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Algorithms
And Flowcharts

Starting definition
Input + Processing → Output
A Computer is:
• a device that takes information (input),
• processes that info to create new information
and
• gives the new information back (output)

Two Computer Elements
• Hardware

Two Computer Elements
• Hardware
• Software

The physical components that make up a computer system.
Two Computer Elements

- Hardware
- Software

The instructions, or steps controlling what the computer does.

Hardware Running Software

When written in a computer’s machine language – made up of 0’s and 1’s – the computer’s hardware can perform the actual steps – or the algorithm – that the code is trying to implement.

Algorithm

An algorithm is any well-defined computational procedure that takes some value or set of values as input and produces some value or set of values as output.

Programming Languages

Later we will see algorithms can be implemented on a computer system by using a variety of programming language to precisely encode the procedures or steps that need to be done.

Machine vs High-level Language

- Machine language uses 0’s and 1’s and can be directly understood by the computer’s hardware
- High-level programming languages use certain words, symbols and numbers that a programmer can understand but hardware cannot.
- High-level code has to be converted to machine language in order for it to run

Back to Algorithms

- Programming languages are used to implement algorithms
- We will start talking about programming languages including Scratch in a little while
- However, before trying to design software using some language, one needs to know how to precisely convert a problem into an algorithm
Designing an Algorithm

- First, you have to **understand the problem**.
- After understanding, then **make a plan**.
- **Carry out the plan**.
- **Look back** on your work. How could it be better?

Understanding the Problem

- What are you asked to find or show?
- Can you restate the problem in your own words?
- Can you think of a picture or a diagram that might help you understand the problem?
- Is there enough information to enable you to find a solution?
- Do you understand all the words used in stating the problem?
- Do you need to ask a question to get the answer?

IPO

- When defining a computer, we referred to **Input**, **Processing** and **Output**
- Likewise, when working on an algorithm, it is useful to think of the necessary input, processing and output that must be done
- This is called the **IPO model**

Algorithm: Add the following test scores:

- **Start**
- **sum = 0**
- Input the first testscore - **90**
- **90, 78, 87, 67**
Algorithm: Add the following test scores:
- Start
- sum = 0
- Input the first test score - 90
- Add first test score to sum → sum = 90
- Input the second test score - 78
- Add to sum → sum = 168
- Input the third test score - 87
- Add to sum → sum = 255
- Input the fourth test score - 67
Algorithm: Add the following test scores:
- Start
- sum = 0
- Input the first test score - 90
- Add first test score to sum \( \rightarrow \) sum = 90
- Input the second test score - 78
- Add to sum \( \rightarrow \) sum = 168
- Input the third test score - 87
- Add to sum \( \rightarrow \) sum = 255
- Input the fourth test score - 67
- Add to sum \( \rightarrow \) sum = 322

Algorithm: Add the following test scores:
- Start
- sum = 0
- Input the first test score - 90
- Add first test score to sum \( \rightarrow \) sum = 90
- Input the second test score - 78
- Add to sum \( \rightarrow \) sum = 168
- Input the third test score - 87
- Add to sum \( \rightarrow \) sum = 255
- Input the fourth test score - 67
- Add to sum \( \rightarrow \) sum = 322
- Output sum

Carpet Example
- Calculate the cost of carpet for three rooms. The carpet price is $26.75 / square yard, padding is $6.50 / square yard. Price includes installation.

Carpet Example
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Carpet Example
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**INPUT:**
- **PROCESSING:**
  - Living room 18ft x 20ft = 360 sq ft
  - Dining room 12ft X 12ft = 144 sq ft
  - Family room 13ft x 20ft = 260 sq ft
  - 764 sq ft = ~85 Sq yd
  - Carpet price = 85 * 26.75 = 2273.75
  - Padding price = 85 * 6.50 =552.50

**OUTPUT:**
- Price to customer
- 2826.25 * 0.07 = 197.84

**OUTPUT:**
- Total cost of carpeting three rooms

IPO Example:
- Calculate the cost of carpet for three rooms. The carpet price is $26.75 / square yard, padding is $6.50 /square yard. Price includes installation.

