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Chambord Castle

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Great communication tool

Useful for monitoring and maintenance work planning

Better understanding of the architecture (symmetries, role of some features and rooms, issues during the construction, etc.)

→ the whole dataset was delivered to the Castle’s curators with… CloudCompare!
Future
In preparation

- Next:
  - Out-of-core support
  - 3D VR
  - More plugins

- And the ever-growing TODO list *(maybe)*:
Thanks for your attention!

www.cloudcompare.org