SISVEL TECHNOLOGY

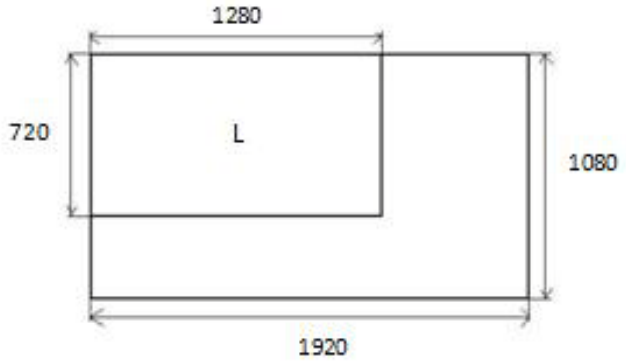
3D Tile Format
and
3DZ Tile Format

Implementation notes

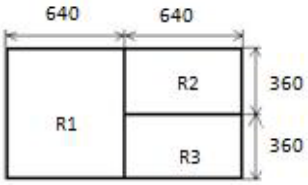
1 Description of the 3D Tile Format

The 3D Tile Format is a frame compatible format that allows storing **two 720p frames in a single 1080p frame.**

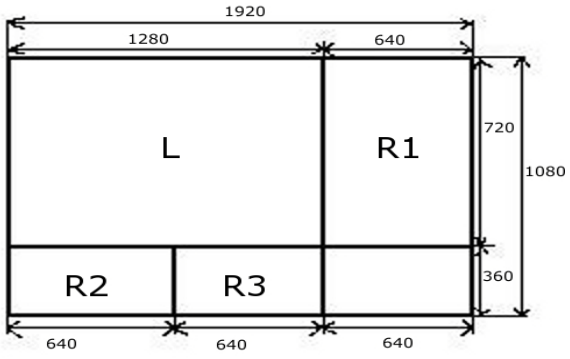
As illustrated in the figure, the first 720p frame (L, in the example) is inserted unaltered in the 1080p container.



The second (R) will have to be cut into slices, so as to fit in the free space left in the container frame.

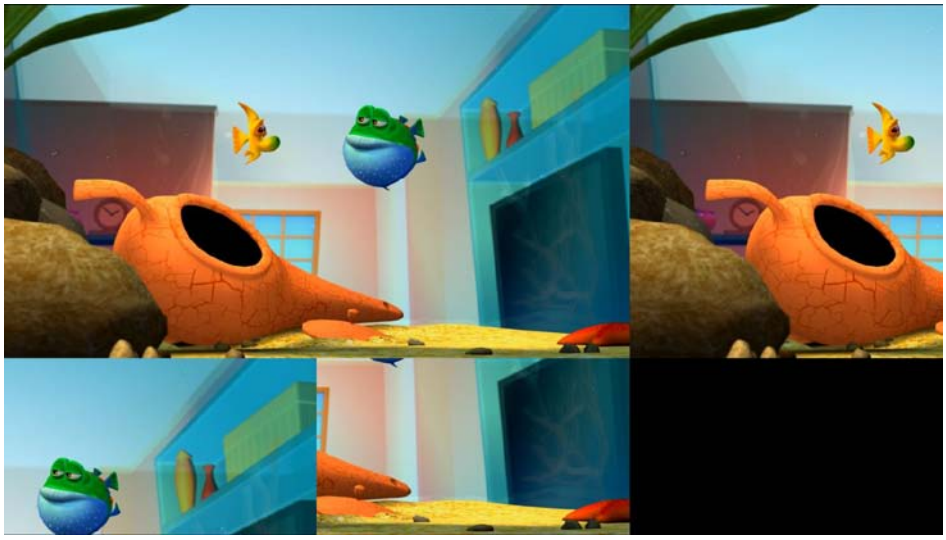


The three slices R1, R2 and R3 can be then inserted in the container frame as illustrated in the following figure.



