White Paper

Broadcast and ProAV
Video and Vision

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Next-Generation 4K Camera Designs with Agilex™ 5 FPGAs

Learn how Agilex™ 5 FPGAs features and IP solutions bring your vision into reality.

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Table of Contents

Executive Summary

Pan-tilt-zoom (PTZ) cameras are built with mechanical lenses and motorized structures that allow them to swivel left to right, tilt up and down, and zoom in and out of a scene. They are typically used to monitor and capture wide open areas requiring a 180- or 360-degree view. Depending on the camera or software, they can also be set to automatically follow motion-triggered activity or adhere to a pre-set schedule.

The global PTZ camera market size was predicted to value at $1,500 million in 2021 and it is expected to reach $3,700 million in 2028, exhibiting a compound annual growth rate (CAGR) of 13.5% during the forecast period1.

Although PTZ cameras have numerous uses and advantages, they also have several drawbacks. In the following sections, we will uncover how the new Agilex™ 5 FPGA family provides the required features to develop powerful yet cost- and power-efficient solutions for next-generation camera designs, along with solutions to overcome the concerns.

Introduction and Use Cases

PTZ cameras are mostly dedicated to applications required to cover extensive areas and wide angles, such as guard stations, supermarkets, airports, churches, museums, construction sites, and parking lots, among countless others.

In this paper, we focus on how PTZ cameras are used in broadcast and proAV applications typically requiring image quality, latency, and video transport and connectivity features, and why FPGAs are the most attractive design alternative.

Hollywood has created a glamorized view of PTZ cameras and how they operate. People who have seen PTZ cameras in movies are often enchanted by them. The next generation of PTZ cameras will certainly come with added features that include better resolution and larger image sensors. They will also incorporate more artificial intelligence (AI) to enable easier control. These added technologies will include motion tracking, facial recognition, and more adaptations to improve those controls. These can also include motion sync, which is an advanced technology that triangulates the positions between two PTZ preset locations and is designed to make PTZ movements look more natural through better synchronization.

Video quality will certainly improve using higher resolution image sensor technologies. Also, the adoption of easier to setup Internet Protocol (IP)-based connections for seamless discovery into workflows to enable lower latency of contribution video feeds will contribute to a superior end user experience.

Yes, PTZ cameras are equipped with a set of features that can empower the creativity of the productions by enabling various capturing modes and facilitating media content transmission for easier collaboration in modern workflows. However, they also have certain drawbacks. One being the blind spots and coverage holes they might leave behind. The major downside of PTZ cameras is their inability to record areas that the camera is not specifically looking at. For example, if the viewer moves the camera to view a certain location and an incident occurs somewhere else, the PTZ camera has

no ability to capture that event. While this is a major concern in security-related applications, it is not in studio-based production flows, although it can impact the coverage of live events such as sports and concerts where relevant to capture events can happen out of the covered area.

The lengthy delay between a command sent and the camera responding is also a common complaint about PTZ cameras. The delay between making a change to the camera's field of vision and seeing that change reflected on the screen is known as "command latency." FPGAs can implement dedicated servo motor control in hardware for a much faster and smoother operation than if it was being executed in software.

Another common criticism of PTZ cameras is that they are fragile due to the lack of reliability of the motors, lenses, and various moving parts.

To overcome the concerns, the electronic pan-tilt-zoom (ePTZ) concept is gaining traction in the industry across camera manufacturers.

ePTZ cameras do not physically move but use digital zoom to give the PTZ effect on a fixed camera. This allows camera operators to magnify areas they would like to focus on and prevents the gaps in coverage. However, you are required to employ a very high-resolution image sensor, or even several sensors to cover a wider area. In fact, with the proper number and physical arrangement of sensors, you can even cover a 360-degree field.

You can perform the stitching operations required for panoramic views and do dynamic zoom or cropping over the region of interest (ROI). You will need warp operations to implement the proper perspective or geometric distortion correction. ROI selection can be done manually by the camera operator or rely on a built-in video analytics module that can perform object detection, classification, and tracking to assist in a fully automated realization.