**INPUT:**
- lengthRoom1, widthRoom1
- lengthRoom2, widthRoom2
- lengthRoom3, widthRoom3
- carpetPrice, paddingPrice
- taxRate

**OUTPUT:**
- totalCost of carpeting three rooms

Example IPO:
- Calculate the cost of carpet for three rooms. The carpet price is $26.75 / square yard, padding is $6.50 /square yard. Price includes installation.

**PROCESSING**
- sum = 0
- room1Size = lengthRoom1 * widthRoom1
- Add to sum: sum = sum + room1Size
- room2Size = lengthRoom2 * widthRoom2
- Add to sum: sum = sum + room2Size
- room3Size = lengthRoom3 * widthRoom3
- Add to sum: sum = sum + room3Size
- sum = sum / 9 (total sq yd)
- price = sum*carpetPrice + sum*paddingPrice
- tax = price * taxRate
- totalCost = price + tax
Algorithm

- **Solving the problem**
  - Start
  - sum = 0
  - Input length, width of room 1 (usually this is given in ft)
  - Calculate sq ft in room1
  - Add to sum
  - Input length, width of room2
  - Calculate sq ft in room2
  - Add to sum
  - Input length, width of room3
  - Calculate sq ft in room3
  - Add to sum (total sq ft)
  - Sum = sum / 9 (total sq yd)
  - Input CarpetPrice, PaddingPrice
    - price = sum*carpetPrice + sum*paddingPrice
  - Input taxRate
    - tax = price * taxRate
  - price = price + tax
  - Output price
  - Stop

Calculate the cost of carpet for three rooms. The carpet price is $26.75 / square yard, padding is $6.50 /square yard. Price includes installation.

**Flowcharts**

- A flowchart is a diagram made up of boxes, diamonds and other shapes, connected by arrows - each shape represents a step in the process, and the arrows show the order in which they occur. Flowcharting combines symbols and flowlines, to show figuratively the operation of an algorithm.

**Example: Add the following test scores:**

- Start
- sum = 0
- Input the first test score
  - Add first test score to sum → sum = 90
- Input the second test score
  - Add to sum → sum = 168
- Input the third test score
  - Add to sum → sum = 255
- Input the fourth test score
  - Add to sum → sum = 322
- Output sum
- Stop

**Visual Algorithms**

- Besides using IPOs, algorithms can also be represented graphically by using **flowcharts**
Example

- **Solving the problem**
  - Start
  - Sum = 0
  - Input length, width of room 1 (usually given in ft)
  - Calculate sq ft in room1
  - Add to sum
  - Input length, width of room2
  - Calculate sq ft in room2
  - Add to sum
  - Input length, width of room3
  - Calculate sq ft in room3
  - Add to sum

- **Input CarpetPrice, PaddingPrice**
  - Price = sum * carpetPrice + sum * paddingPrice
  - Input taxRate
  - Tax = price * taxRate
  - TotalPrice = price + tax

- **Output price
  - Stop**

Calculate the cost of carpet for three rooms. The carpet price is $26.75 / square yard, padding is $6.50 / square yard. Price includes installation.

Carpet buying

More output

You will really ASK the user to enter values.

Programming Languages

- IPOs and Flowcharts are useful to think through an algorithm
- But to get them to work on a computer, you need to encode them using a programming language
- Which ultimately is converted – or compiled – into the computer’s machine language.

