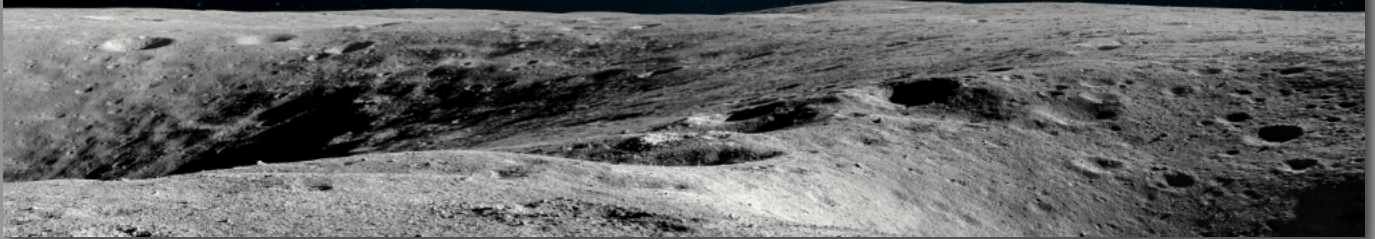


LUNA Warpbox – New FPGA W&B IP-Core

Low-latency, high performance warp correction processor
for 2d media and 3d simulation solutions.



The LUNA Warpbox is a warp and image correction processor for 2d media and 3d simulation, which includes rotation up to $\pm 180^\circ$ as well as upscaling and downscaling. Thanks to its pixel warping ability the warpbox can process complex and even non-linear warp configurations. Bilinear and bicubic subpixel interpolation is available with up to 1/16 in x and y resolution.

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ProjectionTools

WARPING FOR MULTI-PROJECTOR SYSTEMS ON A NEW LEVEL



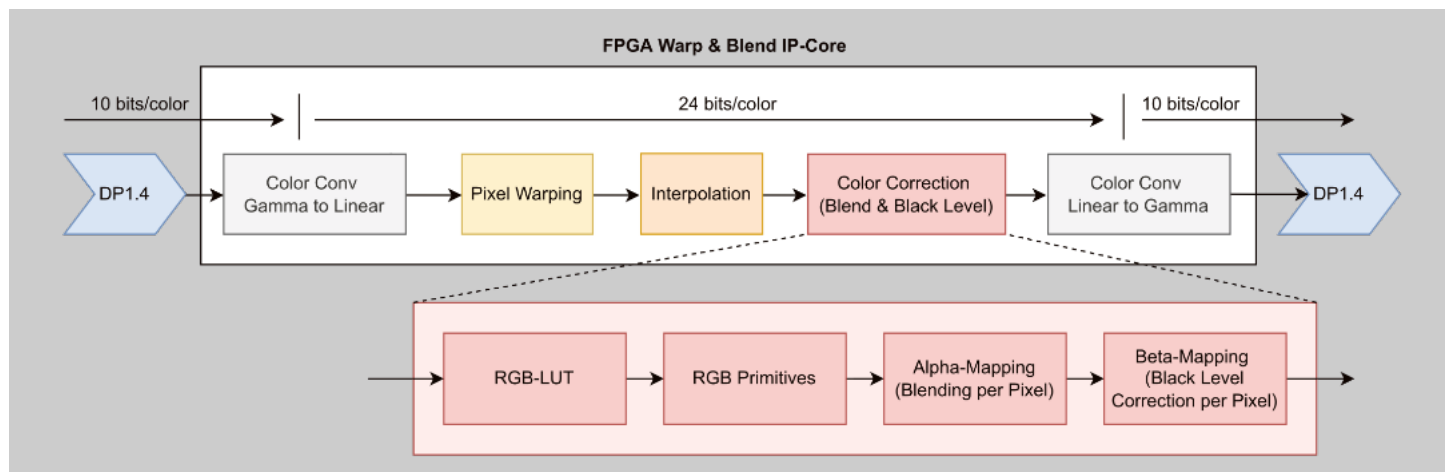
Blend and black level adjustment (MPCDI Alpha and Beta Mapping) can be applied for each color down to pixel level. For further color correction purposes, RGB LUT & RGB primaries are implemented according to MPCDI v2.0.

