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Applications of Time Frequency Analysis in Medicine and Geophysics

Medical imaging research at the Hotchkiss Brain Institute, University of Calgary, is focused on the application of mathematics, computer science, physics and engineering to help understand, diagnose, treat and monitor neurological disease. Several multi-disciplinary research teams, consisting of both basic scientists and clinicians, have been deployed within Foothills Medical Center. This seminar will provide an overview of the Fourier-based medical imaging modalities of computerized tomography and magnetic resonance imaging. It will then cover several medical applications of time/frequency analysis. In particular, our team is using time/frequency techniques to investigate signals and images from patients suffering from stroke, brain cancer, multiple sclerosis, and epilepsy. Finally, we will show applications of our medical time/frequency algorithms to analyze seismic signals for oil and gas discovery. We believe that time/frequency techniques have tremendous potential to advance the fields of science, engineering and medicine.

Note: this presentation will be targeted towards a non-medical audience. Nevertheless, it may contain some graphic images.

RYUICHI ASHINO
Osaka Kyoiku University

Blind source separation using time-frequency analysis

The cocktail party problem deals with the specialized human listening ability to focus one's listening attention on a single talker among a cacophony of conversations and background noise. The blind source separation problem corresponds to a way to enable computers to solve the cocktail party problem in a satisfactory manner. A blind source separation based on time-frequency informations for time-space mixing problems is discussed.

This is a joint work with Takeshi Mandai, Akira Morimoto, and Fumio Sasaki.

PAOLO BOGGIATTO
University of Torino

Weyl quantization and Lebesgue spaces

We study boundedness and compactness properties for the Weyl quantization with symbols in $L^q(\mathbb{R}^{2d})$ acting on $L^p(\mathbb{R}^d)$. This is shown to be equivalent, in suitable Banach space setting, to that of the Wigner transform. We give a short proof by interpolation of Lieb's sufficient conditions for the boundedness of the Wigner transform, proving furthermore that these conditions are also necessary. This yields a complete characterization of boundedness for Weyl operators in L^p setting; compactness follows by approximation. We extend these results defining two scales of spaces, namely $L^q_*(\mathbb{R}^{2d})$ and $L^q_\sharp(\mathbb{R}^{2d})$, respectively smaller and larger than the $L^q(\mathbb{R}^{2d})$, and showing that the Weyl correspondence is bounded on $L^q_*(\mathbb{R}^{2d})$ (and yields compact operators), whereas it is not on $L^q_\sharp(\mathbb{R}^{2d})$.

ERNESTO BUZANO
University of Torino

Continuity And Compactness Properties of Pseudo-Differential Operators

We shall consider pseudo-differential operators with Weyl symbol in Hörmander's classes $S(\mu, g)$ with temperate metric satisfying the uncertainty principle. Under general hypotheses on the Plank function $h = \sup(g^\sigma/g)$ and the weight μ, we give necessary and sufficient conditions on the symbol in order to have a bounded or a compact operator in L^2.

APARAJITA DASGUPTA
York University

Global Hypoellipticity of the Twisted Laplacian

We use pseudo-differential operators of the Weyl type (Weyl transforms) and Fourier-Wigner transforms of Hermite functions to construct the heat kernel and Green function of the twisted Laplacian. The Green function can be used to prove the global hypoellipticity of the twisted Laplacian. Then we introduce a scale of Sobolev spaces to measure the global hypoellipticity. (This is joint work with M. W. Wong.)

NICOLETA DINES
University of Potsdam

Elliptic operators on manifolds with corners

We construct a class of elliptic operators in the corner algebra on a manifold $K = M^{\triangle} := (\mathbb{R}_+ \times M)/(\{0\} \times M)$ with corner v, represented by $\{0\} \times M$, where M is a closed compact C^∞ manifold with an embedded submanifold Y interpreted as an edge.
Starting from a Fuchs type differential operator A on K we construct an associated operator $\mathcal{A}_s$ (for every sufficiently large s) in the corner calculus. The principal symbolic structure in that calculus has three components, namely, the standard interior symbol (corner-degenerate in this case), an operator-valued edge symbol and a corner conormal symbol (edge operator-valued). Ellipticity means the bijectivity of all these three components. In concrete cases it can be very hard to explicitly verify this kind of ellipticity, e.g., the one that concerns the conormal symbol is a complex spectral condition for operators on a manifold with edges. We show the existence of a parametrix within the corner algebra. The ellipticity of A gives rise to the ellipticity of $\mathcal{A}_s$. In this way we obtain a large class of new elliptic operators in the corner calculus. In addition we get explicit corner quantisations of elliptic Fuchs type pseudo-differential operators that appear as parametrices of Fuchs type differential operators.