Programming Languages

- Hundreds of them:
  - Early ones: BASIC, Fortran, Cobol
  - Others: PHP, Java, C++
  - What we are using: Scratch

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Scratch Programming
Lesson 1: Introduction

Scratch
- Start experimenting with it now
- Get software at: scratch.mit.edu or use it in lab
- Do the following:
  1) Load some sample code (use File: Import Projects: Examples) and Run it (click green flag)
  2) Create and save some sprites of your own
     - use New Sprite (lower right), Paint Sprite button
     - Use File:Save As or File:Export Sprite
  3) Design and save a stage
     - Click on stage (lower right) then Backgrounds tab (middle), then Edit button

The Environment

The Environment

The Environment

The Environment

Default Sprite

Objects
Sprites and Stage created and edited from here
The Environment

Available Statements and coding components (Motion)

The Environment

Statement Categories

The Environment

Menu Commands

use New to start new projects
use Save or Save As to preserve your work

The Environment

General Tools

Duplicate
Delete
Expand
Shrink
Can be used on sprites and code

The Environment

Coding Box

Create, add and edit scripts, costumes and sounds here
General Info

- You can have one or more sprites
- All the sprites can be active on the stage at one time
- Each sprite can have one or more scripts, costumes and sounds
- Multiple scripts can be simultaneously affecting what sprite does
- Sprites won’t do anything until at least one of their scripts is activated
- The first statement in a script usually tells what activates it, such as the Green Flag.

The Environment

- Green flag starts many scripts
- Red flag stops scripts

Building Scripts

- Grab statement or coding component you want from proper category
- Place into coding box
- Statements will snap together
- Fill in open spots in statements with proper coding components
- They are shaped so they can only fit into certain types of statements
- To delete a piece of code just drag it out of coding box back into statement section

Starting Script

- Start with this if you want script to start when green flag is clicked
- Start with this if you want script to start when a certain key is hit
Starting Script

Start with this if you want script to start when the actual sprite is clicked

Problem

A checkbook starts with a balance of $1000. Write a script so that when the c key is hit (for check), the value of the check is asked for, the balance is adjusted to reflect the check has been deducted and the new balance is displayed.

Variables

Balance
Check

Scratch Variables

- Use Make a Variable

As soon as it is created, a set of statements is displayed:

Place in code to set variable to some value
Scratch Variables

- As soon as it is created, a set of statements is displayed:

  Place in code to change variable by a set amount (such as increment)

Check this box if you always want variable displayed on the stage

Scratch Variables

- As soon as it is created, a set of statements is displayed:

Check this box if you always want variable displayed on the stage

Scratch Variables

- As soon as it is created, a set of statements is displayed:

  ... if you always want variable displayed on the stage

Checkbook Code

- So far:

  How can we ask questions and display answers?

Input and Output

- Sensing

  Use this to ask a question, and wait for an answer.
**Input and Output**

- **Sensing**

  Use this to ask a question, and wait for an answer. The answer gets placed in a special variable that always exists called: answer.

**Checkbook Code**

Make a variable to hold check value

- **Pen**
- **Variables**

  - Make a variable
  - Delete a variable

**Checkbook Code**

So far:

- This is the first time we built a whole statement by dropping a component into a spot in another.- we grabbed the answer component from inside sensing

**Input and Output**

- **Sensing**

  Since answer will be used over and over for each question, it is wise to usually keep the value elsewhere in another variable so you can get to it whenever you want.

- **Looks**

  Have the sprite say or think things on the stage and leave the message up a set amount of time.
Input and Output

- Looks

The difference between say and think is just one of what type of bubble is linked to the sprite.

Input and Output

- Looks

The difference between say and think is just one of what type of bubble is linked to the sprite.

Checkbook Code

- So far:

When [Esc] key pressed
set balance to 1000
ask how much is check? and wait
set value to answer
say the new balance is for 2 secs

Checkbook Code

- So far:

When [Esc] key pressed
set balance to 1000
ask how much is check? and wait
set value to answer
say the new balance is for 2 secs

- Demo: Balance Checkbook 1

- What is missing?
Calculations

- Operators

Baseball: BattingAverage is \( \frac{\text{Hits}}{\text{Atbats}} \)

Now make this the value for BattingAverage

Drop this operator into Set Variable statement

Physics: Force is Mass \( \times \) Acceleration
Calculations

- Operators

Physics: Force is Mass \times Acceleration

Operators can be combined together. Figure the average of three heights.

