课程编号 课程名称 图机器学习

1. **课堂讲授学时 Lecture Hours 16**
2. **课堂实验学时 Laboratory Hours 16**
3. **课下研讨学时 Colloquia Hours 0**
4. **学生课下投入学时 Individual Study Hours 16**
5. **学分 Credits 2**
6. **开课学年学期**（如果有强制性的要求则必须填，否则可以不填）**Occurrence：1st year, 2nd year, 3rd year, 4th year; Autumn, Spring**
7. **先修课程 Prerequisite(s): 必须先修的课程直接写课程编号和课程名称，建议先修的课程在课程名称后用*号标注，并在下一行注明：*Recommended, not required as prerequisite 线性代数、概率论、计算机科学基础**
8. **课程概要 Course Description:** 100 字以内，学习内容以学术关键词出现。

本课程讲授图机器学习核心技术，覆盖图表示学习、图神经网络、知识图谱、图 Transformer、生成模型、3D 几何深度学习及 LLM 与 GNN 融合，面向大规模图分析与应用。

9. **课程预期学习成果 Course Outcomes:** 用数字 1 到 9 列出每一项主要学习成果

(1) 掌握图结构与图表示学习基础理论
(2) 掌握节点嵌入方法（DeepWalk、node2vec）
(3) 掌握图神经网络（GNN）核心架构与训练
(4) 理解 GNN 表达能力与理论边界
(5) 掌握图 Transformer 与异构图学习
(6) 掌握知识图谱嵌入与逻辑推理
(7) 掌握图推荐系统与关系深度学习
(8) 掌握图生成模型与 3D 几何深度学习
(9) 具备大规模图分析与代码实践能力

10. **教学内容与学时分配 Course Content, Laboratories and Laboratory Hours（有则填，没有则不填）, Colloquia Hours（有则填，没有则不填）：**各章节目录与学时，实验内容与学时，研讨内容与学时

(1) 基础与节点嵌入：2 学时 讲授 + 2 学时 实验
(2) 图神经网络（GNN）：2 学时 讲授 + 2 学时 实验
(3) GNN 训练与理论：2 学时 讲授 + 2 学时 实验
(4) 高级架构（图 Transformer、异构图）：2 学时 讲授 + 2 学时 实验
(5) 知识图谱：2 学时 讲授 + 2 学时 实验

(6) 应用与关系深度学习：2 学时 讲授 + 2 学时 实验

(7) 前沿主题与基础模型：2 学时 讲授 + 2 学时 实验

(8) 生成模型与几何深度学习：2 学时 讲授 + 2 学时 实验

11. 考核与成绩评定 Grading:

Homework+Project: 100%

12. **教材，参考书 Text & Reference Book:** 作者，书名，版本，年份，国际标准书号 ISBN

13. 编写教师 Course Lecturer：

编写教师 Course Lecturer（签字）：Ayush Joshi，Sanyuan Zhao

附录：英文课程教学大纲模板

附录：

Machine Learning with Graphs

1. 课堂讲授学时 Lecture Hours: 16
2. 课堂实验学时 Laboratory Hours: 16
3. 课下研讨学时 Colloquial Hours: 0
4. 学生课下投入学时 Individual Study Hours: 16
5. 学分 Credits: 2
6. 开课学年学期（如果有强制性的要求则 必须填， 否则可以不填） Occurrence: Summer Course
7. 先修课程 Prerequisite(s): Programming-related courses* (*Recommended, not required as prerequisite) Linear Algebra, Probability Theory, Fundamentals of Computer Science
8. 课程概要 Course Description: 100 字以内 ， 学习内容以学术关键词出现。

This course teaches core technologies of graph machine learning, covering graph representation learning, graph neural networks, knowledge graphs, Graph Transformer, generative models, 3D geometric deep learning, and the integration of LLM and GNN, targeting large-scale graph analysis and practical applications.

9. 课程预期学习成果 Course Outcomes:

By the end of successful completion of this course, the student will be able to:

Students are expected to achieve a comprehensive understanding of underlying graph structures and their features, successfully applying machine learning and data mining tools to extract insights from massive networks. In detail:

(1) Analyzing Massive Graphs: Students will tackle the computational, algorithmic, and modeling challenges that are specific to analyzing massive network structures.

(2) Applying ML to Networks: The course aims to equip students with the machine learning techniques and data mining tools necessary to reveal insights across various systems, including social, technological, and biological networks.

(3) Mastering Graph Concepts: Key learning topics include representation learning, Graph Neural Networks (GNNs), reasoning over Knowledge Graphs, algorithms for the World Wide Web, influence maximization, disease outbreak detection, and social network analysis.

(4) Practical Coding and Theory: Students will solidify their learning through a mix of practical coding in assignments and theoretical concepts which will be tested in the final assessment.

10. 教学内容与学时分配 Course Content, Laboratories and Laboratory Hours（有则填，没有则不填）, Colloquial Hours（有则填，没有则不填）;

(1) Module 1[2 hour Lecture, 2 hour labs]: Foundations and Node Embeddings: Introduction to the course, followed by techniques for node embeddings, including DeepWalk, node2vec, and Network Embedding as Matrix Factorization.

(2) Module 2 [2 hour Lecture, 2 hour labs]: Graph Neural Networks (GNNs): Introduction to GNNs (Geometric Deep Learning, Graph Convolutional Networks), followed by a general perspective on GNN design, inductive representation learning, and Graph Attention Networks.

(3) Module 3 [2 hour Lecture, 2 hour labs]: GNN Training and Theory: GNN augmentation and training (e.g., differentiable pooling) and two sessions dedicated to the theory of GNNs, exploring their limits, positional awareness, and substructure counting.

(4) Module 4 [2 hour Lecture, 2 hour labs]: Advanced Architectures: Exploring Graph Transformers, spectral graph representation, and handling Heterogenous graphs to model complex relational data.

(5) Module 5 [2 hour Lecture, 2 hour labs]: Knowledge Graphs: Embedding entities/relations for knowledge base completion, complex embeddings, and reasoning over knowledge graphs using logical queries and box embeddings.

(6) Module 6 [2 hour Lecture, 2 hour labs]: Applications and Relational Deep Learning: Applying GNNs to web-scale recommender systems (e.g., Neural Graph Collaborative Filtering, LightGCN), followed by Relational Deep Learning on relational databases.

(7) Module 7 [2 hour Lecture, 2 hour labs]: Advanced Topics & Foundation Models: In-context learning over graphs, uncertainty quantification, and moving towards Foundation Models for Knowledge Graphs (inductive link prediction, relation graphs) .

(8) Module 8 [2 hour Lecture, 2 hour labs]: Generative Models & Geometric Deep Learning: Deep generative models for realistic graphs and goal-directed generation, followed by Geometric Deep Learning focusing on rotation/translation-equivariant networks for 3D point clouds and molecular conformation.

11. 考核与成绩评定

Homework+Project: 100%

12. 教材，参考书 Text & Reference Book: Yang, C. (2017). Introduction to GIS Programming and Fundamentals with Python and ArcGIS. (1st edition). CRC Press

13. 编写教师Course Lecturer: Ayush Joshi, Sanyuan Zhao

编写教师 Course Lecturer（签字）：