CHARLES EPSTEIN
University of Pennsylvania

Microlocal Methods for Boundary Value Problems

In this minicouse we introduce the some of the concepts and results from microlocal analysis used in the analysis of boundary value problems for elliptic differential operators, with a special emphasis on Dirac-like operators. After a quick review of the geometry of manifolds with boundary, we consider the problem of finding elliptic boundary conditions for the dbar-operator on the unit disk. The rather explicit results, in this special case, delineate the route we follow for general first order elliptic systems on manifolds with boundary. After the functional analytic preliminaries, needed to do analysis on manifolds with boundary, we define and describe pseudodifferential operators satisfying the transmission condition. These operators behave well on data with support in a compact subset with a smooth boundary, and include the fundmental solutions of elliptic differential operators. Using the fundamental solution, we define the Calderon projector and establish its basic properties. We then consider boundary conditions defined by pseudodifferential projections, and find a simple criterion for such a boundary operator to define a Fredholm problem. This includes standard elliptic boundary conditions, as well as certain subelliptic problems. A formula for the index of such a boundary value problem in terms of the relative index between projectors on the boundary is derived.

BRENDAN FARRELL
University of California at Davis

Wiener's Lemma for the Heisenberg Group and a Class of Pseudodifferential Operators

Wiener's lemma states that if a periodic function f has an absolutely summable Fourier series and is nowhere zero, then 1/f also has a summable Fourier series. There has been a long development of theorems in the tradition of Wiener's lemma, most recently pertaining to twisted convolution, time-frequency shift sequences and pseudodifferential operators. The Heisenberg group lies at the heart of many of these recent developments. We present two forms of Wiener's lemma for the Heisenberg group: an integral operator perspective and a convolution perspective. We also discuss the consequences of these theorems for a class of pseudodifferential operators and the importance of such operators in wireless communications.

GIANLUCA GARELLO
University of Torino

Pseudodifferential operators and regularity for solutions of non linear partial differential equations

The application of pseudodifferential techniques to the non linear partial differential equations

$$F(x, \partial^\alpha u) = 0, \qquad \text{where} \quad F(x,\zeta) \in C^\infty(\mathbf{R}^n \times \mathbf{C}^N), \tag{1}$$

became of some interest in the last twenty-five years and they developed in various directions. One of the main tools was introduced by Bony in 1981. The basic idea is to write in (1) $F(x, \partial^\alpha u) = T_{F'(u)}u + r_u$. Despite the linear operator $T_{F'(u)}$ may be considered as pseudodifferential operator with symbol the linearization F' of F at u, it does not belong to the classical Hörmander classes. The Paradifferential Calculus has then been developed for studying all the the mains properties of such operators. One of the problem related to this theory arises from its strong dependence on the radial properties of the Euclidean norm. For such a reason we prefer to study the local regularity by means of pseudodifferential operators with non regular symbols. Namely by differentiating (1) with respect to x_j we have:

$$\sum_{|\gamma|\le m} \frac{\partial F}{\partial \zeta^\gamma}(x, \partial^\alpha u)\partial^\gamma \partial_{x_j} u = -\frac{\partial F}{\partial_{x_j}}(x, \partial^\alpha u),$$

We then reduce (1) to the linear equation: $\sum_{|\gamma|\le m} a_\gamma(x)\partial^\gamma \partial_{x_j} u$, where the coefficients $a_\gamma(x)$ cannot be smooth, since they depends at least by the regularity assumed by the solution u itself. The calculus of pseudodifferential operators with non-smooth symbols becomes then a fundamental tool. It has been developed by many authors, among them R. Coifman and Y. Meyer, M. Beals and M.C. Reed, M. Taylor, J. Marschall. In this talk we fix the attention on pseudodifferential operators with non regular symbols $a(x, \xi)$ which belong to Besov spaces with respect to x and whose derivatives with respect to ξ satisfy estimates of quasi-homogeneous type. The goal is to give results of regularity for quasi-elliptic non-linear equations.