An ePTZ camera can be a convenient way to provide a PTZ-like experience while still recording the entire field of view. You require a powerful and flexible architecture to implement the required video processing functionality to enable ePTZ operations. Uncover how the next generation of the FPGA family – the Agilex 5 FPGA – provides the required set of features.

FPGA Benefits

As we have discussed above, a next-generation, multi-sensor, camera implementation is required to support the sophisticated processing and integration of heterogeneous blocks for optimal and efficient results.

The upcoming Agilex 5 FPGA family provides an excellent platform to adapt to these specific needs as it offers a complete hardware and software configurable architecture.

Agilex 5 devices feature MIPI D-PHY (up to 3.5 Gbps per lane) and the industry's first Enhanced DSP with AI Tensor Block, which delivers high-efficiency AI and digital signal processing (DSP) functionality. Also featured is the FPGA industry's first asymmetric applications processor system consisting of dual Arm* Cortex*-A76 cores and Arm Cortex-A55 cores, which enables you to optimize the performance and power efficiency of their workloads.

In addition, built using Intel 7 technology, Agilex 5 devices offer advanced features such as the second-generation Hyperflex® FPGA Architecture, high-speed transceivers support up to 28.1 Gbps and PCIe* 4.0 x8, double data rate (DDR) memory interfaces up to DDR5 at 4,000 Mbps, and general purpose I/Os from 1.05 V to 3.3 V.

Agilex 5 devices will incorporate a comprehensive collection of intellectual property (IP) cores and reference designs developed in-house and in collaboration with selected partners to facilitate the utilization of the platform's capabilities which can be used as starting points for end users to implement their own.

When it comes to camera designs, you can incorporate IP cores such as MIPI CSI-2, HDMI/DisplayPort/SDI, 3D-LUT, Tone Mapping Operator, Warping, and an extensive suite of Video and Vision Processing IP cores, including a complete image sensor processing (ISP) function entirely developed in-house and optimized for the Agilex 5 architecture. A highly configurable, multichannel direct memory access (DMA) engine will be available for applications required to transfer data across the video pipeline, the DDR memory, and the hard processor system (HPS), as well as to perform image capture and streaming to an external host via PCIe.

