## Abstract

Quantifying the degree of time-variance of a system and the degree of nonstationarity of a random process can help analyze, process, and synthesize signals and systems. In this thesis, we investigate the time-variability of linear periodically time-varying (LPTV) systems and the non-stationarity of wide sense cyclostationary (WSCS) random processes (with discrete-time input and output). We provide measures for the degree of time-variance of a system and the degree of non-stationarity of a random process. Whereas one measure for the degree of time-variance exploits the periodicity of the kernel and provides the measures in terms of Fourier coefficients, the other measure is computationally more efficient and provides the measure in terms of system kernel only. The second measure is also very general and can be used for various time-varying systems. We then consider the non-stationarity of WSCS random processes and, assuming that any WSCS process is the output of some LPTV system with white noise as input, provide a measure for the degree of non-stationarity of the process in terms of the departure of time-varying autocorrelation operator from the time-invariant part. In signal processing applications, multirate systems play an essential part, and we provide explicit expressions for the measures for various scenarios involving multi-rate systems.

We also propose a novel multi-rate system family that can periodically introduce time-varying up-sampling rates. As we observe later, such a structure can model or generate semi-periodic signals like ECG, jitter, and voiced phonemes. This family is termed as TVUSR. Since this family of structures results in time-varying systems, one of the exciting applications of such a family could be to manipulate the non-stationarity of random processes. Hence, we deeply investigate the spectral properties of the output processes of TVUSR for various inputs, including WS-ACS, WSCS, and WSS. We also measure the degree of non-stationarity for a wider class of non-stationary processes.

Motivated by the range of applications that the proposed new family of structures can provide, we also propose a model for ECG signals and provide closed-form expressions for the time-varying autocorrelation function as well as the power spectral density of the process generated by the proposed model, under some assumptions on the model for analytical tractability.