MULTISLOPE CHANNEL MODEL OPTIMIZATION PROCESSING

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Abstract

This paper is focused on propagation channel modeling for mobile communications. Path loss measurements carried out in and around Brno were processed by PSO (Particle Swarm Optimization) multislope modeling process. We optimize one break point and two break points models. Than, we estimate the best MSE fit with the measured data. Lower deviation error was achieved with the two break point channel model.

1 Introduction

We are working on wireless channel modeling for mobile communications. We measured received signal strength (RXLEV) in real GSM network [1]. The near site measurements were carried out in and around Brno city. Collected data were processed with channel modeling optimization process. Particle swarm optimization (PSO) of the multislope modeling technique was applied.

Channel modeling is a complex issue strongly dependent on the individual conditions. Propagation environment affects the character of the communication channel between transmitter and receiver (T-R). Signal distribution inside buildings is different than outside. For outdoor are typical long distances between T-R. According to the density of buildings we can distinguish urban, sub-urban and rural environmental types. Signal attenuation in metropolitan city is significantly higher than in open area. Channel models for outdoor environment are described in [2] [3]. Indoors is T-R distance up to few hundreds of meters. Main factors affecting indoor signal distribution are the building structure, wall structure and number of penetrated floors. Indoor channel models are described in [2]. Formula (1) describes logarithmical dependence of signal path loss on T-R distance. LogDistance model is

$$PL(d) = PL(d_0) + 10 \cdot n \cdot \log_{10}\left(\frac{d}{d_0}\right), \tag{1}$$

where $PL(d_0)$ is the frequency dependant free space path loss coefficient at distance d_0=1m, n is the path loss exponent and d is the T-R distance. The path loss exponent n influences the slope of the propagation model.

2 Multislope modeling

We model measured path loss for distances up to 1 km. The multislope modeling approach described in [2]-[4] was extended with formula (1). Two coupling points at distance 30 m and 1 km sets the borders of our modeling space. Formula (2) determines the position of coupling point. Its free space path loss in the distance d_0=30 m is

$$PL(d_0) = 20\log_{10}\left(\frac{4\pi d_0 f}{c}\right), \tag{2}$$

where c is the speed of light, d_0=1m is the coupling points distance, f is the frequency of transmitted signal.

The basic idea, of the multislope channel model, is to split a propagation path to adjacent parts with different n. The value of n determines the slope of each part. The number of break points sets the number of separated parts see Figure 1. The path loss exponent n, in the area between two coupling points is the subject of an optimization process. The figure Fig. 1 shows multislope model with four break points.

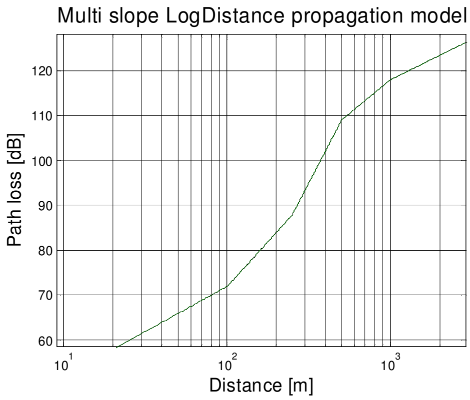

Figure 1: The multislope path loss model, with breakpoints at distances: 100m(n=2), 250m(n=4), 500m(n=7) and 1000m(n=3), over 1km is n=1.8

3 Optimization

PSO [5] is a global optimization process. It improves the solution iteratively by using a number of agents. They search a solution inside a particular space. In each iteration cycle, agents share the best global solution. The main criteria function determines the solution.

In our PSO algorithm, each agent represents one multislope model. The positions of the break points are iteratively changed. The best solution is determined in main criteria function by MSE estimation. MSE counts minimal deviation error between measured data and proposed models.

We optimized multislope models with one break point and with two break points. Results of our processing are summarized in Table 1 and Table 2. The samples of optimized models are on Figure 1 and Figure 2.

Table 1: ONE BREAK POINT MODEL WITH THE BREAKPOINT POSITIONS

MSE deviation error [dB]	*Break point distance of transmitter [m]*	*Breakpoint path loss [dB]*
15.5	192	99
15.4	137	95
15.4	947	120
15.3	115	91
15.6	786	118
15.3	106	90

Table 2: TWO BREAK POINTS MODEL WITH THE BREAKPOINT POSITIONS

MSE deviation error [dB]	*Break point distance of transmitter [m]*		*Breakpoint path loss [dB]*	
	1. BP	*2. BP*	*1. BP*	*2. BP*
15.2	41	349	70	106
13.0	41	673	90	108
12.7	135	990	103	110
13.0	41	745	90	111
12.7	105	948	100	111
13.0	108	689	103	104