PETER GIBSON
York University

Stockwell and wavelet transforms

The purpose of this talk is to relate the so-called Stockwell transform, which has received considerable attention for its potential in certain applications, to the broader context of time- frequency analysis. We discuss its connection to the well- established wavelet transform, with particular focus on the Morlet mother wavelet. In addition, we discuss its connection to the general framework of wave packets. In essence the Stockwell transform is a special type of wavelet transform. Nevertheless, it explicit reference to frequency and corresponding linear sampling casts an unconventional light on the wavelet perspective.

PETER GREINER
University of Toronto

On Carnot-Caratheodory Geometry, PDE-s and the Quartic Oscillator

Let $\triangle = X_1^2 + \cdots + X_m^2$ denote a second order partial differential operator where the $X_j - s, j = 1, \cdots, m$ are given vector-fields with $m \leq n, n$ the dimension of the underlying space. When $m = n, \triangle$ is the elliptic Laplace-Beltrami operator. When $m < n$ we have the class of subelliptic Laplacians. Such operators arise in complex analysis in several variables, in particular in the study of a nonelliptic boundary value problem usually referred to as the $\overline{\partial}$ - Neumann problem. Lately it became clear that the quartic oscillator, which is the mathematical description of the quantum mechanical phenomenon of the double well potential, may be transformed into one of these differential operators.

I shall use a complex hamiltonian formalism to construct explicit inverses and heat kernels for subelliptic Laplacians. These formulas are built from invariants of an underlying Carnot geometry. All such geometries allow an infinite number of geodesic connections between arbitrarily near points. This phenomenon yields canonical submanifolds whose tangent spaces may be used for the missing directions, directions not covered by $X_1, \cdots, X_m$. I shall discuss the quartic oscillator in this context.

KARLHEINZ GROECHENIG
University of Vienna

Time-Frequency Analysis: From Wireless Communications to Abstract Harmonic Analysis

In the first talk I will present some of the basic concepts and intuitions of time-frequency analysis. I will discuss the relation between problems in wireless communication and time-frequency analysis. I will explain the basic principle of OFDM (orthogonal frequency division multiplexing) and its formulation in time-frequency analysis. Surprisingly, the so-called pulse-shaping problem is equivalent to a problem on twisted convolution, and its general solution requires experience and tools in abstract harmonic analysis. Similarly, the modeling of the transmission channel leads to new and interesting problems on pseudodifferential operators. Their treatment is outside the standard theory of PDE and requires a genuine time-frequency approach.

The second talk will be devoted to weight functions in time-frequency analysis. Weight functions are a very technical topic in time-frequency analysis . Many different conditions on weights appear in the literature, and their motivation is sometimes confusing. I will offer a survey of the most important classes of weight functions in time-frequency analysis and how they occur in time-frequency analysis. As a general rule, submultiplicative weights characterize algebra properties, moderate weights characterize module properties, Gelfand-Raikov-Shilov weights determine spectral invariance, and Beurling-Domar weights guarantee the existence of compactly supported test functions.

THOMAS KRAINER
Penn State Altoona

Elliptic boundary problems on a class of noncompact manifolds

We discuss Fredholm criteria and regularity results for elliptic boundary value problems on a particular class of noncompact manifolds. An example for the topological setup would be Euclidean space with a noncompact obstacle removed.

Analytically, the operators under consideration may be regarded as cusp operators on manifolds with corners after suitable compactification of the noncompact ends, and boundary conditions are imposed on some of the boundary hypersurfaces.

Cusp operators (with cusp degeneracy on all boundary hypersurfaces) were introduced by Richard Melrose and Victor Nistor in 1996 in the context of the index problem on manifolds with corners of codimension 1 (unpublished), and in the case of higher codimensions by Robert Lauter and Sergiu Moroianu (2002).

A preprint related to the material presented in this talk is accessible from http://arXiv.org under math.AP/0508516 (2005).

YU LIU
York University

Inversion Formulas for Two-Dimensional Polar Stockwell Transforms

We begin with a definition of a two-dimensional polar Stockwell transform with an arbitrary window. We establish a resolution of the identity formula and hence an inversion formula for it if and only if the window satisfies an admissibility condition. (This is joint work with M. W. Wong.)

CALIN IULIAN MARTIN
University of Potsdam

Elliptic complexes on manifolds with corner singularities

We consider complexes of operators on a (compact) manifold with corner singularities. The operators belong to a so-called corner algebra; they are defined modulo compact operators, by a tupel of principal symbols

$$(\sigma^{\mu}_{\psi}(\cdot), \sigma^{\mu}_{\wedge}(\cdot), \sigma^{\mu}_{c}(\cdot))$$

consisting of the homogeneous principal symbol, the principal edge symbol and the corner conormal symbol, respectively. The ellipticity of the complex is defined as the exactness of the associated complexes of symbols. Parametrices of the elliptic complexes are then constructed. Those give rise to a corresponding generalization of Hodge-decompositions and regularity of harmonic corner forms.

