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| ENSTA Bretagne |
| UV5.4 Status Report |
| Pierre Jacquot – SPID/ROB |

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Summary

[Introduction 2](#_Toc443902007)

[Context 2](#_Toc443902008)

[1. Pre-processing 2](#_Toc443902009)

[1.2 Point Cloud Artifact 3](#_Toc443902010)

[References 4](#_Toc443902011)

[Figure 1 - Graphical representation of the different forms of point cloud artifacts (3) 4](#_Toc443917915)

[Figure 2 - Part of the Kereon scan. The white points on the right of the windows are considered as noise, and are created by the laser going throught the window 4](#_Toc443917916)

[Figure 3 - missing data on Kéréon scan 5](#_Toc443917917)

# Introduction

Computers are constantly increasing in term of power, efficiency and capacity. This quick evolution allow us to manage more and more data at the same time. This ability to deal with a large amount of data permit now to deal with what we called cloud points. This cloud point are the results of laser scans, and basically contain the coordinates and sometimes the color of what the laser is scanning. This ability to represent our world using cloud points have many application. We can for example use this to recreate architectural site, or to recreate an environment in prevision of a future operation(1).

However when we talk about recreating a monument, or an object using data cloud, this also mean that we have to create a 3D version of this model. To do so we have to do a surface reconstruction of the object or monument. This surface reconstruction imply to link each point, in a logical way with each other in order to obtain an accurate 3D reproduction of the desired object.

As you can imagine such a task imply many pre-requisites. Among them we first need to understand how the 3D points cloud has been acquired, what king of object we want to reconstruct (an exterior, an interior, a simple object?). Linking a points cloud also need pre-treatment, so we can obtain the most accurate representation. We’ll therefore need to clear the cloud point of any noise or misplace points and simplify it if it contains too many points, so we can have a light mesh (a mesh is a collection of vertices, edges and faces that defines a shape (2). Here it will be the final 3D representation of the building we’re trying to recreate). Furthermore linking the points between them in not trivial as there is not necessary a right order to do it, and the computer certainly don’t know in advance which order will be the best. Therefore, the main goal of this status report is to find, describe and analyze the best methods to clean and reconstruct a cloud point.

# Context

This project is collaboration between les Phares et Balise (a department of le parc marin d’Iroise) and the ENSTA Bretagne. Les Phares et Balises are currently trying to put forward some of the lighthouses of the Finistère’s coast. These lighthouses are for most of them too far away from the coast and despite their strong cultural interest cannot be visited. To tackle this issue, les phares et balises have organized several laser scans of these lighthouses so that people could visit them. The main idea is to present a 3D representation of these lighthouses (focusing on the lighthouse of Kereon) during the Brest 2016 festival. As meshing a cloud point is not trivial they ask for the ENSTA Bretagne expertise to create a 3D mesh of the lighthouse of Kereon.

# 1. Pre-processing

As I mentioned before, meshing a cloud point require some pre-requisite such as treating the point cloud artifacts (3), find or/and reorganized the normal (4) and adapt your treatment to the class of shapes contained in the scene your trying to reconstruct.

## 1.2 Point Cloud Artifacts

Laser scanning an area often comes with many non-wanted features appearing in our input point cloud. These unwanted features are called artifacts. The most impactful on the surface reconstruction are: the sampling density, the noise, the outliers, the misalignment and the missing data. All of these artifacts will be explained in the next parts and I will give some solutions to clear the artifacts that are currently present in the cloud point I’m working with.

