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N-Rayleigh Distribution in Mobile Computing for Flat-Fading Channel

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Abstract - In wireless communication, the presence of reflectors, obstacles etc, the signal experiences variation in characteristics like amplitude and frequency is known as fading channel [1]. This paper, explain the importance of Rayleigh distributed random variables in mobile computing field. At present time in emerging wireless technology, n-Rayleigh distribution has played an important role. The concept of random process in communication is expansion of cdf and pdf which are mostly used in application of physical science, statistics, and experimental data collection in wireless environment, random modeling and estimation of fading channel.

Keywords : Fading Channel, Radio Propagation, Rayleigh Distribution.

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N-RAYLEIGH DISTRIBUTION IN MOBILE COMPUTING FOR FLAT-FADING CHANNEL

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N-Rayleigh Distribution in Mobile Computing for Flat-Fading Channel

Amit Kumar[α], Sanjay Singh[Ω], Varun Kr. Gupta[β]

Abstract - In wireless communication, the presence of reflectors, obstacles etc, the signal experiences variation in characteristics like amplitude and frequency is known as fading channel [1]. This paper, explain the importance of Rayleigh distributed random variables in mobile computing field. At present time in emerging wireless technology, n-Rayleigh distribution has played an important role. The concept of random process in communication is expansion of cdf and pdf which are mostly used in application of physical science, statistics, and experimental data collection in wireless environment, random modeling and estimation of fading channel.

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I. Introduction

For radio wave propagation through wireless communication channel, the n-Rayleigh distribution has been found to explain precisely amplitude behaviour. A series of statistically random Rayleigh fading process connected by narrow pipes just like n-Rayleigh model which agree well with measurement in forest environment [2],[3]. Amplitude model is used in study of propagation by diffracting street corner.

The probability density function and distribution function for n=1,2 is generally studied but more general form the n-Rayleigh distribution function appears to be absent in studies. Mostly Monte Carlo simulation has been used in studies. Here used an inverse Mellin transform technique from statistics and in terms of Meijer G-function for probability density and distribution function which provides cascade form of distribution function. The additional advantage of this result may be used where distribution of product of Rayleigh independent variables were studied using Monte Carlo simulation. This may be used for proposed n-scattering model. Analytical expression of signal amplitude is needed in study of performance of wireless radio wave propagation [6].

a) Mobile Computation

Mobile Computation requires wireless network to support outdoor mobility and handoff from one network to the next. The term Mobile Computation deals with mobility of hardware, data and software. The access to computing is necessary not only from local one, but also while the user is moving from one place to another [9].

There are many types of computers and phones which have been familiar from last two decades include:

- Wearable computer
- PDA/Enterprise digital assistant
- Smart phone
- Computer
- Ultra mobile personnel computer

b) Challenges of Mobile Computation

i. *Insufficient bandwidth*

Adaptability to network environments ranging from high to low bandwidths and infrared communication links.

ii. *Radiation is Injurious to Health*

Mobile computation device used electromagnetic radiation. The radiation from mobile phone and BTS are potential health hazards. The cellular radio frequency radiation can cause the heating of tissue that leads to an increase in body temperature. Some harmful effects are given below.

- Thermal effect
- Non-thermal effect

iii. *Secrecy Purpose*

Secrecy is a major concern so far as the secure and confidential communication is required. The main schemes for secure communication include:

- Authentication Schemes
- Encryption Schemes

iv. *Expensive Device for Power Supply*

Since the power consumption is always a factor of major concern but the mobile computers must depend entirely on battery power. Combined with compact size, this means unusually expensive batteries used.

v. *Multipath Fading and other Interference*

The interference in a Mobile Computation are due to multipath fading, co-channel interference weather and terrain problems as well as distance-limited connection exist with some technologies. Reception of signal in tunnels and some buildings is poor.

