Xylon d.o.o.

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Core Facts

Provided with Core	
Documentation	User's Manual
Design File Formats	Encrypted VHDL
Constraints Files	Reference designs constraint files
Reference Designs & Application Notes	AMD Vivado™ IP Integrator reference design
Additional Items	- logiADAK Automotive Development Kit based on AMD ZCU102 evaluation borad - standalone and Linux SW drivers and libraries
Simulation Tool Used	
Mentor Graphics' Modelsim	
Support	
Support provided by Xylon	

Features

- Supports:
  - AMD Zynq™ 7000 SoC
  - AMD Zynq™ UltraScale+™ MPSoC
  - AMD Versal™ ACAP
- Supports arbitrary video transformations defined by MLUTs (Memory Look Up Table):
  - lens de-warping
  - video texturing on curved planes (non-linear)
  - homographic transformations; rotating, translating, cropping, perspective changes
  - single pass arbitrary combination of all the above operations
  - supports perspective, cylindrical and spherical virtual camera by means of Xylon's mathematical library
- Enables surround view virtual flying camera feature
- Equalizes colors and brightness in multi-camera system under changing illumination conditions
- Supports correction of fish eye lens distortions
- Suitable for extreme wide-angle lenses (fish-eye) with Field Of View (FOV) up to 180º
- High performance, up to 170 MPix/s at 200 MHz main clock
- Supports up to 2048x2048 input and output resolutions; 60 fps and higher frame rates

Table 1: Example Implementation Statistics for AMD FPGAs

Family (Device)	Fmax (MHz)		LUT[1]	FF[1]	IOB[2]	BRAM Tile	DSP	PLL/ MMCM	BUFG/ BUFR	GTx	Design Tools
	mclk	rclk									
Versal™ ACAP (xcvc1902-vsva2197-2MP-e-S-es1)	250	250	16136	15459	0	36.5	86	0	0	0	Vivado 2023.1
Zynq™ UltraScale+™ (xczu9eg-ffvb1156-2-e)	200	200	14310	13144	0	46.5	86	0	0	0	Vivado 2023.1
Zynq™ 7000 (xa7z045ffg900-2)	150	150	13832	13582	0	46.5	86	0	0	0	Vivado 2023.1

1) Assuming the Automotive Surround View Driver Assistance (DA) system's configuration: 4 input cameras, 4 output images, 32-bit AXI-Lite register interface, 64-bit AXI memory interface for LC, MLUT and MLUT_LVL, 128-bit AXI memory interface for TC and OB, lens correction, color equalization statistic and gain, YUV color space on input and RGB color space on output, 2k input and output resolution
2) Assuming register and memory interfaces are connected internally

Features (cont)

- Higher video input resolutions and frame rates can be supported by multiple IP instances that work in parallel
- Configurable number of video inputs (up to 8) and video outputs (up to 8)
- IP deliverables include standalone and Linux user space driver, helper libraries
- Xylon's advanced logiADAK Builder PC software enables easy configuration/manipulation, of the video output rendered by the logiVIEW IP, within Xylon's ViewMore™ Natural Surround View ADAS SoC solutions
- Tile rendering for improved performance and efficiency
- Supports input/output color spaces: RGB/RGB, YCbCr(4:2:2)/YCbCr(4:2:2) and YCbCr(4:2:2)/RGB
- Independent double/triple buffering for up to 8 asynchronous video inputs
- Independent double/triple buffering for up to 8 asynchronous video outputs
- Simple programming of control registers through ARM® AMBA® AXI4-Lite interface
- Video memory interface type: AMBA AXI4
- Prepared for AMD Vivado™ Design Suite 2023.1. and newer versions of AMD's implementation tools
- Parametrical VHDL design that allows tuning of features set and consumption of FPGA resources
- Simple Plug'n'Play with other Xylon's logicBRICKS IP cores, such as:
  - logiWIN Versatile Video Input
  - logiCVC-ML Compact Multilayer Video Controller
  - logiBITBLT Bit Block Transfer 2D Graphics Accelerator
  - logi3D OpenGL 1.1 3D Graphics Accelerator
  - logiISP Image Signal Processing (ISP) Pipeline

