EXPOWER Ice Breaker

ASTRON, The Netherlands
May 16 – 19

Location : Oude Hoogeveensedijk 4, 7991 PD Dwingeloo
Hotel : Landhotel De Borken, Lhee 76, 7991 PJ Dwingeloo

Day 1

Monday 16 May 2022	
09:00 – 09:30	EXPOWER coordinator
09:30 – 09:50	Lille
09:50 – 10:10	Goettingen
10:10 – 10:30	Stirling
10:30 – 11:00	Coffee break
11:00 – 11:20	Maplesoft/Waterloo
11:20 – 11:40	Delaware
11:40 – 12:00	NIH
12:00 – 12:20	Virtonomy
12:20 – 12:40	SU-Versfeld
12:40 – 14:00	Lunch
14:00 – 15:30	Secondment registration demo
15:30 – 16:00	Coffee break
16:00 – 16:30	Steering committee meeting (plenary)
16:30 – 17:30	Management board meeting *

*Becuwe (secondments), Cuyt (management, WP 3), de Villiers (dissemination), Lee (WP 5), Matos (WP 2), Plonka (WP 4), Prinsloo (dissemination)

Day 2

Tuesday 17 May 2022	
09:00 – 09:30	ASTRON local host
09:30 – 09:50	SU-de Villiers
09:50 – 10:10	Craft Prospect
10:10 – 10:30	NTU
10:30 – 11:00	Coffee break
11:00 – 11:20	KBC
11:20 – 11:40	ITRI
11:40 – 12:00	Genicap
12:00 – 12:20	Mahr
12:20 – 12:40	Siemens
12:40 – 14:00	Lunch
14:00 – 17:00	LOFAR excursion

Day 3

Wednesday 18 May 2022	
09:00 – 10:00	Gielis
10:00 – 10:30	Ou
10:30 – 11:00	Coffee break
11:00 – 11:30	Ou
11:30 – 12:00	Saee
12:00 – 12:30	Knaepkens
12:30 – 14:00	Lunch
14:00 – 14:30	Wijnholds
14:30 – 15:00	Weideman
15:00 – 16:00	Gerhard
16:00 – 16:30	Coffee break
18:30 – 21:00	Workshop dinner

Day 4

Thursday 19 May 2022	
09:00 – 10:30	Q&A session
10:30 – 11:00	Coffee break

Participants :

- Bernd Beckermann
- Stefan Becuwe (online)
- Deepayan Bhowmik (online)
- Fabio Bianciardi
- Andreas Beutler
- Wen-Yang Chu
- Annie Cuyt
- Dirk de Villiers
- Jürgen Gerhard
- Johan Gielis
- Polly Huang (online)
- Phil Karagiannakis (online)
- Ferre Knaepkens
- Wen-shin Lee
- Ridalise Louw
- Ana Matos
- Yvonne Ou
- Gerlind Plonka
- David Prinsloo
- Mina Saee
- Bob Wang (online)
- Rina-Mari Weideman
- Stefan Wijnholds
- Irem Yaman (online)

GT in biology, geometry and technology

Johan Gielis
Genicap Beheer BV, Netherlands

In the study of natural shapes and phenomena, the search for a unifying description is one of the key strategies. At the age of 23, Gabriel Lamé (1795-1860) published a small booklet on geometrical methods. To apply geometry to crystallography, he introduced supercircles and superellipses. A generalization of Lamé curves to Gielis curves enlarges the scope of a unified geometric description to many more natural shapes. In the past decade, this model has been tested successfully on over 40000 biological specimen [1] including tree rings, culms of bamboos, starfish and avian eggs. In the application of mathematics to the natural sciences we adhere to nine principles (three sets of three) that serve as our guide; the complexity of the model, the validation when tested on empirical data, and the connection to mathematical physics and computability.

From a geometrical point of view, Gielis Transformations are a generalization of the Euclidean circle and conic sections, and related to Minkowski and the simplest Riemann-Finsler geometries. Among others, this has opened the door for the application of classical Fourier projection methods to solve boundary value problems (Laplace, Helmholtz,...) on starlike domains in 2D and 3D [2]. With each shape, dedicated trigonometric functions can be defined and generalized Pythagorean Theorems. One example is D-trigonometry based on the diamond or inscribed circle, with potential applications in modeling piecewise linear signals. A natural connection between Gielis transformation on the one hand, and Chebyshev polynomials and pseudo-Chebyshev functions on the other, has emerged [2].

These developments have also found their way in various applications in science and technology. Examples will include minimal surfaces, antenna design and information sciences.

References

[1] J. Gielis, *The geometrical beauty of plants.* Atlantis-Springer, Amsterdam, 2017.
[2] P.E. Ricci J. Gielis, *From Pythagoras to Fourier and from Geometry to Nature.* Athena Publishing, Amsterdam, 2022.

Exponential sums for Nevanlinna-Herglotz functions

Miao-Jung Yvonne Ou[1]**,** ***Jiangming Xie***[2]**,**
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[2] Department of Mathematics, Tsinghua University, Beijing, China

The Nevanlinna-Herglotz-R functions have played an important role in applications in physics and in the study of resolvent of self-adjoint operator. Roughly speaking, they are functions that obey causality. In this talk, I will present several important examples of these functions and explain why the exponential sum approximation of these functions make sense and how it can be used for developing an efficient numerical solver for the corresponding physics system. The method of two-sided residue approximation, which can be used to find the exponents and weights from interpolating in the frequency domain, will also be explained.

