行政院國家科學委員會補助專題研究計畫成果告

※※※※※※※※※※※※※※※※※※※※※※※※

應用於多媒體信號處理的副頻帶濾波器組之設計(III)

Design of Subband Filter Banks for Multimedia Signal Processing (III)

※※※※※※※※※※※※※※※※※※※※※※※※

計畫類別：□個別型計畫　■整合型計畫
計畫編號：NSC90－2213－E－002－096－
執行期間：90 年 8 月 1 日至 91 年 7 月 31 日

計畫主持人：李枝宏
共同主持人：
計畫參與人員：林明哲, 陳宏家, 鄭光鵬, 詹元佑

本成果報告包括以下應繳交之附件：

□赴國外出差或研習心得報告一份
□赴大陸地區出差或研習心得報告一份
□出席國際學術會議心得報告及發表之論文各一份
□國際合作研究計畫國外研究報告書一份

執行單位：國立臺灣大學電機工程學系

中　華　民　國　91 年 9 月　16 日

應用於多媒體信號處理的副頻帶濾波器組之設計(III)

Design of Subband Filter Banks for Multimedia Signal Processing (III)

計畫編號：NSC 90-2213-E-002-096

執行期限：90 年 8 月 1 日至 91 年 7 月 31 日

主持人：李枝宏　國立臺灣大學電機工程學系教授

計畫參與研究生：林明哲, 陳宏家, 鄭光鵬, 詹元佑

一、中文摘要

本計劃已完成預期之研究工作一研究出一項設計具有+1,0,-1 係數值的非均勻副頻帶特性的 FIR 數位濾波器組之理論與技術。於進行多媒體訊號處理時，一項重要的要求即是即時演算及數值穩定性，而使用傳統副頻帶濾波器組，因其係數值位元數過多引起繁雜的數學演算量以及數值穩定性問題。在本項研究工作內，我們先進行研究分析使用非均勻副頻帶濾波器組的運算複雜性，再發展以+1, 0, -1 三種數值來代表係數值的非均勻副頻帶濾波器組的理論，運用複速率信號處理理論來建立系統架構與模型。然後根據此理論成果推導最佳化的技術。電腦模擬實驗已驗證本計畫成果之有效性。

關鍵詞：有限脈衝響應濾波器、副頻帶數位濾波器組。

二、英文摘要

This project has accomplished research work for the development of the theory and system structure of FIR nonuniform division filter (NDF) banks with +1,0,-1 coefficients. Utilizing an approximation scheme and a WLS algorithm, we have developed a method to design a two-channel NDF bank with continuous coefficients under each of two design criteria, namely, least-squares reconstruction error and stopband response for analysis filters and equiripple reconstruction error and least-squares stopband response for analysis filters. It is shown that the optimal filter coefficients can be obtained by solving only linear equations. In conjunction with a proposed filter structure, a method is then presented to obtain the desired design result with filter coefficients constrained to –1,0,+1 only. The effectiveness of the proposed design technique is demonstrated by several simulation examples.

Keywords: FIR Filters, Subband Filter Banks。

三、緣由與目的

Due to the fact that multimedia information becomes a necessary part of modern life, processing the speech or audio signals of multimedia information has been viewed as an important work. However, uniform subband decomposition is not an appropriate scheme to match the requirements for the subband coding of speech and audio signals. The most appropriate decomposition must consider the critical bands of the ear. It has been shown that these critical bands have nonuniform bandwidths and cannot be easily constructed by conventional tree structure based on two-channel QMF banks.

Hardware implementation for an NDF bank generally requires large and complicated digital circuits because NDF banks are designed with real or complex coefficients. To achieve circuit complexity reduction or to speed up filtering operation besides concern for the overall performance, it is preferable to design a NDF bank with coefficients restricted to –1,0,+1 only. Therefore, it is worth exploiting the design problem of two-channel NDF banks whose FIR analysis and synthesis filters have coefficients restricted to –1,0,+1 only.

四、研究方法

First, the NDF banks with a proposed new filter structure for realization is developed。 Then, a method is developed based on an approximation scheme for designing a continuous-coefficient NDF bank with optimal reconstruction response and stopband response for its linear-phase (LP) FIR analysis and synthesis filters in the least-squares (L_2) sense. This method is further incorporated with the WLS algorithm to optimally design NDF banks with minimax (L_∞) reconstruction response and L_2 stopband response for analysis and synthesis filters. It has been To obtain a design with –1,0,+1 coefficients, which achieves the optimal performance, we propose a new filter structure for realization. The coefficients –1,0,+1 are used in the oversampled domain; and the design procedure leads to finely quantized coefficients.

五、研究成果與討論

In this project, we have developed a new structure for implementing an NDF bank and a technique for the optimal design of two-channel NDF banks with linear-phase FIR filters having –1,0,+1 coefficients only. First, we formulate the design problem with continuous coefficients for each of two optimal criteria, namely, least-squares reconstruction response and filter stopband response and equiripple reconstruction response and least-squares filter stopband response. The WLS algorithm has been utilized to achieve the design of equiripple reconstruction behavior. In conjunction with a new filter structure for realization the

analysis and synthesis filters, an efficient method to obtain an optimal design with coefficients restricted to −1,0,+1 only has been presented. The effectiveness of the proposed technique has been demonstrated by several design examples.

六、參考文獻

(1) R.E. Crochiere, "Digital signal processor: Sub-band coding," *Bell Syst. Tech. J.*, vol. 60, pp. 1633-1653, 1981.

(2) M.G. Bellanger and J.L. Daguet, "TDM-FDM transmultiplexer: Digital polyphase and FFT," *IEEE Trans. Commun.*, vol. 22, pp. 1199-1204, Sept. 1974.

(3) P. Vary and U. Heute, "A short-time spectrum analyzer with polyphase network and DFT," *Signal Process.*, vol. 2, pp.55-65, 1980.

(4) J.W. Woods and S.D. O'neil, "Subband coding of images," *IEEE Trans. Acoust., Speech, Signal Processing*, vol. 34, pp. 1278-1288, Oct. 1986.

(5) K. Nayebi, T.P. Barnwell, and M.J.T. Smith, "Nonuniform filter banks: A reconstruction and design theory," *IEEE Trans. Signal Processing*, vol. 41, pp. 1114-1127, Mar. 1993.

(6) S. Wada, "Design of nonuniform division multirate FIR filter banks," *IEEE Trans. Circuits Syst., II*, vol. 42, pp. 115-121, Feb. 1995.

(7) J.-H. Lee and S.-C. Huang, "Design of two-channel nonuniform-division maximally decimated filter banks using L_1 criteria," *IEE Proc. – Vision, Image and Signal Processing,* vol. 143, no. 2, pp. 79-83, Apr. 1996.

(8) Y.-C. Lim, J.-H. Lee, C.-K. Chen, and R.H. Yang, "A weighted least-squares algorithm for quasiequiripple FIR and IIR digital filter design," *IEEE Trans. Signal Processing,* vol. 40, pp. 551-558, Mar. 1992.

(9) L.R. Rabiner and B. Gold, *Theory and Application of Digital Signal Processing.* Englewood Cliffs, NJ: Prentice-Hall, 1975.

(10) Y.C. Lim and S.R. Parker, "Discrete coefficient FIR digital filter design based on an LMS criteria," *IEEE Trans. Circuits Syst.,* vol. 30, pp. 723-739, Oct. 1983.

(11) B. Liu and L.T. Bruton, "The design of nonuniform-band maximally decimated filter banks," *Proc. IEEE Int. Symp. Circuits Syst.,* Chicago, IL, May 1993, pp. 375.