Applications

- Automotive Driver Assistance Systems: Surround View, Pedestrian Detection, Lane Departure Warning, Rear-View Camera, Heads-Up display (HUD)
- Heavy machinery (construction, agriculture) 4, 6, 8 cameras
- Automated parking (Surround view calibrated vehicle surroundings + AI road segmentation and object detection)
- Fish eye lens video processing to projections suitable for AI accelerators (mimicking narrow field of view cameras, no need for DNN models retraining with fisheye dataset)
- Industrial systems: Surveillance Systems like Multi-Head 360° Panoramic Wide Camera with no blind spots, Industrial Pipe Inspection equipment, Test equipment…
- Medical Endoscopy and similar equipment
- Defense video and vision systems, e.g. smart helmets, panoramic turret cameras, etc.

General Description

The logiVIEW Multiview 3D Video Transformation Engine is Xylon's logicBRICKS IP core optimized for AMD Zynq™ 7000 SoC, Zynq™ UltraScale+™ MPSoC, Versal™ ACAP and newer FPGAs. It is designed for high-performance and real-time processing of multiple video streams or still images. The logiVIEW IP core removes fish eye distortions caused by extreme wide-angle Field Of View (FOV) lenses, makes perspective corrections and other homographic transformations (Figure 1) on the captured video. It can also execute complex arbitrary non-homographic transformations, such as video texturing on curved planes (Figure 2), defined by MLUTs (Memory Look-up Table). MLUT transformations are key logiVIEW IP core's feature for 3D Surround View parking assistance ADAS applications (Figure 3). Multiple videos or still images are processed and can be stitched together, resulting in a high-definition video output image. Stitching and blending between multiple video streams is done within the logiVIEW IP core without the need for external IPs.