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c) Mobile Computation: in-vehicle Computation and fleet Computation

The computation technologies are successfully used for Stationary system with fixed network. Mobile computation increases the volatility of some information. Certain data considered static for stationary Computation becomes dynamic for mobile Computation. For example, a stationary computer can be configured statically to prefer the nearest server. Mobile computer needs a mechanism for determining which server to use. As volatility increases then cost, benefit and trade-off points shift, calling for appropriate modifications in the design. Mobility introduces several problems: A mobile computer's network address changes dynamically. There are two main problems raised by mobility. First problem is searching for current location of mobile node and other is to impose a communication structure among nodes. Some limitations in vehicle Computation include:

- *Effect of Pulsation*: Vehicles typically have considerable pulsation that can decrease life expectancy of computer components for example HDDs.
- *Invisibility of Screen Due to Sun*: Visibility of standard screens becomes an issue in bright sunlight.
- *Touch Screens*: These enable users to easily interact with the units in the field without removing gloves.
- *Sensitive to High-Temperature*: Lithium Ion batteries are sensitive to high temperature conditions for charging. A computer for the mobile environment should be designed with a high-temperature charging function that limits the charge to 85% or less of capacity.
- *Problem in Designing Software*: There are many difficulties arises during designing software for moving vehicle.

Mobile Computation represents addition to wire-based local area distributed systems. Mobile Computation also represents the elimination of time-and-place restrictions imposed by desktop computers and wired networks. A quiet revolution is in progress in mobile computation field.

II. RAYLEIGH DISTRIBUTION

Here the distribution function of n-Rayleigh random variables is represented. The Mellin transform technique is used in advanced statistics. The main idea may also be useful in other similar distribution problems [6].

a) Product of independent Rayleigh Random Variables

Consider a product of n independent random variables:

$$Y = \prod_{i=1}^{n} X_i \qquad (1)$$

Where X_i is a Rayleigh distribution [4] random variable with probability density function (pdf) as shown in figure 1.

$$f_{x_i}(x) = \frac{x}{\sigma_i^2}\exp\left(-\frac{x^2}{2\sigma_i^2}\right),\ x \geq 0 \qquad (2)$$

In this way Y is defined and can be called an "n-Rayleigh" random variable. The n th moment of X i.e. $E[X_i^h]$, [6] is shown in figure 2.

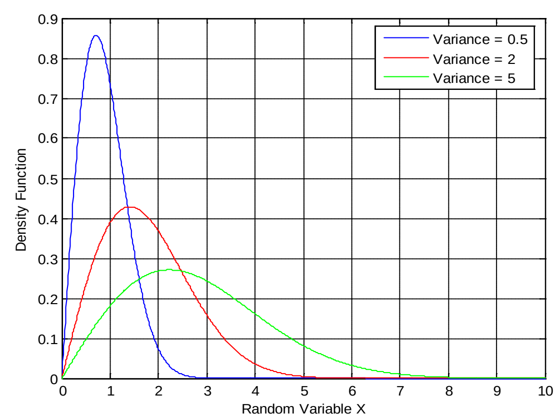

Figure 1: Rayleigh Probability Density Function at Different Variance

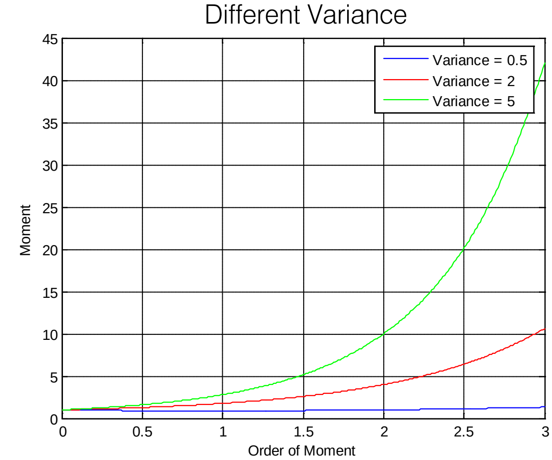

Figure 2 : Moment of Rayleigh Probability Density Function at Different Variance

$$E[X_i^h] = \int_0^\infty \frac{x^{h+1}}{\sigma_i^2}\exp\left(-\frac{x^2}{2\sigma_i^2}\right)dx$$

$$= \left(2\sigma_i^2\right)^{\frac{h}{2}}\Gamma\left(\frac{h}{2}+1\right) \qquad (3)$$

