

## **Tárgyleírás angol nyelvű képzés tárgya esetén**

**Tárgy neve: Graph Neural Networks**

**Tárgyfelelős neve: Gulyás László**

**Tárgyfelelős tudományos fokozata: PhD**

**Tárgyfelelős MAB szerinti akkreditációs státusza: AT**

**Az oktatás célja angolul / Aim of the subject:**

### **Knowledge**

- Detailed knowledge of graph-structured data, traditional and advanced methods for graph representation, and neural network models tailored for graph data.
- Complex and up-to-date knowledge of machine learning methods for graph data structures.
- Comprehensive and up-to-date understanding of Graph Neural Networks, including their architecture, applications, and limitations.
- Has a high level of detailed knowledge and understanding of the technical vocabulary of the relevant field, expressive and conceptual features in English.

### **Abilities:**

- Has the ability to plan, develop, operate, and manage complex machine learning systems for various graph applications, including node and graph clustering, edge prediction, etc.
- Ability to design, implement, and evaluate Graph Neural Network models for various tasks, including node classification, link prediction, and graph classification.
- Proficiency in using Python libraries such as PyTorch Geometric for graph manipulation and neural network implementation.
- Able to communicate in written and spoken English with a high level of technical vocabulary in the field participate in discussions, prepare reports, scientific, technical, and professional technical/technical material (books, articles, etc.) and use it in a creative way.
- Ability to critically analyze research papers, extract relevant knowledge, and apply it to solve practical problems in the field.
- Can work proactively in a collaborative and project (team) environment.
- Has the ability to apply IT skills to a wide range of multidisciplinary professional in a multidisciplinary environment.

### **Attitude:**

- They are committed to critical feedback and evaluation based on self-examination.
- They are committed to lifelong learning, and they are open to acquiring new competencies.
- They share their knowledge and consider it important to discuss their solutions with others.
- They are open to proactive collaboration with other professionals.

### **Autonomy, responsibility:**

- They undertake to meet deadlines and to have deadlines met.

- They bear responsibility for their own studies as well as for the development of their classmates.

### **Az oktatás tartalma angolul / Major topics:**

- Elementary and complex graph properties (centralities, clustering techniques, various classes of graphs, and their generative models)
- Introduction to Graph Neural Networks (GNNs): definitions, applications across different domains (recommendation systems, drug discovery, and social networks)
- Graph representation and classic machine learning methods for graphs (adjacency matrices, Laplacian matrices, and spectral graph theory; classic approaches: DeepWalk and Node2Vec)
- GNN architectures and message passing (architectures of GNNs, message-passing techniques, and types of graph convolutions)
- Detailed applications of GNNs (e.g., link prediction, node classification, and graph classification)
- Classic GNN models (e.g., GCN, GAT, etc.)
- Limitations of classic GNNs: scalability, interpretability, and over-smoothing issues)
- Advanced GNNs: Position-aware Graph Neural Networks, Identity-aware Graph Neural Networks, Adversarial Attacks on Neural Networks for Graph Data
- Recent directions and challenges in GNNs: scalability, interpretability, and efficiency, geometric graph learning and potential ethical considerations in GNN research

### **A számonkérés és értékelés rendszere angolul / Requirements and evaluation:**

Mixed assessment (project assignments and written tests)

### **Irodalom / Literature:**

1. Advances in Graph Neural Networks by Chuan Shi, Xiao Wang, Cheng Yang, Springer, 2023, ISBN: 9783031161735.
2. Kipf, T. N., & Welling, M. (2016). Semi-Supervised Classification with Graph Convolutional Networks. arXiv:1609.02907.
3. Velickovic, P., et al. (2018). Graph Attention Networks, 6th International Conference on Learning Representations
4. *Machine Learning with Graphs* (CS224W, Stanford University) (online)
5. *Graph Neural Networks* (ESE 5140, Penn University) (online)