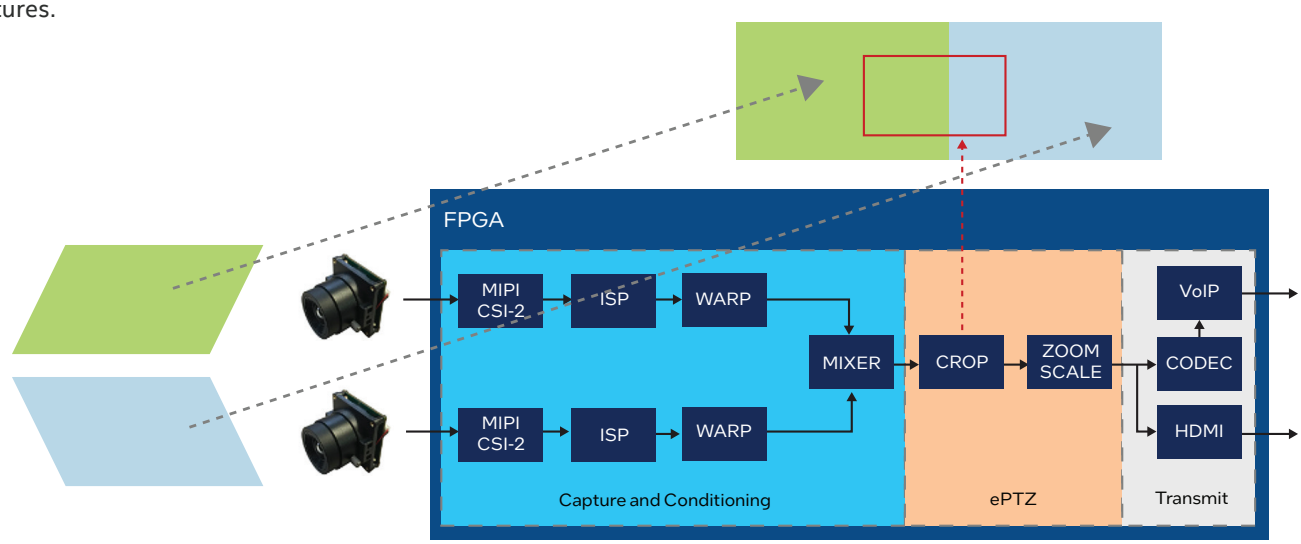

Figure 1. ePTZ operation selecting a ROI from a higher resolution image

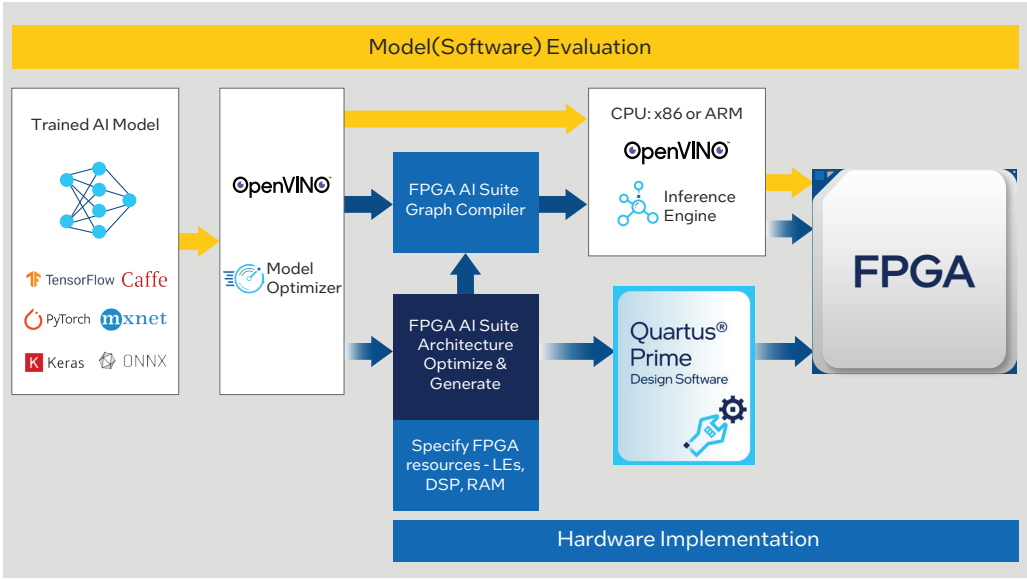

Figure 2. FPGA AI Suite enables model compilation and deployment

As part of our long-term collaboration with our partner ecosystem, IP cores and reference designs including JPEG-XS compression, high dynamic range (HDR) processing, and video over IP connectivity targeting popular protocols, such as NDI, IPMX, and others, will complement the solutions portfolio for camera designs.

The increasing need for more automated and lower latency video analytics on the edge requires the efficient deployment and execution of neural networks and AI workloads for applications such as object detection and tracking, classification, and image segmentation. Agilex 5 devices are the first midrange or edge-centric FPGAs with an AI Tensor Block, making them the ideal choice for edge AI applications.

For INT8 operations in a single DSP block, Agilex 5 devices improve the peak theoretical tera operations per second (TOPS) — up to 2.5 times more than Stratix® 10 FPGAs.

Through a large increase in arithmetic density, Agilex 5 devices fit more multipliers and accumulators in the same footprint of a standard DSP block.

The FPGA AI Suite supports the new AI features and can be used together with the OpenVINO™ toolkit to streamline the process of executing AI models in the FPGA fabric. The FPGA AI Suite enables a push-button flow from industry-standard frameworks, such as Caffe*, PyTorch*, and TensorFlow*, to FPGA bitstreams.

Additionally, Agilex 5 devices carry over the variable-precision DSP architecture from previous FPGAs with hard fixed-point and IEEE 754-compliant floating-point capabilities.

