Topological Evaluation of Volume Reconstructions by Voxel Carving

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1 Introduction

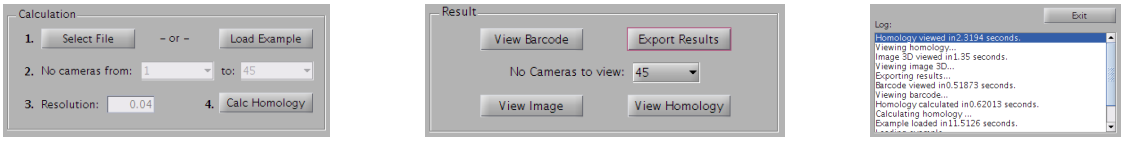
Homology is topologically invariant, meaning it is a property of an object that does not change under continuous (elastic) transformations of the object. *Persistent homology* studies homology classes and their life-times (persistence) in the belief that significant topological attributes must have a long life-time in a filtration (an increasing nested sequence of subcomplexes). In this demo, we work to apply persistence theory for the evaluation of a 3D reconstruction process: voxel carving.

Voxel carving is a technique for creating a three-dimensional reconstruction of an object from a series of two-dimensional images captured from cameras placed around the object at different viewing angles. The technique involves capturing a series of synchronised images of an object, and, by analysis of these images and with prior knowledge of the exact three-dimensional location of the cameras, deriving an approximation of the shape of the object.

The reconstruction process, along increasing number of cameras, can be modelled as a suitable input for persistent homology computation, giving the possibility of a topological understanding of the whole process. More specifically, we analyse the *persistence barcodes* which are graphical representations of pairs of birth and death times of homology classes as a collection of horizontal line segments (intervals) in a plane, in order to extract information about the topological evolution of the reconstructions.

2 Persistence barcodes for topological evaluation of volume reconstructions

This software is organized into four groups. First group (1a) includes the steps to compute homology: selection of the file to be processed or loading of a precomputed example; initial and final number of cameras used in the process of voxel carving to be analyzed; input of the resolution used in the voxel carving process; persistent homology computation for the selected range. The file name is showed in the window to help the user.

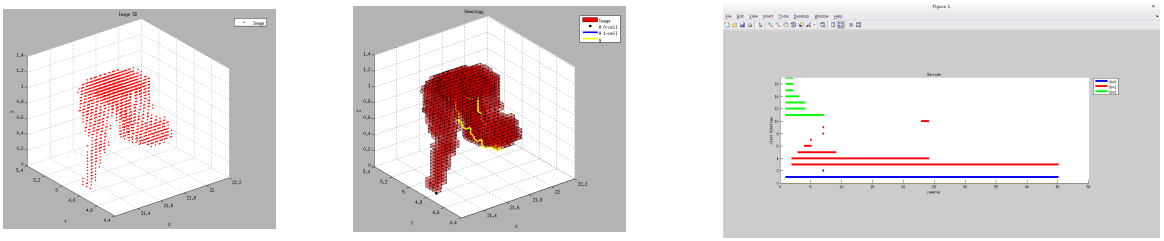


(a) Homology computation (b) Result (c) Log window

Figure 1: Functional groups

Second group (1b) includes the options to show the results of the process of persistent homology computation. The user can view the barcode to analyze the topological evolution. Results with the information of birth and death of homology classes can be exported, too. Futhermore, for a chosen number of cameras, the three-dimesional image from voxel carving, as well as representative cycles of 0 and 1-homology classes can be visualized.

Representation of the 3D image (2a) and 0 and 1-homology classes (2b) are showed on the side hand of the window, while the barcode (2c) is showed in a new window.



(a) 3D Image (b) Homology classes (c) Barcode

Figure 2: Results

Finally, all messages from the application are displayed in field *Log* (1c). The processing time is computed and showed in Log window for all the executed processes.