

Efficient Multiplexing Scheme of Stereoscopic Video Sequences for Digital Broadcasting Services

Kugjin Yun, Kyuheon Kim, Namho Hur, Soo In Lee, and Gwang Hoon Park

This letter introduces a stereoscopic video broadcasting system that provides 3D visual service and has full backward compatibility with legacy digital television (DTV) service in the same channel capacity. The proposed stereoscopic video broadcasting system in this letter is composed of both a hybrid codec and a multiplexer with a newly defined stereoscopic-related signaling method. In conclusion, the proposed method can be effectively applied for 3D broadcasting services without major changes in legacy broadcasting platforms.

Keywords: Stereoscopic, 3D DTV, PMT, multiplexer.

I. Introduction

Recent developments in 3D digital technologies have helped current digital television (DTV) services provide traditional 2D and 3D contents as post-HD broadcasting, which is creating a new emerging market in consumer electronics and 3D content [1], [2]. In order to realize a 3D DTV service, a couple of standard organizations over the world have worked on producing an efficient solution for a 3D DTV broadcasting service which would have backward compatibility with the current DTV specifications and high-quality 3D visual service under the existing channel capacity. In this letter, we propose a new approach that can fulfill those requirements, and thus can

be adapted in legacy digital broadcasting platforms.

II. Digital Stereoscopic Video Broadcasting System

Figure 1 illustrates a conceptual block diagram of the proposed digital stereoscopic video broadcasting system, which provides 2D and 3D DTV programs together, thus allowing the viewer to enjoy 2D or 3D DTV programming depending on his or her choice. The proposed system has a highly efficient multiplexing method of using both a hybrid video codec based on the MPEG-2/AVC [3] and a newly defined program map table (PMT) for stereoscopic-related signaling. This flexible design also satisfies the following system requirements: minimization of both complexity and implementation overhead in a legacy broadcasting system within the constraint of DTV channel capacity; backward and forward compatibility with legacy DTV broadcasting; provisioning of monoscopic and stereoscopic video time-mixed services on air, which brings up maximum 3D visual

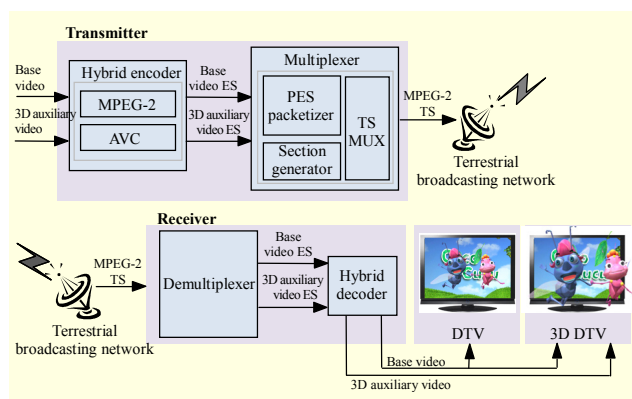


Fig. 1. Conceptual block diagram of DTV stereoscopic video broadcasting system.

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effects, such as advertisements; flexible applicability to all digital broadcasting platforms; and a stereoscopic-related signaling method for satisfying the other requirements.

III. Multiplexing Scheme for Stereoscopic Video Streams

1. Stereoscopic Video Broadcasting Service Scenario

Stereoscopic video programs can be broadcasted through two scenarios. One scenario is to dedicate a broadcasting channel to stereoscopic video programming. The other scenario is to broadcast a program composed of monoscopic and stereoscopic video sequences, as shown in Fig. 2, which will help the viewer experience relatively effective 3D impacts, such as advertisements, and can reduce viewer eye fatigue. Also, a stereoscopic video program can be broadcasted at any particular time.

For successful service under the second scenario, it is necessary to consider two important factors for a stereoscopic-related signaling method. First, for further processing, the stereoscopic-related signaling method has to provide stereoscopic service information that tells whether a broadcasting program is stereoscopic or monoscopic. Second, it can help in recognizing stereoscopic object information, such as a base video for 2D or 3D auxiliary video sequence. This is due to the transmission of these two media streams.

