# An R package for simulating Individual-Based Models

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# Motivations

**Goal**: Simulate the random evolution of an *heterogeneous* population.

- Heterogeneity of human population and increase in socio-economic and geographical gaps in mortality
  - Modeling small/heterogeneous life insurance portfolios
  - Model validation: consistency of mortality forecast
  - Effect of heterogeneity on retirement systems
- Take into account interactions at different levels (individual/local/global)
- Other applications: biology and ecology

**Stochastic Individual-Based-Models**

- Theoretical and simulation framework following advances in mathematical biology and ecology (Méléard et al.)
- Extension to human population (El Karoui, Bensusan, Boumezoued)

## Challenges

- High computational cost and simulation time
- Simulation often based on a particular example
- Need for flexibility

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## Goals of the R package

- Provide a unified framework for simulating a large class of stochastic individual-based models, as well as user-friendly (age pyramid, mortality table...)
- With low computational cost:
  - Efficient algorithm
  - Use of Rcpp
  - Appropriate data structures

# Model

A **population** at time $t$ is a collection of individuals.

An **individual** is characterized by a date of birth $\tau$ and some characteristics $x \in \mathcal{X}$:

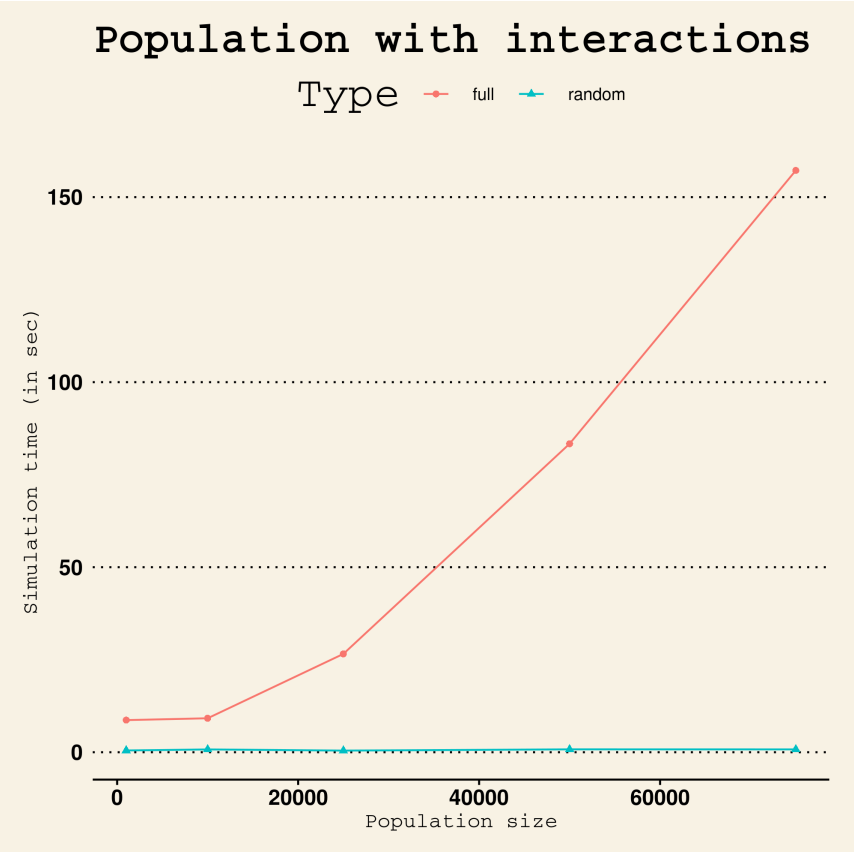
- Gender, place of living, wealth, smoking, marital status, strategy, ...
- Characteristics can change over time.

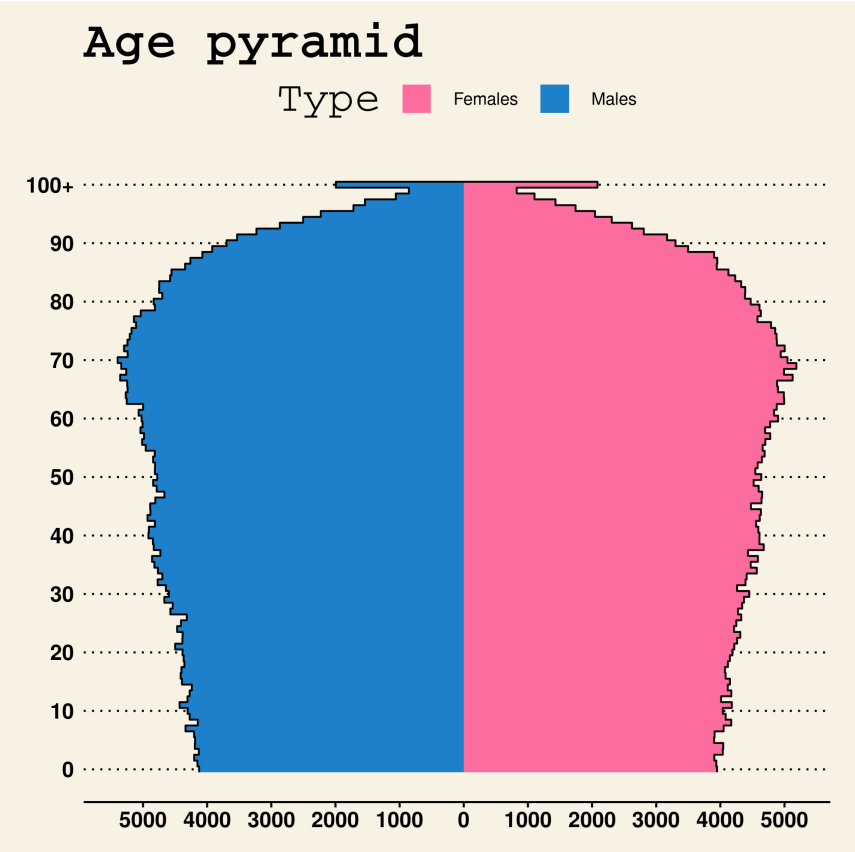
The population evolves following the **events** that can happen:

- Birth/Entry An individual is added to the population
- Death/Exit An individual is removed from the population
- Change of characteristics (swap) An individual changes characteristics from $(\tau, x)$ to $(\tau, y)$

The **frequency** of the events are described by *individual* rates depending on age and characteristics, stochastic environment, the population itself (interactions).

# Illustrations




- Population with size-dependent competition
- R. Ferrière, V. C. Tran

- Human population
- Mortality rates: StMoMo R package
- Population size: $1e6$
- Execution time: 40 secs