When employing image processing systems in the industrial field, the resolution and with it the accuracy are often discussed. At first glance, there seems to be an analogous connection between the number of picture elements (pixels) of the camera and the accuracy, with which the object is assessed: the higher the resolution, the higher the accuracy of the results compared to the real object. This article’s purpose is to clarify the measuring – and consequently also the inspection and recognition – with image processing systems.

**Resolution of Image Processing Systems**

The industrial cameras available nowadays are equipped with sensors of a resolution matrix of at least 640 x 480 pixels. Illustration 1 shows the schematic structure of a CCD sensor; the local resolution is determined by multiplying the number of pixels in the x and y directions.

The electrical signal obtained from the sensor chip is an image of the light quantity of the individual pixels. This analog signal is digitized and saved, and with that represents the measured variable, which is being processed by the image processing software. In the image processing system, A/D converters and frame buffers are matched in their dimensions to the number of pixels and associated brightness values, which are predetermined by the sensor chip.

In the image processing system, measurements are performed between edges, i.e. transitions from dark to light pixels or vice versa. By quantizing the quantity of light in the pixels and defining a brightness threshold value, this edge between two pixels can be found.

It does not always make sense to strive for the highest possible measuring accuracy, since with increasing performance, the devices not only become more expensive, but also more susceptible to malfunctions and — on top of everything — require greater precision during the setup.

**Measurement with Image Processing Systems**

By *measuring*, one understands the numerical acquisition of physical variables, whose knowledge – for example – is important when operating machinery and plants. Measuring means to *compare* the examined variable with a *benchmark*. The *measuring system* is the totality of all components, with which a *measuring method* based on a *measuring principle* is being realized. In the case of the image processing, this also includes the object provisioning, the lighting, the optics, the camera and finally the computer with its storage devices and the programmed algorithm for the digital measuring.

When measuring digitally, only discrete values of the measured variable in coarser or finer gradations can be represented. Since the measured variables can fluctuate constantly, they have to be quantized, i.e. divided into steps. In doing so, the accuracy depends on the fineness of the quantization steps, which - with the corresponding effort - can be pushed as far as desired.

Also relevant for the measuring accuracy, however, are the physical influencing variables, which affect the linking of the input variable and output variable. These can be temperature, position, vibrations, interference fields, supply voltage and many other things.

On the one hand, the achievable measuring accuracy depends on the camera system used, on the other, on the setup and the careful handling of the entire measuring system.
Since the brightness is typically defined with 256 values, the difference of the values between the two pixels can be broken down further. This is referred to as the sub-pixel resolution of the image processing system, which, from a computational standpoint, can be continued indefinitely.

However, with signal noise and weak edge transitions, the computed result will vary greatly and furthermore be affected by the above mentioned influencing variables. Location changes that are connected with the object position, test equipment vibrations, ambient and operating temperatures as well as interference fields (among other things, created by peaks in the supply voltage) are responsible for the fluctuations of the results. For this reason, the result can – in practice – only be utilized up to the first decimal point.

**Accuracy of Image Processing Systems**

In mathematics, accuracy describes the degree of approximation, up to which a number variable is stated. Alternatively, the term exactness (derived from latin term *exigere* = to weigh) can be used as well.

In measuring technology, a measurement possesses a degree of accuracy in relation to the real measured variable, which - however - can never be hit 100%. With multiple measurements, the degree of accuracy can be increased by employing probability. Consequently, the accuracy is the error, with which each measured value is tainted.

In geometry, accuracy is the degree of congruence between the drawing and the object represented by it.

How accurate is then a measured value obtained from a camera picture compared to reality?

The geometry of the image of the workpiece by the camera is a critical factor. The aberrations resulting from the lens can be disregarded, if either an exact adjustment or a calibration of the measuring system is performed and an image processing system of corresponding quality is used.

In this case, the image processing returns a result with an accuracy commensurate to the sub-pixel resolution, whose reproducibility can be deduced from the frequency of occurrences lying within the expected accuracy. Taking the necessary care during the setup and handling of the measuring system also ensures that the results supplied by the image processing system will be reproducible. Therefore, the verification of the measuring equipment capability can easily be furnished by the user.

**Practical application of Image Processing Systems for measuring, inspection and recognition of objects**

The following measures are options to keep the costs for the process-safe operation of an image processing system within reasonable limits:

- Selection of the system components according to the accuracy requirements of the task
- Guaranteeing of the reproducible imaging of the part via suitable optics and lighting
- Sturdy mounting of the cameras and lighting and blocking of extraneous light
- Interference-proof cabling of the system components (among each other)
- Reliable transporting, triggering and positioning of the objects within the measuring system
- Creation of references within the image or to calibratable reference points in the plant
- Multiple measurements and averaging of the results
- Output of the results to the automation system via an industrial interface

In conclusion, it can be stressed that plants with image processing – created taking into consideration the abovementioned points – have satisfied their users with regard to accuracy and stability over decades and have achieved operating efficiency within a very short timeframe.

Further information on image processing systems

[www.siemens.com/simatic-sensors/mv](http://www.siemens.com/simatic-sensors/mv)

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