ERCIM "ALAIN BENSOUSSAN" FELLOWSHIP PROGRAMME

Scientific Report

First name / Family name	Vinay Chakravarthi Gogineni
Nationality	Indian
Name of the *Host Organisation*	Norwegian University of Science and Technology (NTNU), Norway
First Name / family name of the *Scientific Coordinator*	Stefan Werner
Period of the fellowship	01/08/2019 to 31/07/2020

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During the fellowship period, Vinay was with the Signal Processing Group at Department of Electronic Systems, Norwegian University of Science and Technology, where he involved in various research activities. The details of his research are given below:

Fractional-order Correntropy Filters for Processing of α-Stable Signals: Traditionally, signal processing and machine learning techniques have been derived based on the assumption that the signal and noise are Gaussian. This assumption has played a crucial role in mathematical tractability and computationally efficiency of filtering solutions. However, the Gaussian model for signal/noise is being questioned in an increasing number of applications such as underwater acoustics, wideband communications, financial data modeling, and audio signal processing in which the encountered signals exhibit sharp spikes. The class of symmetric α-stable (SαS) random processes has proven to be a very flexible tool for modeling the behavior of such signals. Classical Wiener filtering techniques based on minimizing the second-order moment of an error measure suffer considerable performance degradation when applied to the lower-order SαS signals. Furthermore, except for the Gaussian case, the SαS random processes do not possess finite second-order

moments. To present an inclusive filtering solution, this work derived a new class of fractional-order correntropy adaptive filters that are robust to the jittery α-stable signals. In contrast to conventional correntropy filters, the proposed objective function is compatible with the characteristic function of α-stable processes and captures fractional moments; therefore, the resulting algorithms do not depend on non-existing second-order moments. The work also includes performance and convergence analysis of the derived algorithms. Finally, simulations are conducted to illustrate the effectiveness of the proposed filtering techniques, which indicate that the proposed filters can outperform their counterparts and show less sensitivity to changes in the α parameter. The proposed class of adaptive filters has been successfully extended to distributed network settings.

Graph Kernel Adaptive Filters: Graph signal processing (GSP) aims at extending classical discrete-time signal processing tools to the signals defined over an irregular discrete domain whose elementary units (vertices) are related to each other through a graph One of the key research areas in GSP is the modeling of unknown relations between input and output graph signals through a graph filter. The linear shift-invariant filter models are widely employed in the literature. However, linear models cannot accurately represent many real-world systems that exhibit more sophisticated input-output relations. Prominent examples include the relations between air pressure and temperature, and wind speed and generated power in wind turbines. To this end, using the principles of kernel methods, nonlinear graph adaptive filters have been introduced for the processing of signals over graphs. The performance of the proposed graph filtering algorithms is studied in detail and the conditions for their convergence are derived. Extensive simulations are conducted to demonstrate the performance of the proposed algorithms.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

1. V. C. Gogineni, S. P. Talebi, S. Werner and D. P. Mandic, ``Fractional-order correntropy filters for tracking dynamic systems in α-stable environments,'' *IEEE Trans. Circuits Syst. II: Express Briefs, 2020*, doi: 10.1109/TCSII.2020.2995357.
2. V. C. Gogineni, S. P. Talebi, S. Werner and D. P. Mandic, ``Fractional-order correntropy adaptive filters for distributed processing of α-stable signals,'' *IEEE Signal Process. Lett.,* 2020 *(*Submitted).
3. V. R. M. Elias, V. C. Gogineni, W. A. Martins and S.Werner, ``Adaptive graph filters in reproducing kernel Hilbert spaces: Design and performance analysis,'' *IEEE Trans. Signal Inf. Process. Networks,* 2020 (Submitted).
4. V. R. M. Elias, V. C. Gogineni, W. A. Martins and S.Werner, ``Graph diffusion kernel LMS using random Fourier features,'' in *Proc. Asilomar Conf. on Signals, Systems, and Computers*, 2020 (Submitted).
5. V. C. Gogineni and S.Werner, ``Matrix-based kernel APA for estimating nonlinear channels in wireless sensor networks,'' *IEEE Trans. Veh. Technol.,* 2020 (Under Preparation).

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1. NTNU Open AI Seminar: Decision fusion in wireless sensor networks, Sep. 2019.
2. NTNU Open AI Seminar: AI in the renewable energy sector, Sep. 2019.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

As part of the research exchange programme, I visited *Simula Research laboratory, Oslo*, and was hosted by Valeriya Naumova, Chief Research Scientist, Machine Intelligence Department. During my visit, I presented my research on distributed multitask learning over IoT. We also discussed the possibilities to integrate the concepts/techniques of graph signal processing and deep learning for cancer research. This research visit helped me to interact with various research groups at *Simula* and to build collaborative partnerships.