Where definition of the gamma function is used

$$\Gamma(t) = \int_0^\infty x^{t-1}e^{-x}dx$$

b) Meijer G-function [5]

In the result, the density and distribution functions will be given in terms of the Meijer G-function, which is a generalization of the generalized hyper-geometric function and can be defined using the contour integral representation as:

$$G^{m,n}_{p,q}\left(\begin{matrix} a_1 \ldots\ldots a_p \\ b_1 \ldots\ldots b_q \end{matrix} \middle| Z \right) = \frac{1}{2\pi i} \times \int_L \frac{\prod_{j=1}^{m} \Gamma(b_j - s) \prod_{j=1}^{n} \Gamma(1 - a_j + s)}{\prod_{j=m+1}^{q} \Gamma(1 - b_j + s) \prod_{j=n+1}^{p} \Gamma(a_j - s)} z^s ds \quad (4)$$

The function is defined under following hypothesis [8]:

- $0 \le m \le q,\ 0 \le n \le p$ and $p \le q - 1$
- $z \ne 0$
- No. pair of b_k, $(k = 1,2,\ldots,m)$ differ by an integer or a zero.
- The parameter a_h and b_h are so that no. pole of $\Gamma(b_j - s)$, $j = 1,2,\ldots,m$ coincide with any pole of $\Gamma(1 - a_k + s)$, $k = 1,2,\ldots,n$
- $a_j - b_k \ne 1,2,\ldots$ for $j = 1,2,\ldots,n$ and $k = 1,2,\ldots,m$
- if $p = q$, then the definition makes sense only for $|z| < 1$

Where z, a & b are in general complex-valued. The contour is chosen so that it separates the poles of the gamma products in the denominator. The Meijer G-function has been implemented in some commercial mathematics software packages [5].

c) Density & Distribution function using Meijer G-function

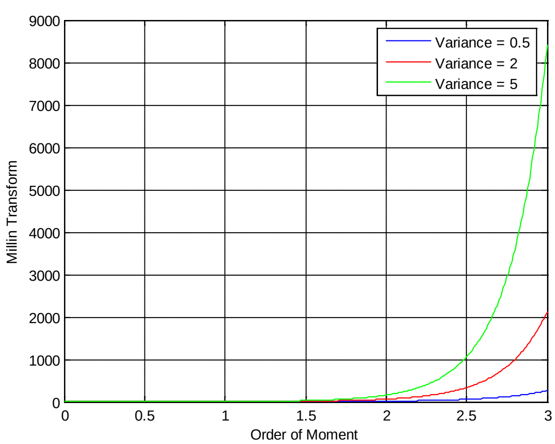

Figure 3 : h^{th} Variance of Inverse Miller Transform of Rayleigh Probability Density Function at Different Variance

Here the probability density functions of the inverse Mellin transform using contour integral. In figure 3, is derived using distinct value of variance Mellin transform defined with respect to order of moment. In application of advanced statistics, definite integral is done by Mellin transform technique. In this way the result may be expressed in terms of *Meijer G-function*.One can find the pdf of as the inverse Mellin transform of $v_h = E[Y^h]$, defined by the contour integral [7].

$$f_Y(y) = \frac{1}{j2\pi} \int_l v_h y^{-(h+1)} dh \quad (5)$$

Variance is defined by the equation 1 and 3 as:

$$v_h = (2^n \sigma^2)^{\frac{h}{2}} [\Gamma(\frac{h}{2} + 1)]^n \quad (6)$$

III. Conclusion

In application of Mobile Computation like data management and transaction method, the wireless path has a multipath profile. Practically there is scattering environment so signal propagation through wireless media is complicated phenomenon due to some effect like shadowing and multipath but n-Rayleigh method may also be helpful in modeling and evaluation for upcoming wireless and Mobile Computation technology.

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