Time-Frequency Analysis and its Applications in Wireless Communication

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Time-frequency analysis provides the representation of the energy distribution of a nonstationary signal in the time-frequency plane. Its applications range over the decomposition of musical and acoustical signals, wireless communication, and analysis of EEG signals. The discrete Gabor transform is a standard numerical tool for time-frequency analysis. Its centerpiece is the window function $g \in L^2(\mathbb{R})$, which has good localization in the time- and frequency-domain, together with its time-frequency shifts $M_{l\beta}\, T_{k\alpha}\, g(x) = e^{2\pi i l \beta x}\, g(x - k\alpha)$ with respect to a lattice $\alpha\mathbb{Z} \times \beta\mathbb{Z} \subset \mathbb{R}^2$.

In wireless communication, orthogonal frequency-division multiplexing is used for data transmission. For OFDM, the time-frequency shifts $M_{l\beta}\, T_{k\alpha}\, g$ form an orthonormal system in L^2. In recent work together with K. Gröchenig, we describe a class of window functions g and construct biorthogonal systems $M_{l\beta}\, T_{k\alpha}\, \gamma$, which can be used in (non-orthogonal) FDM. The mathematical theory behind the construction of these systems is Approximation Theory and Schoenberg's definition of totally positive functions dating back to the 1940's.