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Imaging Insight

Inside...

GigE Vision™: Ready for the revolution

After months of discussion, the Automated Imaging Association (AIA) unleashed the Gigabit Ethernet standard for machine vision movers, shakers, and doers at The Vision Show East in Boston (May, 2006). During November's Vision 2006 in Stuttgart, Germany, the AIA's baby will be a mere six months old. While the standard is in its infancy, the industry buzz is that it will grow up quickly.

Due to its pervasiveness and affordability, Ethernet technology has the potential to revolutionize machine vision. GigE Vision™ is an offshoot of existing Ethernet standards but includes extensions for locating a device on a network, an XML-based device descriptor for describing a camera's feature set, a control protocol for device/application control, and a streaming protocol for data transmission. The purpose of GigE Vision™ is to facilitate interfacing a gigabit ethernet camera to a software package. Thanks to the AIA's efforts, we have a protocol for video transmission that is attuned to the needs of scientific and industrial vision applications.

Matrox Solios GigE

Full data-stream ahead!

Who in our industry hasn't heard of Gigabit Ethernet for machine vision? With connectivity a recurring issue in machine vision application design, simplifying this process should be a boon to customers and suppliers alike.

It was an important step when the AIA took Ethernet technology and established standards for locating a camera on a network, an XML-based descriptor for describing a camera's feature set, and protocols for device/application control and data transmission. Of course, the AIA had some help from key industry players, including Matrox, so the standard is attuned to the needs of scientific and industrial applications.

Matrox prides itself in contributing to this technological evolution, keeping us at the forefront of our industry. With this spirit in mind, we are introducing new hardware and software products for this emerging marketplace. Our Solios GigE interface for x4 PCIe™ leverages our expertise in hardware-accelerated board-level products with support of an optional FPGA. Our MIL GigE Vision™ driver for Windows XP brings our award-winning MIL development kit to an expanded audience.

Speaking of MIL, this issue of Imaging Insight looks at our new Metrology module. We'll also introduce you to our new Hardware QA bench; while the industry tackles connectivity issues head-on, hardware platform and hardware compatibility merits our attention and equal investment. With each step, we strive to bring added-value to our customers.

François Bertrand
Vice President, Sales & Marketing
Matrox Imaging

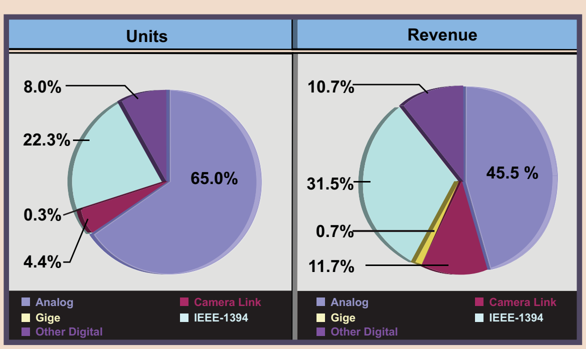
And what about GenICam?
During the next few months machine vision vendors will launch a deluge of GigE Vision™ products onto the market, and many of them will be cameras. The GigE Vision™ standard categorizes the camera's functionality according to its use: image size control, acquisition and trigger controls, digital I/O, and analog controls. Within these categories each feature is flagged as mandatory, recommended, or optional. Out of the approximate list of 180 standard (i.e., non-custom) features, only a handful are mandatory; most are recommended.

So, aside from the technical specs of the camera itself, what will set one apart from the other? The answer is GenICam, and the extent to which the camera supports it. Developed under the auspices of European Machine Vision Association (EMVA), GenICam is an API that allows a camera to describe its capabilities and how to change its settings such as the image size, exposures, gains, or trigger mode. All the camera's features are described in a "camera description file" that follows XML syntax; as long as a the vendor describes the feature in the XML file, the end-user has control over it. When an application or driver parses a camera's XML file, it retrieves the machine-readable equivalent of the camera's "instruction manual" (see *MIL and Solios look at the 'gig' picture* on page 3). GigE Vision™ dictates that a device must support the mandatory features in its XML file to be compliant; many cameras will also include a list of optional features. Essentially, a GigE Vision™-compliant camera will be GenICam compliant as well.

Words to the wise
As with any new technology, however, machine vision developers must be careful before fully adopting GigE Vision™. GigE Vision™ cameras can be connected to any standard NIC, but not all NICs are created equal – some models are better suited to high-bandwidth cameras than others, and in all likelihood you will have to configure your NIC to optimize its performance for machine vision applications. For example, you will probably have to enable support for jumbo frames, interrupt throttling (sometimes called moderation), and receive descriptors. (See *Throttling what?* on page 3.)

