Algorithm, Pseudocode and Flowchart

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Outline

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Introduction

Introduction

- Algorithms, flowcharts, and pseudocode are essential tools for problem-solving
- They provide a bridge between problem analysis and actual programming
- This lecture introduces their concepts, notations, and best practices

Control Structures

Control Flow and Structure of a Program

- Need to be familiar with control structure to be able to write algorithms
- Control flow or control structure can be divided into a few types:
  - Sequence: step by step execution of commands from top to bottom
  - Selection: exceuting a codeblock if certain conditions are met (if-else statement)
  - Iteration: repeatedly executing a codeblock while a certain condition is true, stop the loop if the codition is no longer true
- Every program can be built using the three structures

Additionally, functions (collection of commands) with zero or more inputs can be defined.

Sequence

- Default mode of execution: step by step
- Example: Read number, calculate square, print result

Selection

- **IF**: execute a block if condition is true
- **IF-ELSE**: choose between two alternatives
- **ELSE IF ladder**: multiple conditions

Iteration

- **FOR loop** – fixed number of iterations (repeatedly execute commands for a fixed number of times)
- **WHILE loop** – repeatedly execute while condition is true
- **DO-WHILE loop** – run the commands at least once, then repeat if condition holds

Break and Continue

- **BREAK**: exit the nearest loop immediately (`exit` in Fortran)
- **CONTINUE**: skip rest of current iteration, proceed to next (`cycle` in Fortran)

Functions

- Collection of commands that perform a specific task
- Usually given a name
- Can have zero or more inputs

Recursion

- Function calling itself to solve smaller subproblems
- Example: factorial, Fibonacci
- Must have a base case to terminate

Algorithms

What is an Algorithm?

- A step-by-step procedure to solve a problem
- Unambiguous and finite sequence of instructions
- Example: A recipe for cooking is an algorithm in real life

Characteristics of a Good Algorithm

- Finiteness: must terminate after finite steps
- Definiteness: each step is clearly defined
- Input: specified set of inputs
- Output: specified set of outputs
- Effectiveness: steps can be performed with available resources

Examples of Simple Algorithms

- Finding the maximum of three numbers
- Calculating factorial of a number
- Linear search in an array

Example Algorithm: Finding the Area of a Triangle

1. Input base, b and height, h
2. Let area, $a = bh/2$
3. Output a

Example Algorithm: Factorial of a Number

1. Input an integer, n
2. Set result = 1
3. While n is larger than 1, repeat the following:
   - result = result × n
   - n = n - 1
4. Output the result

Note: In step 3, “While” is a looping construct.

The statements under the “While” key-word are executed repeatedly as long as the condition (n is larger than 1) is true.

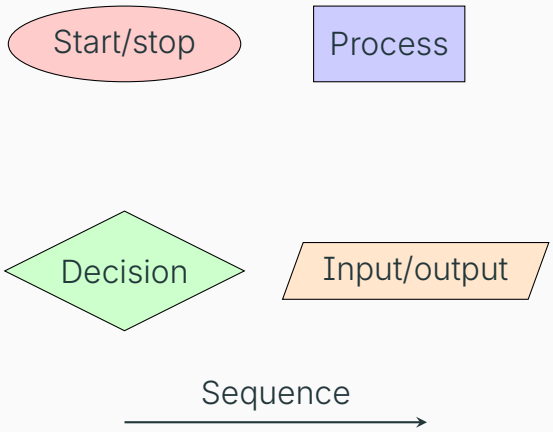
Flowcharts

Definition and Purpose

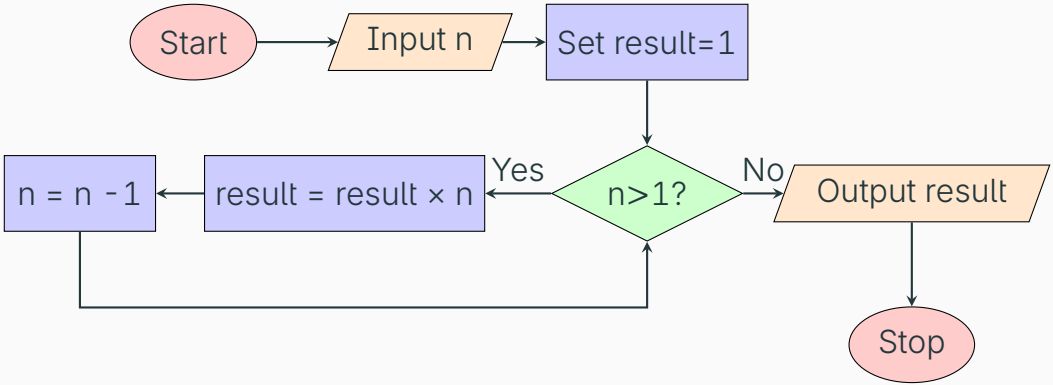
- Flowchart: graphical representation of an algorithm
- Uses standard symbols to show the flow of control
- Helps visualize program logic before coding

