Decisions in Visual Basic I

Topics

- if/else statements
- testing the "randomness" of random numbers
- simple vs compound conditions
- creating your own test cases to verify the correctness of a program
- introduction to concept of "regular expressions"

Preliminaries

If you haven't already done so, start by making a copy of today's lab folder (Lab04) and saving it in your `M:\CS130\Labs` folder. Right-click on the folder you just copied and rename it `Lab04_YourLastName_YourFirstName` (but use your actual last and first names).

You may now work locally by opening the write-up from within the copied folder.

Flipping a coin

1. Launch the RAPTOR software and use it to create and save a new program called `FlippingACoin_Part1.rap` inside the folder `FlippingACoin` inside of your lab folder.

   Complete `FlippingACoin_Part1.rap` so that it generates a random number between 0 and 1, exclusive, and prints `"Heads"` when the number is less than `0.5` and `"Tails"` otherwise (i.e., it is greater than or equal to `0.5`).

When done, save and close file `FlippingACoin_Part1.rap`.

2. Launch VS Express 2013 and open the program `FlippingACoin_Part2` which can be found inside of the folder `FlippingACoin` inside of your lab folder.

   Complete the program `FlippingACoin_Part2` so that is the equivalent of your RAPTOR program, `FlippingACoin_Part1.rap`.

   Run this program 20 times and record below the number of *Heads* and number of *Tails*:

   - number of *Heads*: _____ out of 20 flips
   - number of *Tails*: _____ out of 20 flips

   Does it look like a fair coin (in the sense that the coin is just as likely to generate *Heads* as *Tails*)?

Your program should behave identically to the solution which can be run by double-clicking the file `FlippingACoin_Part2.exe` found in the `Executables` folder inside of your lab folder.

When done, save and close program `FlippinACoin_Part2`.

Checkpoint 1 (30/100): A successful `FlippingACoin_Part2` program:

- is based on a complete and correct `FlippingACoin_Part1.rap` program that displays Heads and Tails based on your user
- simulates a fair coin

3. Use **File Explorer** to navigate to the folder containing the final version of your program `FlippingACoin_Part2` in your lab folder. Copy and paste this program in the same folder, and then right-click on the copy to rename it as `FlippingACoin_Part3`. Launch VS Express and use it to open the program `FlippingACoin_Part3`.

   Make the necessary changes to program `FlippingACoin_Part3` to simulate a **biased** coin instead of a fair one. When flipped, this biased coin is three times more likely to generate Heads than Tails (Hint: recall that you the value `0.5` from the previous part was chosen to split the range `[0,1)` perfectly in half).

   Run this program 20 times and record below the number of *Heads* and number of *Tails*:

   - number of *Heads*: _____ out of 20 flips
   - number of *Tails*: _____ out of 20 flips

   Does it look like a fair coin or a biased coin now?

Your program should behave identically to the solution which can be run by double-clicking the file `FlippingACoin_Part3.exe` found in the `Executables` folder inside of your lab folder.

When done, save and close program `FlippinACoin_Part3`.

Checkpoint 2 (65/100): A successful `FlippingACoin_Part3` program:

- simulates a biased coin that is three times more likely to generate *Heads* than *Tails*

Password crack calculator

Disclaimer. The program that you develop for this exercise should **NOT** be considered a measure of the strength of a particular password. An obvious example would be the password '*P@ssw0rd*', which, according to the program, would take 147.53338 centuries to crack, but in practice would be among the first passwords checked by any cracker worth their salt.

TL;DR

Implement a program to calculate the number of passwords that can be constructed from some alphabet, as well as the time it would take to check the entire search space assuming a cracking program capable of some number of guesses per second.

This exercise will give you a better understanding and appreciation for password composition.

Background

Have you ever wondered why many websites have password requirements like:

- be a minimum of 8
- cannot be based on a word or name
- must contain at least one
  - upper-case letter,
  - lower-case letter,
  - number, and
  - special character: ! $ / % @ #

These are all attempts to prevent users from choosing passwords that are easy to guess. Keep in mind, that in this context, it is not a person guessing, but rather a machine running a *cracking* program, capable of thousands or millions of guesses per second. It turns out that when requirements like this are not enforced, people tend to pick easily guessable passwords. According to a variety of sources, some of the most popular passwords are:

- password
- 123456
- qwerty
- monkey
- password1

By requiring the inclusion of certain groups of characters, it prevents the use of passwords such as those listed above, at least in their most obvious form. If a cracking program is unable to quickly guess a password based on a dictionary of common passwords, such as those above, it may be necessary to use *brute-force* to guess the password, i.e., check all possible passwords that satisfy the requirements.

A useful exercise for any person interested in the security of their password protected identity is to determine how many possible passwords could be constructed from a given set of requirements, and how long it would take a computer cracking program to check all such passwords.

Your task is to create a Visual Basic program that does just that. Your program will take a password as input, then compute the number of possible passwords, called the *search space*, that use the same types of characters as the input password. Then your program will output that search space, along with the amount of time for a computer capable of checking a certain number of passwords per second would take to crack the input password.