But even if the data traffic flows smoothly between the camera, NIC and the PC, connecting a GigE Vision™ camera to a standard NIC, leaves you without the valuable I/O that is standard on frame grabbers (and the same is true for IEEE-1394 adapter cards). Moving the I/O to the camera would be as effective as having it on the frame grabber, except that the cameras may not offer this I/O. Furthermore, moving I/O to the camera does not ensure the application is aware of all the critical information, such as missed triggers. If the data throughput is exceedingly high, multiple cameras are implemented, or substantial processing is required, CPU intensive pre-processing tasks such as filtering, color space conversions and transformations are not addressed with NICs; specialized frame grabbers have traditionally performed these tasks.

So what's a machine vision developer to do? Well, read through this issue of Imaging Insight to see how we are taking the GigE Vision™ revolution in stride. If you're looking to explore the possibilities of GigE Vision™, keep Matrox Imaging in your line of sight!



Facts and figures courtesy of the AIA. Used with permission.

The AIA's 2005 market study indicates that camera manufacturers saw 45.5% of their revenues generated from the sale of analog cameras while the revenue from all digital camera interfaces amounts to 53.9%. While IEEE 1394 appears to be the most popular digital interface, it is still not as widely used as originally expected; the prophecy of the frame grabber's demise has yet to be fulfilled and perhaps, all things being equal, that is also a function of the rate of change in the industrial automation space (why fix something that works!).

However, Matrox Imaging still values the potential offered by digital interfaces, including Gigabit Ethernet, and understands that customers need options, as well as performance. For machine vision developers, this scenario means more digital choices will be available when and if they have to re-engineer their vision systems. The good news: a new standard, however exciting it may appear on the surface, has time to mature. In the "real world" of delivering "real vision" solutions, maturity equals robustness, repeatability and quality, all factors which are significant in the gestalt of machine vision technology.

MIL and Solios look at the ‘gig’ picture

The simple connectivity of GigE Vision™ makes it an attractive option for vision applications, and we’re taking an active role in its development because we believe in its potential as a relevant digital interface. As a member of both the GigE Vision™ and GenICam standards committees, we are participating in creating a viable protocol for real-world industrial environments.

Through our experience with IEEE 1394, we have gleaned valuable insight into the particularities of a software-centric model; in fact, our Matrox 4Sight M platform features IEEE 1394 and gigabit Ethernet ports. We are confident that our GigE Vision™ solutions will satisfy the needs of the machine vision market. We have two, and each allows our customers to take advantage of gigabit Ethernet transfer speeds while harnessing the power of the Matrox Imaging Library (MIL).

GigE Vision™ driver

Are you concerned about sacrificing image processing functionality with a standard network interface card (NIC)? The Matrox Imaging Library was developed as a hardware-independent image processing library, and with our new GigE Vision™ driver, this statement still rings true. The MIL 8.0 driver for GigE Vision™ fully supports GenICam, treating any standard NIC as Matrox Imaging hardware by mapping all the camera’s features (as they are described in GenICam) to their equivalents in the Matrox Imaging Library. This transparency eases board-to-interface portability and speeds up the overall time-to-market by eliminating the need for the user to learn a new API.

The driver is highly optimized, requires very little host CPU intervention to manage incoming GigE Vision™ traffic, and offers good performance with cards that support jumbo packets of pixels and interrupt throttling. The MIL GigE Vision™ driver can co-exist with other Ethernet protocols such as TCP/IP, and supports multiple camera/multiple NIC and multiple camera/single NIC configurations.

Solios GigE

If you consider Gigabit Ethernet’s bandwidth capacity, it should come as no surprise that some applications would generate copious amounts of image data, or require multiple cameras providing multiple view points; pixel after pixel that needs to be transmitted, processed and transferred to the PC. Furthermore, many vision applications require auxiliary I/O for triggers, which are not supported by standard NICs. That’s why we developed a specialized NIC for machine vision users. The Matrox Solios GigE is a x4 PCI Express® (PCIe™) short card with 4 Gigabit Ethernet (GbE) ports. Ensuring that the application can make appropriate decisions is critical for successful deployment, and with a full range of I/Os, you may trigger the Matrox Solios directly instead of the camera; the application will always have the required information to react appropriately at critical points, such as what to do in the event of missing an expected trigger.

For applications that must perform intensive computational operations such as flat field correction, the Matrox Solios GigE offers an optional, configurable FPGA-based processing core that can offload and even accelerate image processing operations from the host CPU. Based on the Altera® Stratix™ family of FPGA devices, the FPGA includes a sizable amount of DDR SDRAM and/or a smaller amount of faster QDR SRAM to maximize the performance of your image processing tasks.

