REPORT ITU-R BT.2005

BIT-RATE REDUCTION FOR DIGITAL TV SIGNALS

(1995)

1 Introduction

The rapid development of source coding techniques and their realization with the help of integrated circuits leads to the conclusion that in the near future many new services will be created which are based on picture coding techniques. Applications will be found not only in the field of broadcasting but also in the area of interactive audiovisual communications. With the techniques available today, a high data rate reduction factor is achievable together with a high quality of the decoded picture. Therefore, efficient use of existing networks is possible and the costs of picture transmission can be significantly reduced.

This Report takes the form of a bibliography with a brief summary given of the contents of each item. It contains books, papers and documents relevant to bit-rate reduction coding and error-correction giving basic information and many references for further investigation for the reader interested in more detailed information.

During the compilation of this Report great care was taken to ensure that the books mentioned are commercially available and that the papers are likely to be found in a technically-orientated library.

2 Introduction to bit-rate reduction techniques

2.1 Predictive, transform and subband coding techniques

Jayant, N. and Noll, P.: *Digital Coding of Waveforms.* Prentice Hall 1984. Introduction to the principles of digital coding for video and speech: Sampling, Quantization, PCM, DPCM, Delta modulation, Delayed Decision Coding, Run-Length Coding, Subband Coding, Transform Coding. Survey of basic techniques with many references.

Netravali, A. and Haskell, B.: *Digital Pictures. Representation and Compression.* Plenum Press 1988. Description of theoretical and practical bases for coding images: Numerical representation of visual information, Common Picture Communication Systems (PAL, NTSC, SECAM etc.), Redundancy-Statistics-Models, Visual Psychophysics, Basic Compression Techniques (PCM, DPCM, Transform Coding, Hybrid Transform Coding), Examples of Codec Designs.

Rosenfeld, A. and Kak, A.: *Digital Picture Processing Vol. 1* Academic Press 1982. Mathematical description of the several parts of a coding scheme using stochastic input processes: Visual Perception, Digitization, Compression, Enhancement, Restoration, Reconstruction. Volume 2 deals with the problems of picture analysis.

Clarke, R.: *Transform Coding of Images.* Academic Press 1985. Theoretical and practical aspects of transform coding systems: Statistical Properties of Images, Orthogonal Transforms, Quantization and Bit Allocation, Practical Coding Techniques, The Human Visual Response, Fast Transforms and System Implementation, Error and Noise Effects, Rate Distortion Theory and Image Coding.

Rao, K. and Yip, P.: *Discrete Cosine Transform Algorithms, Advantages, Applications.* Academic Press 1990. Introductory treaties on DCT algorithms including two-dimensional DCT with theoretical and practical basis for coding sounds and images. This book also presents several applications to filtering for decimation and interpolation, sound coding, video coding with schemes of combination with vector quantization, combination with motion compensation and hierarchical layered coding.

Woods, J. (Editor): *Subband Image Coding.* Kluwer Academic Publisher 1991. This book describes the splitting-up of the input signal for several numbers of subbands, the layout of the filter characteristics for different types of filters and the coding possibilities for the resulting subbands.

Pratt, W.: *Image Transmission Techniques.* Academic Press 1979. Overview of different coding schemes: Image Coding Applications of Vision Models, Predictive Coding, Transform Coding, Hybrid Coding, Frame Replenishment Coding of Television, Binary Image Compression.

Netravali, A. and Limb, J.: Picture Coding: A Review. *Proc. of the IEEE 68* (1980), pp. 366-407. A review of techniques used for digital encoding of picture material. Statistical models of picture signals are covered first, followed by a description of the coding techniques.

Kunt, M., Ikonomopoulos, A. and Kocher, M.: Second Generation Image-Coding Techniques. *Proc. of the IEEE 73* (1985), pp. 549-574. A brief overview of first-generation coding techniques (DPCM, Transform Coding) is given. Afterwards local operator-based techniques and contour-texture oriented techniques are described taking into account the human visual system.

Musmann, H., Pirsch, P. and Grallert, H.: Advances in Picture Coding. *Proc. of the IEEE 73* (1985), pp. 523-548. Predictive coding techniques and transform coding techniques are described in combination with motion-compensated prediction. Different displacement estimation techniques are compared with respect to estimation accuracy.

