Interactive UHD Digital Signage System for Multi-Screen Displays

Sung-Won Moon, Jeongwoo Lee, Jungsoo Lee, and Kisong Yoon

***Abstract*—With the rapid growth of the Ultra High Definition(UHD) video industry, UHD video contents are used for interactive digital signage. Since high-definition video contents are effective to get the attention of customers, advertisers want to use UHD video contents to advertise their products and services. This paper presents a digital signage system with software-based digital signage solution for UHD digital signage contents. The proposed system ingest, encode transfer, decode, and synchronize UHD digital signage contents.**

***Index Terms*—Digital signage, ultra high definition, multi-screen display.**

I. Introduction

Since the digital signage industry has been widely propagated, advertisers want to advertise their products and services by using digital signage devices with high resolution digital video contents. For this reason, advertising producers need digital signage systems with digital signage solution to control Ultra High Definition (UHD) digital video signage contents. Both the cost of digital signage system and the quality of digital signage contents are considered in advertisement market [1]-[3].

In general, a digital signage system with a hardware-based encoder is used to manage high resolution video contents. However, hardware-based encoders are expensive and hard to customize. Furthermore, it is difficult to improve the performance of a hardware-based encoder without changing the machine. To solve these problems, we propose a digital signage system with a software-based encoder to create and manage UHD digital signage contents.

If an UHD digital signage content's quality is low, customers do not feel attractive from the digital signage content whether the content's resolution is UHD or not [4]. The proposed system can encode UHD digital video signage contents with high quality and low bitrate with a software-based encoder which divides an UHD digital signage contents into pieces then divides each piece into slices. By using parallel encoding, the proposed system encodes a video content appropriately for the layout of multi-panel device in short time.

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Fig. 1. Multi-panel based device for digital signage.

Since lots of small panel are cheaper than one big panel, multi-screen based digital signage display device is used to display high resolution video contents. Fig. 1 shows a general form of multi-screen based digital signage display device with four full high definition (FHD) panels which can display UHD video contents. Because of each screen displays a digital signage content separately, the control system needs to synchronize the display devices. In this paper, a digital signage system is proposed which can display separated digital signage content and support interaction between the digital signage content and customers. To attract customers, the proposed system also provides interaction between customers and UHD digital signage video contents.

This paper is organized as follows. The proposed UHD digital signage system is shown in Section II. Implementation results are given in Section III and concluding remarks are given in Section IV.

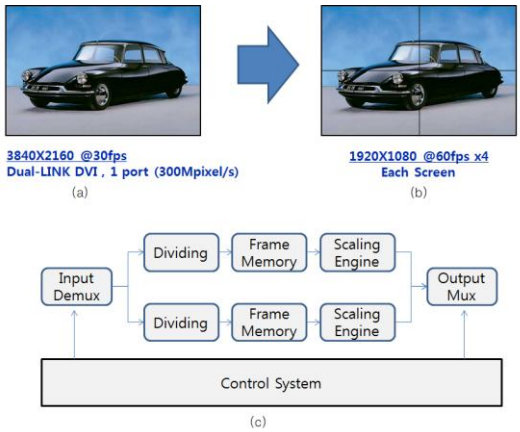

Fig. 2. Concept design of multi-panel based device for digital signage.

II. UHD Digital Signage System

A. Software-Based Encoder Design

Fig. 3 shows the encoding processes of the proposed

soft-ware based UHD digital video signage encoder. First, each frame of digital video signage contents is divided into pieces to suit for the layout of digital signage display device. Each piece is also divided into slices which are encoded in parallel.

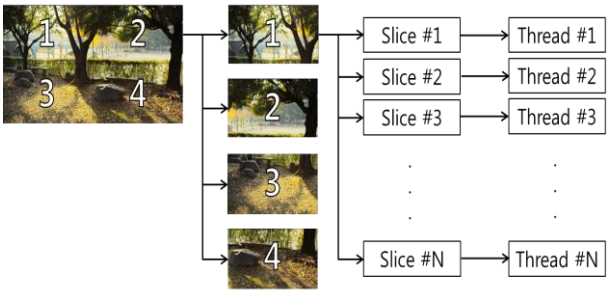

Fig. 3. Design of the digital signage encoder.

Because of a thread is given for a slice, the proposed system can manage the number of slices which are used to encode a frame. Since pieces in same frame are encoded in parallel, the proposed encoder can control parameters for each piece. If a piece's encoding quality is lower than other pieces, the proposed encoder enhances the quality. By using this method, the proposed encoder can normalize the quality of the target UHD digital video signage content [5].

Since the proposed encoder divides a frame into pieces, the encoder set each piece's encoding parameters like bitrate, framerate, size and motion estimation method individually. If an advertiser has different priority of digital signage contents, the advertiser can allocate more bitrate for important digital signage contents. When the encoding is finished, each slice is combined to reconstruct original frame. Because of the frame is combined after dividing process, blocking artifacts can be shown at the edge of slices. To remove blocking effect and get clear frame, deblocking filter and noise reduction filter is applied [6]-[9].

The proposed encoder which uses divide and encode method is faster than a simple whole frame encoder. Since an UHD video frame has bigger size than cache memory, if we encode whole frame without dividing process, the frame data overflow cache memory and violate the memory which should be used for next frame. The memory violation issue is solved by using dividing encoding process, because each divided slice's size is small enough.

