PC Cameras: PC-Host Vision Performance Without Sacrifice

BY **MAX LARIN**, CEO, XIMEA GMBH

ABSTRACT

New class of PC Cameras include all the functionality of an industrial PC inside a high-resolution industrial camera, supporting full OS and image processing library functions, network functions and traditional PC I/O and peripheral support.

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MACHINE VISION SYSTEM INSIDE

All machine vision systems have four basic elements: a camera and lighting to acquire images; software to extract actionable information about the objects in the images; and a computer to run the image processing software.

Smart cameras were the first product to include three (and sometimes all four) of these functions in a single housing. Smart cameras offered smaller sizes and costs compared to PC-host-based machine vision solutions. Depending on the manufacturer, smart cameras also attempted to simplify programming and operation by moving to object oriented programming interfaces masking a reduced-set of image processing algorithms and functions.

Unfortunately, smart cameras weren't very smart. They had slow microprocessors, which limited the sensor size and options the camera could handle; limited memory. Smart cameras are easier for a machine vision professional to set up and install for simple applications, but because these products were often marketed to users with little or no machine vision expertise, in reality, customers often had difficulty setting up smart-camera-based machine vision solutions, even using a smaller image processing toolset.

The result of these conditions was that smart cameras couldn't process high-resolution images with sufficient speed for most industrial processes, run a standard PC operating system (OS) with full network and peripheral functionality, or offer a full set of image processing functions, limiting its ability to tackle complex machine vision applications.

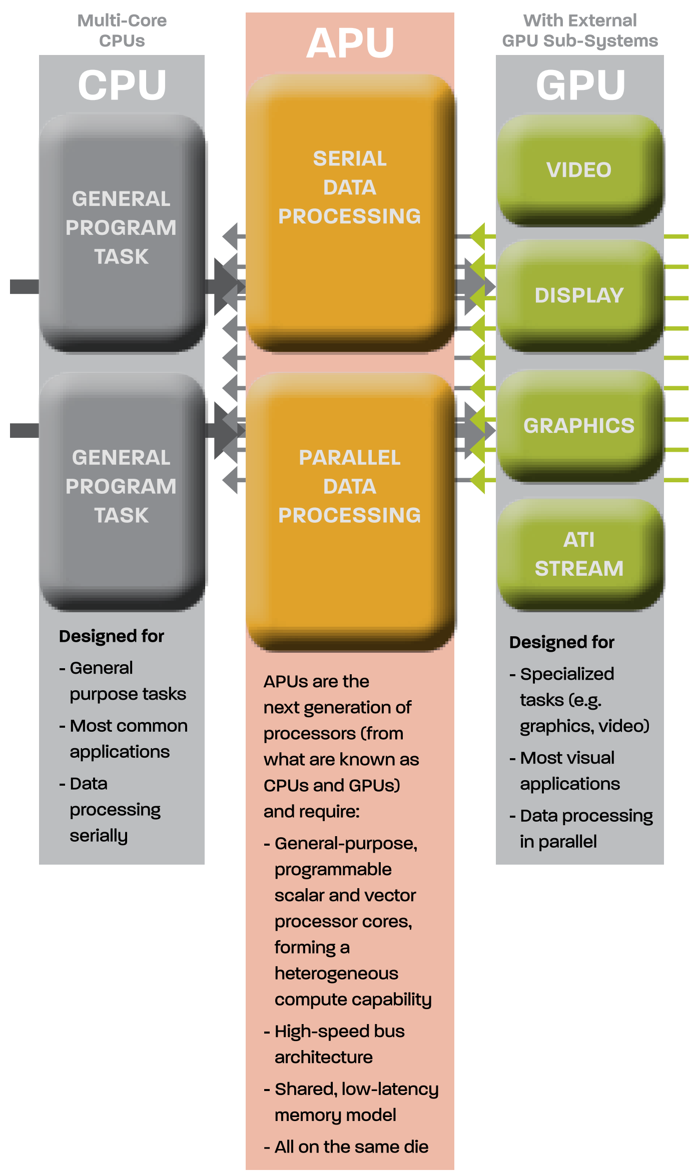
Today, new low-power, high-speed and heterogeneous processors architectures — such as Intel's Atom and AMD's Fusion processors — have led to a new category of compact vision systems called PC Cameras. PC Cameras can deliver up to 90 gigaflops (Gflops) of processing power, more than 26 times the capability of a Pentium-M class, single core microprocessor — enough to support full-image processing libraries, sensor resolutions of 5 megapixels (MP) or more, and standard consumer or embedded operating systems (OS), including full peripheral and network functionality. These PC Cameras finally deliver on the 'smart camera' promise, decoupling the need to buy both software and hardware from a single vendor, offering simplified programming for new and expert designers alike, and improving remote support for today's global marketplace through the improved networkability made possible by running a full OS.

