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.

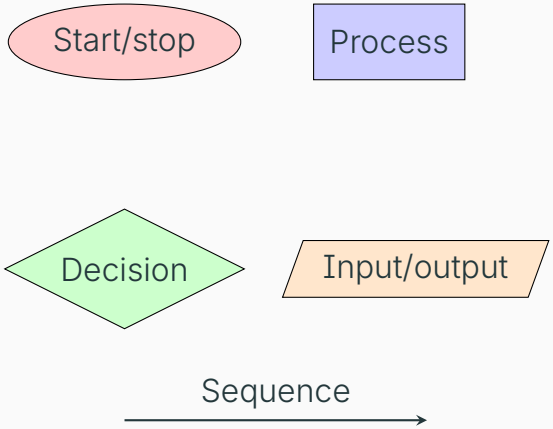
Flowcharts

Definition and Purpose

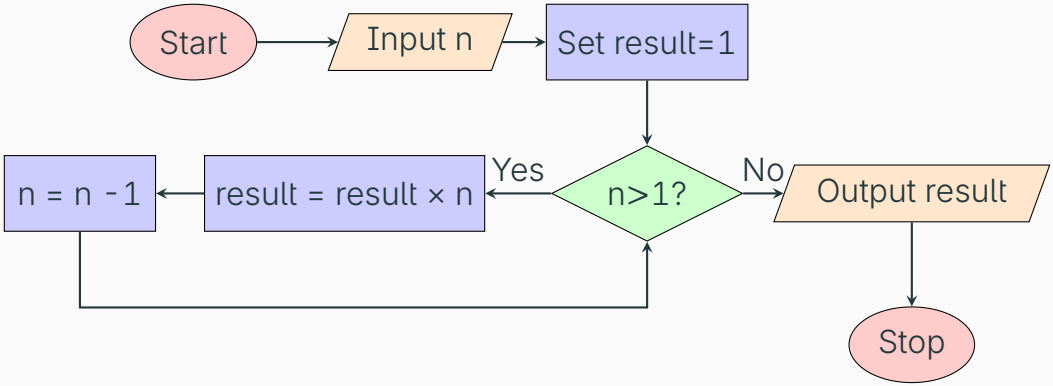
- Flowchart: graphical representation of an algorithm
- Uses standard symbols to show the flow of control
- Helps visualize program logic before coding

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

Examples

Putting It All Together

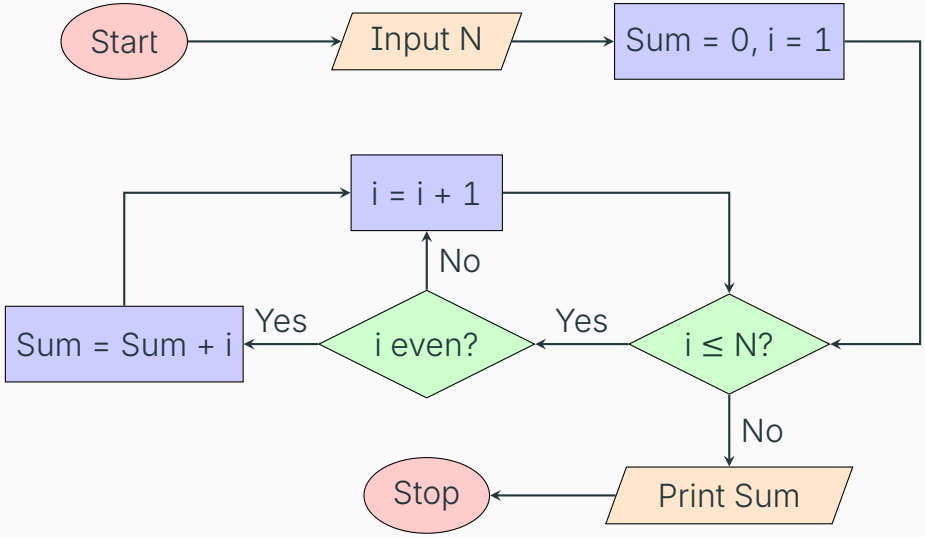
Example task

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.

Example: Quadratic Equation: Handling Edge-Case

Sometimes a quadratic equation may not have real-valued solutions.

```
Start
Input a, b, c
If (b^2 - 4ac) < 0:
    Output: No real-valued soltions
Else:
    x1 = (-b + sqrt(b^2 - 4ac)) / 2a
    x2 = (-b - sqrt(b^2 - 4ac)) / 2a
    Output: x1, x2
EndIf
End
```

Example: Quadratic Equation: Handling Edge-Case (cont.)

Sometimes, there might be only one real-valued solution.

```
Start
Input a, b, c
If (b^2 - 4ac) < 0:
    Output: No real-valued soltions
ElseIf (b^2 - 4ac) == 0:
    x = -b / 2a
    Output: x
Else:
    x1 = (-b + sqrt(b^2 - 4ac)) / 2a
    x2 = (-b - sqrt(b^2 - 4ac)) / 2a
    Output: x1, x2
EndIf
End
```

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?