統計数理研究所
数学協働プログラム

2016 RIMS Joint Research & CoopMath2016

Wavelet analysis and signal processing

Organizer: Ryuichi Ashino (Mathematics Sciences, Osaka Kyoiku University)

Period: Oct. 24, 2016 – Oct. 25, 2016

Location: Research Institute for Mathematical Sciences, Room 111
Kyoto University, Kyoto 606-8502, Japan

Program

October 24

12:50 – 13:00 **Michio Yamada** (RIMS, Kyoto University) **Opening**

13:00 – 14:00 **Leon Cohen** (Department of Physics & Astronomy, The City University of New York)

The representation of functions in time-frequency and position-wavenumber

It has been recognized for over eighty years that transforming functions into the phase space of two non-commuting variables offers considerable insight into the nature of the function, and also has many practical applications. The two most common variable pairs are time/frequency and position/wavenumber. We will describe why such a transformation is an elegant and challenging problem, the immense strides that have recently been made, and how these methods impinge on issues in probability theory, differential equations, approximation methods, and other aspects of analysis. These methods have become standard, and are routinely applied in many areas, including acoustics, radar, biomedical signals, machine fault analysis, image processing, speech, among many others. By way of examples from many fields, we will show why considerable insight is gained in analyzing these signals in phase space.

14:15 – 15:15 **Takeshi Mandai** (Faculty of Engineering, Osaka Electro-Communication University)

On Inequalities about Instantaneous Amplitudes

For a real signal (a real-valued function) $f(t)$, we consider its analytic signal $(\mathcal{A}f)(t) = f(t) + i(\mathcal{H}f)(t)$, where $(\mathcal{H}f)(t)$ is the Hilbert transform of $f(t)$. Its absolute value $A(t) = |(\mathcal{A}f)(t)|$, which is called *instantaneous amplitude*, often represents a coarse variation of $f(t)$, and the graph of $A(t)$ looks like an "envelope" of the graph of $|f(t)|$. However, for some signals, $A(t)$ changes rather rapidly, and it doesn't look like an "envelope" of the graph of $|f(t)|$. We give mathematically rigorous inequalities about $\widehat{A^2}(\xi)$ which can be considered to explain this difference.

15:45 – 16:45 **Toshio Irino** (Faculty of Systems Engineering, Wakayama University)

Acoustic Scale Processing in the Auditory System

This is a joint work with Roy D. Patterson, Department of Physiology, Development and Neuroscience, University of Cambridge.

When we hear a voice over the telephone, we can tell whether the speaker is an adult or a child. We can also extract the message of the communication without being confused by the size information. This shows that auditory signal processing is scale invariant, automatically segregating information about vocal tract shape from information about vocal tract length. Patterson and colleagues have performed a series of experiments to measure the characteristics of size/shape perception [e.g., Smith et al., J. Acoust. Soc. Am. 117(1), 305-318, 2005], and provided a mathematical basis for auditory scale invariance in the form of the stabilized wavelet-Mellin transform (SWMT) [Irino and Patterson, Speech Commun., 36 (3-4), 181-203, 2002]. The mathematics of the SWMT dictates the optimal form of the auditory filter, insofar as it must satisfy minimal uncertainty in a time-scale representation [Irino and Patterson,

J. Acoust. Soc. Am. 101 (1), 412-419, 1997]. The resulting gammachirp auditory filter is an asymmetric extension of the earlier gammatone auditory filter? one which can explain the level dependence of human masking data. Thus, although it is not immediately intuitive, speaker size perception and auditory filter shape are both aspects of a larger, unified framework for scale processing in the auditory system.

18:00 – 20:00 **Friendly meeting (dinner)**

A friendly meeting will be held on the evening of October 24. The time and restaurant will be announced. The fee is about 6000JPY. Participants should contact with Professor Keiko Fujita (Department of Mathematics, Toyama University) **until September 30**. Her mail address is

▷ `keiko@sci.u-toyama.ac.jp`

October 25

9:30 – 10:30 **Leon Cohen** (Department of Physics & Astronomy, The City University of New York)

The transformation of deterministic and random differential equations into phase space

We describe methods that allow one to transform differential equations into phase space differential equations. The advantages are manyfold, providing insight into the nature of the differential equation and also in yielding new methods of solution and approximation. For the case of stochastic processes governed by random differential equations, the approach allows one to deal with nonstationary stochastic systems. As an example, we show how the methods lead to the full solution of Brownian motion.

10:45 – 11:45 **Kunio Yoshino** (Faculty of Knowledge Engineering, Tokyo City University)

Eigenvalue problem of Anti-Wick(Toeplitz) Operator in Bargmann-Fock space and Applications

First we recall the definition of Anti-Wick(Toeplitz) operator in Bargmann-Fock space. And we will give a formula for the eigenvalues of Anti-Wick(Toeplitz) operator with polyradial symbol in Bargmann-Fock space. By using this formula, we can construct symbol function of Anti-Wick(Toeplitz) operator. Clarifying the relationship between Toeplitz operators in Bargmann-Fock space and Daubechies operators in $L^2(\mathbb{R}^n)$, we will show a new proof of the formula of the eigenvalues of Daubechies operators with polyradial symbols.

13:15 – 14:15 **Kazushi Mimura** (Faculty of Information Sciences, Hiroshima City University)

Recent progress in compressed sensing

In recent years there has been many works on compressed sensing that exploits sparsity. We provide an introduction to some typical examples such as spatial-coupling, robust reconstruction, and an application to error correcting codes.

14:30 – 15:30 **Tamotsu Kinosita** (Division of Mathematics, University of Tsukuba)

Wavelet Transforms on Gelfand-Shilov Spaces

We shall study the continuity properties of wavelet transforms in the Gelfand-Shilov spaces with the use of a vanishing moment condition. Moreover, we also compute the Fourier transforms and the wavelet transforms of concrete functions in the Gelfand-Shilov spaces and show the optimality of our results.

For more information, visit our website at

▷ `http://www.osaka-kyoiku.ac.jp/~ashino/rims2016/`

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