Since the two 720p video components have a frame rate of 50fps, the overall frame rate of the resulting composite video will be 50 fps as well. In some specific situations, however, lower frame rates might be also acceptable (24 or 25 fps).

The following figure shows an example of a composite frame according to the 3D Tile Format:



2 Description of the 3DZ Tile Format

In order to support the visualization on autostereoscopic displays, a depth map can be inserted in the empty portion of the 1080p container, as shown in the next figure. The resolution of the depth map is 640x360 pixels. This video arrangement is the so called 3DZ Tile Format:

The 3DZ Tile Format is particularly advantageous due to the fact that it allows serving 2D, stereoscopic and autostereoscopic display with a single stream.

3 Tile Format compression

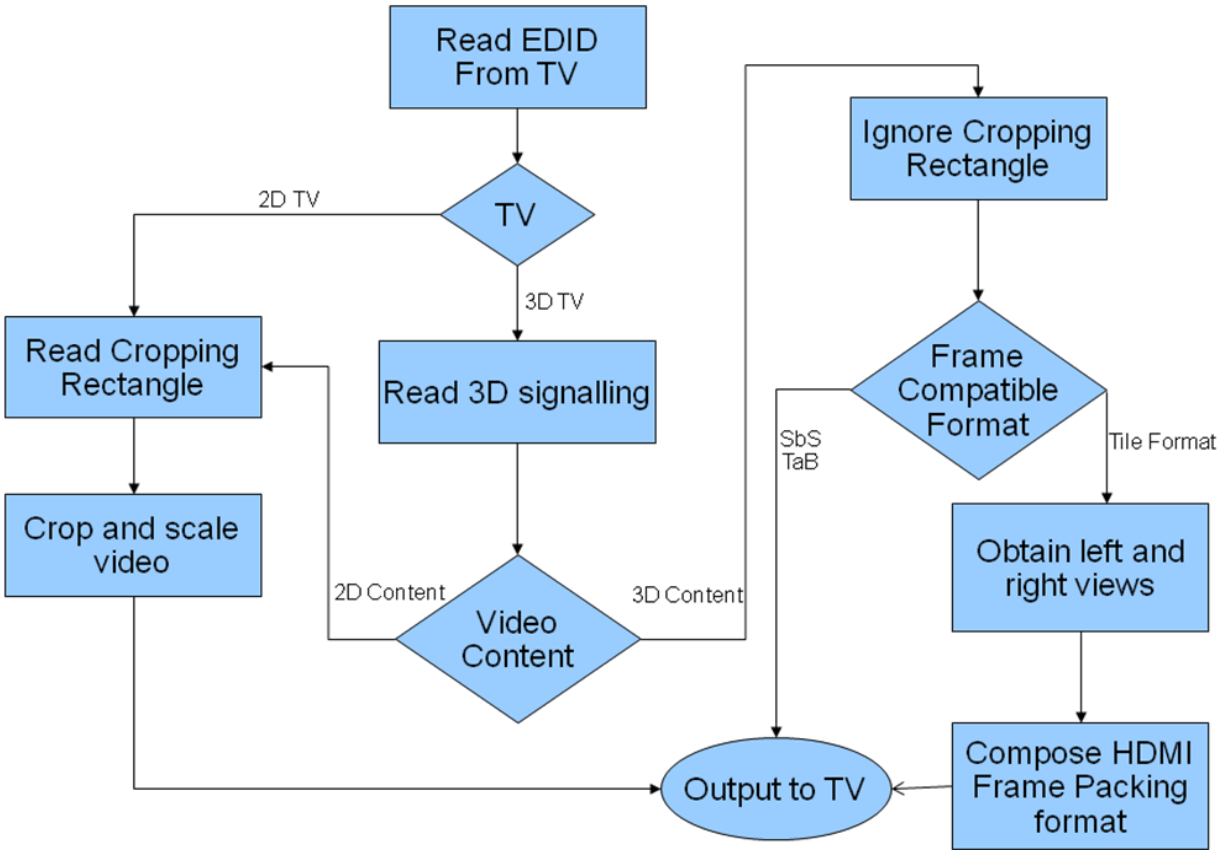
Since it is intended for viewing on autostereoscopic, 3D as well as 2D TV sets, the video will be compressed in AVC/H.264, using a value of 0, 0, 640, 360 (left, top, right, bottom) for the cropping rectangle in the Sequence Parameter Set (see the Annex “A method to transform a frame compatible AVC/H.264 3D picture into a 2Dservice compatible picture”).

