CH-231-A

Algorithms and Data Structures

ADS

Lecture 6

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Spring 2020

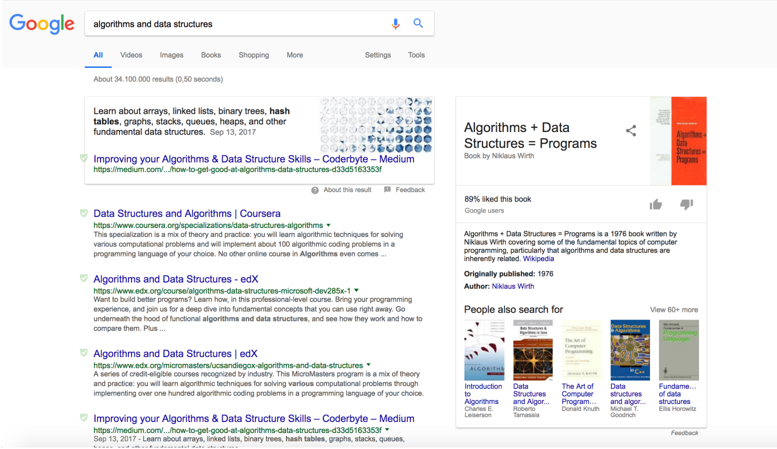
Definition: Algorithm

- An algorithm is a sequence of computational steps which transforms a set of values (input) to another set of values (desired output)
- It is a tool for solving a well-defined computational problem
- Step-wise procedure that can be implemented in a computer program
- Consists of a finite list of well-defined instructions (Turing machine)
- 'Algorithm' stems from 'Algoritmi', the Latin form of al-Khwārizmī, a Persian mathematician, astronomer and geographer

Example: Sorting Problem

- Input
  sequence $< a_1, a_2, ..., a_n >$ of numbers
- Output
  permutation $< a'_1, a'_2, ..., a'_n >$
  such that $a'_1 \leq a'_2 \leq ... \leq a'_n$
- Example (instance of sorting problem):
  Input: 8 2 4 9 3 6
  Output: 2 3 4 6 8 9

Example: Searching



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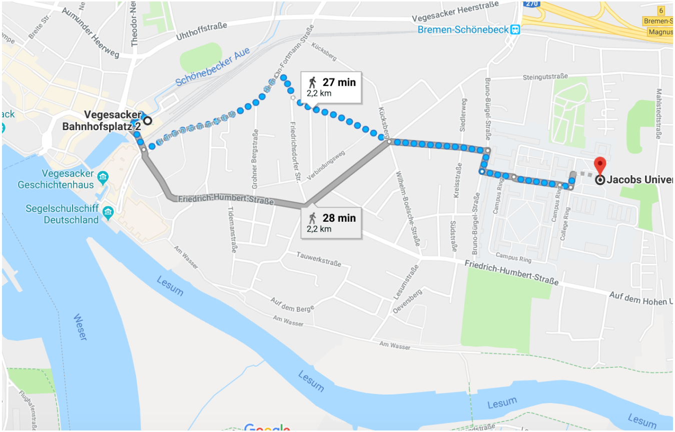
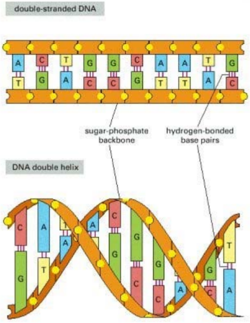
Example: Road map



Graph algorithm

Example: DNA Sequences



String matching

Analysis of Algorithms

- The theoretical study of computer-program performance and resource usage
- Other design goals?
    - correctness
    - functionality
    - robustness
    - reliability
    - user-friendliness
    - programmer time
    - simplicity
    - modularity
    - maintainability
    - extensibility

Performance of Algorithms

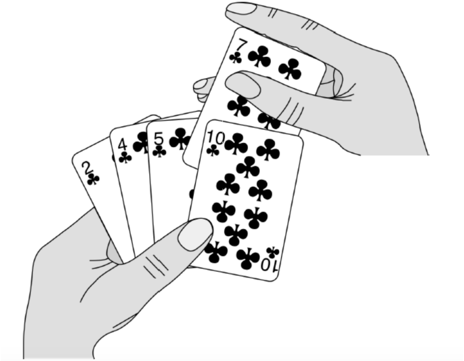
- Analysis helps us to understand scalability
- Performance often draws the line between what is feasible and what is impossible
- Algorithmic mathematics provides a language for talking about program behavior
- "Performance is the currency of computing"
- The lessons of program performance generalize to other computing resources

Definition: Data Structure

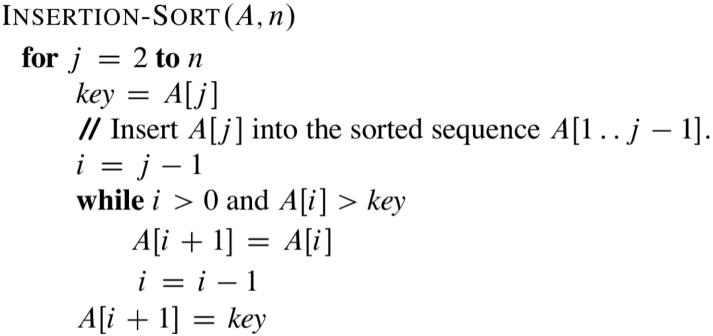
- A data structure is a way to store and organize data in order to facilitate access and modification
- There is typically no best data structure, but each data structure has its strengths and weaknesses
- Which data structure to use, depends on the problem that is to be solved
- Sometimes there is a trade-off between storage (in a data structure) and speed (in accessing a data structure or of an algorithm)

Sorting Problem

First algorithm: Insertion sort



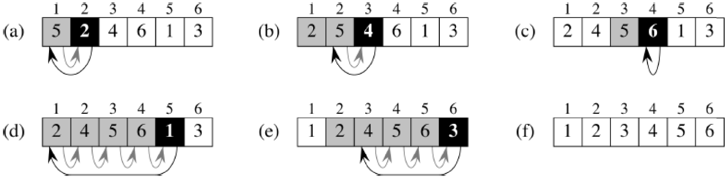
Insertion Sort



```
INSERTION-SORT$(A, n)$
  for $j = 2$ to $n$
      $key = A[j]$
      // Insert $A[j]$ into the sorted sequence $A[1..j-1]$.
      $i = j - 1$
      while $i > 0$ and $A[i] > key$
          $A[i+1] = A[i]$
          $i = i - 1$
      $A[i+1] = key$
```

Insertion Sort: Example

Sort $A = < 5, 2, 4, 6, 1, 3 >$



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