

Realization of an AVS-based Satellite Digital Video System

WANG Guo-zhong¹⁾, ZHAO Hai-wu¹⁾, HOU Gang¹⁾, GU Jun-zhong²⁾

¹⁾ (Central Research Academy of SVA Group Co. Ltd., Shanghai 200233) ²⁾ (East China Normal University, Shanghai 200062)

Abstract AVS (audio video coding standard) is a digital audio-video coding/decoding standard proposed by China since 2002. It adopted many digital audio-video codec techniques developed by Chinese companies and universities in recent years. It has lower complexity in comparison with H. 264/AVC. And very low royalty fee will be charged through one-step license to use AVS including all tools. So AVS is regard as a good and competitive candidate for Chinese satellite TV signal directly to home (DTH). In this paper, the difference of AVS and MPEG-2 is studied. We also analyze alternative approaches, such as direct AVS codec and AVS transcoder, to transmit video stream via satellite, and discuss the design of corresponding transcoding scheme. At last a realization of new generation satellite system with AVS is presented.

Keywords DTH (directly to home), AVS (audio video coding standard), satellite video system, transcoder

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一种基于 AVS 卫星数字视频系统的实现

王国中¹⁾ 赵海武¹⁾ 侯钢¹⁾ 顾君忠²⁾

¹⁾ (上海广电(集团)有限公司中央研究院, 上海 200233) ²⁾ (华东师范大学, 上海 200062)

摘要 2002年中国开始制定了新一代数字音视频编解码标准——AVS。由于它采纳了近几年来国内研究的先进音视频编码技术,其不仅与H. 264/AVS相比,具有较低的复杂度,并可通过一站式授权方式支付少量费用来获得AVS使用权,因此可作为中国卫星电视直接入户方案的一种较好,且具有竞争力的候选标准。在对AVS和MPEG-2的差异进行比较的基础上,分析了两种在传输系统中替代MPEG-2的方法:直接AVS编码和AVS转码,并给出了一种转码方案,最终实现了新一代基于AVS卫星视频广播系统。

关键词 直接入户 音视频编码标准 卫星视频系统 转码器

1 Introduction

Four channels are typically used to transmit digital TV (DTV) signal via cable, terrestrial, satellite, or Internet. And MPEG-2 is successfully used in DTV up to now, and most of DTV broadcasting systems adopt MPEG-2 as its audio-video coding standard. But recently, new candidates such as H. 264/MPEG-4 part 10^[1] and WM9 (windows media 9)^[2] are proposed. In

the terrestrial and satellite video broadcasting, there has been a project to demonstrate that how to deliver WM9 Series content via DVB-T (digital video broadcasting terrestrial) and DVB-S (digital video broadcasting over satellite)^[3]. For us, AVS^[4] is the most probable new candidate.

AVS is a new digital audio-video coding standard established in China. The main motivity to develop AVS is that the royalty fee of foreign codec standards is too high to our internal manufacturers. And furthermore the

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第一作者简介:王国中(1962~),男,教授。现任上海广电(集团)有限公司中央研究院副院长。研究方向为计算机应用,数字电视关键技术、产品开发及产业化研究。E-mail: wang_gz@sva.com.cn

establishments of some video coding standards have ended, so that many good audio-video coding techniques, especially some invented in China, are not enclosed.

Comparing with cable and terrestrial, satellite is the most powerful channel to deliver digital TV signals everywhere. In China, satellite has been used to transfer digital TV signal for several years, and DVB-S has been adopted as Chinese standard for satellite-based DTV. Requirements of DTH become much stronger in recent years, and it will occupy large market in China. But all the existing and potential problems must be solved before it turn into truth. In this paper, we focus on the solution based on AVS.

2 Overview of AVS

AVS working group was established by the ministry of information industry (MII), China, in June 2002. The formal name of AVS is "information technology: advanced audio video coding standard". AVS is an attempt to have the initiative in kernel technologies about digital audio/video coding and will be as a native industrial standard. Most of patents in AVS are localized in China. The total performance of AVS obviously is superior to the ones of H.264/AVC and MPEG-2^[5-7]. Its compression efficiency is higher than MPEG-2 by 2~3 times and similar to H.264/AVC. However, its complexity is lower than the one of H.264/AVC.

