Algorithmic Thinking

To be effective computer users it is necessary to have a general idea how to make a computer solve a problem. Thinking algorithmically is a necessary first step towards solving a problem by computer.

An Assistant's Assistance

- An algorithm is a systematic method for deterministically producing a specified result
- Two participants --
  - The person specifying the algorithm is a programmer
  - Some other agent (person or computer) will execute the algorithm, i.e. follow its instructions, without intervention of the programmer
- Recipes are an example of algorithms written by chefs and followed by cooks to produce a specified food

S'mores: Place a toasted marshmallow on a Graham cracker and then place a square of chocolate on top

The 5 Properties of Algorithms

- All algorithms must have certain properties if the agent is to execute them successfully without intervention by the programmer
  - Input specified
  - Output specified
  - Definiteness
  - Effectiveness
  - Finiteness

Input/Output Specified

- The “input” is the data that will be transformed by the algorithm to create the output
- In giving an algorithm, state
  - The type of data expected -- whole numbers, letter strings
  - The number of data items expected
  - The structure, if any, of the data expected -- a list, table, etc.
- The “output” is the result of the computation -- its description often forms the name of the algorithm
- The features specified are the same as for input
  - The types of data forming the result
  - The number of data items forming the result
  - The structure of the result

Definiteness

- An algorithm must be explicit about how to realize the computation
- Definiteness is achieved by giving commands that state unambiguously what to do, in sequence
- The commands may be...
  - Conditional, i.e. require a decision to be made, and so must be explicit about how to respond to all different outcomes
  - Repeated, and so must be explicit about when to stop the repetition

The definiteness property assures that the executing agent will always know what command to perform next

Effectiveness

- Effectiveness assures that the agent can perform the algorithm’s operations mechanically without intervention
  - No additional inputs, special talent, clairvoyance, creativity or help from Superman
- Effectiveness is achieved by reducing the task to the primitive operations known to the computer
- Definiteness assures the agent knows what command to perform next; effectiveness assures the agent can accomplish the command

A non-effective command would be “Print the NASDAQ’s net change for the next trading day”
Finiteness

- An algorithm must eventually terminate with either
  - The right output
  - An indication that no solution is possible
- A non-terminating algorithm is useless since it is impossible to distinguish between continued progress and being “stuck”
- Finiteness is relevant to computer algorithms since they typically repeat instructions

Language

- People write algorithms, but some other agent will execute them... so they must be expressed in some language
- English and other natural languages are poor choices
  - Ambiguous — multiple interpretations of an utterance
    - “Her lasagna is not very hot”
  - Imprecise — exact meanings have not been assigned to all words and sentences:
    - “all deliberate speed”
  - Recipes try: “fold” is not a synonym for “stir” or “beat”
- Programming languages are formal notations specifically designed for specifying algorithms
- Visual Basic is the language we’ll use

Alphabetize CDs

- Input: Unordered CDs filling a slotted rack
- Output: CDs in slotted rack, alphabetized

Alphabetizing Algorithms

1. “Artist_Of” means the name of the group
2. Pick one end of the rack to be the beginning of the alphabetic sequence. Call that end’s slot the “Alpha” slot
3. Call the slot adjacent to the Alpha slot the “Beta” slot
4. If the Artist_Of the CD in the Alpha slot is later in the alphabet than the Artist_Of the CD in the Beta slot, then interchange the CDs
5. If there is a slot following the Beta slot, begin calling it the “Beta” slot and go to step 4; otherwise, continue on
6. If there are two or more slots following the Alpha slot, then begin calling the slot following the Alpha slot, “Alpha” and the slot following it the “Beta” slot, and go to step 4; otherwise, stop

Algorithm vs Program

- A program is simply an algorithm specialized to a particular situation...
- Alphabetize CDs is an instance of Exchange Sort
- Exchange Sort can be specialized to other cases
  - Sort CDs by other criteria, e.g. title
  - Sort books by title or other criteria
  - Sort canceled checks, students’ homework assignments, vehicles, etc.

The algorithm, being a process with only a limited number of specifics given, is more abstract than is the program