Syllabus
Graph Algorithms

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Approved by The Academic Council
Protocol No 3 June 20, 2019

1. Course Description

a. Pre-requisites

The Course is to be based on the acquisition of the following Courses:

- Mathematical analysis;
- Linear algebra;
- Discrete mathematics.

b. Abstract

Graphs arise in various real-world situations, as there are road networks, water and electricity supply networks, computer networks and, most recently, social networks. The best way to connect set of computers into a network or efficient algorithm to automatically find communities and opinion leaders in Facebook, we're going to work with graphs and algorithms on graphs.

In this course students will learn what a graph is and its most important properties. Students will learn several ways to traverse graphs and how you can do useful things while traversing the graph in some order. We will also talk about shortest paths algorithms. We will finish with minimum spanning trees, which are used to plan road, telephone and computer networks and also find applications in clustering and approximate algorithms.

c. Course Type

Blended learning

2. Learning Objectives

The objective of this course is to form a foundation of graph algorithms.

3. Learning Outcomes

On completion of the course, the students learn how to use algorithms to explore graphs, compute shortest distance, min spanning tree, and connected components.

4. Course Plan

Topic 1. Decomposition of Graphs.

In this topic, we will learn ways to represent a graph as well as basic algorithms for decomposing graphs into parts. In the programming assignment of this module, you will apply the algorithms that we've learned to implement efficient programs for exploring mazes, analyzing Computer Science curriculum, and analyzing road networks. We focus on undirected graphs.

Topic 2. Shortest Paths.

In this topic we will study algorithms for finding Shortest Paths in Graphs. These algorithms have lots of applications. When you launch a navigation app on your smartphone like Google Maps or Yandex.Navi, it uses these algorithms to find you the fastest route from work to home, from home to school, etc. When you search for airplane tickets, these algorithms are used to find a route with the minimum number of plane changes. Unexpectedly, these algorithms can also be used to determine the optimal way to do currency exchange, sometimes allowing to earn huge profit! We will cover all these applications, and you will learn Breadth-First Search, Dijkstra's Algorithm and Bellman-Ford Algorithm. These algorithms are efficient and lay the foundation for even more efficient algorithms which you will learn and implement in the Shortest Paths Capstone Project to find best routes on real maps of cities and countries, find distances between people in Social Networks. In the end you will be able to find Shortest Paths efficiently in any Graph.

Topic 3. Minimum Spanning Trees.

In this topic, we study the minimum spanning tree problem. We will cover two elegant greedy algorithms for this problem: the first one is due to Kruskal and uses the disjoint sets data structure, the second one is due to Prim and uses the priority queue data structure. In the programming assignment for this module you will be computing an optimal way of building roads between cities and an optimal way of partitioning a given set of objects into clusters (a fundamental problem in data mining).

Topic 4. Flows in Networks.

Network flows show up in many real-world situations in which a good needs to be transported across a network with limited capacity. We can see it when shipping goods across highways and routing packets across the internet. In this unit, we will discuss the mathematical underpinnings of network flows and some important flow algorithms. We will also give some surprising examples on seemingly unrelated problems that can be solved with our knowledge of network flows.

5. Reading List

All materials in https://www.edx.org/course/graph-algorithms-uc-san-diegox-algs202x#

6. Grading System

The student's final assessment consists of the assessment of the exam A_{exam} and the accumulated assessment A_{acc} obtained on the platform https://www.edx.org/course/graph-algorithms-uc-san-diegox-algs202x# as follows: $A_{final} = (A_{acc} + A_{exam})/2$.

7. Examination Type

Oral examination. Control elements are not blocking.

8. Methods of Instruction

The course is being studied on the online platform https://www.edx.org/course/graph-algorithms-uc-san-diegox-algs202x#

9. Special Equipment and Software Support (if required)

Not required