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Controlled branching processes as models for logistic population growth

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Controlled branching processes (CBPs) are stochastic growth population models in which the number of individuals with reproductive capacity in each generation is determined by random control functions. This kind of processes is flexible enough to model the evolution of different kind of populations including populations with logistic growth. The logistic population growth is characterized by an initial approximately exponential growth of the number of individuals till they reach an equilibrium value around which they fluctuate. This equilibrium value mainly depends on the carrying capacity of the population.

In this work, we first deal with the modeling of populations with logistic growth through CBPs. Classical deterministic models (such as Verhulst model, θ-logistic model -including Ricker model-, Hassell model -including Beverton-Holt model- or Gompertz model) will find stochastic counterparts based on suitable definitions of CBPs with binomial control functions. These binomial control laws will have a success probability depending on the current population size, carrying capacity and offspring mean.

Secondly, to guarantee the applicability of the introduced processes to model real data sets, we develop the estimation theory of its main parameters. We tackle this problem in the general framework of the CBP, considering a Bayesian perspective. Our aim is to estimate the posterior distributions of the main parameters of the CBP using approximate Bayesian computation and sequential Monte Carlo methods. We illustrate the accuracy of the proposed methodology by analyzing real data sets corresponding to populations with logistic growth using the statistical software R.

The results presented in the talk are part of the recent paper [1].

Keywords: controlled branching processes, logistic growth population models, Bayesian inference, ABC-SMC methodology

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References

[1] M. González, C. Minuesa, I. del Puerto, Approximate Bayesian computation approach on the maximal offspring and parameters in controlled branching processes, *Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas*, 116:147, 2022.