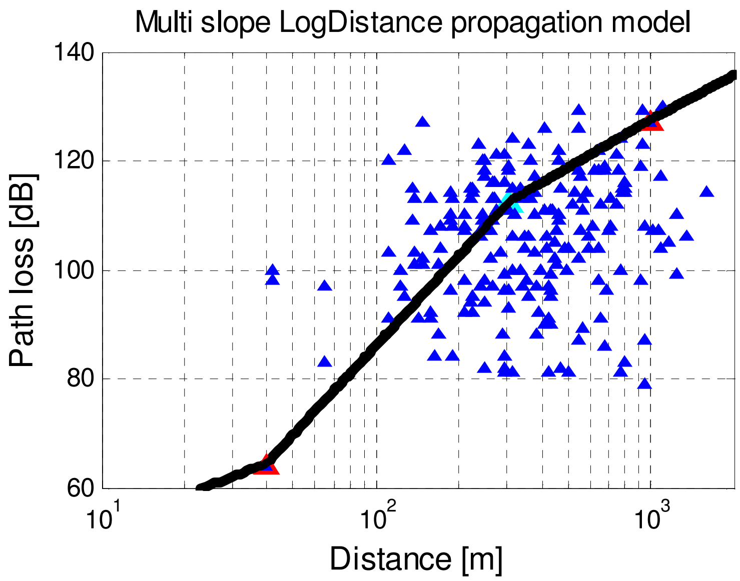

Figure 2: One break point optimized model and measured data. Break point positions are bp0=[40 m; 64 dB], bp1=[305 m; 112 dB] , bp2=[1000 m; 127 dB]

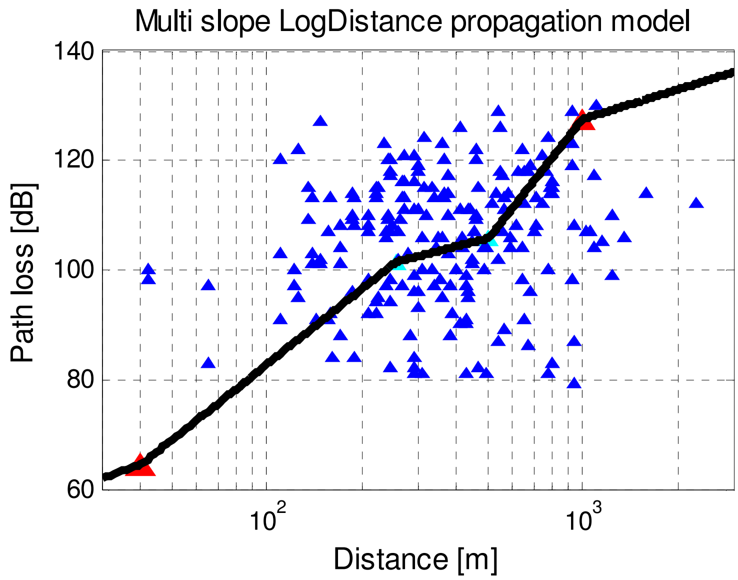

Figure 3: Two break points optimized model and measured data. Break point positions are bp0=[40 m; 64 dB], bp1=[253 m; 100 dB] , bp2=[542 m; 104 dB] , bp3=[1000 m; 127 dB]

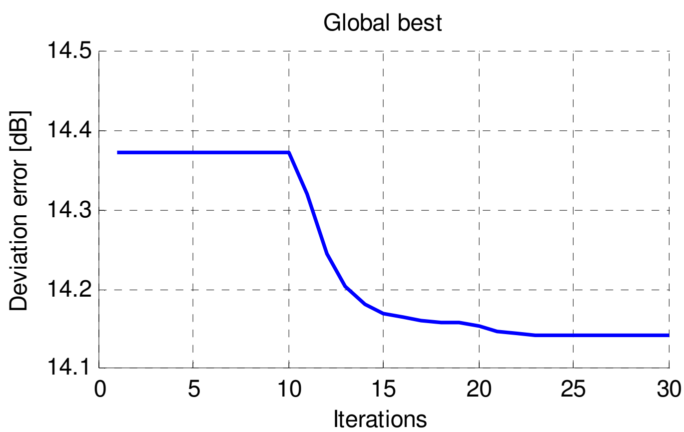

Figure 4: Error function of our optimized two break point model

Our PSO algorithm uses 12 agents with personal scaling factor *c1*=1.5 and global scaling factor *c2*=2.49. Main function of our PSO algorithm has 20 iterations. Figure 4 shows good convergence after 15th iteration. The same PSO settings we use for both one and two break point model.

4 Conclusion

The Propagation channel modeling at the near site of transmitter was described. The POS algorithm was used to the best fit multislope model with measured data. We apply the optimization process with one and two break points. Two breakpoints gives lower values of MSE deviation error (about 13dB), see Table 2. These deviation errors describe fading effects of propagation channel. Results of channel modeling are shown in Table 1 and Table 2. This paper shows the variability of propagation channel and will become the basis for a further work in the outdoor to indoor and the indoor channel modeling.

References

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