The high image quality is guaranteed by the internal color processing, with 24 bits per color (72 bits per pixel) used continuously during the image processing pipeline. Therefore, true 10-bit support is available on DisplayPort 1.4 input and output.

FEATURES

- Filtering: bilinear and bicubic interpolation
- All corrections applied with full resolution
- 4K with 60 Hz
- Warp capabilities
- MPCDI 2d/3d level 2
- MPCDI color correction level 4 blend & black level correction
- True 10-bit per color input/output
- 24-bit per color internal color processing
- Build-in and customizable test image

LUNA WARP & BLEND IP-CORE



The warp processing has interframe processing with a fixed processing time of 50 image lines added to the vertical warp displacement. Together with its color correction ability this makes LUNA Warpbox the perfect choice for multi projector systems displaying high level simulations and other interactive content.

In contrast to other warp processors our video pipeline works entirely in linear color space using a resolution of 24 bits per color. This includes warping, interpolation, color correction, and blend and black level correction. The system is interpolating while warping, with bilinear and bicubic subpixel interpolation on the input

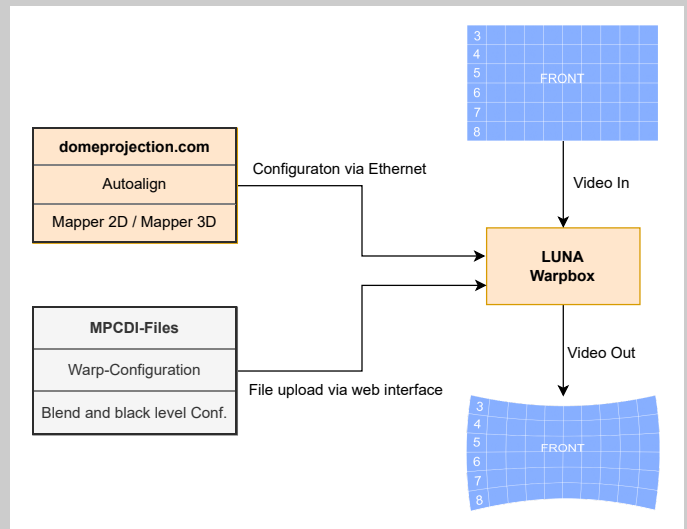
video stream in order to provide the best interpolation results.

The LUNA Warpbox is utilising our newly developed FPGA Warp & Blend IP Core, which is currently working on Zynq UltraScale+™ MPSoC devices.

WARPING FOR MULTI-PROJECTOR SYSTEMS ON A NEW LEVEL

The LUNA Warpbox configuration is generated by tools such as domeprojection.com® ProjectionTools. It comprises an MPCDI format warp configuration as well as blend and black level configurations. The LUNA Warpbox is fully configurable via Ethernet using either the web front end or a configuration file upload.

The LUNA Warpbox is integrated with domeprojection.com® ProjectionTools, therefore providing convenient multi-channel projection support.



WORKFLOW

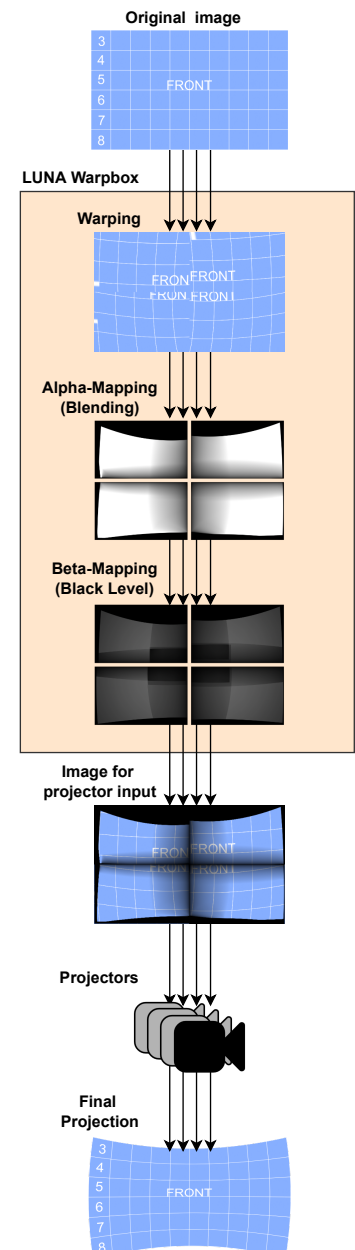
After planning and setting up a multi-channel projection system, it must be calibrated using a tool such as domeprojection.com® ProjectionTools. To facilitate this, the warpbox channels can project test patterns and custom test images directly, thus no additional software installation is required on the image generators (IG). After calibration, the warpbox configuration is generated by domeprojection.com® ProjectionTools and transferred via Ethernet to each warpbox channel.

