Enabling PLC programmers to work seamlessly in a single tool environment that supports PLC, motion control, measurement as well as vision functionality streamlines the engineering process and optimizes efficiency.

TwinCAT Vision: Programming real-time solutions in a PLC environment

Fully integrated image processing in control systems

To date, industrial image processing has generally been kept separate from traditional control technology. It is mostly implemented on dedicated PCs or smart cameras by expert engineers using specialized tools and programming languages. However, image processing solutions built in this way not only involve a considerable effort in terms of engineering and support, they are also almost impossible to synchronize with conventional industrial control systems. This has prompted Beckhoff to take a fundamentally different path that fully integrates machine vision, both in its engineering environment and its runtime system.

Vision integrated

Detection Monitoring
Measurement Identification
Inspection

The Beckhoff approach with image processing is again to concentrate system intelligence in a powerful Industrial PC. This means inexpensive cameras without built-in intelligence can be used for local image capture. In addition, incorporating vision functionality into the software running on the control PC offers substantial flexibility, the only limiting factor being the IPC's computing power. Unlike solutions that rely on smart cameras, this setup not only permits image data and intermediate results to be displayed directly, in full, by an HMI, it enables images to be stored for more extensive analysis as well.

Efficient engineering in image processing

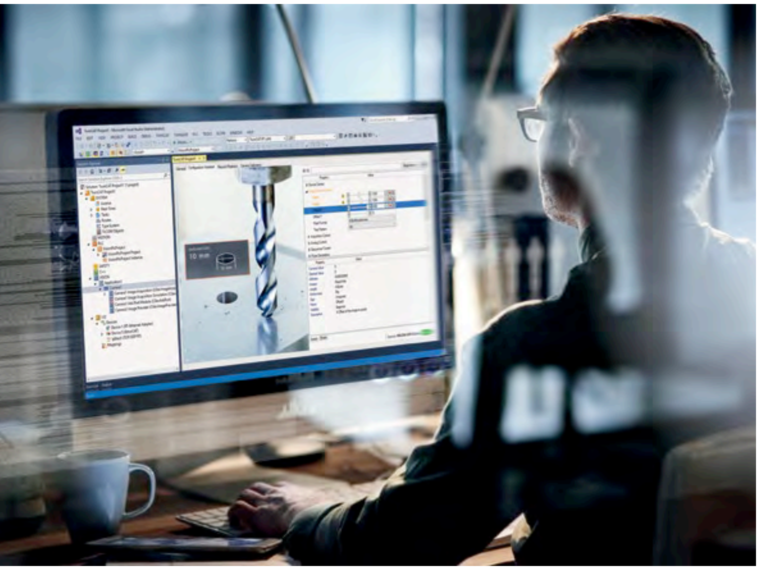
TwinCAT 3 automation software – for PLCs, C++, motion control, safety and now machine vision – is engineered in Microsoft Visual Studio®. This means that automation engineers can work in the same integrated development environment (IDE) as is commonly used to program standard software applications.

The LED driver terminal EL2596 for high-precision lighting control in vision applications is the first specialized hardware product from Beckhoff designed to support the integration of image processing into control systems.

One advantage is that this environment is both familiar and widely accepted all over the world; another is that it allows direct access to source code control, database and testing tool interfaces. In addition, the various field buses that TwinCAT supports can be configured straight from the IDE; and with TwinSAFE, safety-related applications can be configured and programmed as well. Motion control with NC PTP, too, is supported, as are the configuration and programming of CNC applications. Incorporating image processing, therefore, was the next logical step. Other solutions on the market generally need to be configured and programmed through their own user interfaces, but with TwinCAT Vision, configuration, calibration and programming can all be accomplished inside Visual Studio®, eliminating the need to learn additional tools or specialized programming languages. Plus, the development environment integrates smoothly with the HTML5-based HMI.

In Visual Studio®, cameras are as easy to configure as I/O nodes. Any camera that uses a GigE Vision bus and conforms to the GenIcam configuration standard is supported; this standard also makes it easy for the system to incorporate cameras with specialized capabilities. All the cameras connected to the IPC's network interface controller can be found with a simple scan, and each camera's parameters can be retrieved from the relevant GenIcam description file allocated to it. As a result, there is no need to manually assign IP addresses or create extensive parameter lists. The cameras are ready for operation after a few moments, and the live images they capture can be displayed in Visual Studio®. All their parameters can be configured manually using PLC function blocks, both at the engineering stage and later, during live operation.

