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Lecture 0: The course overview

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1 Aim of the course

In this course we aim to 1) learn basic mathematical models of population dynamics and 2) experience numerical calculation of these models, and 3) learn to extend these simple models to stochastic dynamics and 4) implement these stochastic models by simulation.

Prospective students are assumed to have good knowledge of basic calculus and experience in C programming.

In the first half of lecture, I give explanation of topics and in the second half we implement the topics using C language.

2 Overview

Let us think of a simple population dynamics given by

$$\frac{dn}{dt} = birth(n)n - death(n)n = r(n)n \tag{1}$$

where n is the density of a population and $birth(n)$ and $death(n)$ are the per-capita birth and death rate respectively, both of which can depend on the density n. $r(n)$ is the per-capita net rate of increase.

This population dynamics described by differential equation can be readily analyzed. However,

this is nothing more than a"description" of a dynamics of population density where mechanistic processes which determines the fate of each individual birth and death are totally ignored.

The above population dynamics could be translated into the following mechanistic processes. Each individual gives birth to an offspring with probability $birth\_rate\Delta t$ where Δt is a short time interval as well as the individual dies with probability $death\_rate\Delta t$. Both the $birth\_rate$ and $death\_rate$ would depend on the population size, which is now a non-negative integer value. This process is stochastic and is not necessarily gives the same outcome compared to the corresponding deterministic dynamics as described by equation (1).

Such stochastic process is in general difficult to analyze and in some case only simulation can explore the behavior. In this course we will learn basic deterministic population dynamics and extend these into stochastic dynamics which we aim to analyze. We also learn how to implement stochastic dynamics using C language.

In the course we will focus on immigration-emigration model, linear birth and death process model, logistic growth model, competition model and models of spatial movement.

Comparing deterministic and stochastic models we will see and understand how stochasticity can affect the dynamics.

3 Reference books

1. Will Wilson. Simulating Ecological and Evolutionary Systems in C. Cambridge University Press 2000.
2. Modelling fluctuating populations. R.M. Nisbet and W.S.C. Gurney. John Wiley & Sons 1982.
3. Numerical Recipes in C. A famous introduction to numerical calculation using C. The content is available on-line (just google!).