

Lab # 4a – A more realistic population growth



1) Life Science model – the origins: a fast simulation of a rabbit population growth.

The unit we'll be using is a couple of rabbits and we have a monthly time step. We consider that a couple of young rabbits become adult in one month, and when the female rabbit becomes pregnant, it takes one month to produce 2 baby rabbits considered as new young rabbits (kittens) that will wait for another month to become adult etc... (see figure 1). If we suppose that rabbits do not die, we obtain the diagram hereafter (observation made by Leonardo of Pizza). For this first question, you will propose a program simulating the evolution of the number of couples like in the figure below. See the course slides dealing with the model proposed by Leonardo of Pizza. More info on this web site:

<http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fib.html>

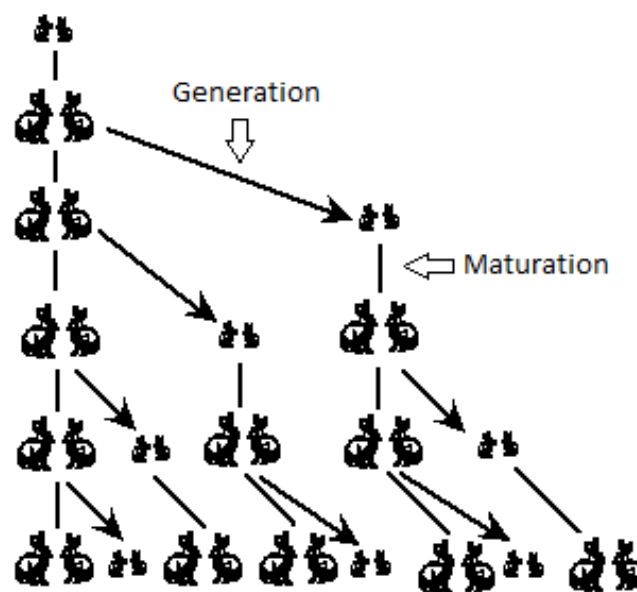


Figure 1: Rabbit population growth (empty spot for a young couple and a filled spot for a couple of adults)

2) A more realistic population growth. This time you have to make your own modeling choices and use the simulated distributions learned with lab #2 (different random variates). It is part of the difficulty.

In this lab you will propose a stochastic discrete event simulation of the growth of a rabbit population which will be more realistic than the previous equations. The mortality rates can take into account diseases and predators. Aging will also be accounted; this supposes that we take into account the birth and death of rabbits. A female rabbit can give birth approximately every month, they give 3 to 9 litters per year, but this

is not uniform, there is more chance to have 6 litters, a bit less for 5 and 7 litters, less again for 4 and 8 litters, and the minimum probability is for 3 to 9 litters. Each year, there are 10% of infertile rabbit females and 15% of them die during childbirth. For each litter you have an equal chance to obtain 3 to 5 kittens (baby rabbits) and a bit less to have 2 or 6 kittens. A random drawing can determine if such baby rabbits are males or females; the natural probability being approximately around 50%. Sexual maturity is reached between 5 to 8 months after the birth of kittens, you can use monthly time step for the simulation. We can also simulate the probability of death according to the rabbit age; this can be given by proposing simple rules about survival. For adults (rabbits at sexual maturity), the survival rate is 75%, for little rabbits it is only 50%. When a rabbit reaches 7 years old, its survival rate is diminished by 15% every year, reaching 0% at the end of year 12 (death of an old venerable rabbit). This model is more realistic than a Fibonacci growth, it can be simulated with the input parameters and probability laws that you will decide. In the past labs everything was guided, now such choices are part of your lab as a modeling activity, it is a new step in difficulty. You can find realistic values using the Internet or Wikipedia depending on the rabbit species (some last longer 15 years, etc...). Implement your code in C (C++ or Java allowed).

Make your implementation choices, you can use fixed size arrays of structures, remain simple in your design. A simple set of distinct arrays is sufficient. Use a fine random number generator and adapt random variates that you have learned in previous labs to the data provided above (for instance propose histograms that could match the observed or given data). Complete missing data with your own choices, try to be “realistic”. Select an appropriate time step and propose a set of results that will enable the study of the population growth. Make your hypothesis and propose realistic probability values when you don’t have known values.

You can decide to simulate first for a few years, and then up to 20 years (maximum) – and this can be tough depending on your coding choices and on the programming language. After some tries with a single adult couple, initialize with more couples since you have observed that the initial population may die (high mortality of young rabbits). Then observe the number of rabbits you have, the growth can be fast for we do not have predators. This simulation can require important computing time on a PC. Remember that what you obtain after a simulation is just the result of a single stochastic experiment. The stochastic variability can be high. You should try different experiments and present proper stochastic simulation results with confidence intervals at 99% ($\alpha = 0.01$). Prepare a written report describing the development and your experiments. **Send your source code (source files .c.h are mandatory) and your PDF report at my e-mail address. Other formats will not be accepted.**