Each channel of the warpbox is fed with a video stream via DisplayPort, containing overlapping and non-warped parts of the final projection. The warpbox then applies warping, blending and black level configuration with the same delay on all channels for an optimal viewing experience. The resulting video streams for each channel are then sent to the projectors and merged in the final projection. Combine several LUNA Warpboxes to increase the number of channels.

BLEND AND BLACK LEVEL CORRECTION

To achieve seamless projection, the projection areas of the channels must overlap. In the overlapping areas the brightness is higher, so the blending reduces the brightness of the overlapping areas and corrects the overall brightness level in the projections down to pixel level.

Most projectors cannot project true black. Therefore, the black level is higher in overlapping sections of the screen. Thus, black level in the non overlapping areas of the screen must be raised to the same black level. For color correction additional RGB LUT and RGB primaries are implemented. Blend and black level correction as well as color correction are calculated with 24 bits per color.



WARPING FOR SINGLE & MULTI CHANNEL PROJECTIONS

The warp processor can apply pixel warping conforming to MPCDI v2.0 on 2d media level 2 and 3d simulation level 2 to a video stream at full resolution. The 4K version of LUNA can process resolutions up to 4K at 60 Hz or pixel clock up to 600 Mpixels/sec.



Figure 1: Initial Image



Figure 2: Image with low level warp



Figure 3: Image with high level warp + turned 180°

At resolutions of 3840x2400px and 4096x2160px at 60 Hz or 2560x1600px at 120 Hz in true 10-bit per color (24 bits per color internal), 1.8 times as many pixels can be written to the framebuffer, allowing an average image stretch of 80% at full resolution. Thanks to pixel warping, complex or nonlinear warp geometry is possible, such as flipping and rotating the image by any angle.

The warp processor is implemented with low latency interframe processing capabilities, meaning the write framebuffer can be safely read while writing. There is a fixed processing time of 50 image lines for any resolution, with the vertical warp shift making up the rest of the total processing time. LUNA is integrated with ProjectionTools, providing convenient multi-channel projection support.

SPECIFICATION

TECHNICAL DATA	LUNA 4K
Video type	DisplayPort 1.4 (17.28 Gbit/s) Input/ Output
No of channels	1 channel
Pixel rate	Warping with up to 600 Mpixels/sec
Example resolutions	120 Hz: 2560 x 1600 x 10 bpc; 60 Hz: 3840 x 2400 x 10 bpc, 4096 x 2160 x 10 bpc, 4096 x 2400 x 8 bpc
I/O Interface	DisplayPort 1.4 (17.28 Gbit/s) Input/Output
Processing	10-bit per color on input and output/ 24-bit per color internal color processing
Warping	MPCDI 2d Media level 2 and MPCDI 3d Simulation level 2 (pixel warping)
Image stretch	Average image stretch < 80% at full resolution
Latency & video timing	Interframe processing with a fixed processing time of 50 image lines, added to the vertical warp displacement
Interpolation	Bilinear and bicubic interpolation 1/16 Pixel subpixel accuracy; Preinstalled interpolation methods including bell shaped and B-spline

TECHNICAL DATA	LUNA 4K
Color correction	Color correction MPCDI level 4, (incl. gamma LUTs, RGB color LUTs and RGB primaries)
Blend and black level correction	Down to per pixel RGB blend and black level correction
EDID control	Loadable EDID, EDID passthrough
Configuration	Via Ethernet (including a web interface), Start configuration; backup and restore, Integrated with ProjectionTools
Features	Video pass-through User defined resolution and timing Predefined, loadable pattern/images OSD and Display for showing current state, name and IP-address
Input power	100-240 VAC, 47-63 Hz, 50 Watt
Size	(W x H x D) 438 x 88 x 320 mm (2U)
Weight	5,5 kg
Certificates	CE on request
Warranty	2 years

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Version Nov. 2022

