https://doi.org/10.48047/AFJBS.6.15.2024.10964-10966

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Stochastic processes:Birth death processes

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Volume 6, Issue 15, Sep 2024

Received: 15 July 2024

Accepted: 25 Aug 2024

Published: 25 Sep 2024

doi: 10.48047/AFJBS.6.15.2024.10964-10966

Abstract:-
In this paper we present the theory of Stochastic processes ,Birth death processes and their Applications/use in population theory and phylodynamics.

Keywords:Birth-death processes,phylogenesis,Markov chains,ergodic,recurrent;

Introduction:-

A stochastic processes is also known as random processes is a collection of random variables that are indexed by some mathematial set.

Familiar examples of stochastic processes such as time series include stock market and exchange rate fluctuation signals ,medical data or temperature and random movement such as Brownian motion or random walks.Birth deaths processes have been used extensively in many applications including evolutionary biology ,ecology,epidemiology (Novazhilov et al ,2006;Crawford et al,2015). For example, Keeling and Ross(2008) demonstrate that probabilities for computing transitions models is practical only when modeling spread of an infectious desease through a very small population.

Birth death processes are continuous time Markov chains that track the number of particles in a system over time.

A birth death processes refers to a Markov chain with a discrete state space.

The states of which can be estimated would have index $i = 0,1,2, \ldots \ldots \ldots \ldots \ldots$

Such that state transitions can occur only between neighbouring states $i \to i+1 \; or \; i \to i-1$

With transition rates

$$q_{i,j} = \lambda_i \; when \; j = i+1 \; i.e \; probability \; of \; birth \; in \; interval \; \Delta t \; in \; \lambda_i \Delta t$$

$$= \mu_i \; if \; j = i-1 \; i.e \; probability \; of \; death \; in \; interval \; \Delta t \; in \; \mu_i \Delta t$$

And $= 0 \;\; otherwise$

The birth death processes is a special case of Markov processes where the state transitions are of only two types birth which increases the state variable by one and death which decrease the state variable by one.it was introduced by William Feller.

The model names comes from a common application the use of such models to represent the current size of a population where the transitions are literal births deaths. Birth death processes have many application in demography epidemiology and other areas.

They may be used for example to study the evolution of bacterias, the number of people with a decrease within a population.

A birth -death processes are classified as recurrent,ergodic and null recurrent and are as follows.

A birth -death processes is recurrent if and only if

$$\sum_{i=o,\infty} \Pi_{n=1,i} \frac{\mu_n}{\lambda_n} = \infty$$

A birth and death processes is ergodic if and only if

$$\sum_{i=0,\infty} \Pi_{n=1,i} \frac{\mu_n}{\lambda_n} = \infty$$

$$\sum_{i=0,\infty} \Pi_{n=1,i} \frac{\lambda_{n-1}}{\mu_n} < \infty$$

A birth and death processes is null recurrent if and only if

$$\sum_{i=0,\infty} \Pi_{n=1,i} \frac{\mu_n}{\lambda_n} = \infty$$

$$\sum_{i=0,\infty} \Pi_{n=1,i} \frac{\lambda_{n-1}}{\mu_n} = \infty$$

Birth death processes are used in phylodynamics in a prior distribution for phylogenesis in a binary tree by which birth event corresponds to branches of the tree and death events corresponds to the leaf. Notably they are used in viral phylodynamics to understand the transmission process and how the people infected changes through time.

The use of generalised birth -death processes in phylodynamics has stimulated investigations into the degree to which the rates of birth death can be identified from the data while the model is unidentifiable in general.

Conclusion:-

In this paper we have presented stochastic processes, birth death processes and their applications/use in population/phylo dynamics.

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