

## Lab # 4a – A more realistic population growth



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

The unit is a couple of rabbits and the time step is of a month. We consider that a couple of young rabbits become adult in one month, 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 short 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. Don't waste your time with this, the 2<sup>nd</sup> part of the labs necessitates much more energy (more info on this web site: <https://r-knott.surrey.ac.uk/Fibonacci/fibnat.html> ).

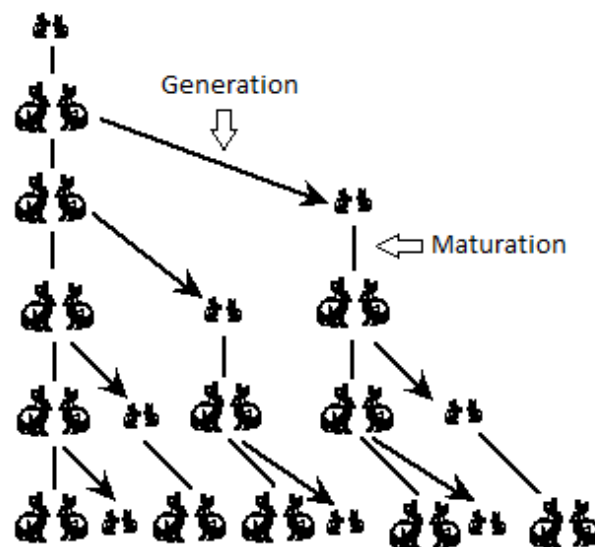


Figure 1: Rabbit population growth (empty spot for a young couple and a filled spot for a couple of adults)

### 2) More realistic population growth where you will have to make your own modeling choices. Use the C, C++ or Java language.

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 4 to 8 litters per year, but this is not uniform, there is more chance to have 5,6 or 7 litters. For each litter you have an equal chance to

obtain 3 to 6 kittens (baby rabbits). A random drawing can determine if such baby rabbits are males or females; the natural probability being approximately around 50%. Unfortunately, in some countries this probability has been changed for humans when girls are killed (before or after birth) if the parents preferred males (up to 100 million women missing in a big country, a eugenic approach which leads to a drama). Sexual maturity is reached between 5 to 8 months after the birth of kittens, but you can simplify and retain an annual 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 60%, for little rabbits it is only 35%. When a rabbit reaches 10 years old, its survival rate is diminished by 10% every year, reaching 0% at the end of year 15 (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 more realistic values using the Internet or Wikipedia depending on the rabbit species.

Make **your** implementation **choices**, you can use fixed size arrays of structures, remain simple in your design. A simple set of distinct arrays can be 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.

You can decide to simulate for a few years (up to 20 maximum – can be tough depending on your coding choices and on the programming language). Initialize with (much) more than an **adult** couple since 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. You can later test the start with 2 young rabbits (1 male and 1 female) and see that the simulation may stop. 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. Prepare a written report describing the development and your experiments.