If measurements are to be taken during image processing, cameras need to be calibrated by converting their pixel dimensions into metric sizes. Calibration can be performed using the usual checkerboard patterns or circles; 3D calibration patterns, too, are supported. A single image is sufficient for calibration purposes, and this is an important advantage: If a camera and/or lens needs to be exchanged for maintenance purposes, this makes putting its replacement into operation much easier and thus less costly.



The ability to measure a drilled hole precisely is just one of many use cases in which an integrated, precisely synchronized vision solution can enhance quality and productivity in the manufacturing process.

Synchronizing motion control, robotics and vision applications in real time – in this case, image processing in combination with an XTS linear transport system – can introduce valuable efficiency gains in machine design and process sequencing.

PLC programmers with vision expertise

Once a camera has been set up and calibrated, programming itself can begin. Because the vision solution is integrated with the standard control technology, this can be carried out using familiar PLC programming languages. C/C++ and MATLAB®/Simulink® can in fact be used as well. Going forward, this will lead increasingly to PLC programmers being able to write image processing code alongside other programming tasks, because machine vision experts and specialist programming languages are no longer essential. At the same time, image processing will gradually become standard automation system functionality, along with motion control, safety, measurement, and other technologies already incorporated into the control software in recent years.

The process of vision programming in the PLC begins simply by adding a library containing the functions and function blocks needed to capture an image, to render and filter image data, to detect and identify objects, and to measure objects in images. In packaging technology in particular, the ability to recognize and identify codes is a key requirement, and the library also includes functions to handle these tasks.

To transfer an image to the IPC, the image must first be captured by triggering a camera. For the most part, cameras are triggered digitally – e.g. by an EtherCAT output terminal that supports distributed clocks functionality and allows synchronization with an accuracy in the microsecond range. Once the captured image has been stored on the IPC, filtering algorithms are applied. To verify that the filters are indeed working correctly, each intermediate step can be viewed as an image in Visual Studio® or the HMI.

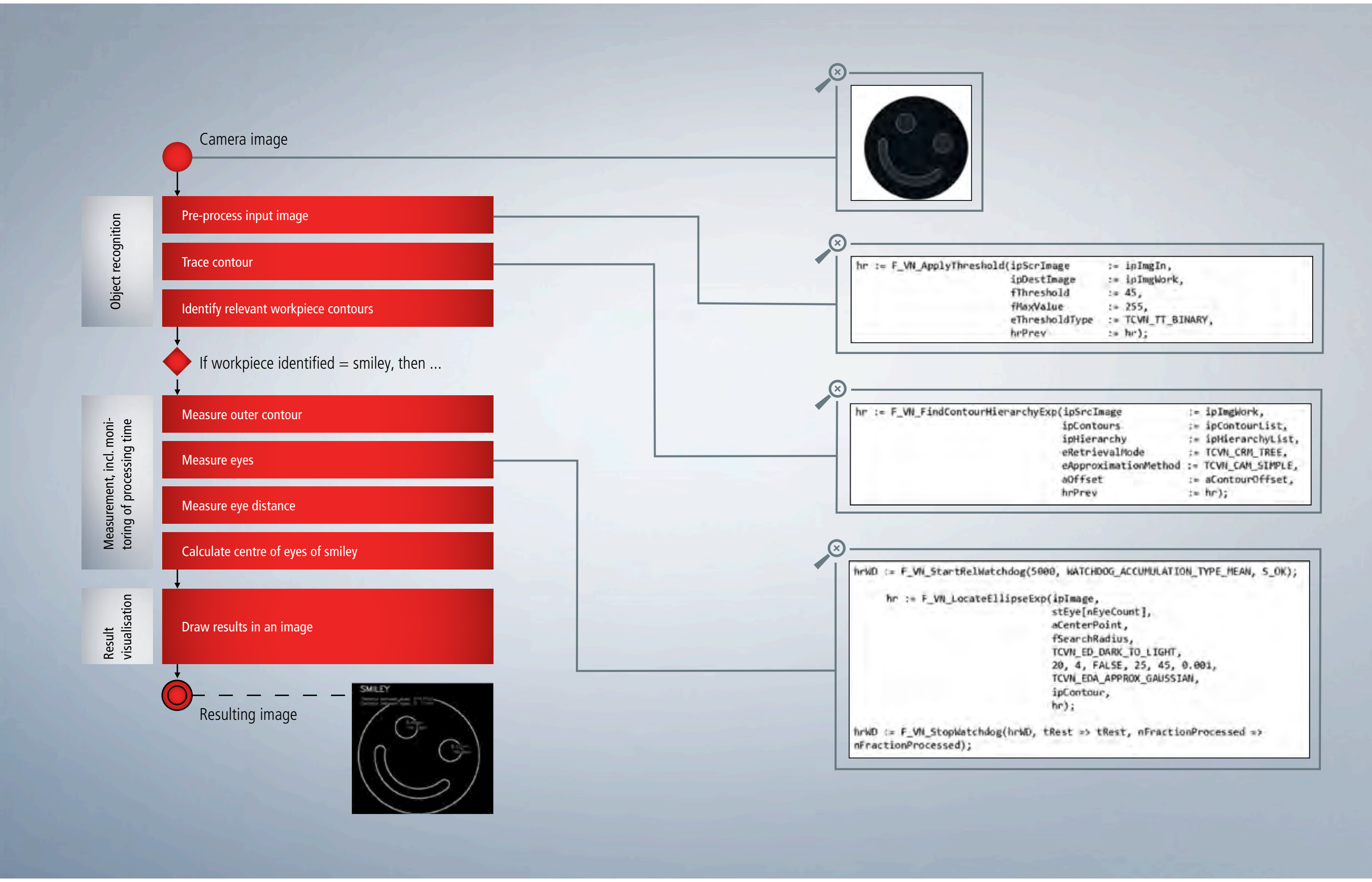
The main search and analysis algorithms can run once the raw image has been rendered. Currently, more than 500 such algorithms are available in a range of categories. These can be switched into and out of the PLC as necessary using online change parameters and/or code, without first having to halt the PLC. Compared to classic C++-based solutions, this is a major advantage when putting systems into operation.

