

Hlawatsch, Franz; Matz, Gerald

Quadratic time-frequency analysis of linear time-varying systems. (English) [Zbl 1035.94002](#)
Debnath, Lokenath, Wavelet transforms and time-frequency signal analysis. Boston, MA: Birkhäuser (ISBN 0-8176-4104-1/hbk). Applied and Numerical Harmonic Analysis, 235-287 (2001).

The development of a symbolic calculus for finite-power signals requires one to regard square-integrability as an essential part of the Stone-von Neumann theorem of nilpotent harmonic analysis [*W. Schempp*, Harmonic analysis on the Heisenberg nilpotent Lie group, with applications to signal theory. Pitman Research Notes in Mathematics Series 147, Longman Scientific and Technical, London (1986; [Zbl 0632.43001](#)); *Acta Appl. Math.* 48, 185–234 (1997; [Zbl 1002.92535](#)); in: Inverse problems, tomography, and image processing (A. G. Ramm, editor), Proc. ISAAC 1997, 129–176 (1998; [Zbl 1001.92536](#)); Magnetic resonance imaging: Mathematical foundations and applications. Wiley-Liss, New York (1998; [Zbl 0930.92015](#))]. In fact it has been established that a general representation of a nilpotent Lie group is determined by its central character if and only if it is square-integrable modulo the center [*C. C. Moore* and *J. A. Wolf*, *Trans. Am. Math. Soc.* 185 (1973), 445–462 (1974; [Zbl 0274.22016](#))]. The strong Stone-von Neumann theorem then provides an isomorphism of the convolution algebra of rapidly declining functions to the algebra of all kernel operators with rapidly declining kernel which extends to an isometric isomorphism of the Hilbert space of square-integrable functions with the algebra of all Hilbert-Schmidt operators, concretely realized as kernel operators with square-integrable kernel. Presently workstations with sufficient computing and graphical display capability are available to implement real-time joint time-frequency transforms and dynamically visualize time-dependent aspects of spectral signal structure.

The paper under review translates in a rather straightforward manner the spectral theory of compact operators into terms of finite-power signals of moving targets and their linear time-varying system theory [*H. L. van Trees*, Detection, estimation, and modulation theory. Volumes I–II, John Wiley & Sons, New York (1968; [Zbl 0202.18002](#)) and (1971; [Zbl 0301.93050](#))]. The authors' system theoretical treatment of kernel operators and their joint filtering processes does not refer to the deeper and unifying background of harmonic analysis on nilpotent Lie groups nor to the practical application of joint time-frequency analysis of linear time-varying systems to radar imaging of moving targets, and extraction of target features from moving targets [*V. C. Chen* and *H. Ling*, Time-frequency transforms for radar imaging and signal analysis. Artech House, Boston (2002; [Zbl 1001.94003](#))]. A treatment of the joint time-frequency filtering processes of chirp signals, which admit a group representational background too and which play a significant role in inverse synthetic aperture radar imaging, has been included into the system theoretical approach.

For the entire collection see [[Zbl 0996.00017](#)].

Reviewer: [Walter Schempp \(Siegen\)](#)

MSC:

[94A12](#) Signal theory (characterization, reconstruction, filtering, etc.)

[47B34](#) Kernel operators