Geometric-Informed Deep Learning and Symplectic Model of New Generation Radar Processing

Frédéric BARBARESCO – THALES KTD PCC SENSING SEGMENT LEADER (Key Technology Domain: Processing Control & Cognition), THALES Land & Air Systems, Meudon, FRANCE

In a first part, we will present pioneering THALES 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 Radars 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. These statistical laws on Lie Groups could describe density of time or space-time covariance matrices for Doppler and STAP Processing. This Symplectic model of Information gives a 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 Radar Information.

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