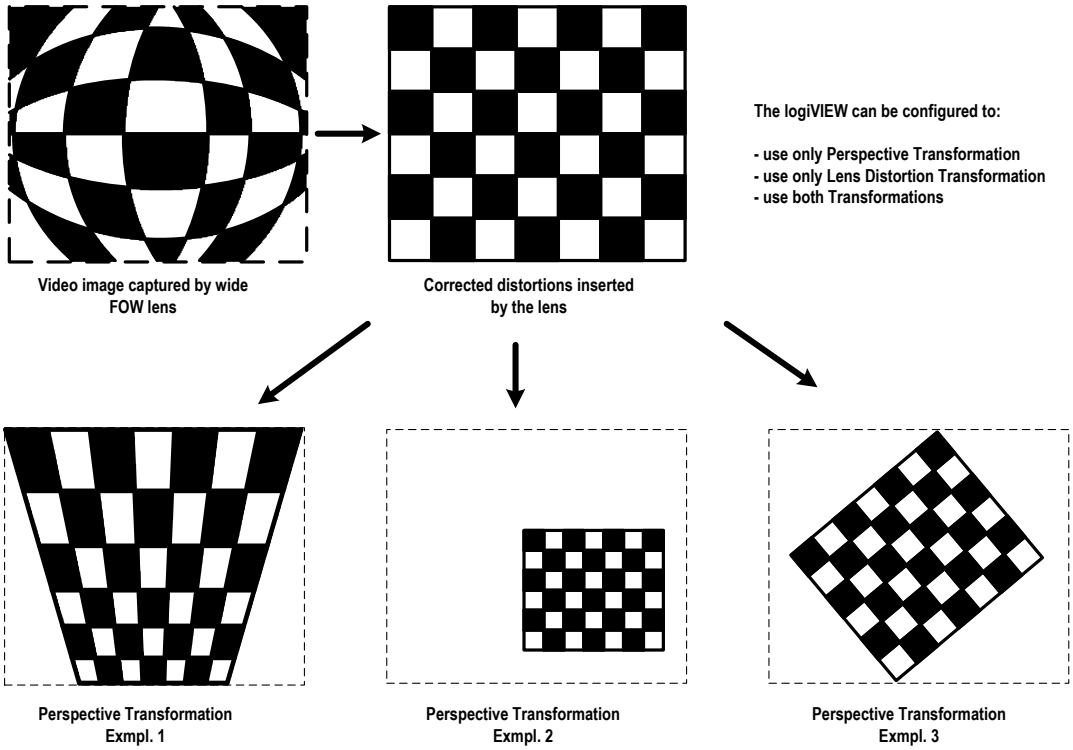

Figure 1: logiVIEW Processing Flow with Lens Correction and Homographic Transformation Examples

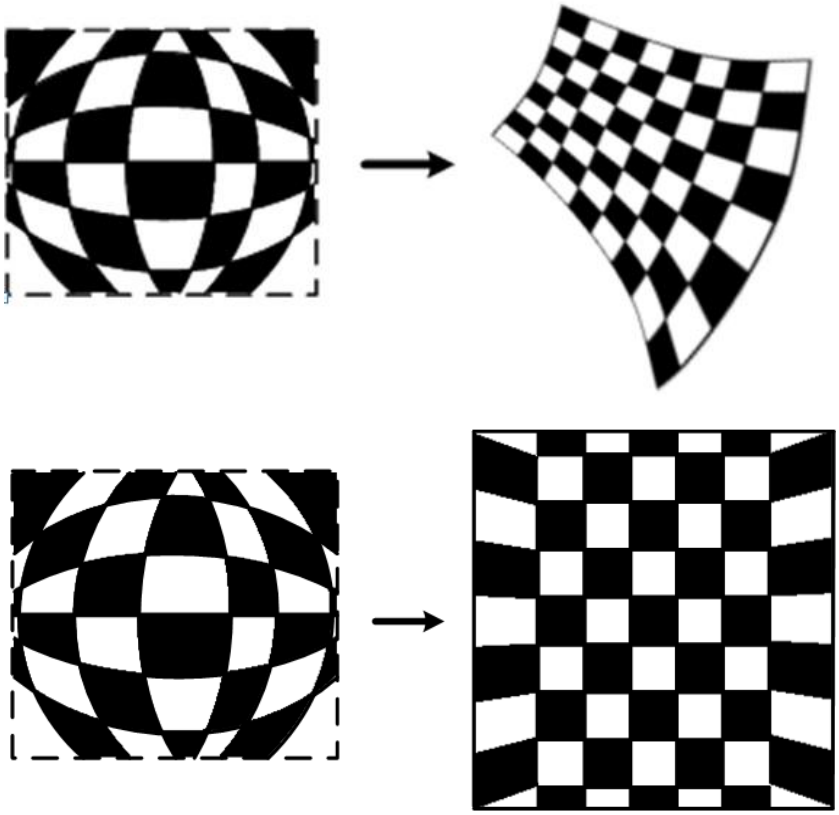

Figure 2: Example MLUT Transformation

LogiVIEW can be used in automotive Driver Assistance (DA) applications, such as the Multi-Camera System for Surround View DA (Figure 3), Heads-Up Displays (HUD), Lane Departure Warning, Rear-View (Back-Up) and others. Due to its high versatility and configurability, it can be also used in other single or multi-camera applications, such as medical endoscopy, surveillance systems (Panoramic 360° View camera – Figure 4), defense equipment, etc. High accuracy, provided by Xylon's patented camera position calibration and highly accurate lens calibration, of the surround view system allows for it to be used as a base for automeatd parking aplications.

