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学位（博士）論文要旨
(Doctoral thesis abstract)

論文提出者 Ph. D. Candidate	生物システム応用科学府　生物機能システム科学専攻 博士後期課程　第２専修/グループ(Department Course) 平成２７年度入学(Your Entrance Fiscal Year) 氏名　崎山　亮恵　㊞ (Your Name(Family, First) and Seal)		
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論文題目 Title	Design of Spectral Graph Wavelets and Filter Banks グラフ信号処理のためのウェーブレット及びフィルタバンクの設計		

論文要旨（和文要旨(2000 字程度)または英文要旨(500words)）
※欧文・和文どちらでもよい。但し、和文の場合は英訳を付すこと。
Write a summary in Japanese (2000 characters) or in English (500words).
If the abstract is written in Japanese, needed to translate into English.

This dissertation addresses the problem on designing spectral graph wavelets and filter banks in order to efficiently analyze and process graph signals.

Spectral graph wavelets and filter banks are one of the fundamental tools for signal processing on graphs. As in the case in traditional signal processing, they can capture features of graph signals by dividing the input signal into some different frequency bands. They are effective to represent signals sparsely since they have basis localized in the vertex domain unlike the graph Fourier transform. Furthermore, they are expected to be useful for many practical applications such as signal denoising, segmentation and compression. Therefore, designs of the efficient spectral graph wavelets and filter banks are an important problem for graph signal processing. Although there exist several conventional transforms, they have several disadvantages: 1) they have strong limitations on filter designs or redundancies, 2) decimated transforms are applicable only to the signal defined on a bipartite graph, and 3) their filter characteristics in graph frequency domain are not enough, i.e., they does not have all desired properties for spectral graph wavelets and filter banks such as tight frame, filters defined by smooth functions, and no DC leakage. To solve these problems, this dissertation proposes three effective approaches about spectral graph wavelets and filter banks: i) M-channel oversampled spectral graph filter bank which have low redundancies and high flexibility in filter design, ii) oversampled graph Laplacian matrix which enables us to apply arbitrary graph signals into decimated transforms, and iii) the method of constructing spectral graph wavelets and filter banks that having all desired properties. This dissertation is organized as follows.

Chapter 1 describes the background, related works and objective of this dissertation.

The notations and preliminaries on graph signal processing are stated in Chapter 2.

Chapter 3 introduces the overall scheme of the graph spectral wavelets and filter banks and shows popular conventional approaches.

In Chapter 4, M-channel oversampled spectral graph filter banks are proposed. Since they are decimated transform with M filters, they have lower redundancies and have more flexibility in their design than the conventional spectral graph filter banks. The perfect reconstruction conditions of the oversampled spectral graph filter banks are shown. Some design examples indicate that the proposed filter banks have good stopband attenuation.

In Chapter 5, the oversampling method for graph signals is presented. It appends the nodes and edges to the original graph before performing graph filter banks. The effective oversampling method is also proposed that can make one bipartite graph that includes all edges of the original non-bipartite graph. It enables us to apply the non-bipartite graphs into any decimated transforms. Furthermore, the theoretical relationship between the proposed oversampling method and a covering method in graph theory is clarified.

Chapter 6 shows the method related to the effective spectral graph filter design. It is proven that any real-valued linear phase finite impulse response filter banks for regular signals can be reused as the filter banks for graph signals. The spectral graph filter bank has the same filter characteristic as the corresponding classical one and inherits the original properties, such as tight frame, smoothness and no DC leakage. Since the filters are defined by a sum of sinusoidal waves, they produce low approximation errors even if we use a lower-order shifted Chebyshev polynomial approximation for acceleration, and the upper bound of the error can be calculated rigorously. It is easily to design the spectral graph filter banks from the regular signal processing counterparts, such as Cohen-Daubechies-Feauveau wavelets, the discrete cosine transform, and the lapped orthogonal transform.

Chapter 7 concludes this dissertation and describes the future works.

The numerical performances of the proposed methods are evaluated by the experiments on denoising and non-linear approximation in each chapter. The proposed methods outperform the conventional decimated and critically sampled spectral graph wavelets and filter banks in all experiments.

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