Surface reconstruction and approximation is a core topic in shape analysis whose objective is to generate output surface meshes with specific geometric properties from heterogeneous data. These data are typically 3D point clouds generated by Laser scanning systems or directly Multiview stereo images. Traditionally, reconstruction and approximation are operated sequentially: we first extract a surface mesh faithful with the 3D input data and then remesh the surface according to geometric and topological quality criteria as a low mesh complexity, a good sharp feature preservation or a good triangulation isotropy. Geometric errors are however easily propagated during this two-step strategy as approximation rarely accounts for consistency with input data. Ideally, reconstruction and approximation should be done simultaneously.

The main survey on surface reconstruction [1] shows that existing methods operate with a similar strategy: they build a geometric data-structure as a voxel grid, an octree or a Delaunay triangulation that partition the 3D space into volume and surface elements. The surface mesh is then extracted from this partition using a metrics that will select volume (respectively surface) elements as inside or outside the output surface (resp. as part of the output surface). Because these geometric data-structures are static, volume and surface elements of such partitions cannot be modified easily. As a consequence, these methods do not offer a real control on the geometric and topological quality of the output mesh.

2018-00641 - [CORDIS2018-TITANE] PhD in computer vision and geometry processing

Level of qualifications required: Graduate degree or equivalent
Fonction: PhD Position

About the research centre or Inria department
The Inria Sophia Antipolis - Méditerranée center counts 37 research teams and 9 support departments. The center's staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators. 1/3 of the staff are civil servants, the others are contractual. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) “Université Côte d’Azur (UCA)”.

Context
Team Presentation
Our overall objective is the computerized geometric modeling of complex scenes from physical measurements. On the geometric modeling and processing pipeline, this objective corresponds to steps required for conversion from physical to effective digital representations: analysis, reconstruction and approximation. Another longer term objective is the synthesis of complex scenes. This objective is related to analysis as we assume that the main sources of data are measurements, and synthesis is assumed to be carried out from samples. The related scientific challenges include i) being resilient to defect-laden data due to the uncertainty in the measurement processes and imperfect algorithms along the pipeline, ii) being resilient to heterogeneous data, both in type and in scale, iii) dealing with massive data, and iv) recovering or preserving the structure of complex scenes. We define the quality of a computerized representation by its i) geometric accuracy, or faithfulness to the physical scene, ii) complexity, iii) structure accuracy and control, and iv) amenability to effective processing and high level scene understanding.

Team website: https://team.inria.fr/titane/

Assignment
He – She will be in charge of leading innovative researches on surface reconstruction and approximation.

Main activities
Context
Surface reconstruction and approximation is a core topic in shape analysis whose objective is to generate output surface meshes with specific geometric properties from heterogeneous data. These data are typically 3D point clouds generated by Laser scanning systems or directly Multiview stereo images. Traditionally, reconstruction and approximation are operated sequentially: we first extract a surface mesh faithful with the 3D input data and then remesh the surface according to geometric and topological quality criteria as a low mesh complexity, a good sharp feature preservation or a good triangulation isotropy. Geometric errors are however easily propagated during this two-step strategy as approximation rarely accounts for consistency with input data. Ideally, reconstruction and approximation should be done simultaneously.

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Objectives

The main objective of this PhD is to investigate on new surface reconstruction methodologies that offer a control on the geometric and topological quality of the output surface. The key idea will be to build and exploit dynamic geometric data-structures that make the space partitions evolve along optimization procedures and adapt to both input data and geometric and topological quality criteria. The expected results of these works are a new family of algorithms able to jointly reconstruct and remesh a surface from different types of 3D data as point clouds and Multiview stereo images. The PhD will explore the following research directions:

- **Designing efficient dynamic partition schemes** – The construction of geometric data-structures usually relies on incremental mechanisms that connect geometric primitives given by, or detected from, data measurements, e.g. [2]. Modifying geometric data-structures to fit them better to data measurements is a much more difficult task, mainly because local modifications are likely to produce an unstable chain reaction in such a complex structure. Some of recent works in the Titane suggest that the key to solve this problem could be found in Stochastic Geometry. The later offers powerful tools to sample configurations of points following arbitrary probability densities that account for data likelihood and priors on the spatial organization of these points, also known as spatial point processes. We demonstrated that one can create a direct correspondence between a configuration of points enriched by a few attributes and some basic geometric data-structures as planar graphs and Delaunay triangulations. As a result, the sampling of point processes becomes a way to generate dynamic geometric data-structures whose evolution is guided by arbitrary probability densities. The PhD candidate will study on how to generalize such strategy to design geometric data structures tailored-made for surface reconstruction and approximation. This will require imagining bijective functions both generic and computationally-efficient. Another important question to solve will concern the memory- and time-efficiency of the sampling mechanisms.

- **Analyzing and combining quality metrics** – In complement to the design of dynamic partition schemes, the PhD candidate will analyze the quality metrics to be considered in order to formulate models both simple and flexible. These metrics should include a distance to input data which is robust to measurement defects as well as geometric quality measures. Beyond individual metrics, a difficult problem to solve will be how to combine them in a simple and effective manner.

- **Designing models for reconstructing specific classes of objects** – The candidate will propose models for reconstructing specific classes of objects as mechanical pieces whose output meshes should be ready for inverse engineering simulations and urban objects whose output meshes should follow some Geographic Information System formalisms. The candidate will also investigate on how adapting the quality metrics to design tailored-made models for practitioners. This could be tackle by directly learning the notion of surface quality from large databases of meshes that they usually have from past experiences.

Keywords

Computer vision, geometry processing, surface reconstruction and approximation, mesh refinement, geometric data-structures

References


Skills

Required qualities: The ideal candidate should have good knowledge in computer vision, 3D geometry and applied mathematics, be able to program in C/C++, be fluent in English, and be creative and rigorous.

Required Diploma and experience: Master degree in Computer Science or Mathematics
Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)