Investigation And Complexity Analysis of A Spatial Audio Codec Based on A Programmable Media-Processor

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Abstract-- This paper presents a complexity analysis of a spatial audio coding scheme (known as MPEG surrounding) based on a commercially available programmable device. The analysis mainly focuses on the complexity of spatial audio cue analysis and synthesis, especially for the additional special tools used during the spatial cue synthesis stage. The analysis results can be a reference during building up a SAC codec on a DSP.

I. INTRODUCTION

With the fast development of newly-emerged computer technologies, digital audio video entertainment equipments are affordable and getting more and more popular. Numerous demands for HD (high definition) display device and the corresponding high quality video and audio digital contents are on the growth. All kinds of audio coding schemes are now in widespread use in multimedia applications. More recently, the trend of information technology (IT) converges toward the digital home, and undoubtedly, consumer electronic devices dedicated to entertainments will hold a significant position in everybody's home. Meanwhile, along with the prevalence of high quality but cheaper multi-channel loudspeaker devices, next generation digital multimedia content with high quality but low bit-rate multi-channel audio is surely to be the main stream in the near future. Now, building up a good multi-channel sound reproduction environment at home has become more practicable and fashionable. This trend is driven by generic movie sounds and more and more multi-channel DVD movies. Furthermore, lots of new multi-channel applications emerged in these years. For example, mobile applications, portable devices, and automotive applications, such as car audio playback setups, tend to have the demand of multi-channel audio playback. A carefully designed audio coding mechanism for gaining best surround performance, is therefore, of interest.

II. THE MPEG STANDARD

The demands for multi-channel audio contents can be served by burgeoning media content types, such as SA-CD and DVD-Audio. On the other hand, for bandwidth-

1. The Philips TriMedia processor IC is commercially available as the TM1500.

constrained and multi-channel applications, the MPEG-2/4 Advanced Audio Coding (AAC) scheme has been developed as an efficient multi-channel audio format. The AAC provides excellent sound quality at bit-rates in the range of 256-320kbit/s for 5-channel materials. Furthermore, MPEG organization now is building up a work plan about spatial audio coding (SAC) [1]. The work plan mainly focuses on:

- 1) *An extremely compact representation of the multi-channel signal.*
- 2) *An inherent ability to present either the multi-channel signal to new equipment or the e.g. 2-channel signal to legacy equipment.*

The MPEG committee has issued a call for proposal (CfP) for spatial audio coding (SAC) [2]. This will be an extension to audio codec for multi-channels. FhG/Agere [3], Dolby [4], Coding Technologies/Philips [5], and Panasonic [6] have submitted their proposals in response to the call. These proposals are based on parametric stereo [7] and BCC (binaural cue coding) [8]. MPEG now has defined the reference model 0 (RM0) for the standardization process. It is a combination of proposals from FhG/Agere and CT/Philips [9]. The infrastructure of the generic spatial audio coding technology is shown in Fig. 1, 2, 3.

III. THE COMPLEXITY ANALYSIS

As mentioned above, the main technique of SAC is BCC (Binaural cue coding). BCC enables parametric representations of a spatial audio and delivers multi-channel output (with an arbitrary number of channels) from a single audio channel plus some side information. It uses parameters like inter-channel time difference, inter-channel level difference and inter-channel coherences, and so forth to support surround sound (such as 5.1 channels) at very low bitrates. Lately the "MP3Surround" [11] technology from FhG uses this technique to add surround-sound capabilities to the MP3 algorithm at the cost of few additional bits. This technique can also be used as parametric stereo to support just two channels for backward compatibility.

Recently, the MPEG committee releases their spatial audio coding RM0 reference software. According to the reference software and its architecture detail [12], we mainly focus on the complexity analysis of the MPEG RM0 reference software

on a programmable media processor¹. We analyzed the complexities of the following stages:

- 1) *Audio source down-mix stage,*
- 2) *Audio cue estimation stage,*
- 3) *Audio cue synthesis stage*

Based on the complexity analysis results, we can further implement the low cost media processor based spatial audio encoder/decoder. Fig. 4 and fig. 5 show the functional profiles of the encoding and decoding process, respectively.

Fig. 1. Generic spatial audio coding scheme.

Fig. 2. The structure of a spatial audio coding encoder.

Fig. 3. The structure of a spatial audio coding decoder.

*****Encoder Process*****

Functions	Total Cycles	Percentage
Hybrid QMF filtering	168666258 clocks	92.280 %
Including:		
Interleave	258069 clocks	0.141 %
QMF filtering	67852891 clocks	37.123 %
Hybrid filtering	100555298 clocks	55.015 %
Calculate cues and downmix	2457478 clocks	1.345 %
Inverse hybrid filtering	11652591 clocks	6.375 %
Total Functions	182776327 clocks	100.00 %

Fig. 4. The profile of a spatial audio coding encoder.

*****Decoder Process*****

Functions	Total Cycles	Percentage
Decode spatial cues	74052 clocks	0.020 %
MDCT to QMF	1921 clocks	0.001 %
Hybrid QMF analysis	16309120 clocks	4.392 %
Parameter smoothing	34425 clocks	0.009 %
Create X matrix	237082 clocks	0.064 %
Make M1 and M2 matrix	796153 clocks	0.214 %
Apply M1 matrix	68849260 clocks	18.540 %
Create W matrix	26650271 clocks	7.177 %
Apply M2 matrix	88919452 clocks	23.945 %
TP Process	169475269 clocks	45.638 %
Total Functions	371347005 clocks	100.00 %

Fig. 5. The profile of a spatial audio coding decoder.

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