ABSTRACT

ARTIFICIAL NEURAL NETWORK BASED SIMULATION OF SHORT-TERM FADING IN MOBILE PROPAGATION CHANNEL

In a typical propagation environment of the contemporary wireless communication systems, a number of reflected source signal replicas are reaching the receiver. By superposition of the received signal replicas, the resulting signal at the reception becomes incidental in time and space, i.e. it loses its deterministic characteristics, which is described by the notion of fading. As a consequence of these stochastic signal fluctuations at the reception, the resulting signal may drop below the reception threshold which disturbs the connection quality. At the same time, due to the different delays of the received signal replicas and transmitted impulse spread, signal dispersion may occur which might lead to the intersymbol interference.

In order to assess the performance of the wireless communication systems, a simulation of single, as well as correlated fading processes, has been of the interest for many years already. For the purpose of radio channel modelling, it is usually assumed that fading underlies the "clean" Rayleigh statistical distribution, which is not often the case in reality. Uncorrelated fading envelopes at the reception points are often assumed in multiple-antenna systems. The analysis, based on such assumptions, does not give a real picture of the communication system performance. Despite this, the existing simulation techniques have been mainly optimized against the theoretical characteristics of the fading process, while the measurement data in real systems have not been taken into account.

The scientific contribution of this PhD dissertation is the development of a novel simulation method of both single and correlated fading processes having desired statistical characteristics, of greater precision as compared to the existing relevant simulation methods. In fact, a novel method was proposed for simulation of short-term fading characterized by statistical and correlation characteristics of the fading process extracted from the received signal in a real communication system. Having in mind the complexity of the task such as simulation of the stochastic signal fluctuations at the reception, the proposed method was based on the artificial neural network principles. Artificial neural networks have been chosen due to their adaptive nature and capability of "learning by an example". Contrary to the existing simulation methods, the optimization of the proposed fading simulator was carried out only upon the measurement data. More precisely, training of the neural network was conducted based on the data measured in a given wireless communication system. The main idea of the proposed method was the estimation of the following fading value by processing

inter-correlated, preceding fading samples through the neural network. In order to navigate the simulator and avoid entering the stationary state, concept of driving signal was introduced which stochastically excited the neural network throughout the simulation procedure.

For the verification of the simulator performance, a comparative analysis against the existing relevant simulation methods was conducted based on which the advantages and disadvantages of each method were highlighted. By analyzing relevant qualitative and quantitative parameters, it was concluded that the proposed simulation method was in better agreement with measurements as compared to the existing methods. As it was based only upon the measurement data, the flexibility of the proposed method was reflected in its capability of simulating the fading process experienced in, practically, any chosen measurement environment. Despite the fact that training of the neural network was computationally demanding process, the proposed method showed, after the optimization of the network weight coefficients, a satisfying performance against the real time requirements as well.

Furthermore, a potential application of the proposed method for the simulation of other stochastic signals was investigated, which possess the so-called quasi-periodic characteristics similar to the short-term fading fluctuations. As one of the complex stochastic processes from the perspective of statistical analysis, the electroencephalogram, which represents the measure of electrical activity inside the human brain, was taken into account for the verification of the proposed method performance and its application.

KEYWORDS: Short-term fading, Rayleigh fading, Artificial neural networks, Mobile propagation channel, Diversity, Stochastic process simulation.