To start, let's define the *password alphabet*. The *password alphabet* is the set of letters, numbers, and other characters that are allowed to be used to compose a password. So for example, if only lower-case letters were allowed in a password, then the alphabet would be a-z and its size would be 26. However, if upper-case letters as well as numbers were allowed, then the alphabet would be a-zA-Z0-9 and its size would be 62.

Given this definition, then the total number of passwords of length L that can be created from an alphabet of size C can be expressed as:

(1)
$$C^L$$

Since a cracking program does not know a priori how many characters are in the password it is trying to crack, it will have to check not only those passwords of length L, but also those password whose length is less than L. Thus, using equation (1), the *search space* for a password of length L can be expressed as:

(2)
$$(C^1 + C^2 + \cdots + C^L) = C(C^L - 1)/(C - 1)$$

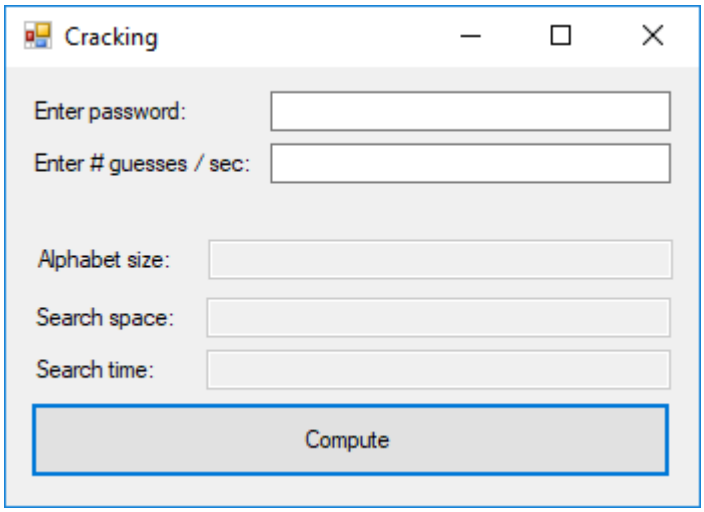
Given a cracking program capable of checking G passwords per second, the time it would take (in seconds) to check all passwords in a search space of that size can be expressed as:

(3)
$$(C(C^L - 1)/(C - 1))/G$$

Keep in mind that this is not an indication of how long it would take to crack a particular password, only of how long to check the entire search space. It is conceivable that any given password will be found in less time than that calculated. Still, it allows one to compare the effect of alphabet size and password length on the search space and time.

Instructions

1. Launch VS Express 2013 and open the program `PasswordCrackCalculator_Part1` which can be found inside of the folder `PasswordCrackCalculator` inside of your lab folder.



You are to write a program that accomplishes the tasks described in the previous section. The interface for your program should match that of the example above.

Before you can even think about computing the size of the search space and how long it would take to check, you must determine the size of the alphabet. For this problem, the alphabet will be dictated by the password entered by the user.

For example, if the user entered the password `PASSWORD`, then the alphabet size would be 26 because `PASSWORD` only contains upper-case letters, of which there are 26. However, if the user had entered `PaSSwORD`, then the alphabet size would be 52 because `PaSSwORD` contains both upper- and lower-case letters.

Any valid password entered by the user can only contain characters belonging to one of the following character types:

- lower-case letters [a-z],

- upper-case letters [A-Z],
- digits [0-9], and
- special characters [!$/%@#].

To compute the total size of the alphabet based on the user input password, determine which character types are included in the user's password and add an amount appropriate for that character type to a variable called `alphabetSize`.

To find out if a `String` contains any one of a set of characters, you can use the `Like` operator. For example, to check if the `String` variable `passwd` contains any lower-case letters and add the appropriate amount to the variable `alphabetSize` if it does, you should use the following Visual Basic code:

```
If passwd Like "*[a-z]*" Then
    alphabetSize = alphabetSize + 26
End If
```

The correct pattern for each of the different characters types is as follows:

- lower-case letters `"*[a-z]*"`,
- upper-case letters `"*[A-Z]*"`,
- digits `"*[0-9]*"`, or
- special characters `"*[^$/%@#]*"`.

Complete `PasswordCrackCalculator_Part1` so that it takes a user input password and computes and outputs the alphabet size based on the user's input. After you get your program working, fill out the following table, making sure that your expected output and actual output are consistent.

Test Table 1		
Input values for your program *(run your program for each of the following cases)*	**Expected program output for alphabet size** *(what output you expect your program to produce for the given input — please compute by hand and write down missing entries [indicated by ???])*	**Actual program output for alphabet size** *(what output your program actually produces for the given inputs)*
`"PASSWORD"`	26	
`"PaSSwORD"`	52	
`"P@SSwORD"`	68	
1	???	
0	???	
1	???	

Your program should behave identically to the solution which can be run by double-clicking the file `PasswordCrackCalculator_Part1.exe` found in the `Executables` folder inside of your lab folder.

When done, save and close program `PasswordCrackCalculator_Part1`.