2. Stereoscopic-Related Signaling Method

The previous subsection explains the necessity of a stereoscopic-related signaling method for a mixed 2D and 3D program. For the stereoscopic-related signaling method, this letter proposes newly defined descriptors as shown in Fig. 3, where **stereoscopic_service_descriptor()** is used to identify the broadcasting mode, base view, left/right image, and stereoscopic composition type in a 3D DTV receiver. In this descriptor, a `stereomono_service_flag` equal to 1 indicates that

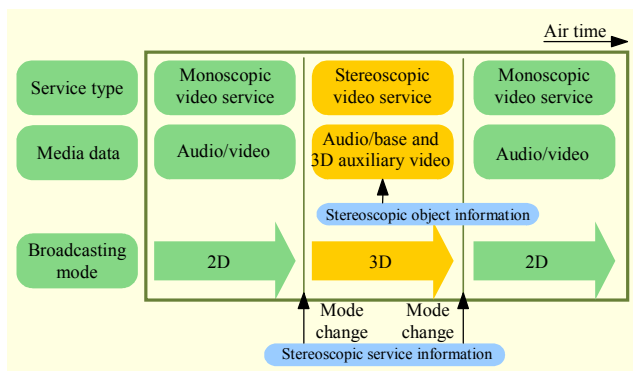


Fig. 2. Service scenario for DTV stereoscopic video broadcasting.

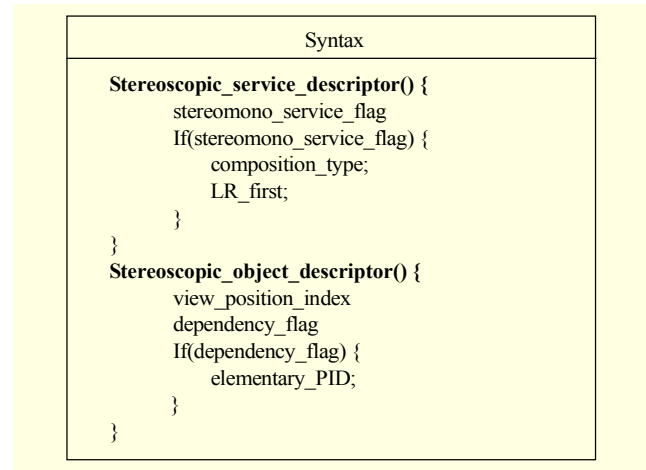


Fig. 3. Descriptors for stereoscopic-related signaling.

the current broadcasting program includes stereoscopic video, `composition_type` tells the stereoscopic video composition type, and an `LR_first` equal to 1 signals that a base view is the left one, which will be played in a conventional 2D DTV receiver. This descriptor shall be conveyed in the descriptor loop following the `program_info_length` field in the PMT for the initial information of the stereoscopic video broadcasting. Thus, this descriptor can be used for automatic controlling modules of a 3D display at a receiver.

Since a stereoscopic video sequence is rendered by conversion into a single 3D display format such as horizontal interleaving, it needs to be recognized as an object even though a stereoscopic video sequence is composed of both a base sequence and 3D auxiliary video sequence. Thus, **stereoscopic_object_descriptor()** is used to provide the dependent relationship between a base and a 3D auxiliary video stream as an object. In this descriptor, when both `view_position_index` and `dependency_flag` are equal to 1, it indicates that a current video stream is a left-view and 3D auxiliary video sequence, such as a 3D advertisement. Finally, `elementary_PID` indicates the PID of a base video stream. Also, this descriptor may be placed in the descriptor loop of the PMT for a video elementary stream (ES).

3. Multiplexing Scheme

As explained in the previous subsection, due to backward and forward compatibility with legacy 2D broadcasting systems, a stereoscopic service requires two ESs: a base sequence and 3D auxiliary video sequence. To transmit two ESs, it is necessary to develop a new multiplexing scheme.

