12-months Research Engineer on
Computer graphics, Artificial Intelligence and Geometry Processing,

Fast and Frugal Processing of Massive 3d point clouds

Supervision:

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This vacancy is part of the SSLAM project (ANR-22-CE23-0004) and will contribute to the PONCA open source library.

Context: the SSLAM project

3D acquisition devices are becoming easily accessible and widespread thanks to the decrease in the costs of the technology and its improvement. Their main advantage is the capture of our environment as a full 3D representation composed of millions or even billions of unorganized points denoted *point clouds*. However, there is a need for efficient and reliable processing systems to help expert users to analyze and reconstruct geometrical structures from large scale 3d point clouds. The ambition of the SSLAM project is to develop and demonstrate a framework for the **interactive analysis and understanding of acquired 3d point clouds with billions of points**.

Robustly analysing the geometry and the semantic of large-scale acquired 3d point clouds remains a challenge out of reach of existing frameworks. On the one hand, local geometry analysis has been studied for decades and several robust approaches have been proposed to characterize the geometry of a point and its neighborhoods at different scales. On the other hand, ML techniques (e.g., neural networks) have been introduced in the past years to infer high level knowledge such as semantics, using deep and complex architecture. It has been shown that the performances of these networks are improved by large learning sets that includes hallucinated data (e.g., perturbed by noise and sampling), which increases the training requirements in memory, energy and time. This is because the first layers of these networks need to extract geometrical properties directly from the point coordinates, in order to disambiguate between artefacts and relevant structures before reaching the decision layers. Our hypothesis is that **enriching an unstructured 3d point cloud with multi-scale differential quantities** allows to define more compact network, focused on the decision tasks. It allows to reduce the number and complexity of layers in charge of extracting geometrical properties, and **defer this task to well-known geometric models with theoretical guarantees [LC*21]**. The remaining layers focus on the concepts, and we can expect an improvement of the generalization of the resulting networks. We also observed that using compact networks require less data, energy and time for training and evaluation [HL*22], which enable the design of interactive labeling and classification systems [CB*23].

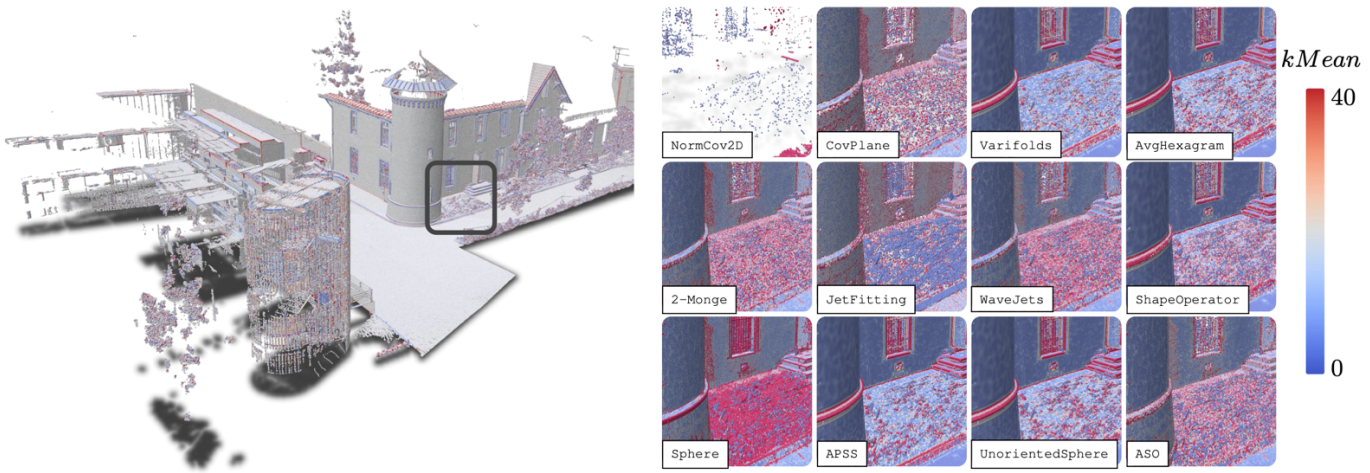

Figure 1. Comparison of several point-based differential estimators available in PONCA (source: Léo Arnal)

Project goals

The general objective of this project is to improve geometry processing and IA pipelines through the development of industry-grade open-source libraries for 3d point cloud processing. PONCA, which stands for POiNt Cloud Analysis, is a library developed at the *Institut de Recherche en Informatique de Toulouse* (IRIT) and used by the startup RollingDot to develop frugal and scalable Machine Learning approaches for massive point clouds classification, segmentation and reconstruction. The library implements several models to characterize the geometry sampled by a 3d point cloud, as illustrated in Figure 1. In order to optimize for runtime efficiency and energy consumption, the library is implemented in C++ and can be compiled both for CPU and GPU (CUDA) execution.