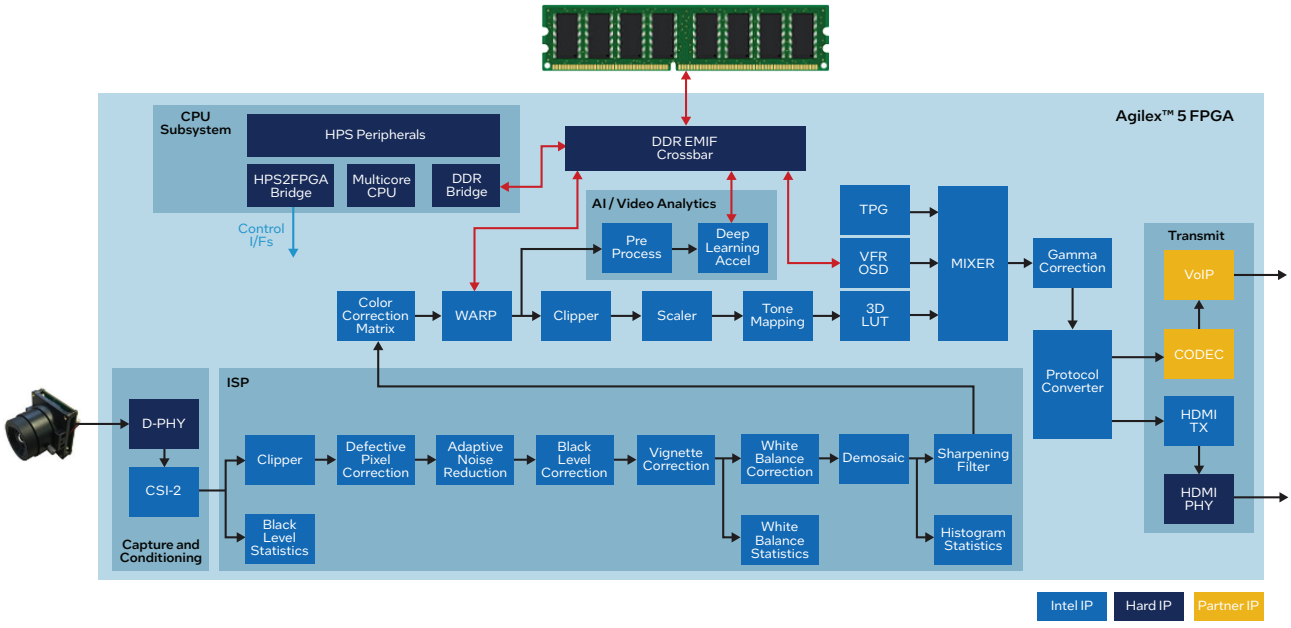

Figure 3. Detailed block diagram of a fully-featured vision camera

To complement the extensive collection of in-house IP cores for camera design, we continue planning with our partners the availability of companion cores to extend video processing capabilities, such as mezzanine codecs like JPEG-XS and HDR processing, to obtain the best results under all illumination conditions for the highest image quality. We are also working with our partners to enable remote connectivity to transport the captured content across ubiquitous, low-cost 1GbE networks using industry-standard protocols, such as NDI and IPMX, for a complete integration and interoperability with compliant equipment.

Conclusion

The Agilex 5 FPGA family comes with the right mix of features and hardware and software configurability to make it the ideal platform for applications requiring high-performance processing, low power, and a low-cost footprint for the intelligent edge. Video and vision applications are exploding, and cameras are becoming the universal sensor for numerous use cases. With built-in AI and video analytics capabilities on the device, you can enable real-time operations for latency-sensitive applications.

The complete hardware and software reconfigurability allow you to extend lifetime operations while keeping up to date with new standards, regulations, and operational features and requirements.

The Agilex 5 FPGA family will be rolled out in 2024, including full support for the required IP cores, development kits, documentation, and reference designs implementing complete solutions for 4K camera applications. With these solutions, customers can focus their efforts on developing value-added expertise and accelerate their time to market with product variations.

References

[1] PTZ Camera Market Report (Business Research Insights)

- Industry Insights: PTZ Cameras in Broadcasting Applications (Newscast Studio)
- Agilex 5 FPGA and SoC FPGA
- Video and Vision Processing Suite
- Warp FPGA IP
- OpenVINO Toolkit
- FPGA AI Suite

For further enquiries, please visit our FPGA Design Services page.

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