ALIP MOHAMMED
York University

Wavelet multipliers on $L^p(R^n)$

We give results on the boundedness and compactness of wavelet multipliers on $L^p(R^n), 1 \leq p \leq \infty$. (This is joint work with Yu Liu and M.W.Wong)

ALESSANDRO OLIARO
University of Torino

A class of quadratic time-frequency representations

We define a class of time-frequency representations which is based on the short-time Fourier transform and depends on two fixed windows. We show that this class can be viewed as a link between the classical Rihaczek representation and the spectrogram. Correspondingly we formulate for this class an uncertainty principle which have, as limit case, the uncertainty principles for the Rihaczek representation and for the spectrogram. We finally consider the questions of marginal distributions. We compute them in terms of convolutions with the windows and prove simple conditions for which average and standard deviation of the distributions in our class coincide with that of their marginals.

GOTZ PFANDER
International University Bremen

Operator sampling applied to time-varying communication channels

We shall discuss the use of pseudodifferential operators for the modeling of mobile communication channels, for pulse shaping and, in particular, to solve the channel measurement problem:

Shannon's sampling theorem states that a bandlimited function can be recovered from its samples, as long as we use a sufficiently dense sampling grid. Here, we shall "beef up" this classical theorem, replacing functions by "bandlimited operators", that is, by pseudodifferential operators which have bandlimited Kohn-Nirenberg symbols. We show that such operators can be recovered from their action on a distribution which is supported on a sufficiently dense sampling grid.

C. ROBERT PINNEGAR
Calgary Scientific, Inc.

Localization of signal and image features with the TT-transform

Each local spectrum of a short-time Fourier Transform (STFT) has a windowed time series as its Fourier transform pair. If the STFT is modified to give its window wavelet-like scaling, this leads to corresponding changes in the local spectra, and in their Fourier transform pairs. The latter still resemble windowed time series, except that higher frequencies tend to cluster towards the midpoint of the window, while lower frequencies are more "spread out". These changes reflect the multiresolution nature of the modified STFT (which is also called the S-transform). The suite of modified time-local time series, when considered at all possible values of the window midpoint, give a time-time distribution called the TT-transform. TT-transforms of multidimensional functions can also be defined, by generalizing the one-dimensional case. Here, the basic attributes of the TT-transforms of one-dimensional time series, and two-dimensional images, are discussed.

RAPHAEL PONGE
University of Toronto

Heisenberg calculus and spectral theory of hypoelliptic operators

On a boundary of a complex $D \subset \mathbb{C}^{n+1}$ the $\overline{\partial}$-complex induces a complex of differential forms called the Kohn-Rossi complex. This complex makes sense on any manifold endowed with a Cauchy-Riemann (CR) structure. The associated Laplacian, called the Kohn Laplacian, is not elliptic, but it can be hypoelliptic under some geometric conditions.

The relevant pseudodifferential calculus to study the Kohn Laplacian is the Heisenberg calculus independently introduced by Beals-Greiner and Taylor in the mid 80s. The calculus holds in full generality for Heisenber manifolds, including contact manifolds and foliations, and it allows us to study further operators on such manifolds like Hörmander's sum of squares, the horizontal sublaplacian, the contact Laplacian and the CR invariant operators recently constructed by Gover-Graham.

The *motto* of the Heisenberg calculus, which goes back to an idea of Eli Stein, is to construct a class of pseudodifferential operators which are modelled at each point of the Heisenberg manifold by left-invariant pseudodifferential operators on the Heisenberg group. This stems from the observation that, in various senses, the Heisenberg group is tangent to the Heisenberg manifold at each of its points. As a result a get a pseudodifferential calculus with a complete symbolic calculus which allows to carry out explicit parametrix constructions for the main hypeolliptic operators and to obtain sharp regularity estimates for these operators.

In this talk we will present further results on the Heisenberg calculus and several new applications of this calculus: invertibility and hypoellipticity criteria, metric estimates for Green kernels, resolvent, complex powers and spectral asymptotics of hypoelliptic operators, noncommutative geometry, local index formula in CR geometry.

