

CH-231-A

Algorithms and Data Structures

ADS

Lecture 6

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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 $\langle a_1, a_2, \dots, a_n \rangle$ of numbers
- ▶ Output
permutation $\langle a'_1, a'_2, \dots, a'_n \rangle$
such that $a'_1 \leq a'_2 \leq \dots \leq a'_n$
- ▶ **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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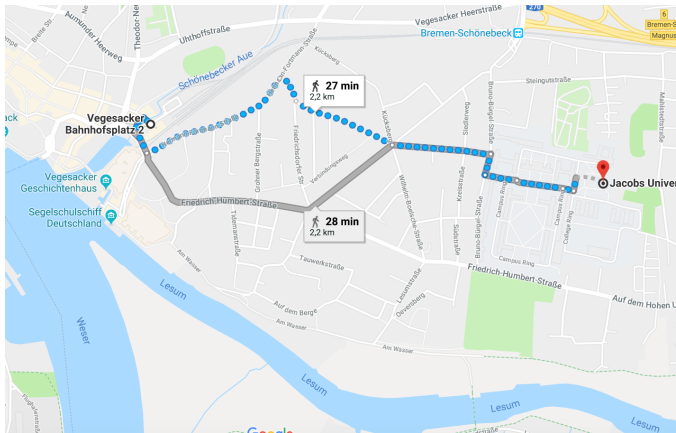
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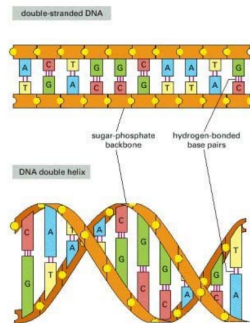
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Example: Road map



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

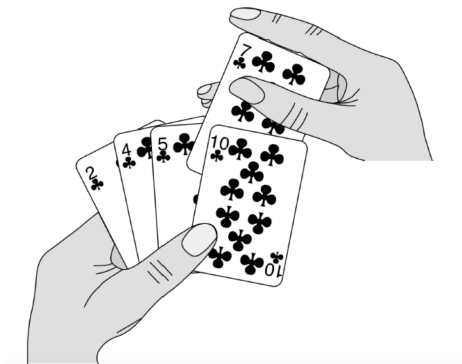
- ▶ Analysis helps us to understand scalability
- ▶ Performance often draws the line between what is feasible and what is impossible
- ▶ Algorithmic mathematics provides a language for talking about program behavior
- ▶ "Performance is the currency of computing"
- ▶ The lessons of program performance 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 $A[1 \dots j - 1]$.

$i = j - 1$

while $i > 0$ and $A[i] > key$

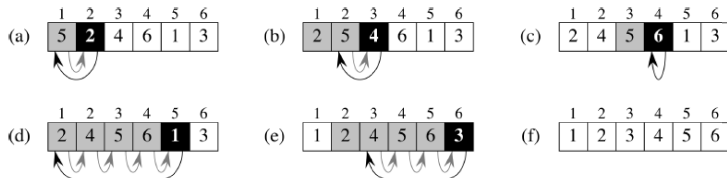
$A[i + 1] = A[i]$

$i = i - 1$

$A[i + 1] = key$

Insertion Sort: Example

Sort $A = \langle 5, 2, 4, 6, 1, 3 \rangle$



INSERTION-SORT(A, n)

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$key = A[j]$

 // Insert $A[j]$ into the sorted sequence $A[1 \dots j - 1]$.

$i = j - 1$

while $i > 0$ and $A[i] > key$

$A[i + 1] = A[i]$

$i = i - 1$

$A[i + 1] = key$