Visiting Report Dr. Ramkumar IISc Distinguished Visiting Chair Professor
Prof.dr.ir. Geert Leus
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This report provides a summary of my 2 week visit to the Division of Electrical, Electronics, and Computer Sciences (EECS) at IISc. First of all, let me thank everyone involved for providing me the opportunity to visit IISc as the Dr. Ramkumar IISc Distinguished Visiting Chair Professor. Below I will elaborate on the two main items. One item is the lecture I gave and the other is related to the interactions and collaborations I enjoyed.

Lecture

I gave a lecture on "Compressive and Sparse Array Processing" in the Faculty Hall of IISc on December 19, 2024. Array processing has been a key area in the signal processing community for many decades. Generally, regular arrays have been considered but more recently there has been a growing interest in compressive and sparse arrays, fuelled by the trend to move to higher frequencies and higher apertures. Compressive and sparse arrays can reduce the hardware cost and power consumption and are hence attractive for applications such as massive multi-input multi-output communications, automotive radar, and acoustic imaging. In the talk I presented, I established the basic model for compressive and sparse array processing and discussed how to perform digital beamforming and direction of arrival (DoA) estimation for such arrays. Modern techniques were discussed that go beyond classical subspace-based methods, leveraging optimization theory and sparse signal processing. Furthermore, not only the standard signal-based processing was considered but also more advanced covariance-based techniques, allowing for an increased number of degrees of freedom. Throughout the talk I also discussed compressive and sparse array design, mainly aiming at maximizing identifiability. Yet in the last part of the talk I delved into performance-based sparse array design, which fits into the field of sparse sensing. Here both convex and submodular optimization methods were presented to design optimal sparse arrays for DoA estimation.

Interactions and Collaborations

My visit included a conversation with the Dean of the Division of Electrical, Electronics, and Computer Sciences (EECS), Dr. Rajesh Sundaresan. Mainly organizational issues were discussed in that meeting. We further enjoyed a tour of the Centre for Brian Research (CBR) at IISC guided by Dr. K.V.S. Hari. It was nice to get an overview of all the exciting work (both theoretical as well as experimental) that is carried out over there. I also had several technical discussions with IISc professors (Dr. S.P. Chepuri, Dr. C. Murthy, and Dr. A. Chockalingam) as well as with master and PhD students. In particular, I collaborated on two key topics in the field of signal processing and machine learning.

Graph-based state-space models for modelling long-range dependencies in graph time-series (in collaboration with Dr. S.P. Chepuri and Mr. Ayushman Raghuvanshi): Long-range dependencies in time-series have recently been shown to be well-modelled by state-space models (SSMs). Such models provide a better accuracy compared to long short-term memories (LSTMs) or recurrent neural

networks (RNNs) for instance. The goal of this collaborative project is to extend this to graph time-series, an area that has not been explored yet. The complication here is that two domains are involved, the graph domain as well as the time domain. This increases the model complexity and demands for more intricate SSMs that exploit the structure of the graph.

Sensing using a dynamic RIS (in collaboration with Dr. S.P. Chepuri and Mr. Yuvraj Singh): A reflecting intelligent surface (RIS) has been mainly considered for improving the quality of wireless communication links. However, a RIS can also be used for sensing. By placing a sensor close to the RIS, the sensor measurement can be viewed as a weighted linear combination of the target signals reflected by the RIS. As such, it can be viewed as a compressive measurement of the RIS signal. Moreover, different measurements can be obtained by changing the reflection coefficients of the RIS and making it dynamic. As such, a compressive model is obtained from which the RIS signal (or the target locations) can be obtained. The model is different from the standard compressive sensing model, and hence non-trivial algorithm design is required.

Finally, I would like give a big thank you to the staff from IISc, and Dr. S.P. Chepuri in particular, for their hospitality during my visit. I enjoyed it very much from a technical as well as a personal perspective. I look forward to the continuation of my visit in April of 2025.

Kind regards,

Prof.dr.ir. Geert Leus
Delft University of Technology
Delft, The Netherlands