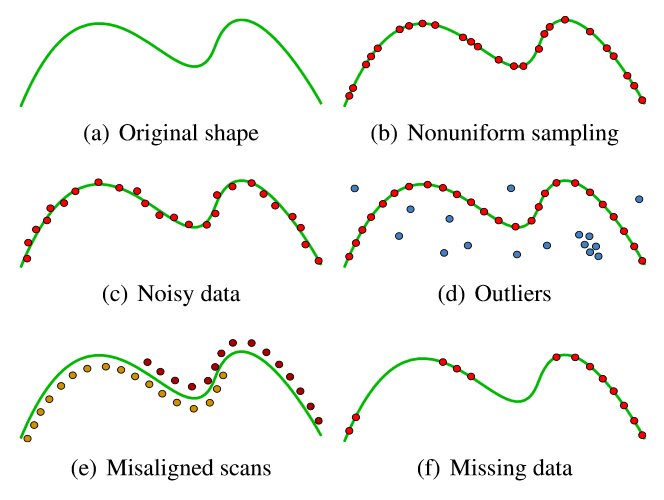


Figure 1 - Graphical representation of the different forms of point cloud artifacts (3)

**Non uniform sampling:**

Non uniform sampling is visible on figure 1(b). This king of artefacts is in majority due to the positioning of the scanner regarding the object or scene we are scanning. Other factors impacting point sampling are the orientation of the scanner and also the shape of the objects we are scanning. A good way to tackle this issue is to scan an object multiple time, and with various angle in order to have the right amount of point.

**Noise:**

One of the most common artefact. Noise is due to many factors, including the sensor of the scanner, the distance and orientation of the surface scanned, the inner characteristic of the surface scanned. For example reflective surfaces are a major source of noise as well as windows (figure 2). You can either try to eliminate noise (which can be fairly easy on the example figure 2), or you can produce a surface that passes near the noise.

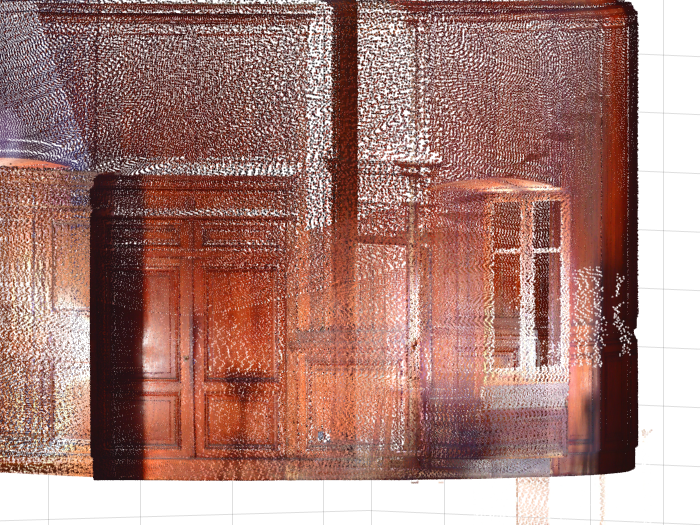


Figure 2 - Part of the Kereon scan. The white points on the right of the windows are considered as noise, and are created by the laser going throught the window

**Outliers:**

The outliers are the points far from the true surface. These artifacts are due to structural artifacts in the acquisition process. This type of artifact often appear in multi-view stereo acquisition when points taken with a different angles result in false correspondences. This is important to note that outliers must not be taken into account in the surface reconstruction and must be detected and erased.

**Missing data:**

Missing data are due to limited sensor range, high light absorption and occlusions in the scanning process. To avoid this kind of problem multiple scanned must be done in order to overlap them, reducing the quantity of missing data, but causing sometimes misaligned scans (figure 1(e)). In the case of the Kereon scans we can see some missing data located on the floor area (figure 3), where the scanner was laid.

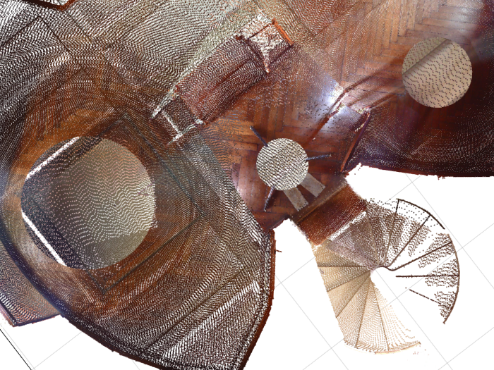


Figure 3 - missing data on Kéréon scan

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