VLADIMIR RABINOVICH
National Polytechnic Institute of Mexico

Reconstruction of input signals in time-varying filters: Methods based on the theory of pseudodifference operators.

We consider the problem of reconstruction of input signals u in time-varying filters of the form

$$Au(x) = \sum_{j \in \mathbb{Z}} a_j(x)u(x-j), x \in \mathbb{Z}$$

We consider the algorithms of reconstruction of signals based on the theory of band-dominated and pseudodifference operators given in the recent book: V.S.Rabinovich, S. Roch, B.Silbermann, Limit Operators and its Applications in the Operator Theory, In ser. Operator Theory: Advances and Applications, vol 150, Birkhäuser, 2004 .

The following classes of filters are considered: slowly time-varying filters, perturbations of the periodic time-varying filters, casual time-varying filters, and finite filters acting on signals with finite number of values.

LUIGI RODINO
Universita di Torino

Semilinear Pseudo-Differential Equations and Applications to Travelling Waves

We report on some recent results obtained by Cappiello, Gramchev and Rodino, concerning semilinear pseudo-differential equations. The linear parts of such equations are given by the so-called SG-pseudo-differential operators, introduced by Parenti and Cordes, and then studied further by Coriasco, Schulze and many others. These operators are defined on the whole Euclidean space, and a suitable ellipticity condition at infinity (SG-ellipticity) implies for them the Fredholm property in a scale of weighted Sobolev spaces. In particular one obtains that bounded eigenfunctions belong to the Schwartz space S . Here we prove a more precise result of exponential decay and holomorphic extension, namely eigenfunctions of linear SG-elliptic equations belong to the Gelfand-Shilov space of order (1,1). The result extends to semilinear perturbations by a technique of a priori estimates. Applications concern solitary travelling waves. In particular, the celebrated KdV equation reduces, for travelling waves, to the Newton equation, basic example of semilinear SG ordinary differential equation. Similar examples are provided by higher order travelling wave equations and stationary solutions of semilinear Schroedinger equations in higher dimension. Also some non-local models in Fluid-Dynamics, suggested by Bona, provide travelling waves equations, which can be seen as semilinear perturbations of SG-elliptic pseudo-differential operators. Our result of exponential decay and holomorphic extension can be tested directly on the explicit form of the solutions for the Newton equation and other one-dimensional equations, whereas provide new information for the other higher dimensional models.

BERT-WOLFGANG SCHULZE
University of Potsdam

Pseudo-differential Calculus on Manifolds with Geometric Singularities

Differential and pseudo-differential operators on a manifold with (regular) geometric singularities can be studied within a calculus that is inspired by the concept of classical pseudo-differential operators on a smooth manifold. The operators form an algebra with a principal symbolic hierarchy, the length of which is equal to the order of the singularitiy (plus 1). Those symbols (partly being operator-valued) determine ellipticity and the nature of parametrices. It is typical in this theory that, similarly as in boundary value problems (which can be regarded as a special case of problems on a manifold with edge, here the boundary) there are trace, potential and Green operators, associated with the strata of the configuration. The operators, obtained from the symbols by applying various quantisations, act in weighted distribution spaces with multiple weights. We outline some essential elements of this calculus, give examples and applications, and comment on new challenges and interesting problems of the recent development.

ROBERT G. STOCKWELL
Northwest Research Associates

Why use the S-Transform?

The S-transform is a time-frequency representation known for its local spectral phase properties. A key feature of the S-transform is that it uniquely combines a frequency dependent resolution of the time-frequency space and absolutely referenced local phase information. This allows one to define the meaning of phase in a local spectrum setting, and results in many desirable characteristics that will be described in this presentation.

One drawback to the S-transform is the redundant representation of the time-frequency space and the consumption of computing resources this requires. The cost of this redundancy is amplified in multi-dimensional applications such as image analysis. A more efficient representation is introduced here as a orthogonal set of basis functions that localizes the spectrum and retains the advantageous phase properties of the S-transform. These basis functions are defined to have phase characteristics that are directly related to the phase of the Fourier transform spectrum, and are both compact in frequency and localized in time.

Distinct from a wavelet approach, the S-Transform approach (both overcomplete and orthogonal representations) allows one to directly collapse the local spectral representation over time to the complex-valued Fourier transform spectrum. One can perform direct signal extraction, localized cross spectral analysis to measure phase shifts between each of multiple components of two time series. In addition, one can define a generalized instantaneous frequency (IF) applicable to broadband nonstationary signals.

