AI FOR MOBILE NETWORK DESIGN AND PLANNING

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Abstract:

The problems of designing and planning mobile networks are extremely important today. The radio signal is non-linear in nature and always significantly burdened by noise. Generally, two types of problems are solving independently in practice: the spatial distribution of the locally averaged signal level and simulating its temporal change. It is shown, by experiments, that these kinds of problems can be solved successfully by applying machine learning (ML) techniques. The obtained results are often at the level of the measurement uncertainty.

Keywords: mobile network design, radio propagation, fading

1. Introduction

The nature of the propagation of radio waves is very complex and diverse. Due to the spatial separation of transmitters and receivers, there is a weakening of the signal strength. In addition, the effects of reflection, diffraction, scattering, transmission, refraction, etc. occur during the propagation of radio waves. Therefore, the signal at the reception is very unstable over time and especially in relation to the local change of position of the receiver (and/or transmitter). The spatial shift of the order of the wavelength part can cause a change in the signal level by more than 30 dB. These instabilities of the signal at the reception are known as short-term (or multipath) fading. On the other hand, the local mean value of the signal varies more slowly in relation to the change of position. These relatively slow changes mainly depend on the general characteristics of the propagation environment (distance from the transmitter, obstacles, etc.) and are known as long-term fading (Fig. 1). Log-term fading estimation is of great importance for the design of mobile radio networks. On the other hand, during the development of standards, as well as the production of mobile devices, short-term fading generators play a big role. ML techniques can be used successfully to solve both of these problems.

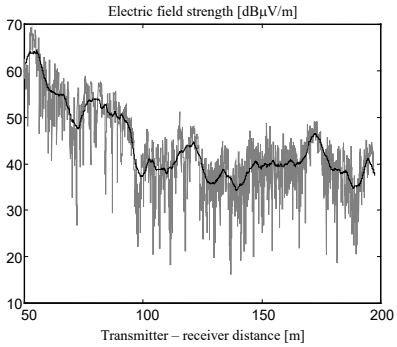

Fig. 1. Typical variations of electric field levels (change of electric field levels is fast - short-term fading, local mean value changes gradually - long-term fading) [1]

2. Signal level estimation (long-term fading estimation)

Several models have been developed for different mobile radio environments (macro, micro, indoor). The popular Artificial Neural Networks (ANN) and Support Vector Machine (SVM) techniques were used. In order to validate the models' quality, extensive electric field strength measurements were carried out in the city of Belgrade, for different test transmitter locations. Generally, the analysis of the developed models has shown that proposed models are fast, accurate (on the order of the local mean measurements uncertainty) and reliable (an example is shown in Fig 2). Although ANN models are easier to implement, in a number of cases the results obtained by these models are on the same level of accuracy or even better compared to SVM models. This is especially true in cases where the accuracy of the obtained model is close to the accuracy of measurement uncertainty.

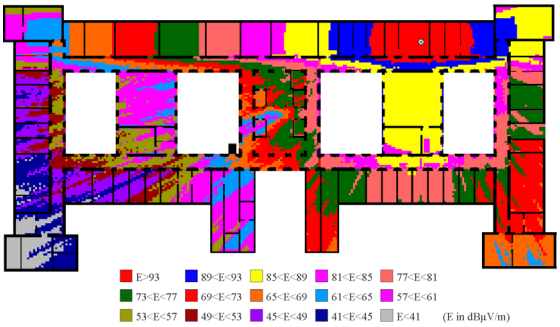

Fig. 2 Coverage prediction – SVM indoor propagation model (x – test transmitter location) [2]

3. Short-term fading generator

As can be seen from Fig 1, there is a clear correlation between adjacent samples of radio signal levels that must be taken into account in addition to other statistical parameters. This problem can also be modeled with ML techniques. However, in order to avoid entering the stationary state of the ANN output signal, the concept of driving signal (DS) had to be introduced. Actually, the DS only indicates the direction in which ANN should estimate the next fading value.

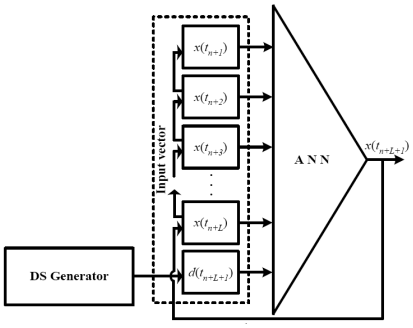

Fig. 3 ANN based fading simulator (DS - Driving signal) [3]

3. Conclusions

Traditionally difficult problems of radio channel modeling can be successfully solved by applying modern ML techniques. A number of models considered have already been successfully applied in the design of real mobile networks. When the proposed models are implemented on standard processors, their numerical efficiency is good, although still not good enough. The implementation on dedicated hardware would certainly significantly contribute to the further expansion as well as their popularity in an engineering practice.

References

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