Relazione Scientifiche Finale sull’attività svolta nell’ambito dell’assegno di ricerca

Nominativo dell’assegnista di ricerca: Arman Kheirati Roonizi

Titolo dell’assegno di ricerca: Metodi e tecnologie evoluti in informatica - Impact of Channel Impulse Response in Multi-channel Observations.

Specificare se si tratta di assegno di ricerca tipo A o tipo B: tipo A

Docente referente: Prof. Roberto Sassi

Durata del contratto da 01/10/2021 a 31/09/2023
Periodo di riferimento della relazione: 01/10/2021 a 30/09/2022

Obiettivi della ricerca:
In order to study the impact of channel impulse response, it was necessary to optimally estimate the signal from its noisy channel recordings. Therefore, the objective of the first year was to design an optimal estimator to obtain the signal from its noisy measurements. The solution was to estimate the desired signal using an optimization approach. During the first year, I stayed in BISP Lab and focused on developing some optimal solutions for the problem in which I developed some new methods.

Risultati della ricerca:
I developed several methods to estimate the desired signal from its noisy measurements. Since ECG is a sparse signal, first I did some researches on estimating sparse signals from their noisy measurements. Then, I proposed a Kalman filter framework for signal denoising that simultaneously utilizes conventional linear time-invariant (LTI) filtering and total variation (TV) denoising. In this approach, the desired signal is considered to be a mixture of two distinct components: a band-limited (e.g., low-frequency component, high-frequency component) signal and a sparse-derivative signal. An iterative Kalman filter/smoother approach is formulated where zero-phase LTI filtering is used to estimate the band-limited signal and TV denoising is used to estimate the sparse-derivative signal. The results have been submitted as a regular paper to IEEE Transactions on Signal Processing. It has been accepted for publication [J1].

I also proposed a general framework for smoothing filter design. In the previous approaches (e.g., quadratic variation (QV) regularization and smoothness priors), the derivative of the signal enters as constraint. These two methods are particularly suited for polynomial signal smoothing, as they use the derivatives of the signal in the regularization term of the optimization problem. Therefore, their performance is significantly decreased for signals that can not be well modeled with a low order polynomial function. To overcome this limitation, I proposed to use a suitable linear (time-variant or time-invariant) differential equation model in the regularization of the optimization problem. The presented approach has many applications in signal processing. Specifically, the QV regularization and smoothness priors are special cases of the proposed framework.

As proof of other applications, it was employed for designing an extension of QV regularization to remove the baseline wander in electrocardiogram (ECG), simultaneous tracking of powerline interference and baseline wander, and T-wave amplitude computation. The results have been submitted to the Journal of Biomedical Signal Processing and Control and is now Under review [J2]. Some parts of the work have been also published in the international conference Computers in Cardiology 2022 [C1 and C2].
Finally, as it is already authorized by the University of Milan, I will visit Duke University, Durham, NC 27708, USA for six month to continue my research plan starting from 01/10/2022 to 31/03/2023.

Attività svolte:
During the first year, I stayed in BISP Lab and focused on developing some optimal solutions for the problem in which I developed some new methods. The project involved presenting the scientific research in international journals and national conferences (IEEE Transactions on Signal Processing, Biomedical Signal Processing and Control and Computing in Cardiology).

Descrizione dell’attività di ricerca svolta all’estero (eventuale; specificare: periodo, luogo, affiliazione):

Prodotti della ricerca conseguiti: (in termini di pubblicazioni, brevetti, …) 
J=journal, C=conference


[C1] A. Kheirati Roonizi and R. Sassi, " An Extension of Quadratic variation regularization for simultaneous baselinewander and powerline interference removal from ECG", Accepted for publication in the international conference Computing in Cardiology 2022

Il titolare dell’assegno di ricerca

Il Responsabile Scientifico:

Valutazione del Responsabile Scientifico: (con un breve giudizio scritto e una valutazione sintetica del lavoro dell’assegnista - Ottimo /Buono /Sufficiente/Scarso)


E’ delegato a firmare il solo docente non disponendo di firma digitale l’assegnista.

Il Responsabile Scientifico

(Firmato digitalmente)

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