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Study on Rician K-factor Estimation from Time-Variant Channel Frequency Response for Performance Evaluation of Deterministic Wireless Channel Emulator

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Drive testing is necessary prior to system implementation to evaluate the robustness of wireless system to the multipath propagation. Wireless channel emulator (WCE) allows virtually drive testing with less expensive and high reproducible. WCE utilizing deterministic channel model has been recently studied for drive testing site-specific scenario. Performance evaluation of communication link typically employs the standard channel model. Hence, the authors previously introduced the parameter mapping technique in [1] to synthesize standard narrowband (NB) and wideband (WB) Rician fading channels based on statistical parameters of site-specific channel. Among parameters, Rician K-factor (K_r) determines a level of fading severity. Hence, estimation accuracy of K_r is important for system evaluation of emulated channel via Rician fading channels. The K_r is typically estimated either from NB time-varying and WB frequency selective fading channels separately. However, site-specific channel represents both fading characteristics in terms of time-variant channel frequency response (TV-CFR). In this work, the analysis of K_r estimation from envelop of both time and frequency TV-CTF samples is studied.

Suppose WCE generates P propagation paths at i-th time instant with Doppler, delay, and path weight. TV-CTF $H_i(t_n, f_m)$ can be computed from these components as deterministic process at nth time $t_n = n\Delta t$ and mth carrier frequency $f_m = m\Delta f$ samples with sampling duration Δt and Δf, respectively. By selecting number of N time and M frequency samples, a total NM envelopes of $|H_i(t_n, f_m)|$ is utilized to estimate K_r via maximum likelihood estimation (MLE). The accuracy of MLE-based K_r depends on NM and the coherency among samples. The latter is parameterized by sampling factors $L_\mathrm{t} = 1/\Delta t \nu_{\max}$ and $L_\mathrm{f} = 1/\Delta f \tau_{\max}$ which are inverse proportional to maximum Doppler $\nu_{\max}$ and delay $\tau_{\max}$. By defining a relative number of time and frequency samples as $\Omega_\mathrm{t} = N/L_\mathrm{t}$ and $\Omega_\mathrm{f} = M/L_\mathrm{f}$, respectively, the accuracy of MLE-based K_r can be statistically analyzed in terms of the total number of relative samples $\Omega_\mathrm{t}\Omega_\mathrm{f}$. The simulation was conducted to evaluate K_r estimation accuracy by varying Ω_t and Ω_f at different K-factor levels. 60 delays and Doppler were generated from a PDF of the exponential-decay power delay profile and Jakes' Doppler power spectrum with equal path weight, respectively. A dominant path parameter was generated in the same manner but with a higher path weight w.r.t K-factor level. Simulation result in Fig. 1 verified that K_r can be estimated from joint time and frequency samples of TV-CFR. Increasing Ω_t and Ω_f reduces estimation error variance. However, the channel with a larger K-factor tends to have a larger estimation error. With the Monte Carlo method (MC), taking an average over multiple ensembles of MLE-based estimation (MLE-MC) with similar $\Omega_\mathrm{t}\Omega_\mathrm{f}$ significantly reduces the estimation error as depicted in Fig. 1 for 50-ensembles averaged.

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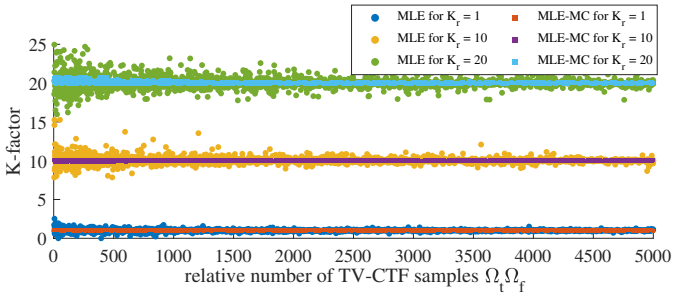

Figure 1. K-factor estimation from TV-CTF using MLE and MLE-MC method at different relative samples

References

[1] N. Keerativoranan and J. Takada, "Deterministic to Standard Channel Parameter Mapping for Performance Evaluation of Wireless Channel Emulator," in *2023 IEICE General Conf.*, 2023.