As shown in Fig. 4, base and 3D auxiliary video sequences are simultaneously encoded by a hybrid encoder, which is composed of both MPEG-2 and AVC encoders in order to

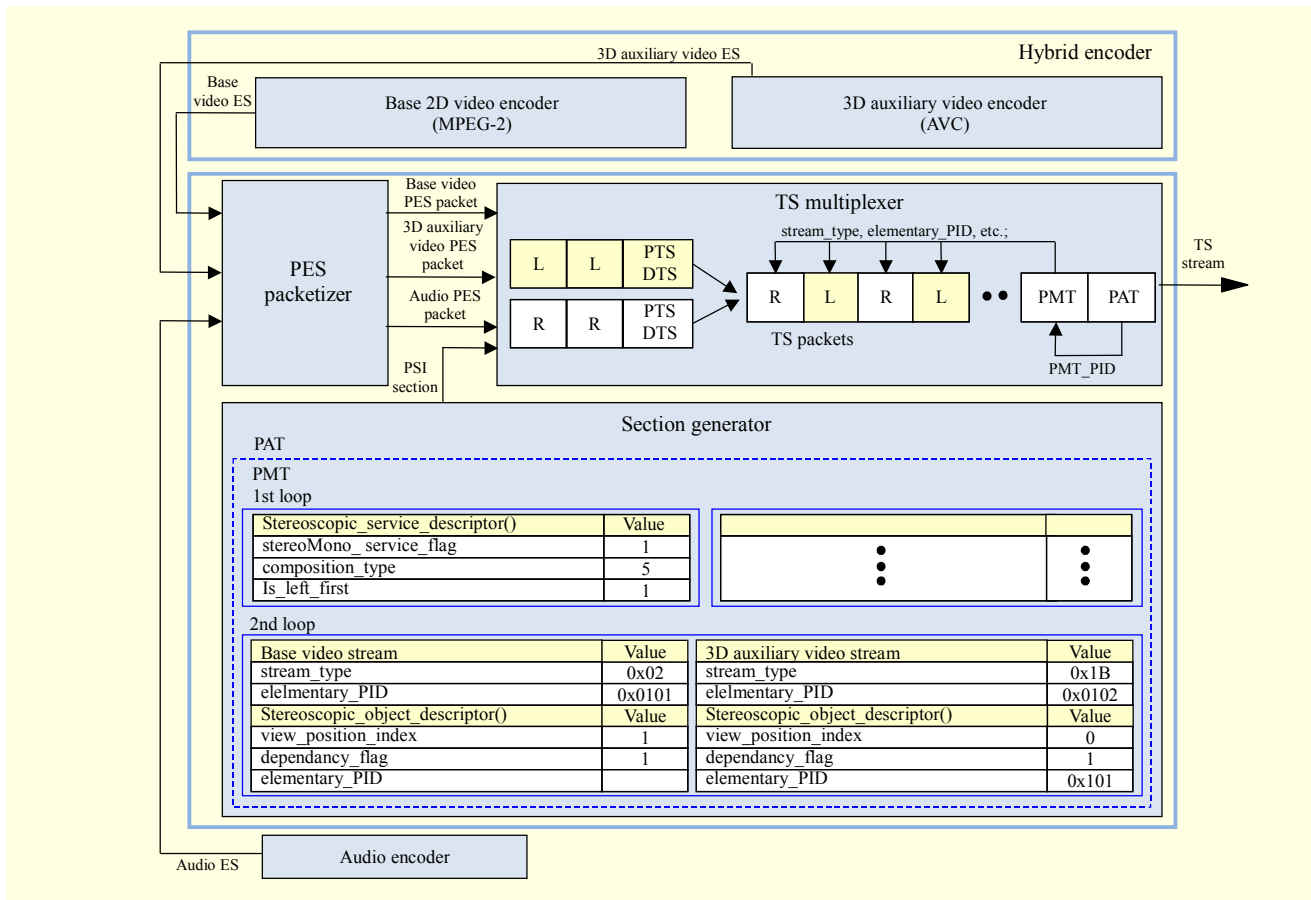


Fig. 4. Block diagram of TS multiplexer for stereoscopic video service.

keep backward compatibility with a legacy system. The encoded ESs are then packetized by a packetized ES (PES) packetizer into PES packets. The transport stream (TS) multiplexer in the proposed system also packetizes both the video ESs and program specific information (PSI) section streams into each MPEG-2 TS packet, which is transmitted through a conventional transmission channel.