The goal of this project is twofold:

1. Develop and maintain the version 2 of the PONCA library:
   - Refactor the template-based programming model to improve genericity, static code checks, compilation performances, and increase compatibility to new mathematical models currently not supported,
   - Evaluate the impact of the algorithmic and data structure change on the energy consumption at runtime using Grid5000 [D21, D22, BC*13],
   - Support the research group by implementing new methods and research results.
2. Develop a proof of concept for 3D point cloud processing on FPGA boards:
   - Design a processing pipeline compatible with FPGA requirements,
   - Implement a proof of concept using Silice (usage of PONCA is preferred but optional).

These missions will be performed in collaboration of the user contributors of PONCA: PhD students, researchers, research engineers from the research team and from RollingDot, who already worked on several proposals that will be studied for PONCA v2.

The recruited engineer will be in charge of studying how to use PONCA to program FPGA board. This mission (expected time: 6 months) will be performed in collaboration with Sylvain Lefebvre and his group through the use of Silice (including dedicated training).

Expected results

- New release of the PONCA library,
- Design and implement of a proof-of-concept system demonstrating FPGA processing for 3D point clouds.

Skills and competences

The candidate should have the following skills:

- Background in Computer Graphics,
- Strong development skills (C and C++),
- Interest for research-related activities, critical thinking and initiative.

Dates and grant

The position is expected to start early 2025 for a duration of 12 months.
Salary will vary depending on the candidate experience.

Working group

The recruited engineer will be hosted at the *Institut de Recherche en Informatique de Toulouse* (IRIT), at Toulouse (France). Toulouse is the capital city of the Occitanie region, the fourth-largest city in France and the centre of the European aerospace industry.
The recruited engineer will collaborate with PhD students and postdocs of the STORM group working on point cloud processing, and with Research Engineers from the StableProxy ANR project and from the startup RollingDot.
The collaboration with Nancy will be supported by travel and short stays depending on the training needs.

Application

Please send your CV and a short motivation letter to: Nicolas.Mellado@irit.fr

References

[CB*23] Maxime Cordeil, Thomas Billy, Nicolas Mellado, Loic Barthe, Nadine Couture, Patrick Reuter. 2023. ImmersiveIML–Immersive interactive machine learning for 3D point cloud classification: the neural network atyour fingertips. IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMARAdjunct2023), Oct 2023, Sydney, Australia.

[HL*22] Chems Eddine Himeur, Thibault Lejemble, Thomas Pellegrini, Mathias Paulin, Loïc Barthe and Nicolas Mellado. 2022. PCEDNet : A Lightweight Neural Network for Fast and Interactive Edge Detection in 3D Point Clouds. ACM Transactions on Graphics, 41(1).

[D21] Georges Da Costa. MojitO/S, November 2021. URL: https://hal.archives-ouvertes.fr/hal-03453537 .

[D22] Georges Da Costa. Expetator: A tool for running hpc applications using several type of leverages and low-level monitoring, 2022. URL: https://gitlab.irit.fr/sepia-pub/expetator .

[BC*13] Daniel Balouek, Alexandra Carpen Amarie, Ghislain Charrier, Frederic Desprez, Emmanuel Jeannot, Emmanuel Jeanvoine, Adrien Lèbre, David Margery, Nicolas Niclausse, Lucas Nussbaum, Olivier Richard, Christian Perez, Flavien Quesnel, Cyril Rohr, and Luc Sarzyniec. Adding virtualization capabilities to the Grid'5000 testbed. In Ivan I. Ivanov, Marten van Sinderen, Frank Leymann, and Tony Shan, editors, Cloud Computing and Services Science, volume 367 of Communications in Computer and Information Science, p. 3–2. Springer International Publishing, 2013. doi:10.1007/978-3-319-04519-1\ 1.

[LC*21] Thibault Lejemble, David Coeurjolly, Loïc Barthe, and Nicolas Mellado. Stable and efficient differential estimators on oriented point clouds. Computer Graphics Forum, 40(5), July 2021. URL: https://hal.archives-ouvertes.fr/hal-03272493