Topological data analysis for the study of self-organization of cells in a biological tissue*

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1 Extended abstract

In this communication, we want to present our ongoing work on topological analysis of images of segmented cells in a biological tissue.

Topological Data Analysis (TDA) studies the shape of data from a topological viewpoint, having *persistent homology* [3, 6] as its main tool. Persistent homology studies the evolution of homology classes and their life-times (persistence) in an increasing nested sequence of spaces (that is called a filtration). The output of persistent homology computation can be codified under the form of a set of intervals (barcode) encoding the birth and death times of each homology class $\{(x_i, y_i)\}_{i=1}^n$ arising in the increasing sequence of spaces. *Persistent entropy* is a simple parameter that can be calculated from the lengths of these intervals and can be statistically studied later. The concept first arose in [2] and can be described as an adaptation of Shannon entropy to this context: $E = -\sum_{i=1}^n \frac{\ell_i}{L} \log(\frac{\ell_i}{L})$, where $\ell_i = y_i - x_i$ and the total length $L = \ell_1 + \ldots + \ell_n$.

In [1], the authors proved that persistent entropy is robust to noise.

Now, we are exploring the power of persistent entropy in a biological context to test if it is able to detect topological differences in cell arrangements in images of biological tissues. In [4], we first applied persistent homology, looking for other organizational traits that could improve the characterization of epithelia. Some initial experiments were described, working on two types of tissues: chick neuroepithelium (cNT) from chicken embryos and wing imaginal disc in the prepupal stage (dWP) from Drosophila. However, it is importat also to compare the latter (dWP) with middle third instar wing discs (dWL), which are two proliferative stages separated by 24h development (and hence, with very similar organization). We have already got initial good results in the study of the discriminative ability of persistent entropy, discovering statistically significant differences between images of the three tissues. These results may open a door to the inclusion of persistent entropy as an important parameter to be taken into account in analysis tools like [5].

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