Lecture 7: How can computation... find what you are looking for?

“Search” has many meanings

- Look up “name” in online phonebook
- Find “credit-worthy” consumers in database
- Find web pages relevant to “computer music”
- Identify suspicious cell phone conversations originating in Country X
- Find the meaning of life

- Today: Very straight-forward
  - Find max element in a LIST
  - Find specified KEY in a LIST

What is a List?

Lists are common data structure
- List of items to buy at grocery store
- List of high scores for game
- List of student names in class
- List of account balances at bank
- List of cities in Wisconsin

Name the List as a whole
- Index into List to access individual items, elements

Lists in Scratch: How to Create?

- [Diagram showing Scratch blocks for creating a list]
  - Create a new list that contains...

- [Diagram showing Scratch blocks for accessing elements]
  - Get the element at index...
Lists: How to Look at the Contents?

- Name: Valuable Numbers
- List of N elements: Element1, Element2, ..., ElementN
- N=100 for Valuable Numbers
  - What value is at element 1? element 10?
  - At what location (or index) is value 73?

Example List in Scratch

- Length of list
- Set the counter value to 1
- Repeat for the number of items in the list
  - Say the item at that place in the list
  - Increase the counter by 1

This block reports how many items are currently in a list.

The number is the same as the length shown at the bottom of the list monitor.
Lists:
How to Change the Contents?

Lists:
How to Change the Contents?

Lists:
How to Change the Contents?

Lists:
How to Remove Items?
Lists:
How to Delete Entire List?

Create a new script:
Create Valuable Numbers

Use comments to describe behavior (esp how modifies shared variables)

Output:
List: Valuable Numbers
Contains 100 elements
Each element: Integer between 1 and 1000

How can you find max value in list? (and its index?)

Loop through List using index variable (i, j, k)

Use comment to describe inputs/outputs

Input:
• List of Valuable Numbers (each positive)

Output:
• Max
• Max index

Local variable:
• index

Robust to length of List
• Otherwise comment should say assumptions
How efficient is an algorithm?

Option 1: Could run and measure how it takes
  • Disadvantage: Depends on hardware

Option 2: Can analyze code
  • Count number of operations performed
  • Advantage: Understand how behavior depends upon size of input
  • Use $N$ for number of elements in input (List)

How many operations to find max?

Count number of Scratch blocks (excl variable ref)

- How many blocks?
  - How many before loop?
    - 3 blocks to start up
  - How many in loop?
    - Assume worst-case
    - Approx 6…
  - How many times is loop executed????

Total: $3+6^*N$ blocks
  - $O(N)$ blocks
  - # times loop executed, not # blocks in loop

How to display matching Name?

- Take care to use broadcast and wait (and not just broadcast)
- Can use Max Index to "index" into Name list
How would you modify “Find Max” to find specified key?

How can you find Key in List?

- Adjust comments to indicate Key Index = 0 means not found
- Can stop looking when find key

How many steps to find Key?

- Best case (minimum)?
  - 1 loop!
- Worst case (maximum)?
  - N loops
- Average case?
  - N/2 loops
- Still O(N)

Programming Concepts

General
- Divide high-level functionality into logical units
- Comment which are input and output variables
- Descriptive naming is important
- Initial state must be specified
- Goal is to make "non-fragile" code
- Incrementally implement and test code as you go
- Should consider "complexity" of algorithm (number of operations)

Data Structures
- Decision trees: states plus transitions
- Lists of variables

Logic
- Searching: Looping through all elements of a list

Variables
- Parameters (to blocks) specify behavior
**Scratch Features**

Execution within script proceeds sequentially
Add Comments to describe Input/Output of Scripts

**Basic blocks**
- Tour of many Motion and Looks blocks
- X-Y coordinate system for Stage
- Random numbers

**Activating scripts**
- When Green Flag is Clicked (initial state)
- When I receive <message> (broadcast and wait vs. broadcast)

**Data Types**
- Ask questions: User types string "answer"
- String manipulation: letter << of <strings, join << <<
- Variables: Numbers (floats and integers), Lists (length of List, delete all of List, item << of List)

**Control Blocks**
- repeat number of times
- repeat until <condition is true>
- <condition> then <action1> else <action2>

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**Challenge:**
What does this script do?

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**Today’s Summary**

**How to find elements in a List**
- How many ops to find max element of List: O(N)
- How many ops to find (existing) key in List: O(N)

**Reading:**
- Invitation pp 55-66 and 80-88 (Searching and complexity)

**Announcements**
- HW 2 should be turned in now
- HW 3 Available: Due next Wednesday
  - Implement simple Scratch program to draw Square and calculate perimeter
  - Paper+pencil: Practice with repeat loops and variables

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**What does this code do?**

**Output:**
- List: Valuable Numbers
- List: Names
  - 100 elements, each element is a 5 letter random string