

Multi-Format Encoding / Decoding

White Paper

MFE/D: The Solution for 2.35:1 and 4K / Ultra HD Video Content

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Contents

Background and Problem Definition	.2
New 4K / Ultra HD High Resolution Displays	.2
2.35:1 Movies for 21:9 TV and Projection	. 2
Solution and Opportunity	.3
The Basics of MFE and MFD	.3
Encoding	.3
Decoding	.6
Additional Usage	.9
Summary	.9

Background and Problem Definition

New display technologies, including 4K / Ultra HD and 21:9 TVs and projectors plus extra large (65"+) displays, are pushing the limits of current video distribution methods. These new displays beg for higher resolution content, however, the methods currently available to provide content have recently undergone the transition to HD and digital. Investment for another round of infrastructure changes is not a high priority. Broadcast, streaming and physical media need a simple, inexpensive solution to help them overcome these capacity constraints while continuing to provide improved performance. Folded Space has created video encoding and decoding algorithms that are a paradigm shift in video processing, providing actual higher resolution for 2.35:1 content and advanced image processing for all content without having to resize the video distribution infrastructure.

New 4K / Ultra HD High Resolution Displays

Consumer electronics manufacturers are responding to increased demand for wider aspect and higher resolution displays to present high performance content. These displays include 4K Ultra HDTVs and projectors, wider format 21:9 flat panels, and 16:9 projection systems fitted with anamorphic lenses. However, even though these new displays allow for a more immersive and higher performance experience, video content is still not available to take advantage of it. This means such displays must use conventional scaling algorithms to modify available content, often resulting in visible softening of the picture.

Problem 1: New ultra-widescreen 21:9 and higher resolution 4K Ultra HD displays are hitting the market, but the lack of full resolution content means that conventional scaling must be used, resulting in a less vibrant and detailed picture.

2.35:1 Movies for 21:9 TV and Projection

Over 70% of top grossing motion pictures are created by their directors with the 2.35:1 aspect ratio to intentionally make the film more panoramic and immersive. While visually stunning in commercial theaters, these ultra wide films do not fit into the format of conventional 16:9 HDTV displays. The central image must be squeezed down to fit within the width of a conventional display with black bars placed above and below the image. This alteration significantly diminishes the original immersive effect.

Problem 2: The majority of top box office movie content is reduced to fit an HDTV's width and placed between black letterbox bars for home viewing, significantly diminishing the immersive effect of the film's native format.

Consequently, such films also do not fit the format of conventional HD consumer media such as Blu-ray[®] discs. The inclusion of the black letterbox bars result in the use of only ~810 lines of vertical resolution for the primary image. This means that no ultra wide screen films, including some of the most extraordinary movies ever made, can be displayed in the home in the Full HD resolution of 1920x1080.

Problem 3: The majority of the most popular movies ever made are NOT available in Full HD resolution because their format doesn't fit the standard 16:9 HD container.

Solution and Opportunity

Folded Space MFE & MFD algorithms solve the above problems by exploiting a new approach to high resolution image delivery and reconstruction that avoids the soft/hazy image caused by typical scaling while providing actual higher resolution from existing video distribution methods such as a Blu-ray disc.

During creation of what would otherwise be letterboxed wide screen content, Multi-Format Encoding (MFE) stores **33% more vertical resolution on a standard Blu-ray Disc**. During playback, Multi-Format Decoding (MFD) utilizes this additional resolution along with new image reconstruction processing to allow the consumer to choose one of three formats depending upon their display. A separate MFD mode is in development for 4K TVs and projectors to allow reconstructed content to be displayed at **3840 x 2160, QuadHD resolution**. Each MFD format and mode provides a <u>minimum</u> of 33% additional resolution over standard letterboxed video.

If the playback device does not have MFD, an MFE-encoded disc still provides a high quality letterbox version of the film.

The Basics of MFE and MFD

Encoding

MFE software is used during the workflow process while digitally processing a video feature for Blu-ray or other HD media. To create an MFE encoded video product, original media that is either anamorphic 2K or preferably 4K resolution is used to create a high quality 2560x1080 uncompressed input source. This source is then transformed by MFE to create a high quality 1920x810 letterboxed image. During the transformation, data representing an additional 33% of vertical resolution is stored as gray bars in the unused letterbox space of the 16:9 frame.



MFE encoded letterboxed content with the gray bars "revealed," clearly showing the extra 33% vertical resolution stored in the area normally reserved for the black letterbox bars.

While the letterboxed image itself represents a resolution of 1920 x 810 (the same as typical 2.35:1 films on current Blu-ray), the additional 33% of data in the grey bars is able to be reintegrated into the letterboxed image using the MFD process to create a FullHD anamorphic widescreen image at 1920 x 1080. To be consistent with the appearance of current letterboxed content, the gray bars created by MFE are concealed with black Java graphics.

From this starting point, three high resolution formats can be reconstructed via MFD processing as shown below:







*Note: Resolution is provided by MFD reconstruction algorithms and includes an actual 33% increased vertical resolution when an MFE encoded source is used.

The format below is the default produced by the MFE encoding process, showing the java graphics in place. Including this format, four formats are available from a single disc.



The encoding process is royalty-free for studios and is a straight forward addition to the workflow process for compressionists. Minimal post production work is needed to create appropriate Java coding for menu graphics and masking of the MFE letterbox bars, **making MFE discs fully compatible with players even if they do not have MFD capability**.

MFE creates a solution, allowing the consumer the flexibility to choose the format that best fits their equipment and viewing preference. Since MFE Letterbox is fully compatible with existing players and current Blu-ray standards, content providers and consumers can immediately adopt MFE discs. Immediate adoption of MFE by content providers allows standard content to be distributed while simultaneously creating a base of content for next generation products that are able to decode and display for additional performance.

