Topological Data Analysis for Oncology

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Topological data analysis (TDA) is an emerging mathematical field that uses topological and geometric approaches to quantify the "shape" of data. Persistent Homology (PH), the most prominent method from TDA, captures topological invariants such as connected components, loops, and voids in data at multiple scales. The output from PH can be visualised in a barcode which can further be vectorised to enable integration with statistical and machine learning tools. In recent years, PH has been successfully applied to study many biological phenomena.

In this mini course I will introduce the mathematical concepts behind TDA and PH and show applications to both experimental data from oncology and the output from mathematical models. I will in particular demonstrate how PH allows us to quantify the effect of drugs on experimental data of vascular networks of tumours and how we can use similar approaches to stratify the parameter space of a mathematical model of tumour vasculature. I will then show how we can combine TDA and mathematical models to understand the effect of structural features of vascular networks on perfusion level and response to radiotherapy. Finally, I will present how PH can give insight into spatial relations in data and how it can complement machine learning approaches for biological data.