Advanced Programming

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- Course Information
- Introduction to Programming paradigms
- Introduction to Basic Programming in Python
- Data structure to represent knowledge and its practical use cases
- Object oriented programming
- Functional Programming
- Analysis of Algorithms - Time and space complexities

EXPECTATIONS!

- The course does not require any background in programming, but requires considerable dedication and hard work
- Attend all the classes
- Submit assignments on time. There will be no extensions
- Learn more about your machine
- Practice, practice..., practice$^{\infty}$

COURSE LOGISTICS

- Grades are based on quizzes, mid semester exam, assignments and End semester Exams
- There will be at least 6 quizzes
- There will be at least 8 assignments
- Quizzes and Mid/End semester exams - 60%
- Assignments - 40%
- Submit all assignments using Colab

Books

- [1] *Introduction to Algorithms, Third Edition*
- [2]*Algorithm Design*
- [3] *Algorithms*
- Python official Documentation for 3.12.1

Algorithmic Patterns

SIMPLE PATTERNS

- An algorithmic pattern describes a core solution strategy for solving a problem
- There are/may be several solutions to the same problem
- It is important to examine the problem and choose the right technique
- Simple Patterns
  - Sequential
  - Iterative
  - Recursive
- Brute Force

DIVIDE AND CONQUER

Break down a problem into smaller, self-similar subproblems - solve them iteratively or using recursive approach

- Merge sort
- Quick sort
- Matrix Multiplication
- Fast Fourier Transform
- Nearest Neighbors

GREEDY ALGORITHMS

Make locally optimal choices at each step, hoping to reach a global optimum

- Dijkstra's shortest path algorithm
- Beam search

DYNAMIC PROGRAMMING

Breaking the problem into multiple overlapping subproblems

- Levenshtein distance
- Travelling Saleman

BACKTRACKING

- Explore possible solutions by building a solution incrementally
- Backtrack (undo choices) if a solution path doesn't lead to a valid solution
  - N-Queens problem - placing 8 queens in a chess board in a way that no two queens attack each other
  - Sudoku solver item Route planing

MORE ALGORITHMIC PATTERNS

- Hill climbing - Finding an approximate solution to a problem by generating candidate solutions that are better solutions over the previous candidate solutions
  - Machine Learning algorithms, many image processing algorithms
- Branch and bound
  - Making a round trip by visiting N cities - find the shortest path that visits all cities with the minimum total distance
  - - Assembly line of manufacturing
- Monte Carlo
- Particle Swarm Optimization
- Las Vegas

Programming Paradigms

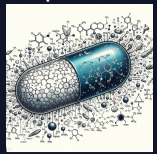
PROCEDURAL PROGRAMMING

- Breaks the programs into multiple procedures/subroutines
- Uses statements that change a program's state, like assignments and control flow structures (if-else, while, for loops)

OBJECT ORIENTED PROGRAMMING

- Abstraction
  - Hide the internal working of the function - we will what it does but will not know how it does
- Encapsulation
  - Placing data and methods in a single unit - restricting and or protecting internal variables from direct access to prevent the unauthorized use of data
- Inheritance
  - Eliminate redundancy
- Polymorphisms
  - Taking multiple forms of actions using a single interface to the outsize world

Examples - Banking application, capsule, car



FUNCTIONAL PROGRAMMING

Function as First class citizen - Treats computation as the evaluation of mathematical functions

- Uses functions to transform inputs into outputs without modifying external data - Avoids side-effects

Example

Lisp, Haskel, Clojure, Scala

DECLARATIVE PROGRAMMING

Specifies the desired output, not the exactly how it should be achieved

Example

Structured Query Language

LOGIC PROGRAMMING

Expresses problems as logical statements and relationship

Example

Prolog - Uses rules and inference mechanisms to derive solutions

EVENT-DRIVEN PROGRAMMING

- Program flow driven by events (user actions, system signals, messages)
- Structure:
  - Program idle until an event occurs
  - Event loop monitors for events and triggers event handlers
  - Event handlers execute specific code blocks
- Use cases: GUI applications, web servers, game development, network communication, embedded systems

MULTIPROCESSING

- Key concept: Executing multiple processes concurrently
- Structure:
  - Each process has independent memory space and resources
  - Processes communicate through IPC mechanisms
- Use cases: CPU-intensive tasks, parallel computations, independent tasks

MULTITHREADING

- Key concept: Executing multiple threads within a single process
- Structure:
  - Threads share memory space and resources
  - Threads communicate and synchronize more easily than processes
- Use cases: I/O-bound tasks, improving GUI responsiveness, web servers

REFERENCES

[1] Thomas H. Cormen et al. *Introduction to Algorithms, Third Edition*. 3rd. The MIT Press, 2009. ISBN: 0262033844.

[2] Jon Kleinberg and Eva Tardos. *Algorithm Design*. Addison Wesley, 2006.

[3] Sanjoy Dasgupta, Christos H. Papadimitriou, and Umesh Vazirani. *Algorithms*. 1st ed. USA: McGraw-Hill, Inc., 2006. ISBN: 0073523402.