MFE is compatible with current 16:9 HD and Blu-ray standards and is also compatible with current HDMI, broadcast, satellite and HDTV architectures. However, to help Blu-ray players identify both ultra wide screen movies as well as MFE content, we anticipate requesting minor changes to Blu-ray metadata specifications.

Decoding

MFD algorithms involve fast, simple, highly parallel binary operations designed to be easily integrated into a video device such as a Blu-ray player, streaming device or display. MFD is designed to produce the four higher resolution visual formats, using additional resolution if MFE content is available.

Implementation of MFD depends on the processing power and capabilities of the device. While some devices may be able to incorporate MFD by upgrading firmware, others will require MFD to be incorporated onto a chip.

As presented above, CE manufacturers can now support four different formats from HD media and one ultra high performance mode:

- MFD 4K (3840x2160)
- MFD SuperHD WIDE (2560x1080)
- MFD FullHD WIDE (1920x1080 anamorphic)
- MFD 16:9 Full (sides cropped to 1920x1080)
- MFE Letterbox (1920x810)

When MFD is used with MFE content, all movies displayed at 1080 vertical resolution include an actual 33% greater vertical resolution than the letterbox version due to extra resolution data stored in the letterbox area. Full and 2560 modes use MFD reconstruction processing to provide full resolution in the horizontal direction.

The Magic of MFE and MFD

Quite unlike conventional scaling, MFE/MFD algorithms are based on a fundamentally new and proprietary process that utilizes a transformation relationship between an original image, a very high quality representation of that original image at a specific lower resolution and a set of extra resolution data. This transformation relationship is reversible. In other words, the lower resolution image can be combined with the extra data to losslessly reconstruct the original image with at most a very minor computational error. Further, the transformation relationship from original image to lower resolution image is specifically formulated to minimize later reconstruction dependency on the extra data.

This formulation along with a unique formatting of the extra data means that not only is the extra data resistant to error from compression algorithms, but also that any error that does exist has a minimal impact on the reconstruction. These transformation features combined with minimal dependence on extra data provides for a very high performance reconstruction of the original image even in the absence of the extra data with very little estimation.

MFD algorithm computations are highly parallel as well as fully represented by fast, bitwise binary operations, providing an implementation easily within the capabilities of digital image processing components used in today's display devices. The algorithms are not only compact but also easily directed to use available extra resolution data or a variety of user selectable extra data estimation algorithms, all resident in the MFD algorithm kernel.

The following diagram shows a conceptual flow for MFD:



The above diagram represents one possible approach for delivering ultra wide and higher resolution content within the current Blu-ray specifications and architecture. Actual integration of MFD processing may vary and no conclusions regarding the validity of the above should be made.

Additional Usage

Streaming video distribution: Streaming video content providers can send an MFE encoded content stream to customers with MFD devices to enjoy any of the three MFE formats for highest performance from 2.35:1 movies. Additionally, the standard letterbox version can also be offered as HD standard to customers without an MFD device. Storing multiple copies at the server is unnecessary and bandwidth is conserved even though higher resolution content is being provided to the subscriber.

Broadcast TV and Sports: Much live and recorded content, especially sports, can benefit from the more immersive format of 2.35:1. Broadcasters can migrate to higher camera resolutions then broadcast their content either on regular channels or premium channels with MFE processing. On regular channels, broadcasters can either chose to provide a pre-processed MFD Full screen version or a letterboxed version of the event to their standard viewers with conventional HD receivers and displays. Premium channel subscribers with MFD receivers will be able to immerse themselves in the action with a 21:9 display or anamorphic system to enjoy the full broadcast image with the highest performance.

Summary

MFE's backwards compatibility means next generation content can be available now.

Since consumers can play MFE content on existing equipment, content providers can start building a base of content supporting the creation of newer devices that can exploit the encoded resolution.

MFD supports next generation displays. Even in advance of MFE content, MFD algorithms are specifically formulated to provide the best image quality in support of next generation displays without the excessive softening of conventional scaling. 4K Ultra HD and 21:9 displays with MFD can use conventional sources to provide improved performance now.

MFE means a single source, a single stream, for multiple formats and resolutions. MFE eliminates the need for multiple format inventories, reducing storage requirements and minimizing bandwidth requirements for higher resolution content.

MFD gets rid of black letterbox bars for movies that represent 70% of the top selling motion pictures. MFD supports the highest quality presentation of ultra wide format movies without black bars for the most immersive experience. Even if consumers zoom and crop these movies for their current displays, MFD provides the absolute best quality, especially when MFE content is used. At the same time, MFD supports the highest quality and resolution for either anamorphically enhanced projection systems or new 21:9 displays. Four formats on a single disc. The choice is in the hands of the consumer.

MFE finally provides a means to allow 2.35:1 motion pictures to be presented in full resolution. All three enhanced MFD modes can access the true additional resolution data on an MFE Blu-ray disk or MFE stream to display the maximum performance possible from 16:9 4K Ultra HD and new 21:9 / 2.35:1 displays.

Blu-ray Disc[®] is a registered trademark of the Blu-ray Disc Association. © 2012 Folded Space Folded Space develops and commercializes the MFE family of intellectual properties dedicated to providing and preserving the highest performance presentation of major motion pictures in the ultra wide screen aspect ratio of approximately 2.35:1. Folded Space is a new division of Panamorph Inc., which is the world's leading manufacturer of digital projection anamorphic lenses for home cinema. For further information please visit http://www.Folded-Space.com.