The Matrox Solios GigE is supported under Microsoft® Windows® XP, and may be programmed with the Matrox Imaging Library (MIL)/ActiveMIL or MIL-Lite/ActiveMIL-Lite development toolkits for creating custom applications; ready-made configurations for the FPGA-based processing core are included with these development toolkits. Custom configurations and processing functions can also be created using the Matrox FPGA Developer’s Toolkit (FDK) Altera® Edition.

Throttling *what*?

Standard network interface cards (NICs) are not created equal. Make sure yours supports these features to ensure optimal GigE Vision™ performance:

- **Jumbo Frames:** gigabit-Ethernet packets crafted to hold more than the 1500-byte standard packet. Transferring data in larger packets improves GigE Vision™ performance by interrupting the CPU fewer times than what would occur if the image data were transferred in smaller blocks.
- **Interrupt Throttling:** a feature of NICs that prevents events from interrupting the host system. Events are queued to reduce the number of interruptions to the host processor, allowing the system to perform more efficiently. After a specified number of events are queued, the GbE controller sends a delivery notification and the data stream interrupts the CPU only once. Interrupt throttling is sometimes referred to as moderation.
- **Receive descriptors:** software metadata used by the NIC to buffer packets in memory. A large buffer space protects the waiting packets and ensures they will not be overwritten before the host can handle the data. The number of receive descriptors is directly proportional to the number of packets it can buffer.

Shock treatments:

Shanghai Electric Utility Uses Machine Vision To Read Meters

By the end of 2002, the city of Shanghai had topped over 13 million permanent citizens. Take a moment to ponder the number of dwellings and businesses where those people live and work, and it's easy to consider the kinds of challenges the Shanghai Power Corporation faces each day. About a year and a half ago, the utility began updating its clients' electricity meters, a process expected to take between five and ten years! That means collecting hundreds of thousands of kilowatt/hour meters from customers' homes and businesses and replacing them with newer, more accurate models. The utility also wants to record and store the final readings from all of those meters, but entering that data proved to be a more daunting task than actually collecting the meters themselves. Shanghai Electric Power Corporation wanted to ensure accurate records for all the meters, a procedure that demands automation, but gets some help from human hands.

In March 2005, Shanghai Power Corporation contacted Microview Science & Technologies Inc., a systems integrator based in Beijing. "One of the essential requirements," recalls Yu Zhao, Applications Engineer at Microview, "was to capture images of the meters and read the data simultaneously – both the bar code and the numeric characters – and store the results in a database."

The process appears simple enough. The meters are collected and placed into a carton according to their size. One carton holds eight 1-phase meters or three 3-phase meters. At the plant, a worker places the cartons on a conveyor belt that brings them to the workstation, where an operator then shunts the camera into position through a 3-axis manipulator. When the camera is in the correct position, the operator manually triggers the camera. Once the picture is taken, image processing algorithms read the meter's barcode and the numeric digits (which determined electricity usage) and is compared with the old data. The image, bar code result and numerical reading are stored in the database, and the camera takes the image of the next meter which is analyzed in the same manner. When the procedure is complete for all the meters in the carton, they travel to the end of the line where they are sorted according to their results. Some are destroyed and others are sent to smaller cities to be re-used. Says Zhao, "Given the scope of this project, industrial automation has greatly improved the efficiency of the production line."

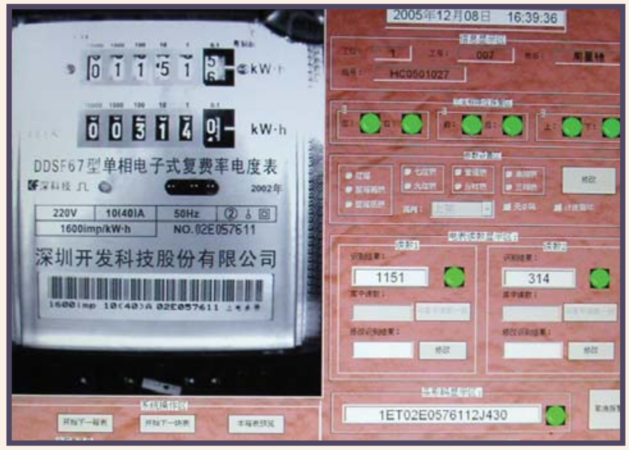
The system

Microview's solution uses an IBM Server X346, 3 Dell 5150n workstation computers, 3 Matrox Imaging Iris P1200 smart cameras fitted with a Pentax CCTV 12mm lens, 3 OEM light sources, 4 Santek MT500/1000 UPS devices, and one TP-Link 100M/16-port device. The image analysis is performed by the Code Reader and String Reader modules from the Matrox Imaging Library. "The image processing software is extremely important to the application," explains Zhao. "Because the meters display both numerals and a bar code, we needed a solution that could handle the two different input types simultaneously." Zhao says they considered other machine vision vendors, but changed their minds when that meant purchasing two discrete vision systems, one for bar codes and one for character-reading. "With the Matrox Imaging Library we could read strings and the bar codes with a single machine vision system, and that allowed us to keep costs down," he notes.