Build two addition operators. Slide one into the other.

Operators can be combined together. Figure the average of three heights.

Create a division operator.

The current value of a variable can be used in a calculation to figure out the next value of a variable.

Slide the three-way addition into the division.
Set this average variable to this complete calculation.
Calculations

- Operators
  - The current value of a variable can be used in a calculation to figure out the next value of a variable.
  - Double X

Checkbook Code

- Calculate the new balance

  The new balance is the old balance minus the check value.

  Example. Balance: 1000   Check:100
  new Balance: 900
Checkbook Code

- Calculate the new balance
  The new balance is the old balance minus the check value.

Checkbook Code

- Calculate and display balance. End Script.

Other Operations

- Combining Text

  join hello world

  Notice space after hello?

Other Operations

- Combining Text

  join hello world

  Notice space after hello? This creates:
Other Operations

- Combining Text

```
join hello world
```

Notice space after `hello`? This creates: `hello world`

This can be given to Say or Think.

- Combining Text

```
think join hello world
```

Can combine a lot together - even text and variables - to make more interesting statements.

- Combining Text

```
join PlayersName, who plays for the Yankees is batting:
join Batter batting average
```

Can combine a lot together - even text and variables - to make more interesting statements.

Place one join in another

- Combining Text

```
join join PlayersName, who plays for the Yankees is batting: Batter batting average
```

Given to Say, this would display:
Other Operations

- Combining Text

```
when green flag clicked
set balance to 1000
ask "how much is check?" and wait
set value to answer
set balance to balance + value
say join "the new balance is $" + balance for 2 secs
stop script
```

Given to Say, this would display:

```
How much is the check?
```

Checkbook Code

- Use one Say

```
when green flag clicked
set balance to 1000
ask "how much is check?" and wait
set value to answer
set balance to balance - value
say join "the new balance is $" + balance for 2 secs
stop script
```

Checkbook Code

- Use one Say

```
when green flag clicked
set balance to 1000
ask "how much is check?" and wait
set value to answer
set balance to balance + value
say join "the new balance is $" + balance for 2 secs
stop script
```

Checkbook Code

- So we can handle many checks, lets only set balance to 1000 when the green flag is clicked.

```
when flag clicked
set balance to 1000
```

Checkbook Code

- So we can handle many checks, lets only set balance to 1000 when the green flag is clicked.

```
when flag clicked
set balance to 1000
```

See two scripts for one sprite?
Checkbook Code

- Extension: Hey, how about handling deposits when d is clicked?

- Extension: Hey, how about handling deposits when d is clicked?

Checkbook Code

- Extension: Have some fun with multimedia.
  Edit the sprite to be a checkbook:
  
  - Rename “checkbook”
  - Click costumes tab
  - Import or paint a checkbook

Checkbook Code

- Extension: Have some fun with multimedia.
  Edit the sprite to be a checkbook:

Checkbook Code

- Extension: Have some fun with multimedia.
  Edit the stage to be a scale:
  
  - Click Stage
  - Click Backgrounds tab
  - Click Edit

Checkbook Code

- Extension: Have some fun with multimedia.
  Edit the stage to be a scale:
Checkbook Code

• Extension: Have some fun with multimedia.
  Now include Motion commands in code to move
  checkbook sprite along the scale as the balance changes.
  • Go to X: ? Y: ?
    Place sprite at certain point on screen
    Hint: move pointer on stage and lower right
    will display x, y coordinates
  • Point in direction ?
    Specify direction you want sprite to point
    Next time it moves will be in that direction.
    -90 is left; 90 is right
  • Move ? steps
    Move a certain amount of steps in current direction.

Full code.

Demo: Balancing Checkbook

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