2.2 *Other techniques*

Mallat, S.: A Theory for Multiresolution Signal Decomposition: The Wavelet Representation. *IEEE Trans. on Pattern Analysis and Machine Intelligence 11* (1989), pp. 674-693. Mathematical description of the wavelet transform and of the building up of an orthonormal set of basis functions for a wavelet representation applied to data compression in image coding.

Chui, C.: *An Introduction to Wavelets.* Academic Press 1992. Introductory treaties on wavelet analysis with an emphasis on spline-wavelets and time-frequency analysis. Classification of wavelets, the wavelets transforms, multiresolution analysis and wavelet algorithms for decomposition and reconstruction are presented. This book is suitable for beginner's course on wavelet coding.

Antoine, J.: Wavelet Analysis in Image Processing; in Vandewalle, Boite, Moonen, Oosterlinck (editors) *Signal Processing VI: Theories and Applications*, Elsevier Science Publishers 1992, pp. 23-30. Review of the general properties of the 2D wavelet transform, both in its continuous and its discrete versions. Applications in image processing are also given.

Daubechies, I.: Orthonormal Bases of Compactly Supported Wavelets. *Commun. of Pure and Applied Math. Vol. XLI* (1988), pp. 909-996. This paper describes the conditions for an orthonormal wavelet and methods to construct orthonormal wavelet bases of compact support.

Malvar, H. and Staelin, D.: The LOT: Transform coding without Blocking Effects. *IEEE Trans. on Acoustics, Speech and Signal Processing 37* (1989), pp. 553-559. A theory of the lapped orthogonal transform and its optimization, a fast LOT algorithm derived from DCT, block effects and coding effectiveness compared to DCT, and an example of still image coding are presented.

Lu, G.: Fractal image compression. *Image Communication 5* (1993), pp. 327-343. The paper describes the principle and common techniques of fractal image compression and gives an introduction to the three main techniques. These are iterated function systems, segment-based coding and yardstick coding, all applied to intraframe coding.

Jacquin, A.: Image Coding Based on a Fractal Theory of Iterated Contractive Image Transformations. *IEEE Trans. on Image Processing 1* (1992), pp. 18-30. The system design for the coding of monochrome images is shown using iterated contractive transformations. This allows the decoding process to be started with an arbitrary image which converges to a fractal approximation of the original picture.

Stackhouse, W. (Chairman): Report of the Task Force on Digital Image Architecture. *SMPTE Journal 101* (1992), pp. 855-891. This report describes the features which should be fulfilled inside a generic coding system usable in a global communication network. Fundamental issues are examined necessary for achieving a compatible set of standards.

2.3   *Error correction*

Chapter 13 "Information Theory and Coding" in Taub, H. and Schilling, D.: *Principles of Communication Systems,* McGraw-Hill 1986, pp. 511-609. Introduction to the methods for error detection and correction using block codes and convolutional coding. Error rates in uncoded and coded transmission systems are compared.

Viterbi, A. and Omura, J.: *Principles of Digital Communication and Coding.* McGraw-Hill 1979. Mathematical description of the fundamentals of digital communications and block coding, the performance analysis of block codes, convolutional coding and the performance analysis of such codes. The book also contains a characterization of several channel models and gives an introduction to the rate distortion theory.

Blahut, R.: *Theory and Practice of Error Control Codes.* Addison-Wesley 1984. This book is written for the engineer who is interested in the applications of error-control codes. After an introduction to the algebra, different codes (block codes, cyclic codes, RS codes, BCH codes, convolutional codes etc.) are explained and examples for their realization are given.

Peterson, W. and Weldon, E.: *Error-Correcting Codes.* MIT Press 1972. This book covers almost all the fundamentals of error correcting codes, and discusses every subject strictly. Therefore the book is a bible for the researchers and engineers who want to study the theory of error correcting codes in detail.

Clark, C. and Cain, J.: *Error-Correction Coding for Digital Communications.* Plenum Press 1981. The book features decoding techniques for various codes. The fundamental concept of coding, the introduction to soft decision decoding, and system applications are also given.