Challenges in development

Since the image capture process would be manual, Zhao and his team placed a high priority on simplicity and flexibility. The image capture software has two modes, one for the 1-phase meters and one for the 3-phase meters; the operator only has to reset the software type at the workstation to account for the different sizes. The meters themselves presented a more difficult situation. First, the thousands of different model types employ different fonts, which would make defining the font extremely cumbersome, if not impossible. Next, the meter's face features numbers that are not part of the dials (such as a serial number), which could interfere with the character-reading result. The plastic casing on the meter is often dirty, which can also interfere with the character-reading. Finally, the backgrounds of the dials are both black and white, which adds an extra step in specifying the read operation's settings. Finally, the white numeric dials with black numerals lie within a black rectangular frame which has the potential to confuse the read operation. The robust nature of MIL's String Reader module proved invaluable; defining/locating the string and their associated fonts is performed quickly, and the read operations are robust enough to read characters in poor or non-uniform lighting. In some cases, one of the meter's indicators may be between two values and cannot be 'read' by the String Reader; at such times, the operator must manually check the meter and record its value at the workstation.

"We could keep costs down by working with Matrox," explains Zhao. "By developing with MIL we had all the image processing tools in one package and achieved very accurate results." Integrating the system with the Iris smart camera meant working with a single vendor, which prevented compatibility issues. Zhao's team programmed the application with MIL on the PC for image capture, pre-processing, barcode reading and character reading.



The user interface.

Soon the application will be run on the Iris camera itself, since the Windows CE operating system facilitates programming on the camera directly. "We also received excellent technical support, which was very important to us," adds Zhao.

Now and in the future...

Presently, Microview has deployed a three-workstation system at Shanghai Electric Power Corporation, and there are plans to integrate an additional two workstations. They also hope to sell the system to Shanghai's other power utility. Considering features such as reading different input types simultaneously with a high level of accuracy, and the flexibility to develop the system as the customer's needs change, Microview shouldn't have to try hard to find customers. But Zhao intends to get the most out of this technology and adapt it for other machine vision applications.

The differences in the meters brought challenges to the project. Note the meter in the center has 5 characters to read, while the others have 6. The center meter's right-side digit is between two values; the operator must manually record this reading.

Metrology measures up

The use of imaging for inspecting and the manufacture of parts has moved way beyond nuts and bolts. The complexity of performing those measurements has grown as well. So Matrox Imaging now offers a more versatile and integrated measurement tool to facilitate these tasks – with the same performance as classical feature extraction.

Since May the new Metrology module has been available with the Matrox Imaging Library (MIL) 8.0 with Processing Pack 3. Now developers have a robust tool for geometric dimensioning and tolerancing applications. The Metrology module calculates the measured and constructed geometric features that are derived from a template, and also validates tolerances based on a template. The Metrology module can determine the measurements of features such as arcs, circles, line segments, and points; these same features can also be constructed within the image. Tolerances can be determined from dimensions, positions, and shape, and can involve features such as distances and length, coordinates, angularity, concentricity, parallelism, perpendicularity, roundness and straightness.

Having the tools is one thing; knowing how to use them is another. Arnaud Lina, MIL Processing Group Manager, recently contributed to an article for Control Engineering magazine, and offered a few tips to consider:

- Ensure the vision-based metrology reproduces the specific definition of the tolerances to measure. There are several different methods for testing perpendicularity, for example, so you must be sure the vision solution can perform the exact test required.
- Acquire images in the best possible conditions since accuracy will be affected by contrast and noise.
- Imaging-based metrology should be feature-based; a technology that extracts geometric features from grayscale pixel values. These algorithms mimic how real-world metrology is performed and are robust enough to handle changes in illumination.
- Calibrate! Choose a software package that works in real-world coordinates, and position the camera to avoid significant distortion and perspective. Extract the metrology features from the source (distorted) image and measure them in the plane in which the calibration was performed. Performing metrology operations on the distorted image maintains the level of accuracy.
- Rely on basic geometrical manipulation rather than complex math. By adopting a metrology package that uses multiple sub-coordinate systems, you can easily construct new features that are geometrically derived from other features.
- Choose a metrology tool that can reposition the metrology template (layout of regions) automatically. For example, if a geometric pattern recognition operation is used to locate the position and orientation of a part, based on these results, the metrology regions should be automatically positioned correctly.
- To optimize operations, make regions as tight as possible around the feature being measured.

