# Introduction to Topological Data Analysis (code)

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**Module 1 (Introduction to Python)**

**Introduction to Python programming:** Introduction to programming platforms: VSCode and Python. Basics of Python data-types and operations. Installation of relevant TDA packages and understanding their usage.

**Module 2 (Introduction to Topological Data Analysis)**

Topology of Spaces: metric spaces, manifolds, graphs.

Homology in $Z_2$: cycles, voids, and higher dimensional holes.

Homology Algorithm: Smith normal form, reduction algorithm

Complexes: simplicial complexes, Cech and Vietoris—Rips complexes. manipulate complexes using TDA libraries, data structures for simplicial complexes.

Topological Persistence: filtrations, persistent homology, reduction algorithm to compute persistence.

Persistence Diagrams (PD): visualization of PDs in Python, Manipulating PDs in Python, persistence landscape. distance between PDs: Wasserstein distance, Bottleneck distance.

**Module3 (Data Analysis using TDA)**

**TDA in Time series:** Basic time-series analysis: expectation, correlation, autocorrelation, Stationary vs. non-stationary time-series, Linear vs. non-linear time-series, Non-linear dynamical systems, Phase portraits, Time-delay embedding (Taken's theorem), Time-series analysis using TDA.

**Applications of TDA in Finance:** reading the following papers

- Gidea, M., & Katz, Y. (2018). Topological data analysis of financial time series: Landscapes of crashes. In Physica A: Statistical Mechanics and its Applications (Vol. 491, pp. 820–834). Elsevier BV. https://doi.org/10.1016/j.physa.2017.09.028
- Goel, A., Pasricha, P., & Mehra, A. (2020). Topological data analysis in investment decisions. In Expert Systems with Applications (Vol. 147, p. 113222). Elsevier BV. https://doi.org/10.1016/j.eswa.2020.113222

- Gidea, M. (2017). Topological Data Analysis of Critical Transitions in Financial Networks. In 3rd International Winter School and Conference on Network Science (pp. 47–59). Springer International Publishing. https://doi.org/10.1007/978-3-319-55471-6_5
- Guo, H., Xia, S., An, Q., Zhang, X., Sun, W., & Zhao, X. (2020). Empirical study of financial crises based on topological data analysis. In Physica A: Statistical Mechanics and its Applications (Vol. 558, p. 124956). Elsevier BV. https://doi.org/10.1016/j.physa.2020.124956

**Reference:**


- Computational Topology for Data Analysis by Tamal Dey and Yusu Wang
- Nonlinear Time Series Analysis, By Holger Kantz, Thomas Schreiber, Cambridge University Press.