

# Acceleration of Local Registration Algorithms For Fresco Reconstruction

November 28, 2023

**Problem statement:** This internship is part of a research project focusing on the problem of recovering the optimal spatial organization of a damaged support from its original elements (see Figure 1). Main applications include the reconstruction of artworks in *cultural heritage restoration* and *archaeology*. This is highly motivated by the restoration of damaged paintings during earthquakes as well as the discovery of mosaics or frescoes from excavations (e.g. Pompeii). This problem is challenging because of *local aspects* (elements must locally match with each other) and *global aspects* (the reassembled elements must depict a picture with semantic content). More precisely, we have to deal with (i) a very large set of fragments (typically many thousands), (ii) highly variable characteristics of fragments, (iii) irregularly shaped and eroded fragments, (iv) spurious fragments, (v) missing fragments and (vi) [complete] degradation of the fresco model. Attempts to solve this problem include features matching [3], machine learning [1] or Marked Point Processes (MPP) [2]. The latter involves a local relocation step of fragments using gradient descent but remains computationally demanding.



Figure 1: Example of an ideal fresco reconstruction (top left) from both fresco model (top right) and a collection of fragment images (bottom). Only a subset of the latter are represented.

**Objectives:** The aim will consist in improving the running time of the relocation step of fragments in [2]. For doing so, several ways will be considered (translation of the existing code in C/C++, GPU acceleration, parallelism, second-order methods such as Newton/BFGS, etc.). Secondly, a comprehensive comparative study will be led between these approaches and evaluated on existing simulated datasets.

**Prerequisites:** A candidate at master level (or equivalent) with a good mathematical and image processing background as well as good programming skills. Knowledge in optimization is preferred but not mandatory.

**Duration/salary:** From 4 to 6 months / About 530 euros per month.

**Ph.D. continuation:** Possible.

**Location:** The internship will take place in the SATIE lab at Gif-sur-yvette (30 minutes from Paris).

**Contact:** Please feel free to send an e-mail to (by order of preference)

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## References

- [1] G. Heck, N. Lermé, S. Le Hégarat-Mascle, F. Malgouyres, and P. Dondi. End-to-end jigsaw puzzles solving using transformers. *Submitted to Pattern Analysis and Applications (PAA)*, 2023. preprint.
- [2] N. Lermé, S. Le Hégarat-Mascle, F. Malgouyres, G. Heck, and P. Dondi. Automatic MPP-based fresco reconstruction. *Submitted to Pattern Recognition Letters (PRL)*, 2023. preprint.
- [3] N. Lermé, S. Le Hégarat-Mascle, B. Zhang, and E. Aldea. Fast and efficient reconstruction of digitized frescoes. *Pattern Recognition Letters (PRL)*, 138:417–423, 2020.