A New Cutting Quadratic Method for Min-Max Problem

Mina Saee[1]***, D. Russell Luke***[2]***, Adrian S. Lewis***[3]
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[2] Georg-August-Universität Göttingen/Institute of Numerical and Applied Mathematicsn, Germany
[3] Cornell University/ School of Operations Research and Information Engineering, USA

We present a Bundle Newton method for minimizing the maximum of smooth convex functions which incorporates recent developments in nonsmooth analysis. Our proposed method is a two-phase approach where in the first phase random sampling and "cutting quadratics" are applied to identify the active manifolds at the solution. This phase of the algorithm is finitely terminating. The second phase of the algorithm proceeds along the lines of conventional approaches, though our analysis shows superlinear convergence without the usual assumptions of strong convexity

References

[1] J.V. Burke, A.S. Lewis, and M.L. Overton. Approximating subdifferentials by random sampling of gradients. *Mathematics of Operations Research*, **29**, 567-584, 2002.
[2]J. B. Hiriart-Urruty, C. Lemarechal. *Convex Analysis and Minimization Algorithms, I & II.* Grundlehren Math, Wiss. Springer-Verlag, New York, 305-306, 1993.
[3] M. Fukushima, Z.Q. Luo, and P. Tseng. A sequential quadratically constrained quadratic programming method for differentiable convex minimization. *SIAM Journal on Optimization*, **13**, 1098-1119, 2003.
[4] Y.E. Nesterov, A.S. Nemirovskii. *Interior-Point Polynomial Algorithms in Convex Programming.* SIAM Publications, Philadelphia, 1994.
[5] R.T. Rockafellar. *Convex Analysis.* Princeton University Press, 1970.
[6] R.T. Rockafellar, R.J. Wets. *Variational Analysis.* Grundlehren Math, Wiss. Springer-Verlag, Berlin, 3 edition, 2009.
[7] M.V. Solodov. On the sequential quadratically constrained quadratic programming methods. *Mathematics of Operations Research*, **29**, 64-79, 2004.

Least-squares Multidimensional Exponential Analysis

Ferre Knaepkens[1]***, Annie Cuyt***[1]***, Wen-shin Lee***[2]***, Yuan Hou***[1]
[1] Department of Computer Science, University of Antwerp, Belgium
[2] Computing Science and Mathematics, University of Stirling, United Kingdom

Exponential analysis consists in extracting the coefficients α_j, $j = 1, \ldots, n$, and exponents ϕ_j, $j = 1, \ldots, n$, of an exponential model, from a limited number of observations of the model's behaviour. Since there are $2n$ unkown parameters for n exponential terms, this directly leads to a non-linear square system of $2n$ equations. However, in practice the signal is often perturbed by noise, hence, additional samples are collected and accumulated in an overdetermined non-linear system. Now the question remains how such a noisy overdetermined system behaves and how we can use this information to improve the accuracy of the results. In the case of a square system it is shown in [1] that the exponential analysis problem is deeply intertwined with Padé approximation theory and symmetric tensor decomposition, for both the one-dimensional and multi-dimensional cases. In particular the connection with Padé approximations is very interesting, since it allows the use of Froissart doublets to effectively filter out the noise and correctly estimate the number of terms n. It still remains to be shown that these properties also hold for the least-squares setting of the exponential analysis problem.

Furthermore, we focus on three different application domains, ranging from only one dimension to three-dimensional problems, each with its own challenges. First up is one-dimensional direction of arrival estimation, then image denoising of structured images and finally inverse synthetic aperture radar. We combine sub-Nyquist sampling, a validation technique based on Froissart doublets and new matrix pencil methods in order to tackle these challenging engineering applications.

References

[1] F. Knaepkens, A. Cuyt, and W.-s. Lee, From Exponential Analysis to Padé Approximation and Tensor Decomposition, in One and More Dimensions. In *Computer Algebra in Scientific Computing*, G. Vladimir, K. Wolfram, S. Werner, and V. Evgenii (eds.), 116–130. Lille, 2018.

Exponentials in radio astronomical data processing

Stefan J. Wijnholds
Innovation & Systems, ASTRON, The Netherlands

In this talk, I give an introductory overview of radio astronomical signal processing and highlight several data processing challenges in which exponential functions play a pivotal role. These challenges include image reconstruction from radio-interferometric data, localisation of individual antennas in a large array, delay fitting and analysis of time series in search for transient phenomena. However, this is definitely not an exhaustive list and merely intended to give the audience a flavour of challenges in radio astronomy where exponential analysis techniques play a key role.

Antenna Position Estimation through Sub-Sampled Exponential Analysis of Signals in the Near-Field

Rina-Mari Weideman[1]***, Ridalise Louw***[1]***, Ferre Knaepkens***[2]***, ,Dirk de Villiers***[1]***, Annie Cuyt***[2]***, Wen-shin Lee***[3]***,Stefan J. Wijnholds***[1,4]
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Antenna position estimation is an important problem in large irregular arrays where the positions might not be known very accurately from the start. We present a method using harmonically related signals transmitted from an Un- manned Aerial Vehicle (UAV), with the added advantage that the UAV can be in the near-field of the receiving antenna array. The received signal samples at a chosen reference antenna element are compared to those at every other element in the array in order to find its position. We show that the method delivers excellent results using ideal synthetic data with added noise. Furthermore, we also simulate the problem in a full-wave solver. Although the results are less accurate than when synthetic data are used, due to the effects of mutual cou- pling, the method still performs well, with errors smaller than 4% of the smallest transmitted wavelength.

New Features in Maple 2022

Jürgen Gerhard
Research and Development, Maplesoft, Canada

An overview of the new features in Maple 2022 will be given, including real root finding, formal power series, intersection multiplicities, an interface to arblib, print layout mode, signal processing, and many more.