Content

Course Code	Course Name	Semester	Theory	Practice	Lab	Credit	ECTS
MATH 614		2	3	0	0	3	7

Prerequisites	
Admission Requirements	

Language of Instruction	English
Course Type	Elective
Course Level	Doctoral Degree
Objective	-This course bridges the gap between abstract algebraic topology and data science. It covers the mathematical foundations of persistent homology, stability theory, and the algorithmic implementation of topological summaries. The course concludes with modern applications in machine learning, including vectorization methods and topological deep learning.
Content	This doctoral course provides a rigorous introduction to Topological Data Analysis (TDA). It covers the mathematical foundations of simplicial complexes and algebraic homology, followed by the theory and computation of Persistent Homology. Key topics include the construction of filtrations (Vietoris-Rips, Cech), stability theorems (Bottleneck and Wasserstein distances), and efficient algorithms for computing topological invariants. The course concludes by integrating TDA with Machine Learning through vectorization methods (Persistence Landscapes, Images), the Mapper algorithm, and Topological Deep Learning applications
References	•Edelsbrunner, H., & Harer, J. (2010). Computational Topology: An Introduction. AMS. • Zomorodian, A. J. (2005). Topology for Computing. Cambridge University Press. (Excellent for algorithms and complexity). • Hatcher, A. (2002). Algebraic Topology. Cambridge University Press. (The standard reference for rigorous Homology theory). • Oudot, S. Y. (2015). Persistence Theory: From Quiver Representations to Data Analysis. AMS.

Theory Topics

Week	Weekly Contents
1	Introduction & Topology Basics
2	Simplicial Complexes & Filtrations
3	Simplicial Homology
4	Introduction to Persistence
5	Algorithms for Persistence
6	Representations of Persistence
7	Metric Geometry of Persistence
8	Midterm
9	Stability Theorems
10	Vectorization of TDA
11	The Mapper Algorithm
12	Multiparameter Persistence
13	Topological Deep Learning
14	Applications