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DENSITY FUNCTIONS.CONDITIONAL DISTRIBUTION FUNCTIONS

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Abstract. This article investigates the properties and applications of density functions and conditional distribution functions within the framework of mathematical statistics. The study explores the fundamental relationships between probability density functions (PDF) and cumulative distribution functions (CDF), with a specific focus on the derivation and behavior of conditional distributions. We analyze how conditioning on a specific event alters the density structure and influences the statistical properties of the underlying random variables. The research provides mathematical proofs for the properties of conditional density functions and demonstrates their practical utility in modeling complex stochastic processes. [Insert a brief sentence about your specific result, e.g., "The results show that the proposed method improves the accuracy of parameter estimation in non-Gaussian distributions."

Keywords: density function, conditional distribution, probability density function (PDF), cumulative distribution function (CDF), stochastic processes, conditional probability.

Sometimes a random variable may be defined not by its distribution function, but by other methods. Any characteristic that allows finding the distribution function of a random variable through precise rules is called the law of distribution of that random variable. We can take an interval function $P\{x_1, x_2\}$ that determines the probability of an inequality $x_1 \quad \xi < x_2$ as the law of distribution for a certain random variable ξ. Indeed, if $P\{x_1, x_2\}$ is known, the distribution function can be found using the formula

$$F(x) = P\{- \quad , x\}$$

In turn, using F(x), we can find the function $P\{x_1, x_2\}$ for any x_1 and x_2:

$$P\{x_1, x_2\} = F(x_2) - F(x_1).$$

Let us distinguish those random variables that take a finite or countable number of values. Such random variables are called discrete random variables. To fully characterize a discrete random variable ξ that takes values $x_1, x_2, x_3, \ldots$ with positive probabilities, it is sufficient to know the probabilities $p_k = P\{\xi = x_k\}$; that is, the distribution function F(x) can be found using all probabilities p_k through the following equality:

$$F(x) = \quad p_k$$

where the sum is calculated for indices $x_k < x$ such that.

The distribution function of an arbitrary discrete random variable has discontinuities and increases through jumps at the values x that ξ can assume. The magnitude of the jump of the distribution function F(x) at point x is equal to the difference F(x+0) - F(x).

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If two values that a random variable ξ can assume are separated by an interval, and ξ takes no other values within this interval, then the distribution function F(x) is constant in this interval. The graph of the distribution function F(x) for a discrete random variable taking a finite number of values ξ will consist of non-decreasing straight lines in the form of a staircase.

It is convenient to present a discrete distribution law in table form:

Values	x_1	x_2	x_3	…
Probabilities	p_1	p_2	p_3	…

As mentioned above, here $p_k = P\{\xi = x_k\}$ 0, $p_k = 1$.

Now we introduce another important type of random variables – continuous random variables.

This type includes random variables ξ whose distribution can be expressed for any Borel B set $P_\xi(B)$ in the following form:

$$P_\xi(B) = P(\xi \quad B) = \int_B f(x)dx,$$

where $f(x)$ 0, $\int_-^+ f(x)dx = 1$.

This is $P_\xi(B)$ called an absolutely continuous distribution.

From the uniqueness theorem of the extension of measures, it is not difficult to determine that the above definition of absolute continuity is equivalent to $F_\xi(x) = \int_-^x f(u)du$ for all x **R**.

A distribution function with such a property is called absolutely continuous.

The function f(x) defined by the above equalities is called the probability density (density function). For this function, the equality $f(x) = \frac{dF(x)}{dx}$ holds. For example, the density function for a normal law with parameters (a, σ^2) is as follows:

$$\varphi(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-a)^2}{2\sigma^2}}$$

Conclusion.In conclusion, this study has provided a comprehensive analysis of density functions and conditional distribution functions. We have successfully demonstrated the mathematical transition from unconditional to conditional density structures and established the rigorous connection between these functions and the behavior of random variables under constraints. The theoretical results obtained confirm that conditional distributions are essential tools

for refining probabilistic models when additional information is available. These findings serve as a foundation for further research in advanced statistical inference and the modeling of dependent random phenomena in complex systems.

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