SMPTE ST 2066:2012

SMPTE STANDARD

Disparity Map Representation for Stereoscopic 3D

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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Operations Manual.

SMPTE ST 2066 was prepared by Technology Committee 10E.

Intellectual Property

SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

Each holder of claimed IPR has assured the Society that it is willing to License all IPR it owns, and any third party IPR it has the right to sublicense, that is essential to the implementation of this Standard to those (Members and non-Members alike) desiring to implement this Standard under reasonable terms and conditions, demonstrably free of discrimination. Each holder of claimed IPR has filed a statement to such effect with SMPTE. Information may be obtained from the Director, Standards & Engineering at SMPTE Headquarters.

Attention is also drawn to the possibility that elements of this Standard may be subject to IPR other than those identified above. The Society shall not be responsible for identifying any or all such IPR.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

Stereoscopic 3D image capture and generation equipment provide images having intrinsic depth cues due to disparity, that can be perceived when stereoscopic imagery is properly presented to both eyes. Lest depth cue conflicts result, these disparities are considered when such stereoscopic sources are composited, including with other stereoscopic images, subtitles, captions, and graphic overlays. Other manipulations of stereoscopic images also benefit from knowledge of disparity values: For example, in depth keying, a matte or keying signal is derived from disparity information and used in the compositing of two stereoscopic sources. Disparity information also enables the exaggeration or attenuation of the intrinsic depth cues downstream from a stereoscopic source.

For stereoscopic images generated computationally (for instance, from graphic animation devices that produce a stereoscopic output), disparity values can be provided that are authoritative. However, in the case of stereoscopic image capture systems (that is, devices to capture real-world images, such as stereoscopic camera rigs), disparity is estimated. This can be from the images themselves, or from a fusion of image data and another data source, for example, LIDAR (Light Detection and Ranging). When estimated, the disparity values that result are sometimes less than certain.

In general, for compositions and other manipulations, an accurate representation of disparity values corresponding to each pixel of each image in a stereoscopic image pair is needed to achieve the highest quality result.

During the composition or manipulation of stereoscopic images, the intrinsic depth cues due to disparity are changed. When desired, a new disparity map is obtained through a corresponding operation, or is derived anew from the resulting stereoscopic image pair. The new disparity map accompanies the corresponding stereoscopic image pairs for use in subsequent processing.

1 Scope

This document provides a standard for data representation of disparity maps for use in exchanges between stereoscopic 3D video production and mastering systems, and is particularly suited to live events. These disparity maps represent only horizontal disparity and thus presume that the corresponding stereoscopic image pairs have no Vertical Misalignment.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or text that contains the conformance language keywords: "shall," "should," or "may." Informative text is text that is potentially helpful to the user, but not indispensable, and that can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:".

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and, in addition, indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms

3 Definitions and Acronyms

The following definitions are used in this document:

3.1
Disparity Units
DU
Disparity Units are an image-width referenced measure used to represent disparities in a stereoscopic image pair.

The full width of a stereoscopic image shall be defined as 61440 Disparity Units. Thus, for an image that is ‘w’ pixels wide, each pixel would have a width of 61440/w Disparity Units, which is an integer for the image widths of 1280, 1920, 2048, 3840, 4096, and 7680 pixels for the image formats defined in SMPTE ST 274, SMPTE ST 296, SMPTE ST 2036-1 and SMPTE ST 2048-1.

By this definition, a Disparity Value represented as an integer number of Disparity Units has a precision of w/61440 pixels. For example, in a stereoscopic image that is 1280 pixels wide, a value represented by Disparity Units has a precision of 1/48th pixel.

Note: The constant 61440 is the least common multiple (LCM) of the common image widths 1280, 1920, 2048, 3840, 4096, and 7680 pixels.

3.2
Disparity Value
a Disparity Value is the horizontal displacement between corresponding points in a stereoscopic image pair, measured in Disparity Units, from a point in the left-eye image plane* to the corresponding point in the right-eye image plane, with displacement to the right being positive; except when the distance between the corresponding points is not known, in which case the Disparity Value is an appropriate special value as defined in Section 6.

When one or the other of the corresponding points in the image plane is outside the image itself, as can occur near the right and left edges of the image, the actual Disparity Units measure of the Disparity Value for the point inside the image, if known, should be provided.

When both of the corresponding points in the image plane are within the image, but a foreground object hides one or the other, the actual Disparity Unit measure of the Disparity Value for the non-hidden point, if known, should be provided.

3.3
Disparity Map
a Disparity Map is an array representing multiple Disparity Values corresponding to a particular one of the images in the stereoscopic image pair, and the metadata necessary to interpret the representation.

3.4

Vertical Misalignment
Vertical Misalignment as used herein is defined as vertical deviation between corresponding points.

Note: These disparity maps represent only horizontal disparity and thus presume that the corresponding stereoscopic image pairs have no Vertical Misalignment.

4 Disparity Value Representation

The range of possible Disparity Values, not including the special values defined in Section 6, is the interval [-61440, +61440], requiring at least a 17-bit representation.

Note: A Disparity Value will be substantially the same sign and value when measured with respect to either image. The sign does not reverse when measuring from the right-eye or left-eye image.

5 Disparity Map Characteristics

The following characteristics shall be provided to govern the interpretation of Disparity Values as represented in a Disparity Map.

* Here, an “image plane” is the infinite mathematical plane within which the finite rectangle of the image resides. The coordinate axes of this plane are the same as those used to define pixel coordinates within the image. By this definition, a corresponding point can exist outside the extent of an image.

5.1 Map Width

An unsigned integer representing the number of columns in the Disparity Map. A Disparity Map shall be the same width as the corresponding images.

5.2 Map Height

An unsigned integer representing the number of rows in the Disparity Map. A Disparity Map shall be the same height as the corresponding images.

5.3 Map Image Tag

A single character, ‘R’ or ‘L’, indicating respectively whether a Disparity Map represents disparities from the right-eye or left-eye image of the image pair.

6 Special Values

Special values shall not be considered to represent disparity, but shall be interpreted to represent the following condition at the corresponding image pixel(s):

6.1 Unknown

The value 0x0FFFF (65535) shall represent an unknown Disparity Value

Note: The value 0x0FFFF is intended as a 17-bit value.

Annex A Bibliography (Informative)

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 274:2008) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 274M-2008). Documents with the same root number (e.g. 274) and publication year (e.g. 2008) are functionally identical.

The following standards contain provisions that, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

The following documents are among those consulted in deriving the requirements addressed by this standard:

REPORT OF SMPTE TASK FORCE ON 3D TO THE HOME, Society of Motion Picture and Television Engineers, 2009

In particular, these standards describe the image resolutions supported by this standard:

SMPTE ST 274:2008, Television — 1920×1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

SMPTE ST 296:2012, 1280×720 Progressive Image Sample Structure — Analog and Digital Representation and Analog Interface

SMPTE ST 2036-1:2009, Ultra High Definition Television — Image Parameter Values for Program Production

SMPTE ST 2048-1:2011, 2048×1080 and 4096×2160 Digital Cinematography Production Image Formats FS/709