Maximum synch precision

The image processing algorithms are executed in the TwinCAT real-time system, and a key benefit is that the vision algorithms can run at the same cycle time as, or in sync with, the PLC, motion control, and measurement applications. Consequently, there is no need to coordinate communication between a non-real-time application and real-time PLC, motion control or measurement processes, which avoids commonly associated problems such as communication delay and jitter.

Integrating image processing on the PLC has another important advantage: PLC programmers can directly process the results returned by an image processing algorithm in the same way as output from an analog sensor. For instance, they can write instructions along these lines: "If the object detected in the image is round, set this digital output to TRUE." Programmers can also use a full array of familiar PLC debugging features. This means that they can display an image at any time during execution just as if they were monitoring a variable. And if an image is processed in multiple stages, it can be viewed directly in Visual Studio® at each stage. This makes testing algorithms exceptionally quick and easy. Programmers are able to switch parameters online – to shift the region of interest in an image, for example – and then observe the effects directly. Being able to alter parameters online (common practice in PLC programming) means that entire algorithms can be changed out on a running PLC, too. This capability enables image processing solutions to be put into operation and optimized quickly.

Like other peripherals, external devices used by machine vision applications can also be synchronized using EtherCAT and distributed clocks. Most cameras, for instance, have a digital trigger input. If this is driven by a digital output on an EtherCAT Terminal, the images captured can be matched exactly to, e.g., the position of a conveyor belt. Likewise, lighting can be timed and controlled



Measurement tasks and contour, color, and key-point feature detection functions can now all be programmed in typical PLC fashion.

extremely accurately – again, based on the exceptional timing precision with EtherCAT. The new EtherCAT EL2596 terminal, designed to control LED lighting, has been developed specifically for applications like this.

Conclusion

TwinCAT Vision breaks new ground as the first automation solution to integrate image processing technology in full, both at the configuration and programming level and in real-time operation. It enables PLC programmers to work with common PLC programming languages in a familiar environment to configure, program and commission control applications with built-in image processing. By integrating vision functionality in real time, TwinCAT Vision allows PLC, motion control and image processing applications to be synchronized with highest accuracy; in combination with EtherCAT, it achieves the same timing precision with cameras and lighting. The image data captured can be incorporated into the HMI or saved at any time. The solution simplifies engineering and support, too.

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Further information:
www.beckhoff.com/twincat-vision