Imai, H.: *Essentials of Error Control Coding Techniques.* Academic Press 1990. The theory and the applications or error control coding are described. The applications to communication systems, computer systems and audio-video systems are discussed in detail. Therefore, the book is useful for the engineers who are interested in the applications of error control coding.

Pietrborn, S.: Trellis-Coded Multidimensional Phase Modulation. *IEEE Trans. on Information Theory 36* (1990), pp. .... An efficient method of partitioning multi-dimensional MPSK signal sets is presented. This method provides flexibility in achieving a variety of information rates with various coding gain.

3   **Standards for different applications**

Wallace, G.: The JPEG Still Picture Compression Standard. *Commun. of the ACM Vol. 34, No. 4* (1991), pp. 31- 44. Description of the algorithm used for the coding of still pictures. The several processing steps necessary for the implementation of the algorithm are explained.

Digital Compression and Coding of Continuous-Tone Still Images, Part 1, Requirements and Guidelines. *ISO/IEC JTC 1 Committee Draft CD 10198-1* (March 1991). Official paper of ISO/IEC for the JPEG still image compression standard. Available through the national standardization bodies.

Le Gall, D.: MPEG: A Video Compression Standard for Multimedia Applications. *Commun. of the ACM Vol. 34, No. 4* (1991), pp. 47-58. Description of the MPEG-1 algorithm used for the coding of video signals at about 1.5 Mbit/s. The algorithm is optimized for the processing of video frames for digital storage media.

Information technology - Coding of moving pictures and associated audio for digital storage media up to about 1.5 Mbit/s. *ISO/IEC JTC 1 Draft International Standard DIS 11172* (1992). Official paper of ISO/IEC for the MPEG-1 coding standard. Available through the national standardization bodies.

Okubo, S., McCann, K. and Lippman, A.: MPEG-2 Requirements, Profiles and Performance Verification in *International Workshop on HDTV'93, Proceedings Vol. 1.* This paper describes MPEG activities for formulating the framework of a generic video coding standard usable for a number of applications, typically distribution, storage and retrieval and communication services. Available from Dr. L. Chiariglioni, CSELT, via G. Reiss Romoli, 274, I-10148 Turin.

Information technology - Generic coding of moving pictures and associated audio. Recommendation H.262. *ISO/IEC JTC1 Committee Draft CD 13818-2* (November 1993). Official paper of ISO/IEC for the MPEG-2 coding standard for video signals. Available through the national standardization bodies.

Liou, M.: Overview of the p x 64 kbit/s Video Coding Standard. *Commun. of the ACM Vol. 34, No. 4* (1991), pp. 60-63. Description of the video coding standard for videotelephony using the Integrated Services Digital Network (ISDN) following CCITT Recommendation H.261. The possible video input formats, the signal processing and the data structure are explained.

Video Codec for Audiovisual Services at p x 64 kbit/s. *Recommendation ITU-T (CCITT) H.261.* Description of the video coding standard for videotelephony at output bit rates between 64 kbit/s and 1 920 kbit/s. The Recommendation is available from the ITU, General Secretariat - Sales Services, Place des Nations, CH-1211 Geneva 20.

Transmission of component-coded digital television signals for contribution-quality applications at bit rates near 140 Mbit/s. *Recommendation ITU-R CMTT.721-2.* This Recommendation describes the coding scheme used for TV input signals according to Recommendation 601 if a high picture quality is wanted. For the data reduction an intra-field hybrid PCM/DPCM coding scheme is used. The Recommendation is available from the ITU, General Secretariat - Sales Services, Place des Nations, CH-1211 Geneva 20.

Transmission of component-coded digital television signals for contribution-quality applications at the third hierarchical level of Recommendation ITU-T G.702. *Recommendation ITU-R CMTT.723-1.* This Recommendation describes the coding scheme used for TV input signals according to Recommendation 601 if a high picture quality is wanted for an output bit rate of 34 Mbit/s. For data reduction a hybrid DCT coding scheme including motion compensation is used. The Recommendation is available from the ITU, General Secretariat - Sales Services, Place des Nations, CH-1211 Geneva 20.