

A calibration plate permits the calibration of the camera. Following calibration, the software corrects perspective deformations in less than 5 ms (center). As a result, the disparities and distances of deformed images can be measured with subpixel accuracy (right)

Standard Software Replaces Specialized Solutions

EFFICIENT LIBRARY FOR 3D IMAGE PROCESSING

With ›Halcon 8.0‹, 3D applications, e.g. in robotics, can not only be implemented but also speeded up. The software library promises savings in time and costs to users in industrial automation.

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Machine vision is a wide-ranging technology which is rapidly gaining in importance. It is intended to permit product quality to be checked more rapidly and faults to be reliably identified. If necessary, the machine vision system will intervene as a regulating factor. It will even become the controlling technology for entire machines, as is shown in the case of robots or assembly lines in the production environment.

To date, many problems have been resolved with specialized programs. The standard Halcon 8.0 software now offers an opportunity to avoid the high costs of in-house programming or the purchase of specialized programs. Halcon provides an integrated development environment (IDE) and, with the aid of the new software operators incorporated in version 8.0, tasks can be carried out easily and rapidly.

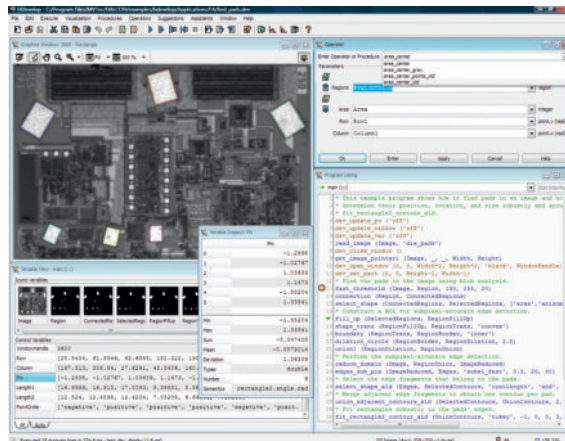
In the improved graphic user interface of ›HDevelop‹, provision has been made to incorporate the experience of customers and MVTech sales associates.

Development environment with new assistants

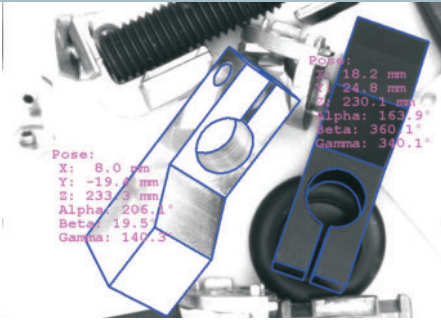
So-called ›HDevelop assistants‹ have been introduced in version 8.0. By means of these assistants, frequently used operator sequences can be compiled much more easily. In the future, the scope of the assistants will be expanded by the addition of further modules for typical machine-vision applications.

HDevelop offers a practicable graphical user interface (GUI) which permits the pro-

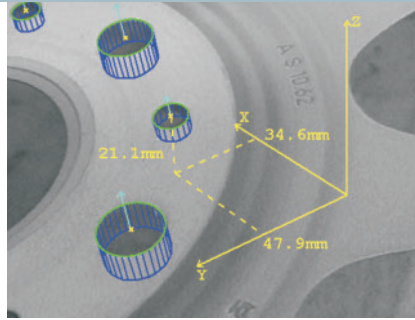
gramming code to be formulated in a straightforward manner. Each HDevelop assistant is displayed in its own window. The user interfaces have been redesigned. Layout parameters such as color, typeface and type size can be preselected and the operating language can be chosen from English, German, French, Spanish, Turkish, Japanese, Chinese and Korean. The new syntax-highlighting system improves legibility. Overlaid and direct zoom functions facilitate the viewing of the images. Thanks to online help, the user can make a direct



1 HDevelop permits the rapid prototyping of a machine vision program. It exports the program as a source code in C++, C, C# or Visual Basic. This code can then be directly integrated into the application code



2 The 3D matching function identifies the 3D position and orientation of 3D objects, based on their CAD model, with only a single camera



3 The 3D position and orientation of circular and rectangular objects can be determined with only one camera



4 Shape-based matching processes color and multi-channel images

choice from over 1300 software operators in order to integrate them into the code.

The library offers a new interface for all .NET programming languages. With Mono, this interface along with the .NET interface for »HDevEngine« is also available for Linux. Thus, the software also offers a native code export towards VB, .NET and C# for the .NET programming environment (Figure 1).

With regards to the package as a whole, the speed offered by version 8.0 has increased by an average of 25 percent, while individual operators are up to 500 percent faster. On the one hand, this can be attributed to improved data storage management. On the other, it is due to the efficient use of MMX and SSE2, and to modifications to the Halcon core. In addition, the Halcon developers have optimized automatic parallel processing (an internal feature of the program) such that the performance of multi-core processors is utilized more efficiently without any additional expense for a programmer. Halcon automatically splits the data across the available cores, processes it separately in each core, then reassembles it.