MOORE'S TIPPING POINT

By 2006, microprocessor technology and compact flash memory had advanced to the point that smart cameras such as Sony's XCI-SX1 with Geode processors could generate 1000 megaflops (Mflops) — sufficient to run a full Window's operating system and full image processing library. But megahertz-speed microprocessors meant the smart camera could still only process VGA-resolution images using the latest, most efficient algorithms. This meant either the smart camera had to have a very small field of view, or defects needed to be relatively large to be visible in the VGA images. Also, because of the low processing power and high overhead of modern OS, the manufacturing process needed to be relatively slow — running at dozens of parts per minute rather than hundreds or thousands.

APU's Combine Best of CPU, GPU

Until now, transistor budget constraints typically mandated a two chip solution for CPU and GPU fuctions, forcing system architects to use a chip-to-chip crossing between the memory controller and either the CPU or GPU. These transfers affect memory latency and consume system power. The APU's scalar x86 cores and SIMD engines share a common path to system memory to help avoid these constraints. Courtesy of AMD



The CURRERA-G PC Camera houses a single-board-computer built around AMD's new Fusion accelerated processing unit (APU), which combines the power of both CPU and GPU cores on a single die, to deliver up to 90Gflops of processing power.

Why not use a more powerful processor, you might ask? The answers were — and still remain — heat, size, and ruggedness.

Desktop and industrial PC's use fans to actively cool the microprocessor, which allows the PC's brain to work faster and process more data. A smart camera with a fan loses several advantages: namely, it's size and ruggedness. Production systems that don't use moving parts don't fail as often. Also, adding a fan, vents, and drive electronics would make the smart camera considerably larger — a bad thing for space-constrained retrofit customers and OEMs; vents also make the system vulnerable to contaminants, increasing the chance of system failure.

ATOM, FUSION, AND THE BIG BANG

Microprocessors took a big step forward in 2008 when Intel announced the new Atom microprocessor designed for net books and Internet devices based on 45-nm lithography technology. By shrinking the size of the circuits on the microprocessor, Intel's Atom could deliver about the same performance (2-3 Gflops) of a mid-range Pentium M class PC, or an order of magnitude more than the Geode predecessors used in the first PC Camera models.

But just as important as performance is power consumption and associated heat generation. The Atom microprocessor consumes 20% less power than a Pentium M class at full speed, and considerably less during idle times, allowing the unit to cool faster and better than previous models.

Early this year, Intel upped the ante by adding a graphic processor unit (GPU) to the x86-based CPU, while AMD joined the fray with the Fusion accelerated processing unit (APU), which, like the new Atom E6xx class microprocessor, places a GPU core on the same die as the CPU. Using Fusion's 40-nm lithography technology, the latest PC cameras, such as XIMEA GmbH's CURRERA-G PC Camera, can now deliver up to 90 Gflops of processing power, more than enough to challenge any single-core PC-host vision system.

Of course, microprocessor development never stops. PC Camera users won't have to wait long for a significantly more performance. Very soon, aggressive PC Camera makers will deliver up to

480 Gflops in a PC Camera through AMD's new A-Series APU announced in August 2011. Combined with new or enhanced network protocols, such as Intel's Thunderbolt technology, GigE and 10GigE, CamExpress, and zero copy transfers among other data handling improvements, PC Camera users will be able to 'slave' multiple cameras to a single PC Camera, potentially taking the percentage of machine vision applications that can be served by PC Camera technology from roughly 80% to well over 90% of all machine vision applications.