In Fig. 4, the proposed system defines a PMT using the stereoscopic-related signaling information suggested in subsection III.2. For example, **stereoscopic_service_descriptor()** is in the first PMT loop described for the initial information of stereoscopic video broadcasting, and the values of the parameters in the **stereoscopic_service_descriptor()** are set as `stereoMono_service_flag=1` (3D broadcasting), `composition_type=5` (left-view and right-view sequences), and `LR_first=1` (the base view is the left image, that is, the left image is an independent stream). In the second PMT loop, both base and 3D auxiliary video ESs are assigned with a different `stream_type` and `elementary_PID`. For a base video stream, the values in the **stereoscopic_object_descriptor()** are set as `view_position_index=1` (left image) and `dependency_flag=0` (independent stream). For a

3D auxiliary video stream, the values in the **stereoscopic_object_descriptor()** are set as `view_position_index=0` (right image), `dependency_flag=1` (dependent stream), and `elementary_PID=0x101` (base video stream elementary_PID).

For accurate frame-based synchronization between a base video stream and a 3D auxiliary video stream, these video streams are multiplexed with the same decoding time stamp (DTS) or presentation time stamp (PTS) on a basis of a program clock reference.

4. Transport System Target Decoder (T-STD) Model

For the construction or verification of a stereoscopic video broadcasting service, this letter proposes a new transport system target decoder (T-STD) for modeling a stable decoding process that has a stereoscopic video buffer composed of both MPEG-2 and AVC video buffers for buffer and synchronization management, as illustrated in Fig. 5. After the demultiplexing and depacketizing processes, stereoscopic video streams are transmitted to the hybrid decoder by comparison of the time stamps in the two video streams.

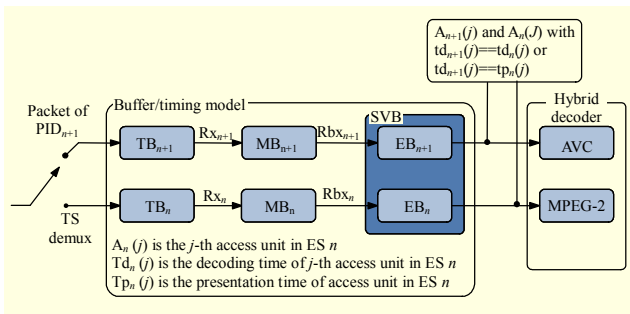


Fig. 5. T-STD model for stereoscopic video broadcasting.

IV. Experimental Results

The purpose of this experiment is to verify the proposed multiplexing scheme, which consists of a stereoscopic-related signaling method and T-STD model for a synchronization scheme, while keeping backward compatibility with a legacy DTV broadcasting system. In Fig. 6, stereoscopic video content is encoded by MPEG-2 for a base 2D video sequence and by AVC for a 3D auxiliary video sequence. Then, the stereoscopic video streams are multiplexed in the manner suggested in section III. The generated TS streams are demultiplexed, decoded, and rendered simultaneously by a 3D player and a legacy TS player, such as Windows Media Player ver. 12.0.7600. The legacy TS player can show a monoscopic video service by receiving only a base video (MPEG-2) stream, which confirms backward compatibility with a legacy 2D broadcasting system. Also, the 3D DTV media player is able to play a stereoscopic video while guaranteeing synchronization between these two streams.

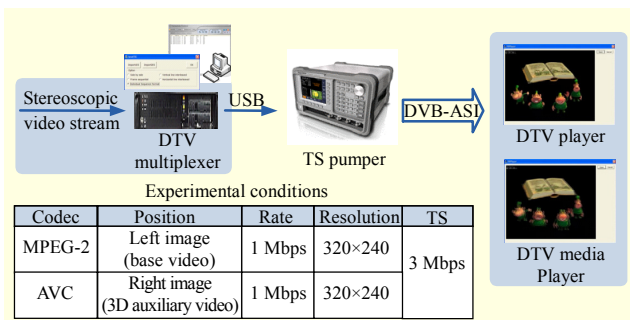


Fig. 6. Experimental configuration and the results of stereoscopic video service.

V. Conclusion

With the rapid development of digital 3D technologies in recent years, stereoscopic video broadcasting service is expected to be realized and will bring about realistic broadcasting services in the near future. However, it is still necessary to provide a legacy 2D DTV service to viewers.

Therefore, this letter proposed and verified a stereoscopic video broadcasting system using the scheme of stereoscopic-related signaling and T-STD-based multiplexing, while maintaining backward compatibility with a legacy 2D broadcasting system. With the flexibility of the proposed system, it is possible to provide various solutions with high-quality 3D DTV service that can be adapted in all digital broadcasting platforms.

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