B. Encoder Implementation

H.264 codec is used to encode UHD digital signage contents. The H.264 format is the most popular codec for high resolution video contents and has high compression ratio. The H.264 standard also considers dividing frames into slices. The proposed system supports main profile which is appropriate to generate high compressed video contents [10].

The proposed encoder encodes target UHD digital video signage contents as follows. First, read a raw UHD digital video signage content with encoding parameters. We use YUV stream format for raw UHD digital video signage contents. The proposed encoder is created and initialized with given encoding parameters. Next, the input YUV stream is divided into pieces logically and each piece is divided into slices by considering number of thread. Each slice is encoded by single thread in parallel. After a frame is encoded, the proposed encoder gets QP of each piece to control next frame's quality.

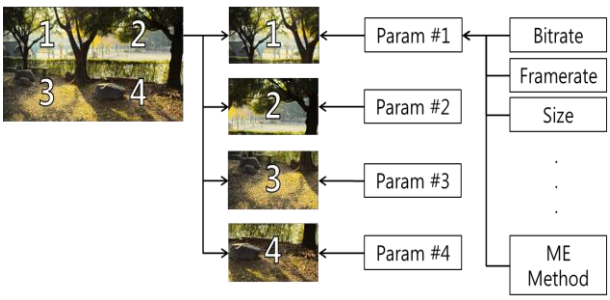

Fig. 4. Encoding parameters of the digital signage content.

If specific piece's quality is too high or low, it will be adjusted in next frame.

Since digital signage contents can be transferred in online, the UHD digital signage video content's bitrate should be less than 30Mbps. It means that the compression ratio of the target UHD digital video signage content should be very high. The proposed method can compress the raw YUV stream to 30Mbps H.264 video without degrading the resolution of digital signage contents.

Fig. 5. User interface of the proposed digital signage display system(top) and implementation sample of proposed digital signage display device(bottom).

C. Interactive Digital Signage Display System

Fig. 5 shows the proposed digital signage display system. An encoded UHD digital signage video content is transferred to UHD digital signage decoder. Since an encoded UHD digital signage content is divided into pieces, the proposed system decodes each piece in parallel to play each piece at the same time. When decoding is over, an optimized digital signage display device receives the decoded contents. A daisy chain system is used to synchronize multi-screen displays. The proposed digital signage display system supports infrared ray-based 32 points multi touch interaction with calibration and noise reduction technique.

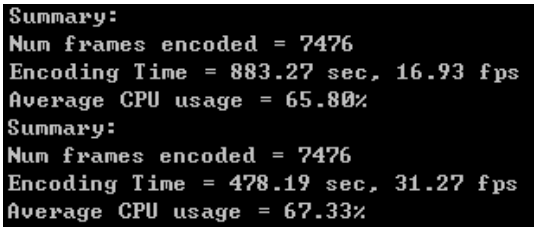

Fig. 6. Performance of simple whole frame encoder (top) and the proposed encoder (bottom).

Due to a digital signage system with large display device is usually located on public place; the digital signage system should notice public information like emergency alerts. Because of the proposed digital signage system supports streaming an UHD digital signage contents in real time by using HTTP Live Streaming (HLS) technology, public information can be noticed with the digital signage display device.

The proposed system provides optimized user interfaces (UI) to browse UHD contents on display device. The UI shows encoded contents and user can make projects and schedules by using encoded contents. The proposed system provides timeline to edit a schedule and user can apply a schedule to the target client. Users can check the condition of clients remotely.

III. Experimental Results

Two Intel Xeon X5680 processors are used to encode UHD digital video signage contents to evaluate the proposed method. The proposed method uses OpenMP technology for parallel processing. The resolution of videos which are used to evaluate the proposed has 3840×2160. The target UHD digital video signage content is divided into four pieces and same initial encoding parameter is given for every piece. In this paper, a simple H.264 encoder in IPP sample is compared with the proposed system's software-based UHD digital signage encoder.

Fig. 6 shows that the proposed method is 85 percentage faster than the existing simple whole frame encoding based on IPP H.264 encoder despite IPP encoder also supports multi thread processing. The proposed encoder is faster than existing method because the two-level parallel processing need less time to pipeline threads which encode slices. The encoded UHD digital video signage contents which are encoded by using the proposed method have high fidelity after encoding. The average peak signal to noise ratio (PSNR) of encoded contents is over 45dB and even the minimum value is over 35dB while encoded contents are compressed to 30Mbps H.264 video. We also checked the fidelity based on human visual system by using multi-panel based digital signage display device with experts. The encoded UHD digital signage contents have no blocking artifact and have high fidelity. Since the encoder control each piece's quality, every panel's content have similar quality.

To display UHD video contents, four 55inch display devices are connected by using daisy chain technology. The proposed display system supports 32point multi touch interaction. Figure shows the interaction between user and display device. Nine UHD contents can be played at same time and the UHD contents are controlled smoothly without delay.

IV. Conclusions

In this paper, we proposed a software-based UHD digital signage encoder which can encode UHD digital video contents with high fidelity in short time by using parallel encoding technology. Our experimental results show that the proposed encoder guarantees better speed than an existing encoder on same system. In future research, we will try to use HEVC codec to reduce the bitrate of digital signage contents and encode 3D UHD video contents with the proposed encoder.

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