Internship proposal — Master 2

Segmentation and Mesh Edition Based on Normal Vector Accumulation

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Supervision and contact

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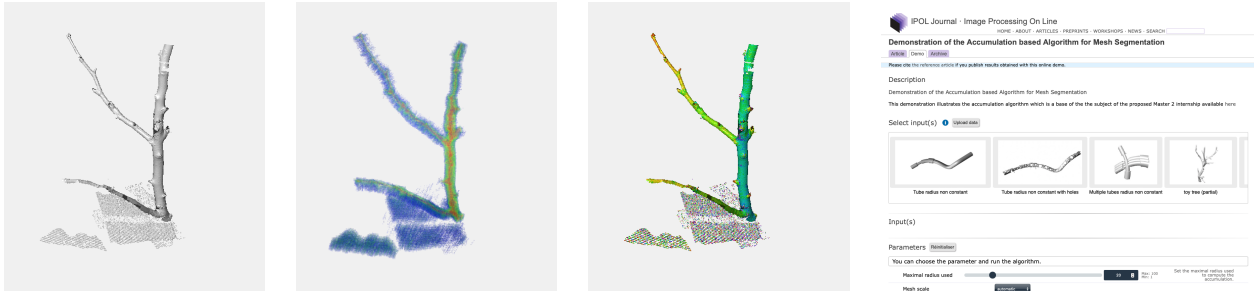
Localization

The candidate will be attached to the laboratory LIRIS located at *Campus Porte de Alpes* (Bron).

Motivations

In the context of shape acquisition and modeling, the identification and separation of geometric structures can be of key importance to simplify, edit or improve the quality of a mesh. These research axis have concrete applications in video games where 3D shapes can be modeled from scans and then edited and re-meshed and eventually animated from a skeleton. In parallel, recently the acquisition methods based on photogrammetry have been democratized and now allow to produce 3D reconstructions from a number of photos without manual editing or complex parameters.

The other motivation of this topic is to continue the work based on the accumulation of normals [1, 2] which introduced a method of centerline extraction able to handle partial meshes without geometric or topological constraints. This method relies on a simple idea of ray tracing that accumulate score in the digital space. Figure 1 illustrates this method applied on the partial scan of a tree branch (image (a)) with the display of the accumulation space (image (b)) and the associated distance of the maximal accumulation value (image (c)).

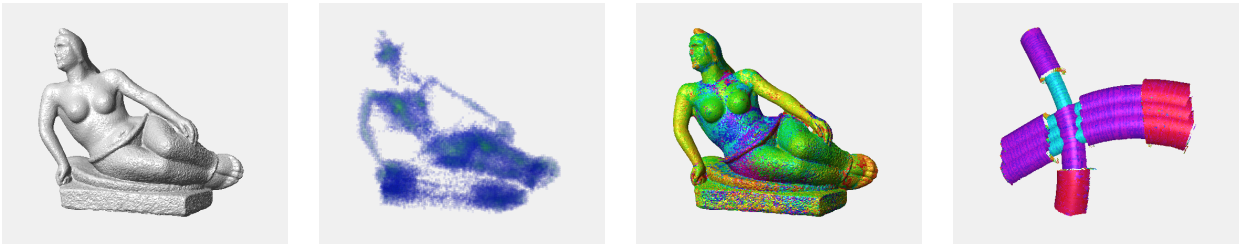


(a) (b) (c) (d) on line demonstration [1]

FIGURE 1 – Illustration of the centerline extraction method presented in [1, 2]. Image (a) represents the input mesh, image (b) illustrates the accumulation space calculated from the object normals, and image (c) represents the object thickness estimated from the maximum accumulation values. The online demonstration[1] to reproduce these results is shown in image (c). The code is available here :
https://github.com/kerautret/CDCVAM

In this internship the idea is to continue exploring the concepts of this method through segmentation, smoothing, editing and reconstruction objectives. The main idea is to exploit the simplicity and the implementation of the method based on accumulation to adapt it to the exploitation in a concrete product as a plug-in for *Blender*.

