

# Complex-Valued Deep Neural Network for Radar Applications

## PhD Project description

Radar signals are generally complex-valued (In-Phase and Quadrature channels with reduced Shannon sampling rate, polarimetric channels, interferometric channels, etc.). Also, radar processing schemes are generally based on complex filtering (FFT, Wavelets, Wiener, Matched Filter, etc.) and so impossible to be developed with classical Neural Network. Nowadays, Machine Learning Networks developed in the scientific community are mainly based on real nature of the signals (images, etc.). If the richness of information (mainly related to its physical meaning nature) contained in the phase has to be exploited, conventional Deep Neural Networks schemes have to be completely revisited.

## Scientific & technical challenge

We propose in this PhD topic to develop new architectures of Neural Network taking into account the the complex valued nature of radar signals. These new schemes will be based on the design of complex valued activation functions, complex thresholds, complex-valued optimization methodologies based mainly on complex gradient-descent-based problems. Finally, these new methodologies will be analyzed in terms of convergence of extended backpropagation algorithms (allowing the computation of complex neural weights). The improvement of such systems will be also analyzed in terms of performance compared to traditional Neural Networks.

## Applications

The applications related to this work are centered around radar applications. We can cite some examples of radar applications:

- Super Resolution in SAR imaging: the goal is here to Investigate super resolution process based on machine and deep learning techniques for radar imaging. The key challenge is how to reconstruct high resolution radar image using limited sampling frequency and integration window. This process is performed in Fourier/spectral domain in which data features are complex-valued.
- SAR images segmentation: the goal is here to segment and classify complex-valued mono or multivariate Synthetic Aperture Radar images.
- SAR change detection: the goal is to highlight and analyze spatial changes with temporal series of complex multivariate SAR images.
- Detection and recognition in Range-Doppler spaces: the goal is here to perform targets detection and recognition tasks in conventional detection map (range-Doppler, angular-range-Doppler, etc.)

## Contact

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