Assignment #4 – Parallel Shakespearean Monkeys

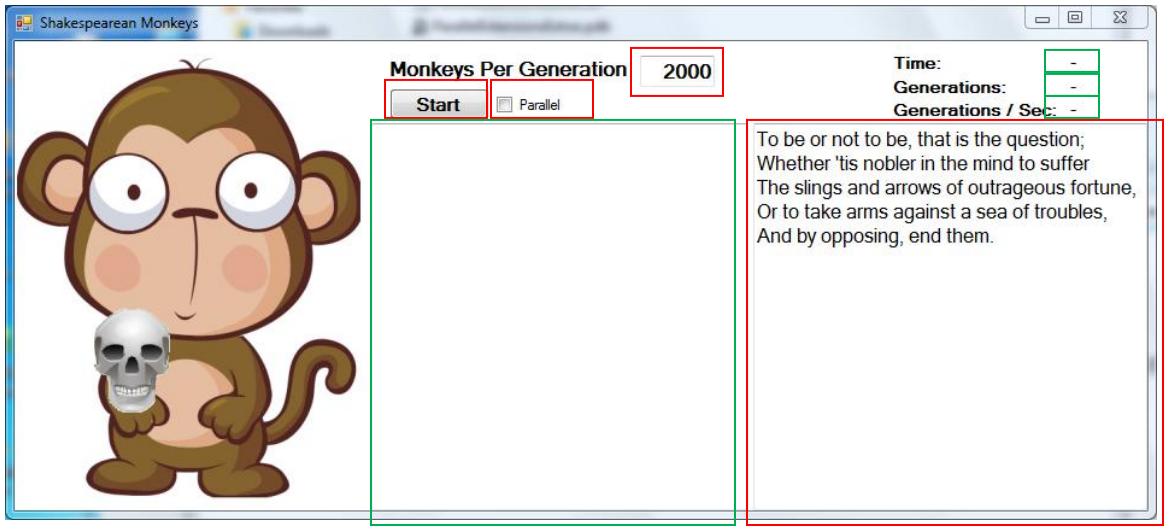
Part II

Specs

You are required to build a Java Swing application that illustrates the Shakespearean Monkeys genetic algorithm, taking the given demo as a model (which is adapted from an MSDN parallel extensions demo).

GUI

The GUI must be a close match to the demo GUI (except the picture which could be replaced by your favourite pet):



The following controls, highlighted by red contours, define algorithm *inputs* and *control* its behaviour:

- PopulationSize (initially 2000): the number of monkeys in a generation (editable)
- TargetText (initially Hamlet's stance): the target text (editable)
- Start button (initially caption Start): the first click changes its caption to Cancel and starts the evolution; the second click (now using caption Cancel) stops the evolution (regardless if the evolution runs sequentially or in parallel)
- Parallel checkbox (initially unchecked): if checked, requests a parallel evolution; otherwise, requests a sequential evolution

The following controls, highlighted by green contours, define algorithm *traces* (including its final *output*):

- Time (initially -): total time since evolution start (secs)
- Generations (initially -): number of generations
- Generations / Sec (initially -): average number of generations per second (i.e., evolution speed)
- Best current text (initially blank): a sequence of best generated texts; the last one, which matches the target text, should be highlighted by a greenish background colour

Evolution rules

Clicking on the Start button must also *validate* the user inputs:

- The PopulationSize box must contain a number in the range 1 to 10,000
- The TargetText must contain a text of length in the range 1 to 100 and all characters must be in the range 33 to 126 (i.e. they are all non-control printable 7 bit ASCII characters)
    - The demo also accepts newlines and carriage returns (which are among the control characters), but you are not required to accept these
- Errors panels must be raised if these conditions are not met

Rules for *updating* the trace controls:

- The trace controls are reset to their initial values each time a new evolution starts (i.e., after a click on the Start button).
- Then, as generations evolve very fast, the trace controls should *only* be updated when the current best text is strictly better than the previous (it is possible that, at times, the new generation performs worse or no better than its parent, in which case *no* update should occur).