Flowchart Shapes

- **Start/Stop**: ellipse
- **Process**: rectangle
- **Decision**: diamond
- **Input/Output**: parallelogram
- **Sequence**: arrow



Example Flowchart: Factorial of a Number



Pseudocode

Purpose of Pseudocode

- Represents algorithms in structured, human-readable code
- Independent of programming language, but may include programming key-words
- Easier to understand and refine before coding

Conventions

- Indentation to show structure
- Keywords like IF, WHILE, FOR
- Use natural language mixed with structured logic

Example pseudocode: Area of a Triangle

```
Start
Input base, height
Set area = base * height / 2
Output area
End
```

Example pseudocode: Factorial of a Number

```
Start
Input n
Set result = 1
While n>1:
    result = result * n
    n = n - 1
EndWhile
Output result
End
```

Example Pseudocode: Factorial of a Number using Recursion

A recursive function (function that calls itself) named `Factorial()` is defined that takes a single input:

```
Function Factorial(n):
    If (n==0):
        Return 1
    Else:
        Return n * Factorial(n-1)
    EndIf
EndFunction
```

Note: “a==b” checks whether a is equal to b, returns True if they are equal, otherwise, returns False.

Best Practices

- Keep flowcharts clean and uncluttered
- Use consistent symbols and indentation
- Pseudocode should be language-independent
- Algorithms should be logically ordered and unambiguous

Common Pitfalls

- Overcomplicating flowcharts with too many details
- Ambiguous pseudocode (mixing multiple languages)
- Ignoring edge cases in algorithms
- Writing unstructured logic

Putting It All Together

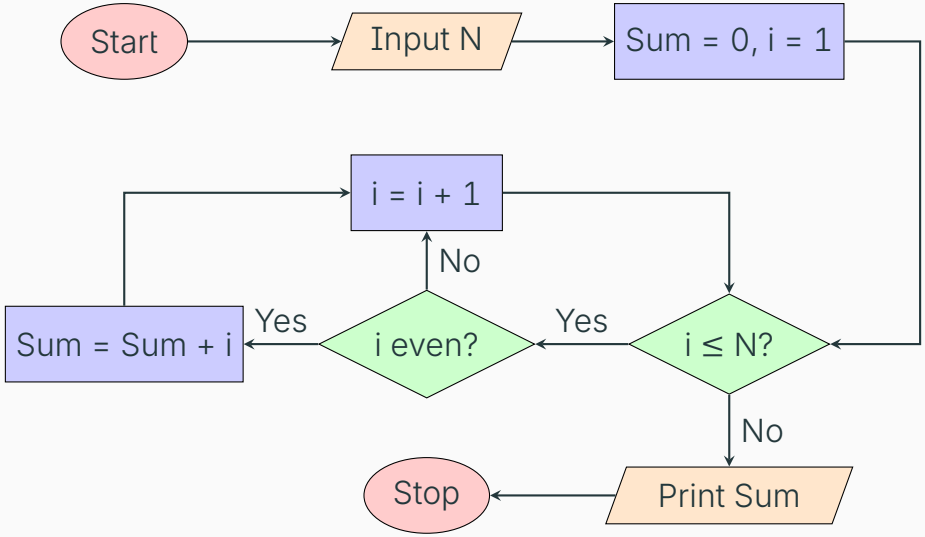
Example task

Compute the sum of all even numbers from 1 to N

Algorithm

1. Read n
2. Set sum = 0, i = 1
3. While i <= n:
    - If i is even, add i to sum, else do nothing
    - Add 1 to i
4. Print sum

Flowchart


Start
Input N
Sum = 0, i = 1
i = i + 1
No
Sum = Sum + i
Yes
i even?
Yes
i ≤ N?
No
Stop
Print Sum

Pseudocode

```
Start
Input n
sum = 0
i = 1
While (i <= n):
    If (i is even):
        sum = sum + i
    EndIf
    i = i + 1
EndWhile
Output sum
End
```

Example: Find whether a number is even or odd

```
Start
Input num
If (num mod 2 == 0):
    Output Even
Else
    Output Odd
End
```

Note: In the above, $x \bmod y$ returns the remainder when x is divided by y.

Example: Solution of quadratic equation

The equation is given as: $ax^2 + bx + c = 0$

```
Start
Input a, b, c
x1 = (-b + sqrt(b^2 - 4ac)) / 2a
x2 = (-b - sqrt(b^2 - 4ac)) / 2a
Output x1, x2
End
```

Note: In the above, `sqrt(p)` returns the square root of p.

Exercises

Exercises

1. Design an algorithm and flow chart to find the largest of the three numbers
2. Develop pseudocode for computing the sum of the digits of a given integer
3. Write an algorithm and pseudocode to check whether a number is prime

Questions?