Additionally, the logiVIEW IP core can be configured to use an optional Memory Look-Up Table (MLUT) block at each video output. The MLUT can be programmed with an arbitrary transformation function to execute different transformations on input video picture's parts, for example linear perspective transformations which enable scaling, rotation, cropping, translation, as well as combination of all of these transformations.

Figure 1 shows several example outputs. MLUT can also perform nonlinear transformation, for example video texturing on a curved plane (Figure 2). The MLUT transformations are key logiVIEW IP core's features for 3D Surround View parking assistance ADAS applications (Figure 3).

The logiVIEW is a highly configurable IP core. AMD implementation tools enable easy tuning of the logiVIEW's consumption of programmable logic resources and the features set setup through an easy-to-use GUI interface. Table 2 shows a small excerpt of the configuration parameters list that can be setup prior to the core's synthesis time. IP configurations which utilize only the lens transformation, or only MLUT transformation are good examples of balancing between the required features set and used programmable logic resources.

The logiVIEW IP core can handle an arbitrary number of video inputs and video outputs as long as the system architecture allows it. The available memory bandwidth, frame rates of input video cameras, and other system parameters determine the number of supported video inputs and outputs by a single logiVIEW IP core.

For example, the YUV 422 video format requires lower memory bandwidth than the RGB video format, and the logiVIEW IP core configured to use the YUV can support more video channels and higher video resolutions with the same memory subsystem (SoC bus and memory controller IP core) and the memory connected to the FPGA. Video format can be setup through IP core's configuration GUI interface.

In video applications that require more processing power than offered by a single logiVIEW IP core instance, it is possible to implement parallel processing of video inputs' segments by multiple logiVIEW IP core instances and to achieve application goals.

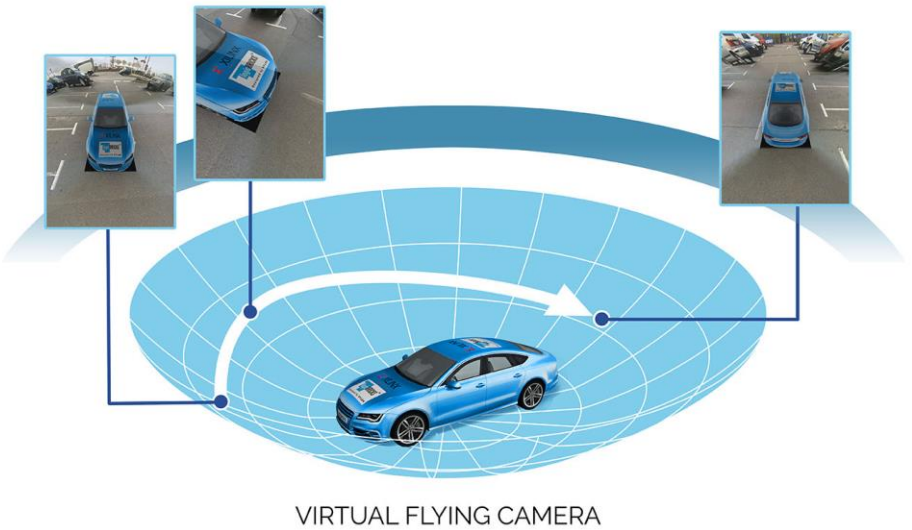

Figure 3: Xylon's Four-Camera Surround View DA Demo System – 3D View generated by logiVIEW MLUTs

logiVIEW Application - Automotive Surround View Driver Assistance

The Surround View driver parking assistance provides an unmatched awareness of the situation by enabling the driver to see 360-degrees around the vehicle on the LCD instrument cluster or the Central information Display (CID). The system uses at least 4 cameras, furnished by extreme wide-angle fish eye lenses, which cover separated zones around the vehicle. The logiVIEW must remove the lens distortions, correct perspectives to four high-resolution input video streams, and stitch the corrected video images in a single display of vehicle's surroundings.