Needless to say that exactly like other frame packed formats, the Tile Format is not limited to a particular resolution or frame rate. However, using a 1080p50 container frame leads to better results when compared to other resolutions.

4 Converting the 3D Tile Format to the HDMI frame packing format

Given the resolution and the frame rate of the Left and Right video components (720p and 50 fps), the transfer of the 3D decoded video from an IDR to a display will be implemented using the HDMI frame packing mode as described in HDMI Specification Version 1.4a, 3D Signalling Portion, 8.2.3.2 3D video format structure.

The following flow chart illustrates a possible implementation of the decoding of “service compatible” 3D frame packing formats (including the Tile Format) on a Set-Top-Box:


Read EDID From TV
TV
2D TV
3D TV
Read Cropping Rectangle
Read 3D signalling
Crop and scale video
2D Content
Video Content
3D Content
Ignore Cropping Rectangle
Frame Compatible Format
SbS TaB
Tile Format
Obtain left and right views
Compose HDMI Frame Packing format
Output to TV

ANNEX

A method to transform a frame compatible AVC/H.264 3D picture into a 2D service compatible picture

1 Introduction

Based on standard specifications, an AVC/H.264 encoder is able to compress rectangular images having horizontal or vertical sizes that are integer multiples of the macroblock size (16 pixels).
This actually clarify that formats such as the 1920x1080 have to be adapted, so as to cope with said limitation. In the specific case of the 1080 format, the encoder adds 8 empty lines to the video, so that the output format will be 1920x1088.

The cropping rectangle parameter has been introduced as a means to enable a decoder to recover the original image format, cropping the extra empty lines at the bottom.
Since there are no theoretical limitations to the values this parameter could be set to (any values within the boundaries of the image frame are considered valid), the cropping rectangle can be used as a "tool" to output any rectangular region of the input frame.

In particular, if the input frame is a composite frame used for 3D stereoscopic video broadcasting (the so called Side by Side or Top and Bottom Frame Compatible modes), the cropping rectangle can be used to delimit an area within the frame containing only one of the two 2D views: as illustrated in the drawings below, a AVC/H.264-compliant decoder, after decompressing such a video it would only output the view contained within the cropping rectangle.

Decoded output (with cropping rectangle in red)

Cropped output

Scaled output

The output video, properly scaled, provides a 2D-compatible format.

Preliminary tests have demonstrated that most of the existing TVs and set-top-boxes, already equipped with an integrated AVC/H.264 decoder, are designed for cropping and presenting the video correctly.

The aspect ratio of the video on the screen can be controlled automatically by means of the Sample Aspect Ratio (SAR), the parameter which describes "the ratio between the intended horizontal distance between the columns and the intended vertical distance between the rows of the luma sample array in a frame" (AVC/H.264 specification, paragraph 3 Definitions - 3.131).

By specifying a SAR of 2:1, the horizontal dimension of the cropped video will be doubled in width at display time; while with a SAR of 1:2 the vertical size of the cropped video will be doubled at display time.