Checkpoint 3 (70/100): A successful `PasswordCrackCalculator_Part1` program:

- produces correct output for all test cases in Test Table 1

- must also have successfully completed Checkpoint 2

2. Use **File Explorer** to navigate to the folder containing the final version of your program `PasswordCrackCalculator_Part1` in your lab folder. Copy and paste this program in the same folder, and then right-click on the copy to rename it as `PasswordCrackCalculator_Part2`. Launch VS Express and use it to open the program `PasswordCrackCalculator_Part2`.

   Enhance your program so that instead of outputting just the alphabet size, it outputs the search space size as well. To do this, first recall the equation for computing the search space size,

$$C(C^L - 1)/(C - 1),$$

   where C is the alphabet size and L is the length of the password. Since you computed the alphabet size in Part 1, you are just missing the length L. Luckily this information is easily ascertained from the user input password with the following line of Visual Basic, assuming you are using variables, `passwd` and `passwdLength` to store the input password and its length respectively:

```
passwdLength = passwd.Length
```

   After you get your program working, fill out the following table, making sure that your expected output and actual output are consistent.

Test Table 2		
Input values for your program *(run your program for each of the following cases)*	**Expected program output for search space size** *(what output you expect your program to produce for the given input — please compute by hand and write down missing entries [indicated by ???])*	**Actual program output for search space size** *(what output your program actually produces for the given inputs)*
`"PASSWORD"`	26	
`"PaSSwORD"`	52	
`"P@SSwORD"`	68	
1	???	
0	???	
1	???	

TODO: finish this part by having student complete a table of search space sizes, then have them discover that Integer is not big enough and fixing that problem.

Your program should behave identically to the solution which can be run by double-clicking the file `VideoRentalStore_Part4.exe` found in the `Executables` folder inside of your lab folder.

When done, save and close program `VideoRentalStore_Part4`.

Checkpoint 4 (75/100): A successful `VideoRentalStore_Part4` program:

- produces correct output for all test cases in Test Table 2

- must also have successfully completed Checkpoint 2

Your program should output **EXACTLY** two lines to the console. The first line should report the size of the search space, i.e., total number of passwords that can be constructed, and the second should report the time to search the entire space. The output format of your program should **EXACTLY** match the following example:

```
Search space size: 1558868884
Time to search:    2.57749 weeks
```

which can be produced by the following two lines of Java code:

```
txtAlphabetSize.Text = alphabetSize
txtSearchSpace.Text = searchSpace
txtSearchTime.Text = searchTime
```

where `size`, `time`, `unit` are three variables that represent the search space size, the time to search, and the units for the time respectively.

To make your program more user friendly, it should present the time to search using the most appropriate unit of measurement from the following list:

- seconds,
- minutes,
- hours,
- days,
- weeks,
- years, or
- centuries.

For example, if the number of seconds to search the space is less than 60, it should use the unit *seconds*, however if it is greater than 60, but less than 60×60=3600, then it should use the unit *minutes* and so on, all the way up to *centuries*. To keep things consistent, we will define a year as 52 weeks.

Testing

One of the most important tasks when developing a piece of software is to test it to ensure its correctness. To this end, you should create a set of test cases to test your code under different conditions. For this exercise, the test cases will be different values of the variable `PROTOTYPE`. You should manually compute the search space size and time to search for each of the test cases, and then check your results against those of your program. Some examples of test cases might be:

- `"aaaa"`
- `"AAAA"`
- `"0000"`
- `"!!!!"`
- `"aA0!"`

Be judicious about your choice of test cases, so that you are not repeating calculations that will ultimately produce the same results. For example, it is probably not necessary to check both `"aaaa"` and `"bbbb"` since they define the same alphabet and have the same maximum length.

If you are satisfied with your set of test cases and your program is producing correct results, then your set of test cases is inadequate. If you have found a test case for which your program produces incorrect output, or you cannot come up with any such cases after thinking about it for some time, then you should download and run this testing program.

After downloading the testing program to the directory where you developed your own program, make sure that your program is compiled, and click the `Test` button in DrJava. This will run your program using a pre-defined set of test cases and report whether or not your program produced the correct output. The testing program should report two failures (test8 and test9). If it reports more, then you should address each of them until only these two remain.

Improvements

D level

- get input from user
- output a simple message using input

C level

- add calculations and output for:
  - alphabet size
  - search space
  - search time
- deal with limitations of Integer and introduce Single data type for computing searchTime
- evaluate a set of test conditions to check correctness

B level

- add units to output
- deal with more limitations of Integer and introduce Long data type for computing searchSpace
- format output to 3 decimal places [lookup Math.Round online]
- identify and evaluate a set of test conditions to check correctness

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A level

- ??? deal with limitations of Long for computing searchSpace [lookup BigInteger data type online]
- ??? blend if statements into a single regular expression
- do error checking to see if password contains any invalid characters [lookup more regular expressions online]
  - print error message and exit [lookup Close() online]
- identify and evaluate a set of test conditions to check correctness
- ??? rewrite unit if-ladder without compound conditions ???