3D Vision for wide-ranging tasks

The third-generation 3D matching function permits the rapid development of so-called »bin-picking« and other typical robot functions. This matching system finds objects on the basis of a CAD model with the same efficiency and robustness as

shape-based matching. The CAD models are transferred in DXF format. To identify an object on the basis of its CAD model in any feasible 3D position, the software needs only a single image and, consequently, only a single camera (Figure 2).

Another innovation lies in the determination of the position and orientation of rectangular objects in any arbitrary 3D position, similar to the established process of determining the 3D position and orientation of circles (Figure 3).

Three-dimensional camera calibration is available for both matrix and line scan cameras (Title picture). This function can be used in any situation where line scan cameras are employed for inspection purposes in production operations, e.g. the automotive, printing, semiconductor manufacturing and food and drinks industries, timber processing and every other industrial operation involving production lines and conveyor belts. Its advantage is that both external and internal camera parameters can be reliably determined. Image (pixel) coordinates are transmitted in the form of world coordinates, making it possible to undertake measurements in subpixels to an accuracy of 1 μm in a field of view of 10 mm. This considerably simplifies robot control and referencing. Calibration is an essential prerequisite for high precision, adaptable measuring purposes.

In industry, it is often necessary to locate an object for the identification of an entire assembly and to align this assembly in accordance with the position of this object (a technique known as alignment). The technique is in widespread use as a 2D process. The position of an assembly, e.g. an electronic circuit board, can be precisely oriented in accordance with known lettering on an integrated circuit. Halcon 8.0 now offers the possibility of identifying the position, relative to the camera, of an assembly such as a cylinder block, using 3D

matching (pose estimation). If the position is known, the actual measuring task, e.g. an inspection, can be performed.

Halcon also carries out stereo measurements. For stereo vision, two cameras are needed. Special algorithms formulate disparity and distance images reliably and in the minimum of time. In this way, high precision measurements can be carried out. Another method of making three-dimensional measurements is the »depth from focus« process. In this case, the blurring of a »target« object is used to precisely determine its distance relative to the camera.

Object identification and OCR

Halcon even matches objects which are partially located outside the image. In addition, shape-based matching now also offers the possibility of identifying objects in images with differently scaled coordinate axes. Shape-based matching can also be achieved in color and other multi-channel images (images with an unlimited number of channels, Figure 4). Moreover, images from cameras with 8 to 16 bit gray-scale depth, such as X-ray images, can be processed in this way. For correlation-based matching with normalized cross correlation (NCC), nine new operators are available with translation and rotation matching. This gray-scale-based matching system compensates not only for gray-scale variations but it is also resistant to textures, blurring, and deformations.

An alternative to multi-layer perceptron (MLP) technology is offered by »support vector machines« (SVMs) for classification purposes. These SVMs serve either as general classifiers for objects or for image information. In addition, Halcon 8.0 features an SVM front end, which not only permits faster training than is possible with MLP but also offers a slight im- ▶

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► **provement in quality.** The new gradient characteristic of OCR, in conjunction with the SVM classifier, reduces the failure rate for common image sequences to well below 1 percent. The syntactic, lexicon-based autocorrection feature significantly increases the identification rate of OCR (**Figure 5**).

In training, an expanded variation model reduces the required data storage capacity by 12 percent, thereby leading to a marked increase in speed. In addition, it is now possible to directly specify the ideal image and the variation image, which again saves storage capacity. A new method for the determination of the optical flux, the so-called multi grate (**Figure 6**), delivers excellent results for applications in security and monitoring techniques, and even in quality control.

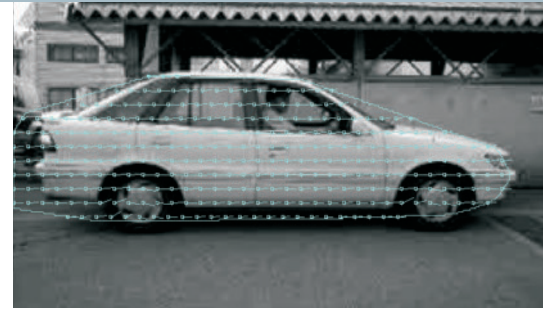
The barcode reader with improved algorithms is now more robust. In some cases, the interfaces to the image feeder devices have been replaced and augmented, with the result that also in the future the software will continue to be independent of the hardware.



5 Innovations in the software improve the OCR identification rate

Summary: 3D vision is the future

Thanks to an improved user interface and the introduction of assistants, machine vision functions can be carried out both faster and more easily with the Halcon 8.0 software library. With over 1300 operators and countless solutions for three-dimensional applications, this standard software renders specialized solutions superfluous. The user can work faster and, thanks to the software, less time is needed for computations. The underlying reasons for this are improved data storage manage-



6 Halcon offers methods for the segmenting of image sequences, such as the optical flux

ment and more efficient internal parallel processing.

The 3D matching is based on the data of the CAD model and requires only a single camera. Through the 3D camera calibration for line scan and matrix cameras, the camera parameters can be reliably determined. Even 3D alignment, stereo measurement, object identification and the OCR function have been significantly improved.

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