Responsiveness

- The application must remain responsive at all times (thus the Start event handler must start at least one background thread even for sequential evolutions, and, of course, more for the critical parts of the parallel evolution)
- In particular, a click on the Cancel button (button Start's other face) must completely cancel the evolution as soon as possible and revert to its initial caption, Start

Major assessment criteria

Programs which compile and run as expected will be further differentiated according to the following criteria:

- On typical lab machines (4-8 logical cores), the parallel version should run substantially faster than the sequential version
- The parallel version should run comparably to the parallel demo version or even faster (because the demo is not optimised)
- The source code is readable and well structured
- The coding differences between the sequential and the parallel version are well localised; most of the lines should be common between the two versions
- The GUI updates are performed in a thread-safe manner (i.e. a background thread can legally update only (1) using thread-safe controls and methods or (2) using Swing utilities)
- The background threads are properly "cancelled" (some form of cooperation seems needed)
- There are no *race* conditions between the background thread (e.g., where required, use proper locks or concurrent data structures)
- Of course, your code must *not* "cheat" by identifying matching positions: you can only base your evolution on a single fitness score

Last but not least

- Please read the note on Plagiarism and Cheating in our Assignments page.

Pseudocode

Internally, the code uses the following additional input parameters:

- CrossoverProbability (default 0.87): the probability that a pair of parents will cross over their genomes while generating a pair of children; otherwise, the children are identical to their parents
- MutationProbability (default 0.02): the probability that a newly generated child will suffer one random mutation

We recommend that the expected algorithm should follow the following high level pseudocode (this is just a hint, you can do better, if you want):

```
// to keep the app responsive, run all this in a background thread (not in GUI/EDT)

create the initial random population (strings or arrays of valid characters, each one
same size as the target text size, i.e. TargetText.Length)

evolution loop
   cancel if cancellation was required
   compute fitness scores and find best match of the current generation
…update the GUI if the new best is strictly better than the previously displayed best
   break if the best text matches the target text

   // create new generation
   repeat PopulationSize/2 times, sequentially or in parallel
      p1 = random parent, giving more chances to high quality monkeys
      p2 = random parent, giving more chances to high quality monkeys
      if random < CrossoverProbability then
         CrossoverIndex = random between 1 and p1.Length
         c1 = 1st part of p1 + 2nd part of p2
         c2 = 1st part of p2 + 2nd part of p1
      else
         c1 = p1
         c2 = p2
      if random < MutationProbability then
         randomly change one single char in c1
      if random < MutationProbability then
         randomly change one single char in c2
      add c1 and c2 to the new generation
   goto repeat
goto evolution loop
```

The red highlighted words indicate critical parts.

- update the GUI: do this properly, because you are in a background thread
- repeat: the single most efficient point to swap between a sequential and a parallel execution mode; there are a few other places, but the cost/benefit will be marginal; the demo introduces parallelism only at this point
- add c1 and c2 to the new generation: in the parallel mode, you can have a race condition, as several threads could try to update the new generation at the same time
- the next discussion suggest one good way to give more chances to high quality parents (it is a simple well-known statistical procedure)

How to select parents

This is best explained by an example. Consider that we have a target text of length 10 and four monkeys, m[0], m[1], m[2], m[3], with 3, 8, 3, 5 matching characters (respectively), as indicated in the following table:

Monkey	Text	Matching count	Difference count	Breeding weight
m[0]	…	3	7	1
m[1]	…	8	2	6
m[2]	…	3	7	1
m[3]	…	5	5	3

The highest matching score, 8, is achieved by m[1], which can also be viewed as the smallest difference to the target, 2 = 10 - 7. The largest difference, 7, is achieved m[0] and m[2].
For an efficient breeding, monkeys should receive the breeding weights as indicated in the last column, i.e. computed by the following formula:

current breeding weight = (largest difference – current difference + 1).

With this formula, m[1] gets the highest breeding weight, while m[0] and m[3] the lowest (but they can still marginally contribute, e.g., by lucky mutations).

The following pseudo-code shows how to randomly select a high quality parent:

```
sum-of-weights = sum of breeding weights (11 in our case)
val = random number between 0 and sum-of-weights-1 (0, 1, 2, …, 10)
for i = 0 to PopulationSize-1 do
   weight = breeding weight of m[i]
   if val < weight then
      select m[i] as parent
      break
   val = val – weight
end for
```

Demo

The demo is a .NET program, slightly adapted from a MSDN parallel extensions sample, which is compiled for the .NET 4.5 platform, as installed in the labs.

If you want to experiment it on other machines, you need .NET 4.5, which is best achieved by installing VS 2012 Professional (or higher).

As student in computer science, you can download and install at home a free non-expiring version, to use it for university related studies.