2 The cropping rectangle and the SAR in the AVC/H.264 standard

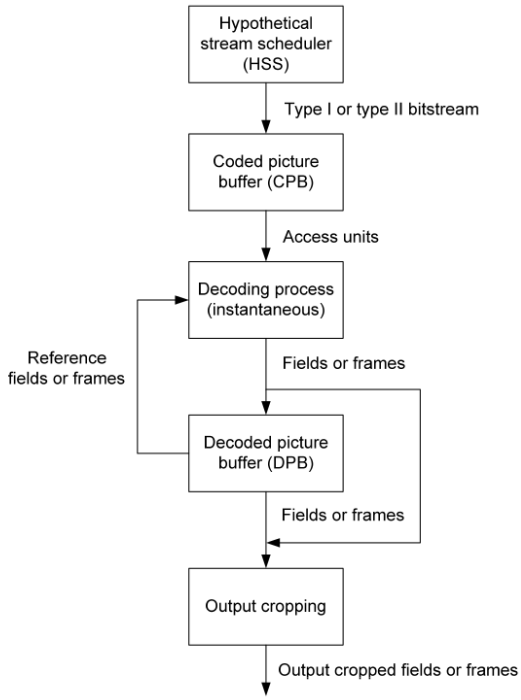
The "Cropping Rectangle" is one of the parameters conveyed in the AVC/H.264 Sequence Parameter Set. It is introduced in Clause 6.2 "Source, decoded and output picture formats of the standard".

> […]
> The width or height of pictures output from the decoding process need not be an integer multiple of 16 and can be specified using a cropping rectangle.
> […]

The syntax for the parameter is described in clause 7.3.2.1.1 "Sequence parameter set data syntax" and the semantics thereof id specified in clause 7.4.2.1.1 "Sequence parameter set data semantics"

> […]
> frame_cropping_flag equal to 1 specifies that the frame cropping offset parameters follow next in the sequence parameter set. frame_cropping_flag equal to 0 specifies that the frame cropping offset parameters are not present.
> frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, frame_crop_bottom_offset specify the samples of the pictures in the coded video sequence that are output from the decoding process, in terms of a rectangular region specified in frame coordinates for output.
> […]

The behavior of the decoder is described in Annex C (Hypothetical Reference Decoder) of the standard. The following picture illustrates how the cropping feature is carried out right after the decoding process.



> […]
> The HRD contains a coded picture buffer (CPB), an instantaneous decoding process, a decoded picture buffer (DPB), and output cropping as shown in Figure C-2.
> […]

In clause C.2.2, this behavior is specified:

> […]
> When output, the picture or a view component of the picture shall be cropped, using the cropping rectangle specified in the active sequence parameter set for the picture or the view component.
> […]

As mentioned earlier, the SAR is described in definition 3.131. Because the display process is outside the scope of the AVC/H.264 specifications, it is only specified as an assistive means to control the format of the displayed video.

3 The Cropping Rectangle and the SAR in the DVB standard

ETSI TS 101 154 V1.9.1 (2009-09), Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream, paragraph 5.7.1.2 Aspect ratio (in 5.7 AVC/H.264 HDTV IRDs and Bitstreams, 5.7.1 Specifications common to all AVC/H.264 HDTV IRDs and Bitstreams):

- **Encoding**: The source aspect ratio in AVC/H.264 HDTV Bitstreams shall be 16:9. The source aspect ratio information shall be derived from the aspect_ratio_idc value in the Video.
  Usability Information (see values of aspect_ratio_idc in ITU-T Recommendation H.264/ISO/IEC 14496-10 [16], table E-1).
  The frame cropping information in the Sequence Parameter Set may be used when appropriate.

- **Decoding**: H.264/AVC HDTV IRDs shall support decoding and displaying AVC/H.264 HDTV Bitstreams with the values of aspect_ratio_idc as specified in table 12.
  The source aspect ratio information shall be derived from the pic_height_in_map_units_minus1 and the pic_width_in_mbs_minus1 and the frame cropping information coded in the Sequence Parameter Set (SPS) as well as the sample aspect ratio encoded with the aspect_ratio_idc value in the Video Usability Information (VUI). See values of aspect_ratio_idc in ITU-T Recommendation H.264/ISO/IEC 14496-10 [16], table E-1). AVC/H.264 HDTV IRDs shall support frame cropping.