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ABSTRACTS 1.2

JOACHIM TOFT
Vaxjo University

Pseudo-differential operator algebras and modulation spaces

The talk is based on the joint paper *Weyl operator algebras and modulation spaces* by A. Holst[1], myself and P. Wahlberg[2].

In this talk we discuss algebraic properties for pseudo-differential operators with symbols in appropriate modulation spaces. These discussions go back to 1994 where J. Sjöstrand proved that the modulation space $M^{\infty,1}$ is an algebra under any pseudo-differential operator product. This can also be formulated as follows. Assume that $s, t_1, t_2 \in \mathbf{R}$, $a, b \in M^{\infty,1}(\mathbf{R}^{2d})$ and $c \in S'(\mathbf{R}^{2d})$ satisfy $c_s(x, D) = a_{t_1}(x, D) \circ b_{t_2}(x, D)$. Then $c \in M^{\infty,1}$. Here $a_t(x, D)$ denotes the pseudo-differential operator which takes the form

$$a_t(x, D)f(x) = (2\pi)^{-d} \iint a((1-t)x + ty, \xi) f(y) e^{ix-y\xi}\, dy d\xi$$

when $a \in S(^{2d})$ and $f \in S(d)$. We also recall that if $p, q \in [1, \infty]$ and ω is an appropriate weight function on ^{2d}, then the modulation space $M^{p,q}_{(\omega)}(d)$ is defined as the set of all distributions f such that

$$aM^{p,q}_{(\omega)} \equiv \Big(\int \Big(\int F(\chi(-x)\, f)(\xi)\omega(x,\xi)^p \, dx \Big)^{q/p} d\xi \Big)^{1/q}$$

is finite (with obvious modification when $p = \infty$ or $q = \infty$). Here F is the Fourier transform and $\chi \in S(d) \setminus 0$ is fixed. We also set $M^{p,q} = M^{p,q}_{(\omega)}$ when $\omega = 1$.

Later on, during the year 2001, Sjöstrand's result was improved by J. Toft who proved that if $p, q, r \in [1, \infty]$ are such that $1/p + 1/q = 1/r$, then the map $(a, b) \mapsto c$ is continuous from $M^{p,1} \times M^{q,1}$ to $M^{r,1}$. An other related result was established by D. Labate during the year 2001, who proved that $M^{p,p}_{(\omega)}$ is an algebra when $1 \leq p \leq 2$ and ω is appropriate.

In this context we shall here present a general result, which contains all these results. In particular we give sufficent conditions on the parameters $p_j, q_j \in [1, \infty]$ and weight functions ω_j, $j = 0, 1, 2$ such that the map $(a, b) \mapsto c$ from $S \times S$ to S is continuously extendable to a map from $M^{p_1,q_1}_{(\omega_1)} \times M^{p_2,q_2}_{(\omega_2)}$ to $M^{p_0,q_0}_{(\omega_0)}$. We also present some necessary conditions in the unweighted case, i. e. we give examples on the parameters p_j, q_j such that $(a, b) \mapsto c$ is not continuous extendable to a map from $M^{p_1,q_1}_{(\omega_1)} \times M^{p_2,q_2}_{(\omega_2)}$ to $M^{p_0,q_0}_{(\omega_0)}$.

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M.W. WONG
York University

Plancherel Formulas for Integral Transforms in Time-Frequency Analysis

We give an overview of the Plancherel formulas for the Fourier transform, the Gabor transform, the wavelet transform and the Stockwell transform in time-frequency analysis. The significance of the Plancherel formulas in the reconstructions of images from their time-frequency spectra is demonstrated and the role of these formulas in the genesis of pseudo-differential operators is elucidated.

HONGMEI ZHU AND CHENG LIU
York University

Time-frequency analysis in instantaneous frequency and amplitude estimations

Instantaneous frequency (IF) and instantaneous amplitude (IA) are critical parameters to describe a non-stationary signal whose frequency characteristics vary over time. In many situations such as seismic, radar and biomedical applications, the signal is often multi-component and noisy, for which the traditional methods for IF and IA estimations lose their effectiveness. In this talk, we propose an adaptive technique to measure the IF and IA using a time-frequency distribution given by the Stockwell transform. This method is based on the facts that the energy of a time-frequency distribution peaks about the IF and that the Stockwell transform offers an optimal time-frequency resolution. Our IF and IA measures are robust to noise, precise and effective for a large variety of signals. We illustrate and compare the performance of this new method and the other commonly used methods on both simulated and real data.