In order to be compatible with MPEG-2, the high-level syntax structure of AVS is encoded just like MPEG-2. The video stream of both MPEG-2 and AVS is composed of sequence header and some frames, and only GOP (Group of Picture) is an option. In AVS, a frame includes the picture header and a few of slices, and a slice is composed of a slice header and a number of macroblocks.

But the important differences between the two standards are as follow, mainly:

(1) MPEG-2 holds four kinds of basic scalable coding tools: data partitioning, spatial scalability, temporal scalability and SNR scalability. Besides them, it also provides hybrid scalability that is

combined by these four basic tools. But AVS currently doesn't include scalable coding.

(2) Three kinds of chroma sampling formats: 4:2:0, 4:2:2 and 4:4:4 are provided in MPEG-2. But AVS currently doesn't support 4:4:4.

(3) The transform matrix and quantization process are different. The 8×8 DCT is accepted in MPEG-2, and AVS uses an 8×8 integer transform that approximates DCT. The quantization of AVS classifies the DCT coefficients into three kinds according to their locations, and does not control the quantization step of each coefficient alone.

(4) AVS supports the intra-frame prediction based on spatial correlation. But MPEG-2 uses the DC coefficient prediction in transform domain for high compression efficiency.

(5) MPEG-2 prescribes that a slice can't span two or more rows. But AVS redefines the slice that is composed of some full rows of macroblocks.

(6) A macroblock of progressive sequence can be encoded with frame mode and field mode in MPEG-2, but AVS doesn't support.

3 A Scheme of AVS-based Satellite Digital Video System

As known, satellite bandwidth is expensive. If more TV programs can be transmitted in limited channels, customers will pay less cost to satellite network providers. Thus satellite TV may be more competitive than other transmission modes. Based on the advantages of AVS analyzed above, a satellite TV transmission system with AVS is implemented by us.

In order to avoid completely updating existing MPEG-2 digital TV broadcast devices, the AVS transmission system can be implemented by two kinds of schemes. One is based on AVS encoder, and another on AVS transcoder. The scheme of AVS encoder based approach is shown as in Fig. 1 (a), in which an AVS transmission system substitutes for all modules using MPEG-2 encoder and decoder. Thus the devices of MPEG-2 will not be reused. The cost is rather huge for the digital TV service providers and the users owning

MPEG-2 devices. The second scheme^[8,9] as shown in Fig.1 (b) can greatly reduce the cost. Before transmitting TV program, we use a module to transcode MPEG-2 stream into AVS one, and then send the AVS stream to the multiplexer. Therefore all modules using MPEG-2 encoder can be still used, without any changing. Of course, receiver must support AVS decoding, which can be realized by upgrading Set-Top Box. In fact, the development of transcoder is easier and more efficient than using the new AVS encoder to replace MPEG-2 encoder. Here much useful coding domain information can be referenced when re-encoding, thus the latter is accepted by us.

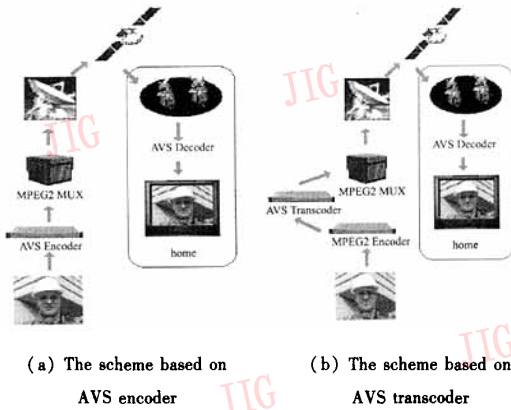


Fig.1 Satellite TV transmission system based on AVS

4 MPEG-2 to AVS Transcoding System

We designed an enhanced pixel domain transcoder (EPDT) from MPEG-2 to AVS. Fig. 2 is its flow chart. It shows that some input coded elements of MPEG-2, such as sequence header, macroblock mode and motion vector, may be reused in the process of AVS encoding and avoid being encoded again. This method can reduce computation burden and increase transcoding speed, while achieving high visual quality.

