Keynote Speaker biography - Frédéric Barbaresco

Senior THALES Expert in Artificial Intelligence at the Technical Department of THALES Land & Air Systems. SMART SENSORS Segment Leader for the THALES Corporate Technical Department (Key Technology Domain "Processing, Control & Cognition"). THALES representative at the AI Expert Group of ASD (AeroSpace and Defense Industries Association of Europe). 2014 Aymée Poirson Prize of the French Academy of Science for the application of science to industry. Ampère Medal, Emeritus Member of the SEE, and President of the SEE ISIC club "Information and Communication Systems Engineering". He is French MC representative of European COST CaLISTA (Cartan geometry, Lie, Integrable Systems, quantum group Theories for Applications) (https://www.cost.eu/actions/CA21109/). General Chair of the following events: the "Geometric Science of Information" international conferences (https://franknielsen.github.io/GSI/), MaxEnt'22 conference at Institut Henri Poincaré (https://maxent22.see.asso.fr/), Ecole de Physique des Houches SPIGL'20 in July 2020 on « Joint Structures and Common Foundations of Statistical Physics, Information Geometry and Inference for Learning » (https://franknielsen.github.io/SPIG-LesHouches2020/) and FGSI'19 Conference "Foundations of Geometric Structures of Information" in February 2019 at IMAG "Institut Montpellierain Alexander Grothendieck" (https://fgsi2019.sciencesconf.org/). CIRM Luminy Seminar organizer of TGSI'17 "Topological and Geometrical Structures of Information" (http://forum.cs-dc.org/topic/361/tgsi2017-presentation-organisation-abstract-submission). Guest Editors of Special Issues "Lie Group Machine Learning and Lie Group Structure Preserving Integrators". Author of more than 200 scientific publications and more than 20 patents.

Keynote Title:
Lie Groups Statistics and Machine Learning for Radars based on Symplectic Structures of Information Geometry

Keynote Summary:

In a first part, we will present pioneering THALES Sensors/Radars algorithms: Geometric Matrix CFAR based on Jean-Louis Koszul's Information Geometry and its extension for STAP, Complex-Valued Convolutional Neural Networks and Covariance-Matrix-Valued HPDNet for Micro-Doppler ATDR, Lie Group-based Convolutional Equivariant Neural Network from Geometric Deep Learning for Doppler clutter map, IEKF (Invariant Extended Kalman Filter) Frenet-Serret Tracker based on Lie Groups for hyper-maneuvering targets, Tracker parameters tuning by Deep Learning and finally, Multi-Agent Reinforcement Learning for Radar Task Scheduling and Active-Track/TWS collaborative Resources Management.

In a second part, we will present Avant-Garde tools using statistics on Lie Groups for different sensors applications (detection, tracking and recognition). From French Jean-Marie Souriau's Symplectic Model of Statistical Physics and Russian Kirillov's Representation Theory of Lie Groups, we will introduce Gaussian statistical density for Lie Groups defined as Maximum Entropy Gibbs density on coadjoint orbits though moment map. This Symplectic model of Information gives new geometric foundation for Entropy, defined purely geometrically (and no longer axiomatically) as Casimir Invariant Function in Coadjoint Representation. We will conclude with new perspectives opened by this new Symplectic Theory of Heat and Information.

Bibliography:
[1] F. Barbaresco. Innovative tools for radar signal processing Based on Cartan's geometry of SPD matrices & Information Geometry. IEEE Radar Conference, 2008.

[2] F. Barbaresco. Robust statistical Radar Processing in Fréchet metric space: OS-HDR-CFAR and OS-STAP Processing in Siegel homogeneous bounded domains. 12th International Radar Symposium (IRS), pages 639–644, 2011.

[3] F. Barbaresco. Information Geometry of Covariance Matrix: Cartan-Siegel Homogeneous Bounded Domains, Mostow/Berger Fibration and Fréchet Median. Matrix Information Geometry; Springer, p. 199–256, 2012.

[4] M. Arnaudon, F. Barbaresco, and L. Yang. Riemannian Medians and Means With Applications to Radar Signal Processing. IEEE, August 2013.

[5] A. Decurninge, F. Barbaresco. Robust Burg Estimation of Radar Scatter Matrix for Mixtures of Gaussian Stationary Autoregressive Vectors. IET Radar, Sonar & Navigation, Volume 11, Issue 1, p. 78–89, January 2016.

[6] F. Barbaresco. Information Geometry Manifold of Toeplitz Hermitian Positive Definite Covariance Matrices: Mostow/Berger Fibration and Berezin Quantization of Cartan-Siegel Domains. International Journal of Emerging Trends in Signal Processing (IJETSP), March 2013.

