行政院國家科學委員會專題研究計畫　期中進度報告

子計畫三:應用於音視訊及多媒體信號處理的副頻帶濾波器組之設計(1/3)

計畫類別： 整合型計畫
計畫編號： NSC91-2219-E-002-046-
執行期間： 91 年 08 月 01 日至 92 年 07 月 31 日
執行單位： 國立臺灣大學電機工程學系暨研究所

計畫主持人： 李枝宏

計畫參與人員： 計畫參與研究生：林明哲, 楊元豪, 林煜偉, 詹元佑

報告類型： 精簡報告

處理方式： 本計畫可公開查詢

中　華　民　國 92 年 5 月 13 日

行政院國家科學委員會補助專題研究計畫期中成果報告

應用於音視訊及多媒體信號處理的副頻帶濾波器組之設計

(1/3) Design of Subband Filter Banks for Applications in Audio, Video, and Multimedia Signal Processing (1/3)

計畫類別：□個別型計畫　　■整合型計畫

計畫編號：NSC91－2219－E－002－046－

執行期間： 91 年 8 月 1 日至 92 年 7 月 31 日

計畫主持人： 李枝宏

共同主持人：

計畫參與研究生：林明哲, 楊元豪, 林煜偉, 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 92 年 5 月 13 日

應用於音視訊及多媒體信號處理的副頻帶濾波器組之設計 (1/3)

Design of Subband Filter Banks for Applications in Audio, Video, and Multimedia Signal Processing (1/3)

計畫編號：NSC 91-2219-E-002-046

執行期限：91 年 8 月 1 日至 92 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, 楊元豪, 林煜偉, 詹元佑

一、中文摘要

本計劃已完成預期之研究工作一基於 L_2 最佳化準則的 FIR 具有線性相位且低相位延遲之鏡像對稱副頻帶濾波器組之理論

與設計，基於最小平方重建誤差與最小平方 FIR 濾波器止帶響應之設計理論，在本項研究內，我們研發基於 L_2 最佳化理論設計以 FIR 濾波器為架構具有線性相位且低相位延遲之鏡像對稱之副頻帶濾波器組理論與設計技術。在理論上，研究推導 FIR 具有線性相位且低相位延遲之鏡像對稱之副頻帶濾波器組的系統架構模型。然後，研發設計此副頻帶濾波器組的最佳化技術。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 quadrature mirror filter (QMF) banks with linear phase and low group delay response. Utilizing an approximation scheme and an iterative algorithm, we have developed a method to design a two-channel QMF bank with continuous coefficients under the design criteria, namely, least-squares 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 an iterative algorithm, a method is then presented to obtain the desired design result. 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 audio or video signals of multimedia information has been viewed as an important research work. To deal with the difficulty of large data capacity required for transmitting multimedia signals, one of the possible remedies is to develop advanced digital signal processing technology for reducing the required information regarding the audio and video signals. In other words, the techniques of bandwidth compression and decompression, coding and decoding should be considered. Using subband filter banks has been recognized as an efficient approach for achieving the above purposes. Most of conventional design techniques consider the design of quadrature mirror filter (QMF) banks using finite impulse response (FIR) filters with some kind of symmetry in filter coefficients to keep the linear phase response. However, the system delay of the designed QMF bank is determined by the lengths of the FIR filters used; hence, the long overall system delay of a QMF bank with linear-phase FIR analysis filters may prohibit practical applications for processing multimedia signals. Therefore, it is worth

investigating the design of FIR QMF banks with low group delay. In this three-year research project, we will focus on the development of design theory for subband filter bank with low group delay. Based on several useful optimization criteria, we will develop efficient techniques for designing the subband filter banks to achieve the goals of minimizing magnitude and group delay errors for processing audio and video signals of multimedia data

四、研究方法

First, the QMF banks with a low group delay response for realization is developed。Then, a method is developed based on an approximation scheme for designing a continuous-coefficient QMF 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 an iterative algorithm to optimally design QMF banks with L_2 reconstruction response and L_2 stopband response for analysis and synthesis filters. It has been shown that the design method can achieve satisfactory design results.

五、研究成果與討論

In this project, we have developed a technique for the optimal design of two-channel QMF banks with linear-phase FIR filters and low group delay response. First, we formulate the design problem with continuous coefficients for the optimal criteria, namely, least-squares reconstruction response and filter stopband response. An approximation scheme has been utilized to achieve the design of optimal response behavior. In conjunction with an iterative algorithm, an efficient method to obtain an optimal design with low group delay response 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) V.K. Jain and R.R. Crochiere, "Quadrature mirror filter design in the time domain," *IEEE Trans. Acoust., Speech, Signal Processing*, vol. 32, pp.

353-361, Apr. 1984.

(6) C.-K. Chen and J.-H. Lee, “Design of quadrature mirror filters with linear phase in the frequency,” *IEEE Trans. Circuits Syst., II*, vol. 39, pp. 593-605, Sept. 1992.

(7) P.P. Vaidyanathan, *Multirate Systems and Filter Banks*, Prentice-Hall, Englewood Cliffs, New Jersey, 1992.

(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) T.Q. Nguyen and P.P. Vaidyanathan, “Two-Channel perfect reconstruction FIR QMF structures which yield linear-phase analysis and synthesis filters,” *IEEE Trans. Acoust., Speech, Signal Processing*, vol. 37, pp. 676-690, May 1989.

(11) M. Vetterli and D. Le Gall, “Perfect reconstruction FIR filter banks: some properties and factorization,” *IEEE Trans. Acoust., Speech, Signal Processing*, vol. 37, pp. 1057-1071, July 1989.

(12) B.-R. Horng and A.N. Willson, Jr., “Lagrange multiplier approaches to the design of two-channel perfect reconstruction linear phase FIR filter banks,” *IEEE Trans. Signal Processing*, vol. 40, pp. 364-374, Feb. 1992.

(13) T.E. Tuncer and T.Q. Nguyen, “General analysis of two-band QMF banks,” *IEEE Trans. Signal Processing*, vol. 43, pp. 544-548, Feb. 1995.

(14) C.K. Goh and Y.-C. Lim, “An efficient weighted L_p algorithm for the design of quadrature mirror filters,” *IEEE Trans. Signal Processing Letters*, vol. 4, pp. 79-81, Mar. 1997.

(15) S.S. Lawson and A. Klouche-Djedid, “Technique for the design of two-channel approximately linear phase QMF filter bank and its application to image compression,” *IEE Proc. Vision, Image and Signal Processing*, vol. 148, pp. 85-92, Apr. 2001.

(16) H. Xu, W.-S. Lu, and A. Antoniou, “Improved iterative methods for the design of quadrature mirror filter banks,” *IEEE Trans. Circuits and Systems II: Analog and Digital Signal Processing*, vol. 43, pp. 363-371, May 1996.

(17) W.-S. Lu, H. Xu, and A. Antoniou, “A new method for the design of FIR quadrature mirror filter banks,” *IEEE Trans. Circuits and Systems II: Analog and Digital Signal Processing*, vol. 45, pp. 922-926, July 1998.

(18) K. Nayebi, T.P. Barnwell, and M.J.T. Smith, “Low delay FIR filter banks:

design and evaluation," *IEEE Trans. Signal Processing*, vol. 42, pp. 24-31, Jan. 1994.

(19) E. Abdel-Raheem, F. El-Guibaly, and A. Antoniou, "Design of low-delay two-channel FIR filter banks using constrained optimization," *Signal Processing*, vol. 48, pp. 183-192, Feb. 1996.