1. https://ipolcore.ipol.im/demo/clientApp/demo.html?id=5555531082027



(a) (b) (c) (d)

FIGURE 2 – Example of application for the separation of tubular part of an input mesh obtained by photogrammetry (image (a)) with the accumulation obtained (image (b)) and the distance associated with the accumulation maximum (image (c)) [2]. The image (d) represents another application case where the accumulation method allows to extract thickness information even on disconnected surfaces that intersect.

Sujet

In this internship, we propose to explore different perspectives of the accumulation algorithm through the following directions :

- **Interactive selection of tubular structures.** The accumulation-based centerline extraction algorithm also retrieves an estimate of the thickness that is directly given through the maximum value of the accumulation value computed along the ray (shown in color in image (c) in Figure 1. A possible method could be to introduce a growing region based algorithm defined from the selection of a face and to exploit the discrete accumulation space (the set of voxels representing the obtained accumulation shown on image (b) of the same figure). This space would allow to constrain the region growth by integrating the geometric information accumulated in the voxels.
- **Split of tubular parts.** Thanks to the previous point, it will be possible to discriminate tubular parts even if they are physically connected to the rest of the mesh. For example, a goal would be to propose a tool allowing to separate and detach the arm from the rest of the body (like the right arm represented on the mesh of the image (a) of the figure 2). Following the progress of this point, it could be interesting to propose the implementation of this algorithm in a plug-in for the 3D modeling software *Blender*.
- **Smoothing and surface reconstructions** : Another point of interest could be to study the exploitation of the accumulation algorithm to define a surface smoothing or a partial reconstruction of tubular sections.

The references of the accumulation method [1, 2] and the associated code will be a starting point to begin this topic. It will also be interesting to take inspiration from the different solutions proposed in the literature to segment a mesh into distinct parts even if they suppose to have as input a surface manifold type mesh representing a volumetric object or exploit geometric quantities such as curvature [4], geodesic distances [5] Even if these hypotheses limit the direct exploitation of these methods it could be interesting to look at the strategies used.

Awaited skills

Programming (C++ and/or Python), image analysis and processing. A experience in image processing, in the use of C++ libraries (e.g. DGtal libraries (e.g. DGtal [6]) or graphical user interface programming (QT) or plug-in programming would be a plus in the application.

Applications

To apply, you can email your CV and latest transcripts to the following address bertrand.kerautret@univ-lyon2.fr.

Potential extension

The basis of this master subject could be declined into a thesis subject that could be linked to other types of applications in the field of application with the extraction of blood vessels or the analysis of roots in collaboration with the INRAE.

2. Experimentation available here : : https://ipolcore.ipol.im/demo/clientApp/demo.html?id=5555531082027&archive=590152

Références

[1] B. Kerautret, A. Krähenbühl, I. Debled-Rennesson, and J.-O. Lachaud. Centerline detection on partial mesh scans by confidence vote in accumulation map. In *ICPR*, pages 1376–1381, 2016.

[2] Bertrand Kerautret, Adrien Krähenbühl, Isabelle Debled-Rennesson, and Jacques-Olivier Lachaud. On the Implementation of Centerline Extraction based on Confidence Vote in Accumulation Map. In *Proceedings of the First Workshop of Reproducible Research in Pat. Rec.*, volume 10214, pages 109–123. Springer, 2016.

[3] Lior Shapira, Ariel Shamir, and Daniel Cohen-Or. Consistent mesh partitioning and skeletonisation using the shape diameter function. *The Visual Computer*, 24 :249–259, 2008.

[4] Alan P Mangan and Ross T Whitaker. Partitioning 3d surface meshes using watershed segmentation. *IEEE Transactions on Visualization and Computer Graphics*, 5(4) :308–321, 1999.

[5] Julien Tierny, Jean-Philippe Vandeborre, and Mohamed Daoudi. Topology driven 3d mesh hierarchical segmentation. In *IEEE International Conference on Shape Modeling and Applications 2007 (SMI'07)*, pages 215–220. IEEE, 2007.

[6] Dgtal : Digital geometry tools and algorithms library. http://dgtal.org.