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| *Title:* | **HDRTools: Generalized Scaling and Tone Mapping Support** | | |
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# Abstract

This contribution presents several new enhancements that were introduced to the latest version of HDRTools. In particular, the HDRTools package now supports generalized scaling, using Lanczos filters, mapping of HDR content to displays with limited brightness, and EXR files with non-linear input data among other things. A tool for analyzing gamut information is also included. A new version of HDRTools, v0.14, which includes all of these updates, is expected to be released during the upcoming MPEG meeting. A beta version is already available to interested parties.

# Introduction

The HDRTools software package [1] is a system available to MPEG members and the video research community in general, with the intent of providing a variety of video signal processing, analysis, and conversion tools. The software original focused on High Dynamic Range (HDR) and Wide Colour Gamut (WCG) video content, however support for SDR formats has also been introduced and the software has been extended in focus. The package includes a variety of tools for converting video data from one format to another, including color space conversions, applications of transfer functions, chroma format conversion, scaling, primitive tone mapping, and filtering among others. It also includes some basic video analysis tools, including tools for video quality measurement.

There have been numerous requests to add scaling and better tone mapping support in HDRTools. We have made attempts to address these issues in the upcoming revision, which hopefully will be useful to researchers and to future MPEG development activities. Other new features and bug fixes were also introduced in the software including a new tool, named GamutTest, which can be used for video sequence gamut analysis, improved RGB data support, and support for non-linearly encoded EXR files among others. A more detailed description of these tools/enhancements is provided in the next section.

# New Tool/Feature support in HDRTools

## Support for non-linear EXR data

At the 116th MPEG meeting, new video sequences were donated [2] to the video community to better support current and future SDR and HDR video coding activities. Unfortunately, the HDR video sequences provided in [2] included content that used a proprietary format that was not previously supported by HDRTools. More specifically, these sequences were provided in the EXR file format with video samples encoded using the normalized (range 0 to 1) non-linear PQ transfer function. Although these frames could be read using the HDRTools package, they were interpreted as linear video data and improperly converted or processed afterwards.

Given the importance of this new video material, support for this new format was added in the new version of HDRTools. A user can now set also for EXR video files both the input file video range (SourceNormalizationScale) and the transfer function (SourceTransferFunction), whereas these parameters were previously ignored. To avoid issues with old files, we have also introduced the parameter “EnableLegacy” that permits files in previous version of HDRTools and the HDRConvert tool to operate without any changes.

## Video Rescaling

Support of arbitrary rescaling has been extended in HDRTools with the addition of a generalized lanczos implementation. Currently rescaling is supported through the HDRConvScaler tool and is only performed on linear, floating point data. Future extensions will be added to allow support for this tool directly within HDRConvert, on also non-linear and fixed precision data, as well as by adding additional filters that might also be more appropriate for downconversions (e.g. bilinear, bicubic etc). Currently the number of taps for the Lanczos filter used is hard-coded to 6, but that will also be extended in a next revision. From an implementation perspective, the software automatically computes the appropriate lanczos phase filters given the horizontal and vertical scaling ratio and assigns these filters to every filtered position. Each position is filtered on the fly, without the use of any intermediate buffers. Even though this adds a bit in terms of processing complexity, it reduces the memory requirements of the process. This method, i.e. separable filtering without the use of intermediate interpolation/buffering, is used by several other software and hardware systems because of its memory and pipelining benefits. In future implementations we will also provide support for a filters that make use of a limited number of phases, as is also commonly done in many implementations.

## Display Mapping – From HDR to displays of Limited Dynamic Range

Given the emergence of HDR and WCG video content and applications, display mapping of HDR content on displays of limited dynamic range has recently become one of hottest topics in the video industry. Having the ability to display HDR/WCG content on any display with and without metadata is highly desirable and advantageous for the deployment and adoption of such technologies.

One such method was introduced in Report ITU-R BT.2390 [6] particularly targeting display referred HDR systems, such as systems based on the PQ transfer function (ITU-R BT.2100 [3]). According to this technique, the characteristics of the display can be accounted for to define a mapping function or process named the “electrical-electrical transfer function” or EETF. As described in ITU-R BT.2390, *this function can provide a toe and knee to gracefully roll off the highlights and shadows, while providing a balance between preserving the artistic intent and maintaining details*. An example EETF process is then recommended in this document where the knee roll of is computed using a hermite spline. Two different options are suggested in that document, the first one using the ICTCP color representation that is described in ITU-R BT.2100, whereas the second one used the Y’CbCr representation. It is suggested that the first method is superior than the former.

Figure 2‑1. Block Diagram of signal chain showing location of EETF application



Inspired by the hermite spline method of ITU-R BT.2390 we introduced 3 new display-mapping modes in HDRTools that utilize the same approach. The first mode performs this method in the IPT color representation domain that was presented in [3][4], whereas the second and third mode utilize the xvY’ and Y’u’v’ domains (Constant Luminance representations) respectively. The IPT color representation is very similar to the ICtCp and we do not expect a significant difference between the two. We, however, preferred the use of the IPT color representation since this is already well defined compared to the XYZ CIE 1931 representation instead of BT.2020. For all these modes, the PQ transfer function was used instead of a power law gamma transfer function. These modes can be easily selected in the software by setting the parameter ToneMappingMode in the HDRConvert tool.

Although for the IPT case we have used the method described in [6] for adjusting also the color information, for the other two colour representations no colour adjustments were performed in this implementation. So it is quite possible that in some scenarios color saturation may be observed. Currently our recommendation is to use the IPT method instead of the other two.

# Gamut Analysis

A new tool was also included in HDRTools, named GamutTest, which can report statistics relating to the Gamut of an input video sequence. More information about this tool can be found in [7].

# Other improvements/features

Several other smaller improvements or bug fixes were introduced into the software. In particular, it was requested (Canon) that HDRMontage is able to support only a single input sequence, allowing simple manipulations to be performed, such as cropping, on video content without conversions. We have also corrected bugs in the xPSNR and regionwise PSNR computations, issues with RGB raw inputs and outputs, as well as some issues with certain transfer functions (e.g. support of different black point and peak brightness in BT.1886) among others.

# Conclusion

Several new enhancements were made to the HDRTools software that will be released during the upcoming MPEG meeting. Enhancements include generalized scaling, display mapping, and gamut analysis tools among others.

# References

1. HDRTools Master branch: [https://gitlab.com/standards/HDRTools/](https://gitlab.com/standards/HDRTools/" \t "_blank)
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4. Ebner; Fairchild (1998), *Development and Testing of a Color Space with Improved Hue Uniformity*, Proc. IS&T 6th Color Imaging Conference, Scottsdale, AZ, pp. 8–13.
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6. Report ITU-R BT.2390-0, *High dynamic range television for production and international programme exchange.*
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