COMP 5250/6250: ALGORITHMS FOR AI

Course Description: This course introduces the core computational concepts that power modern Artificial Intelligence systems. The course covers foundational data structures, algorithmic thinking, search, graphs, optimization, and scalable computation through AI- and machine learning-driven applications. Students will develop the computational reasoning skills necessary to design, analyze, and implement efficient AI workflows and intelligent systems.

Prerequisites: COMP 5230/6230 and COMP 5100/6100, or equivalent with department approval.

Credit Hours: 3

Objectives: By the end of this course, students will be able to:

- Demonstrate foundational algorithmic and computational thinking for Artificial Intelligence systems.
- Analyze the efficiency and scalability of algorithms and data structures used in AI and machine learning workflows.
- Implement and apply common data structures including arrays, hash maps, trees, graphs, and priority queues in AI-driven applications.
- Apply classical search, traversal, and optimization algorithms to intelligent agents and decision-making problems.
- Understand the role of similarity search, embeddings, and retrieval systems in modern AI applications.
- Interpret computational tradeoffs related to memory, runtime, scalability, and data organization in AI systems.
- Design and evaluate simple AI pipelines using appropriate algorithms and data structures.
- Communicate computational solutions and reasoning effectively in the context of AI and machine learning applications.

Tentative Course Outline:

Week 1: Computational Thinking for AI, Algorithms and Complexity for AI

Week 2: Arrays, Lists, Stacks, Queues, and Efficient Data Organization, Assignment 1

Week 3: Hash Maps, Dictionaries, Sets, and Lookup Structures for AI Pipelines

Week 4: Trees, Binary Trees, Hierarchical Representations, Decision Trees, Assignment 2

Week 5: Graphs, Graph Representations, Traversal Algorithms, Knowledge Graphs

Week 6: Search Algorithms Part 1 — Breadth-First Search, Depth-First Search, Pathfinding

Week 7: Search Algorithms Part 2 — Heuristic Search, Greedy Search, A* Search, Assignment 3

Week 8: Midterm Review and Midterm Examination

Week 9: Sorting, Ranking, Similarity Search, and Recommendation Systems

Week 10: Dynamic Programming, Optimization, and Sequential Decision Making, Assignment 4

Week 11: Probabilistic and Randomized Algorithms, Sampling, Monte Carlo Methods

Week 12: Embeddings, Vector Similarity, Nearest Neighbor Search, Retrieval Systems

Week 13: Distributed and Scalable AI Systems, Parallelism, GPU Computing, Data Pipelines, Assignment 5

Week 14: Algorithms for Modern AI Applications — Agents, Planning, Retrieval-Augmented Generation, Recommendation

Week 15: Ethical and Societal Considerations in Large-Scale AI Systems

Week 16: Course Review and Final Exam