Xylon's ViewMore Natural Surround View solution, which is based on the logiVIEW IP core, enables drivers to dynamically adjust the position of the virtual flying camera and to see naturally looking vehicle's surrounding in a three-dimensional hemispheric view displayed in fine-detail HD resolution. This complete ADAS solution is presently used on the road in production automotive systems. The solution can be fully evaluated on the AMD Zynq™ UltraScale+™ AP SoC based logiADAK Automotive Driver Assistance Development Kit.

To learn more about Xylon's Surround View ADAS, please visit:
http://www.logicbricks.com/Solutions/Xylon-ADAS-Development-Kit.aspx

logiVIEW Application – Multi-Head 360° Video Camera for Surveillance Applications

Video surveillance multi-head camera with no blind spots that shows 360° view (Panoramic View) of the surroundings can be also based on the logiVIEW IP core. Xylon logicBRICKS IP cores remove lens distortions (fish-eye), make perspective corrections and seamless stitching of three video streams with no dividing "borders", and finally display the resulting panoramic 2D video image. The demo can be upgraded to support much higher video camera resolutions.

To learn more about Xylon's Multi-Head Panoramic Camera, please visit:
http://www.logicbricks.com/Markets/Industrial/Video-Surveillance-Multi-Head-360-Panoramic-View-Camera.aspx

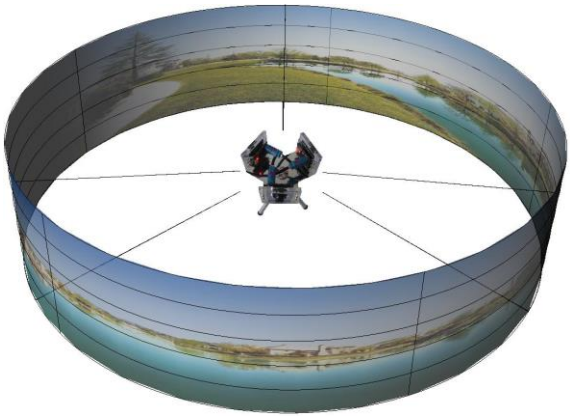

Figure 4: Panoramic View Camera Example

logiVIEW Application – Real-time Low Latency Video Rotation

Medical endoscopes, pipe inspection tools or various advanced defense systems are application examples that require real-time video rotation for an arbitrary angle, which can be dynamically changed in sub-degree steps, and very small video output latency.

Core Modifications

The logiVIEW IP core is supplied in an encrypted VHDL format compatible with the AMD Vivado™ IP Integrator tool. Different logiVIEW configuration parameters are selectable prior to VHDL synthesis, and the following table presents a selection from a list of the available configuration parameters.

Table 2: logiVIEW VHDL configuration parameters

Parameter	Description
C_USE_LT	Use the Lens Transformation block
C_USE_MLUT	Use the Memory Look-up Table block
C_USE_MCD	Use the Miss calibration detection block
C_USE_COLOR_EQU	Use the Color equalization statistic block
C_USE_GAIN	Use the Color equalization gain block
C_USE_IN_BUFF	Enables input image's buffering to prevent video flickering.
C_USE_OUT_BUFF	Enables output image's buffering to prevent video flickering.
C_PIX_IN_FORMAT	Use RGB, YCbCr (4:4:4) , YCbCr (4:2:2) or Luma only input format
C_PIX_OUT_FORMAT	Use RGB, YCbCr (4:4:4) , YCbCr (4:2:2) or Luma only output format
C_CAMERA_NUM	Number of input cameras

The logiVIEW is designed with regard to adaptability to various SoC designs. However, there may be instances where source code modifications are necessary. Upon request, Xylon offers bespoke modifications of the IP for customer's specific functions.

Core I/O Signals

The core signals I/O have not been fixed to specific device pins to provide flexibility for interfacing with user logic. Descriptions of all signals I/O are provided in Table 3.

