Lab # 4 – 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 a that a couple of young rabbits become adult in one month, when the female rabbit becomes pregnant, it takes one month to produce 2 little rabbits considered as new young rabbits 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). http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fibnat.html

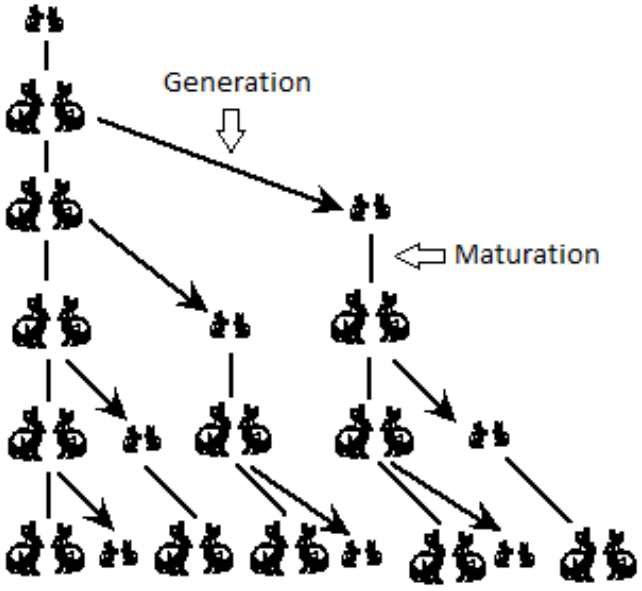

Figure 1: Rabbit population growth (empty spot for a young couple and a filled spot for a couple of adults)

2) More realistic population growth <u>where you will have to make your own modeling choices</u>

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 can give birth approximatively every month. Female 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 baby rabbits. A random drawing can determine if such baby rabbits are males or females; the natural probability being approximatively around 50%. Unfortunately, in some countries this probability has been changed for humans since girls have been killed (before or after birth) when the society preferred males (for

instance more than 100 million women missing in a big country, which is a drama). Sexual maturity is reached between 5 to 8 months after the birth of baby rabbits, 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, use structures (or classes if you want), but remain simple in your design. You can also use a simple set of distinct arrays. Use and adapt random variates that you have learned in previous labs (for instance propose histograms that could match the observed or given data). Complete missing data with choices as realistic as possible. 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 for instance) and observe the number of rabbits you have, the growth will be fast for we do not have predators. Initialize with (much) more than an **adult** couple since the initial population may die (high mortality of young rabbits). This simulation can require non negligible computing time. 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 complete written report, which will be assessed.