[7] F. Barbaresco and M. Ruiz, "Radar detection for non-stationary Doppler signal in one burst based on information geometry: Distance between paths on covariance matrices manifold," 2015 European Radar Conference (EuRAD), 2015, pp. 41-44

[8] A. Le Brigant, F. Barbaresco and M. Arnaudon, Geometric barycenters of time/Doppler spectra for the recognition of non-stationary targets, 17th International Radar Symposium, 2016

[9] Bouleux G., Barbaresco F. (2019) Dilation Operator Approach and Square Root Velocity Transform for Time/Doppler Spectra Characterization on SU(n). In: Nielsen F., Barbaresco F. (eds) Geometric Science of Information. GSI 2019. Lecture Notes in Computer Science, vol 11712. Springer

[10] B. Balaji and F. Barbaresco "Riemannian mean and space-time adaptive processing using projection and inversion algorithms", Proc. SPIE 8714, Radar Sensor Technology XVII, 31 May 2013

[11] Y. Cabanes, F. Barbaresco, M. Arnaudon, and J. Bigot. Non-Supervised High Resolution Doppler Machine Learning for Pathological Radar Clutter. IEEE, RADAR 2019, Toulon, France, September 2019.

[12] F. Barbaresco, Coding & Statistical Characterization of Radar Signal Fluctuation for Lie Group Machine Learning, 2019 International Radar Conference (RADAR), 2019

[13] D. A. Brooks, O. Schwander, F. Barbaresco, J. Schneider and M. Cord, Complex-valued neural networks for fully-temporal micro-Doppler classification, 2019 20th International Radar Symposium (IRS), 2019

[14] D. Brooks, O. Schwander, F. Barbaresco, J.-Y. Schneider and M. Cord, Deep Learning and Information Geometry for Drone Micro-Doppler Radar Classification, 2020 IEEE Radar Conference (RadarConf20), 2020

[15] P.Y. Lagrave, Y. Cabanes, F. Barbaresco, SU(1,1) Equivariant Neural Networks and Application to Robust Toeplitz Hermitian Positive Definite Matrix Classification. In: Nielsen F., Barbaresco F. (eds) Geometric Science of Information. GSI 2021. LNCS vol 12829. Springer, 2021

[16] P.Y. Lagrave, F. Barbaresco. Introduction to Robust Machine Learning with Geometric Methods for Defense Applications. 2021. ⟨hal-03309807⟩

[17] M. Pilté, S. Bonnabel, and F. Barbaresco. Tracking the frenet-serret frame associated to a highly maneuvering target in 3D. In 2017 IEEE 56th Annual Conference on Decision and Control (CDC), pages 1969–1974, Dec 2017. 9, 23

[18] S. Jouaber, S. Bonnabel, S. Velasco-Forero, M. Pilte. NNAKF: A Neural Network Adapted Kalman Filter for Target Tracking. ICASSP 2021 - 2021 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Jun 2021

[19] M. Vincent, A. El Fallah-Seghrouchni, V. Corruble, N. Bernardin, R. Kassab, F. Barbaresco. Monte Carlo Tree Search for Multi-function Radar Task Scheduling. Conference on Artificial Intelligence for Defense, Nov 2021, Rennes, France. ⟨hal-03451838⟩

[20] N. Nour, R. Belhaj-Soullami, C. L. R. Buron, A. Peres and F. Barbaresco, Multi-Radar Tracking Optimization for Collaborative Combat, 2021 21st International Radar Symposium (IRS), 2021

[21] M. Klein et al., AI-Augmented Multi-Function Radar Engineering with Digital Twin: Towards Proactivity, 2020 IEEE Radar Conference (RadarConf20), 2020

[22] F. Barbaresco, Gaussian Distributions on the Space of Symmetric Positive Definite Matrices from Souriau's Gibbs State for Siegel Domains by Coadjoint Orbit and Moment Map. In: Nielsen F., Barbaresco F. (eds) Geometric Science of Information. GSI 2021. LNCS, vol 12829. Springer

[23] F. Barbaresco, Koszul lecture related to geometric and analytic mechanics, Souriau's Lie group thermodynamics and information geometry. Information Geometry Journal SPRINGER, 13th Jan. 2021

[24] F. Barbaresco, Archetypal Model of Entropy by Poisson Cohomology as Invariant Casimir Function in Coadjoint Representation and Geometric Fourier Heat Equation. GSI 2021. vol 12829. Springer, 2021

[25] F. Barbaresco, Symplectic Theory of Heat and Information Geometry, Handbook of Statistics series, Geometry and Statistics, 1st Edition, Elsevier, July 2022