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in probability theory and related fields a stochastic process or random process is a mathematical object usually defined as a sequence of random variables in a probability space where the index of the sequence often has the interpretation of time motivate a definition of the stochastic integral explore the properties of brownian motion highlight major applications of stochastic analysis to pde and control theory background and motivation re interpret as an integral equation $\int_0^t x(t) x(s) ds$ a random variable can be thought of as an uncertain numerical value with values in \mathbb{R} quantity while it is true that we do not know with certainty what value a random variable x will take we usually know how to compute the probability that its

value will be in some subset of \mathbb{R} a random variable also called random quantity aleatory variable or stochastic variable is a mathematical formalization of a quantity or object which depends on random events the term random variable in its mathematical definition refers to neither randomness nor variability but instead is a mathematical function in which a random process or stochastic process on Ω with state space S and index set T is a collection of random variables $\{X_t\}_{t \in T}$ in T such that X_t takes values in S for each t in T probability theory and stochastic processes with applications what is probability theory oliver knill probability theory is a fundamental pillar of modern mathematics with relations to other mathematical areas like algebra topology analysis geometry or dynamical systems variables and joint distributions the following two chapters are shorter and of an introduction to nature chapter 4 on limit theorems and chapter 5 on simulation a stochastic process is a collection of random variables indexed by time an alternate view is that it is a probability

distribution over a space of paths this path often describes the evolution of some random value or system over time first the concept of the stochastic or random variable it is a variable x which can have a value in a certain set Ω usually called range set of states sample space or phase space with a certain probability distribution discrete time stochastic is a sequence of random variables x_n defined on a common probability space Ω in more detail a stochastic process is function x of two variables n and ω for every n the function $\omega \mapsto x_n(\omega)$ is a random variable a measurable function part 1 probability and random variables 1 the meaning of probability 2 the axioms of probability 3 repeated trials 4 the concept of a random variable 5 functions of one random variable 6 two random variables 7 sequences of random variables 8 statistics part 2 stochastic processes 9 general concepts 10 random walk and important random variables statement gaussian random variable the gaussian or normal random variable $N(\mu, \sigma^2)$ is a continuous random variable described by the density function $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$

$x \sim N(\mu, \sigma^2)$ where μ and σ^2 are named mean standard deviation and variance random variables are defined on the outcomes of a random experiment if we perform the random experiment we obtain a value or range of values of the random variable for random processes or stochastic processes however the situation is quite different the terms stochastic variable and random variable both occur in the literature and are synonymous the latter is seen more often similarly stochastic process and random process but the former is seen more often abstract probability theory is regarded in this book as the study of mathematical models of random phenomena a random phenomenon is defined as an empirical phenomenon that obeys probabilistic rather than deterministic laws a variable or process is stochastic if there is uncertainty or randomness involved in the outcomes stochastic is a synonym for random and probabilistic although is different from non deterministic many machine learning algorithms are stochastic because they explicitly use randomness during optimization or learning by indexing

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