Table 3: Core I/O Signals

Signal	Signal Direction	Description
Global Signals		
RST	Input	Global synchronous set/reset
CLK	Input	Memory clock
Memory Interface		
AXI4 Interface	Bus	Refer to AMBA AXI4 specifications
Register Interface		
AXI4-Lite Interface	Bus	Refer to AMBA AXI4-Lite specifications
Auxiliary Signals		
HW_TRIGG	Input	Hardware trigger signal for start of processing, edge sensitive, active high
INTERRUPT	Out	Interrupt signal, level sensitive, active high
VIDEO_IN_CURR_VBUFF	Input	Video input double/triple buffering: Current video memory buffer
VIDEO_IN_NEXT_VBUFF	Out	Video input double/triple buffering: Next video memory buffer to write to
VIDEO_IN_SW_VBUFF	Input	Video input double/triple buffering: Request for buffer switching
VIDEO_IN_SW_GRANT	Out	Video input double/triple buffering: Buffer switching granted
VIDEO_IN_ODD_FIELD	Input	Video input odd field, for de-interlacing

Signal	Signal Direction	Description
VIDEO_OUT_CURR_VBUFF	Out	Video output double/triple buffering: Current video memory buffer
VIDEO_OUT_NEXT_VBUFF	Input	Video output double/triple buffering: Next video memory buffer to write to
VIDEO_OUT_SW_VBUFF	Out	Video output double/triple buffering: Request for buffer switching
VIDEO_OUT_SW_GRANT	Input	Video output double/triple buffering: Buffer switching granted

Verification Methods

The logiVIEW is fully supported by the AMD Vivado Design Suite, which tremendously shortens IP integration and verification. A full logiVIEW implementation does not require any particular skills beyond general AMD tools knowledge.

Recommended Design Experience

The user should have experience in the following areas:

- AMD design tools
- ModelSim

Available Support Products

The logiADAK 7.0 is AMD Zynq™ Ultrascale+™ MPSoC based automotive development platform that showcases multi-camera central module processing including the production-ready “ViewMore Natural Surround View” IP solution. The logiADAK can be used to quickly bring new ADAS innovations to market. It provides ADAS designers with all the resources they need to efficiently develop vision-based ADAS systems, save months of development time and focus efforts on system differentiating functions and performance.

To learn more about the logiADAK Automotive Driver Assistance Kit contact Xylon or visit the web:

Email: support@logicbricks.com
URL: https://www.logicbricks.com/Products/logiADAK-MPSoC.aspx

Ordering Information

This product is available directly from Xylon under the terms of the Xylon’s IP License. Please contact Xylon for pricing and additional information:

Email: sales@logicbricks.com
URL: www.logicbricks.com/Products/logiVIEW.aspx

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Revision History

Version	Date	Note
2.00.	04.06.2010.	Preliminary Xylon release – new doc template
2.00.e	03.03.2011.	Changed data in the Table 2. Added description of new MLUT feature and YCrCB/RGB converter.
2.00.f	01.04.2011	The first public version. Added short Calibration Software description.
3.05	19.11.2012.	Support for bowl-shaped surface projections (3D visualization), dynamic stitching, new calibration software, and the second generation logiVIEW-SVK, updated resources
3.10	18.03.2015.	Initial Vivado version of IP core. Support for non-swizzled texture, non-square pixel size.
3.11	27.05.2015.	Pixel color calculation improved for YUV 4:2:2, added buffer registers and busy flag.
5.1	18.02.2020.	Modified Tables 1, 2 and 3. Modified Figure 1. Added color equalization and a description of the flying camera feature.
5.2	18.02.2020	Modified Tables 1, 2 and 3. Added color equalization and description of the flying camera feature.
5.3	18.05.2021	Modified Tables 1 Added new Versal™ family support info.
5.4	09.10.2023.	Refresh of the whole document (updated tables, tools, links)