Exercises and Repetitions in ALife 2006:

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1 Problem

During the AL lecture, we discussed Dawkins' computer model of evolution by natural selection. The following problems provide good practice in calculating probabilities. They also illustrate the power of selection to generate highly improbable results.

Dawkins models the evolution of the message 'METHINKS IT IS A WEASEL'. For simplicity, ignore spaces, and let the 'correct' 19-letter message be 'METHINKSITISAWEASEL'. Start with a single 19-letter message, in which each letter is randomly chosen from the 26 letters.

1. How many such messages are there?
2. What is the probability that
   (a) at least one of the 19 letters is correct?
   (b) exactly one letter is correct?

Ten copies are made of the original message. In copying each letter, there is a chance of 99/100 of incorporating an unchanged letter, and of 1/100 of incorporating a changed letter - a 'mutation' - which may, with equal probability, be any one of the other 25 letters.

3. Suppose that, in the original sequence, none of the letters matched the correct message. What is the probability that, in at least one of the 10 copies, at least one letter does match the message?

The best of the 10 copies (that is, the copy that matches the required message at the largest number of sites) is chosen as the 'parent' of the next generation. If two or more copies match at the same number of sites, one is chosen at random. This parent is used to generate 10 more copies, in the same way.

4. If the original sequence did not match the correct message at any sites, approximately how many generations will pass before a message matching at least one site is obtained?

5. Sooner or later, a message correct at 18 out of 19 sites will be obtained. What is the probability that, among the 10 copies of such a message, one will be correct at all 19 sites?

6. Approximately, how many generations will it take to progress from 18 correct letters to 19 correct letters?

7. Approximately how long will the whole process, from 0 to 19 correct letters, take?

8. Would it take less time if the 'mutation rate' was increased from 1/100 to 1/10?

9. What, in your opinion, is the least realistic feature of this model, regarded as a model of evolution by natural selection?

Remark

Two hints about calculating probabilities.

1. If you can't calculate the probability that something will happen, calculate the probability that it won't.

2. A useful approximation: $(1-x)^n = e^{-nx}$, if x is small and n is large. Why is this so? Can you give an expression of how good the approximation is?

2 Problem

An artificial ant colony was described capable of solving the traveling salesman problem (TSP).

1. Implement a GA solving the TSP!

2. Implement an evolutionary strategy solving the TSP! (The ES code can be downloaded at http://www.ifi.unizh.ch/ailab/teaching/AL06/).

3. Implement an ant colony solving the TSP!

4. Compare the performance of all three methods for 5, 10 and 30 cities!