Because the coding algorithms of AVS are different from the ones of MPEG-2, the above transcoding method must follow the principles:

- (1) The transcoder temporarily doesn't include the scalable coding.
- (2) After that the video bitstream of MPEG-2

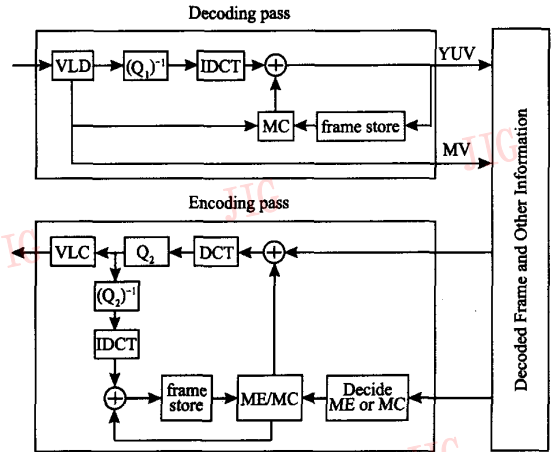


Fig.2 Enhanced pixel domain transcoding diagram

with 4:4:4 format is decoded, the picture would be down-sampled to 4:2:0 format.

(3) The high-level bitstream syntax is unchanged, which means that the location and structure of sequence header and GOP are preserved. The types of I, P and B frame are same after transcoding, which can avoid the delay of frame rearrangement and reduce the computation.

(4) The type of picture is unchanged. The picture with frame coding or field coding is unchanged after transcoding. The progressive frame of AVS can't slit two fields. So the progressive frame can only be coded as frame no matter how it is coded before transcoding. It is observed that the progressive frame of MPEG-2 is seldom divided into two fields.

(5) The slices need be partitioned again, and usually a frame is taken as a slice.

(6) Each macroblock of I frame need be re-encoded by the intra-prediction algorithm of AVS. But some information of input bitstream can bring references.

(7) All of macroblocks coded with field mode in progressive frame are re-encoded with frame mode.

(8) The skipped macroblock in MPEG-2 can only be allowed in skip mode of AVS.

(9) When the motion vector of the macroblock is unequal to zero and all of its DCT coefficients are zero, the motion vector and macroblock mode are directly

used in the AVS encoder. So the mode selection and motion compensation are not required again.

(10) The macroblock encoded with the intra-prediction mode of P frame and B frame in MPEG-2 needs mode selection and motion compensation again. It is easy to estimate the motion vector of new prediction mode because the search candidates could be reduced dramatically in a small range around the original motion vectors.

5 Implementation of Receiver System

We have designed and implemented the DVB-S set-top box that can realize AVS decoding (see Fig. 1 (b)). Fig. 3 shows the architecture of the set-top box that mainly includes:

- (1) RF (radio frequency) receiver; input RF signals and output TS (transmission stream) after tuner, QPSK demodulation, error correction and decryption.
- (2) Demux; input TS of AVS and output audio ES(element stream) and video ES
- (3) Decoder; decode video ES of AVS and audio ES
- (4) Display; audio and video DA, PAL/NTSC encoder and display

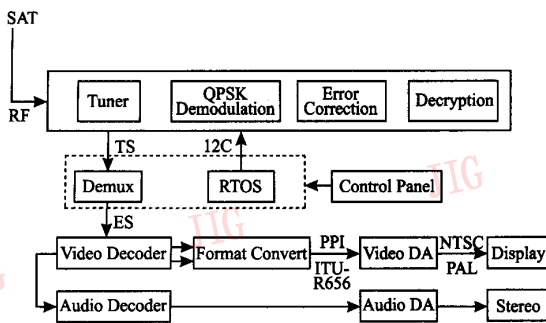


Fig. 3 The architecture of DVB-S set-top box based on AVS

6 Conclusions

In this paper, the application of AVS on satellite is discussed. We present two schemes of implements: one based on AVS encoder, another based on AVS

transcoder. The first scheme can make full use of the coding efficiency of AVS, but has huge cost because of replacing a lot of old devices. The second may reduce the cost greatly, yet can't use AVS to a great extent. In fact, the latter will be accepted in a recently long time, and will be gradually replaced by the first in future.

We also propose a transcoding scheme from MPEG-2 to AVS based on enhanced pixel domain, and a DVB-S set-top box that can complete AVS decoding has been implemented. The satellite TV transmission system based on AVS can save bandwidth 2 ~ 3 times compared with DVB-S based on MPEG-2.

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