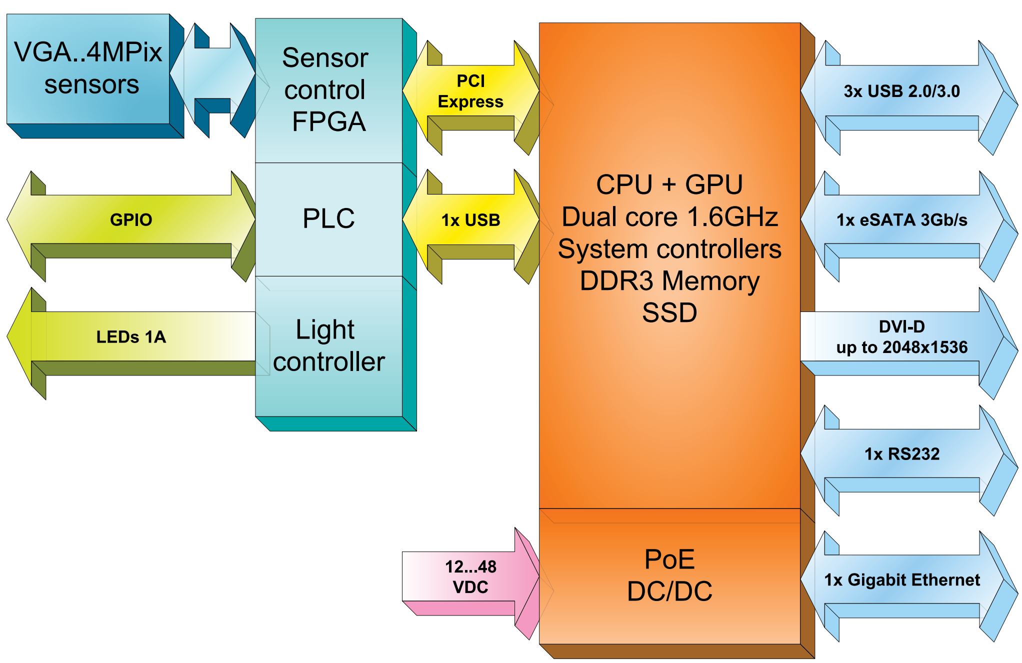
AN END TO LATENCY

In addition to running a full image processing library and OS, the smaller footprint of PC Camera means that data gets from the sensor to the processor faster than on a comparable PC-host system, reducing latency and jitter (dislocations in the image) between image acquisition and processing. The image transfer speed and data integrity from a remote camera to a PC or embedded vision is limited by the cable bandwidth, length and electromagnetic interference (EMI). As anyone with an integrated webcam on their laptop can attest: integrated cameras work much better than remote head based systems.

Unlike standard PC-host machine vision systems, which come with consumer-based operating systems, PC Cameras can choose to run embedded OS. Embedded OS use a componentized architecture that allows the PC Camera maker to choose only those features that are necessary for system and network support. OS modules, such as legacy support for applications designed for older version of the OS, or various API's for Internet Explorer and other

XIMEA CURRERA-G Delivers 90 Gflops with AMD APU

XIMEA's CURRERA-G uses the AMD Fusion APU, combining both CPU and GPU on a single die. The Fusion's ability to deliver up to 90 Gflops with only 18W of thermal design power (TDP) means a fully-function industrial PC can be encased in an industrial camera housing without the need for fans and other moving parts that are prone to failure over time. Note the full compliment of I/O interfaces available on the CURRERA-G PC Camera, which has also been designed to accommodate most major image processing libraries on the market — making it a truly vendor agnostic, universal machine vision solution.



non-essential programs or tasks can be eliminated using an embedded OS, reducing demands on the CPU and latency, while increasing the PC Camera's overall processing throughput. A machine vision system based on an industrial PC can lay the same claim to an embedded OS; however, the cost of an industrial PC with multi-megapixel industrial camera costs more than a PC Camera machine vision solution — and the industrial PC still uses cables and bus interfaces that slow image transfer speed between camera and processor, complicate system integration, and increase the chance of data loss during transfer.

Unfortunately, even an embedded OS is not a 'real time' operating system, which means that determinism — or the assurance that data will be at a certain point at a given time — varies depending on computational load and other factors. While determinism is improved through a PC Camera architecture that puts all components in close proximity to one another and uses on-board interfaces rather than cabling and back planes compared to PC-host systems, the additional processing power of a PC Camera allows vendors to include real-time industrial field bus interfaces. XIMEA's CURRERA line includes an on-board PLC that guarantees nanosecond-level determinism when communicating between the PC Camera and downstream ejectors and other industrial equipment.

PC CAMERAS: THE NEW BEGINNING

The benefits of PC Cameras don't stop with better resolution and usability, higher processing speed, and lower latency; PC Cameras also change the paradigm between customer and vendor.

For example, XIMEA's clients no longer have to let

hardware selection dictate their image processing software program. PC-class processing power and a full OS have allowed XIMEA to develop application programming interfaces (APIs) for the vast majority of major image processing software programs, achieving true plug-and-play compatibility in a machine vision system. Today, XIMEA offers free API's to Cognex's VisionPro, Matrox's MIL, National Instruments LabView, MVTec's Halcon and many more. Other PC Camera vendors still require users to develop their own API's using a C-compiler. This step towards greater compatibility for vision technology is a big deal for customers because integrators tend to sell the machine vision hardware and software they know, which may or may not be the best solution for the customer.

PC Cameras are quickly closing the 'support' gap between integrated solutions and PC-host vision systems. As we all know, industrial equipment, including machine vision systems, are designed to last longer and have better support than consumer systems, which is why an industrial PC costs more than a desktop PC. This is a dual edge sword when it comes to comparisons between PC-host systems and PC Cameras. PC Cameras, like all machine vision systems, are designed for industrial product lifetime support in excess of 7 years, while consumer PC's hardware and software configurations change every week, creating a potential support nightmare for machine vision providers. However, while industrial PC Cameras will fail less and perform better than consumer-based platform solutions because the software and hardware is better integrated and supported, troubleshooting PC Camera hardware can be more difficult because these highly-integrated systems are designed to be disassembled by trained factory personnel.

Fortunately, the full OS capabilities of a PC Camera provide an answer by including full network, Internet and browser support that marks a major improvement compared to traditional smart camera remote support solutions. In today's global economy, improved remote support is a "must" for machine vision providers and customers alike where lean operations cannot withstand periods of unexpected downtime.

In the future, PC Camera vendors will conquer the last "benefit" of PC-host systems compared to PC Cameras: hardware support. It's not a stretch to imagine PC Cameras with "snap in" modular designs that allow the user to replace a failed motherboard, increase the sensor size, or add a higher-speed network interface. Imagine being able to re-purpose a PC Camera for a high-resolution operation simply by snapping out the sensor box and replacing it with a larger array. Science fiction? Just wait.

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