The top right hook does not fall within accepted tolerances when compared to the template (left hook). The bottom right hook passes the inspection.

...and more testing:

Imaging standardizes hardware compatibility

Imagine you've just received your new PCIe™ imaging hardware. Everything is installed but the system can't detect your new device! Or what if you open your computer, locate the right slot, and then discover you can't insert the card because a component on the motherboard is in the way! What do you do? Return the card? Order a new PC?

"You give me a call," laughs Pierre Letarte, former SQA leader and now leader of the new Hardware Quality Assurance (HQA) test site. If there is anyone at Matrox Imaging who fully understands the intricate nature of hardware interoperability, it's Pierre, a 20-year veteran of Matrox.

"We perform two types of testing," explains Pierre, pointing to the row of computers on the table. The first is validation of PC compatibility, where the new CPU and chipset is tested with a previously qualified Matrox Imaging board and released software. The only variable in this testing is the PC, so if there's an incompatibility issue, it's easy to tell whether it's the chipset, or the firmware. "Usually the issue can be resolved by upgrading the BIOS," notes Pierre. "As long as the PC vendor has a BIOS upgrade."

The second type of testing is validation of new revisions of existing products and new boards, which includes both new products and current products that have been ported to new bus technologies, for example PCI-X to PCIe. For this testing, the variable is the Matrox Imaging hardware, and it will be tested with a previously qualified PC and released software. "If we find an issue at this stage, we work with engineering to resolve the matter."

When we design a new board and it has been tested in Engineering, the products are brought to the Applications department, where we test it some more! A new imaging hardware product must be compatible with chipsets, motherboards, and bus interfaces.

The test bench houses 8 to 10 new PCs and a time, and they are sent from manufacturers such as HP, Intel and Supermicro. Letarte has worked hard to establish a good relationship with vendors; with a few phone calls he can get the information about the newest chipsets and PCs. Now that Intel's new core technology has been released, Pierre is moving on to the Core 2 Duo processor.

During the validation phases, Pierre will measure factors such as transmission bandwidth to ensure that the board is performing as expected.

PC-compatibility testing is a full-time activity, and PC compatibility lists are published on our website! But stay in touch with your local distributor to find out which platforms are scheduled to undergo testing.

Catch Matrox and its reps at the following events:

5th China OPTO Valley
(Representative: MVLZ)
Wuhan, China
November 2-5, 2006

Vision
Stuttgart, Germany
November 7-9, 2006
Hall: 4.0 / Booth 320

11th Laser and Optics Exhibition
(Representative: MVLZ)
Beijing, China
December 5-7, 2006

Exhibition on Image Technology and Equipment
(Representative: Canon & NED)
Yokohama, Japan
December 6-8, 2006

More events are listed online! For tickets or more info...

Visit: www.matrox.com/imaging/news_events/events/

Or contact:
+1 (514) 685-2630 ext. 7324
email: jpuccio@matrox.com

Morphis QxT steals the show around the globe!

This year's Matrox Imaging delegation descended upon the beautiful and temperate San Diego for ASIS 2006. The big difference between this show and earlier ones is name recognition. Attendees approached the booth knowing what Matrox Imaging is all about. Visitors wanted to discuss how Matrox Imaging products could solve their applications' needs, which primarily involved MIL's String Reader and the Morphis QxT.

Right after ASIS, Essen Security was held in Germany. This biennial show rivals both ASIS and IFSEC, which are geared for the US and UK markets, respectively. Essen Germany is truly pan-European in scope and even bigger than ASIS in terms of space!

But whether you're in North America or Europe, the trends are the same. IP cameras are still gaining popularity for new installations, but the lack of protocol standardization between IP camera vendors may give system integrators some headaches; the IP camera market still has some work to do. And did you know that straight forward video recording is no longer in vogue? To compete in the marketplace, vendors must offer DVR solutions which feature video analytics that integrate with other systems such as motion detection, access control, or point-of-sale (POS). Video analytics is an industry term used to describe the image processing algorithms that analyze video data for surveillance applications. With our components, our customers design impressive security solutions, from passport readers, to ANPR systems, to cash register surveillance systems. For more information about video analytics visit: www.videoanalytics.org.

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