
Summary: The area of Data Analytics on graphs deals with information processing of data acquired on irregular but structured graph domains. The focus of Part I of this monograph has been on both the fundamental and higher-order graph properties, graph topologies, and spectral representations of graphs. Part I also establishes rigorous frameworks for vertex clustering and graph segmentation, and illustrates the power of graphs in various data association tasks. Part II embarks on these concepts to address the algorithmic and practical issues related to data/signal processing on graphs, with the focus on the analysis and estimation of both deterministic and random data on graphs. The fundamental ideas related to graph signals are introduced through a simple and intuitive, yet general enough case study of multi-sensor temperature field estimation. The concept of systems on graph is defined using graph signal shift operators, which generalize the corresponding principles from traditional learning systems. At the core of the spectral domain representation of graph signals and systems is the Graph Fourier Transform (GFT), defined based on the eigendecomposition of both the adjacency matrix and the graph Laplacian. Spectral domain representations are then used as the basis to introduce graph signal filtering concepts and address their design, including Chebyshev series polynomial approximation. Ideas related to the sampling of graph signals, and in particular the challenging topic of data dimensionality reduction through graph subsampling, are presented and further linked with compressive sensing. The principles of time-varying signals on graphs and basic definitions related to random graph signals are next reviewed. Localized graph signal analysis in the joint vertex-spectral domain is referred to as the vertex-frequency analysis, since it can be considered as an extension of classical time-frequency analysis to the graph serving as signal domain. Important aspects of the local graph Fourier transform (LGFT) are covered, together with its various forms including the graph spectral and vertex domain windows and the inversion conditions and relations. A link between the LGFT with a varying spectral window and the spectral graph wavelet transform (SGWT) is also established. Realizations of the LGFT and SGWT using polynomial (Chebyshev) approximations of the spectral functions are further considered and supported by examples. Finally, energy versions of the vertex-frequency representations are introduced, along with their relations with classical time-frequency analysis, including a vertex-frequency distribution that can satisfy the marginal properties. The material is supported by illustrative examples.

MSC:
68T05 Learning and adaptive systems in artificial intelligence
68-02 Research exposition (monographs, survey articles) pertaining to computer science

Keywords:
graph theory; random data on graphs; big data on graphs; signal processing on graphs; machine learning on graphs; graph topology learning; systems on graphs; vertex-frequency estimation; graph neural networks; graphs and tensors

Software:
GUPPY; TFSAP

Full Text: DOI

References:
[1] Estimate the positions K = \{k 1 , k 2 , . . . , k K \} of the nonzero coefficients using M > K signal samples.
[2] Reconstruct the nonzero coefficients of X at the estimated positions K, along with the signal x at all vertices, using the methods for the reconstruction with the known nonzero coefficient positions, described in Sections 4.1 and 4.2. The nonzero coefficients at positions K are calculated as X K = pinv(A M K )y.
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Cioacă, T., B. Dumitrescu, and M.-S. Stupariu (2019). “Graph-based wavelet multiresolution modeling of multivariate terrain
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