A New Telecentric Level

Telecentric Lenses and Complementary Software Make Measurement Systems Very Compact

While telecentric lenses are usually bulky, various industries have clear space constraints for their measurement systems. A newly designed combination of lenses and software for large fields of view masters the challenge.

With the advent and diffusion of the Industry 4.0 trend, automation is spreading in every manufacturing field and machine vision, in particular, is becoming more and more pervasive. The packaging sector is no exception as testified by an increasing number of tasks that are nowadays solved by automatic inspection and analysis, such as barcode reading, defect or scratch detection or gauging applications, in general.

Large Object Measurement

Speaking about the latter, for measurement applications telecentric lenses are commonly employed because of their characteristics of low distortion, fixed magnification and big depth of field. On the other hand, however, because of their design they result quite bulky in comparison to entocentric lenses – and this is a major problem, especially when large objects are imaged, something quite common in the packaging industry that must deal with almost every dimension of samples. In order to overcome this limitation, Opto Engineering designed the new Core Plus family of ultra-compact telecentric lenses and illuminators for large Fields of View (FOVs). Not only in order to exploit the full potential of the new lenses they also designed a dedicated software called TCLIB Suite that aims to take telecentric vision systems to a new level.

New Opto-Mechanical Design

The length and working distance of a telecentric lens strongly impacts the size of a vision system. This is especially critical when a large FOV telecentric lens is used with a telecentric illuminator as the overall system dimensions are doubled. The Core Plus series are large FOV telecentric lenses for area scan cameras and collimated illuminators with a novel opto-mechanical design that is ideal to measure large objects in a reduced space.

Both the working distance and the mechanical length of the lenses and illuminators have been optimized to make a measurement system as compact as possible: compared to any other telecentric lens and illuminator of similar FoV, the new lenses are up to 45% shorter.

A complete, large FoV telecentric system (lens + telecentric backlight) takes an important amount of space, considering that the front element of both the lens and the illuminator must be at least as big as the FoV. Therefore, with a standard design, the mechanical length of the lens/ illuminator is typically that of half the front element itself. The new lens series brings this back to an almost 1:1 ratio and the design, combined with the use of light materials, saves a lot on weight as well: up to 50% for the largest model.

The Core Plus technology combines a non-standard optical design with a very new way of using curved optical mirror elements.

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TC Core Plus Series

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	Mag. (x)	1/1.8" sensor FOV (mm x mm)	WD (mm)	Lens length (mm)	Overall system height (mm)
TC12192	0.033	216 x 162	527	602	1129
TCCP12192	0.033	216 x 162	336	345	681
With CORE PLUS telecentric lens you save:	- -	- -	**191 (36%)**	**257 (43%)**	**448 (40%)**

TCCP12192 provides a 216mm x 162mm FOV with a 1/1.8" sensor (same as TC12192). Being 257mm smaller and having a 191mm shorter working distance, it allows you to save almost 450mm.

These two elements provide a mechanical length of the optics that is almost impossible to reach with traditional optical solutions. In comparison to Opto Engineering´s standard series the working distance was also reduced, allowing for even larger space saving. Moreover, the lenses feature a built-in mounting flange and standard aluminum T-slot profiles for easy mounting without additional clamps, making their integration easy and cost-effective.

Typical applications include, but are not limited to, measurement and/or inspection of large mechanical parts, bottles and vials, microplates, multiple parts in contemporary, glasses and batteries of smartphones.

Complementary Software Suite

Tclib Suite is a C++ based computer vision software designed to optimize the optical performances of a telecentric setup, typically used for measurement purposes. The use of both a .dll library and dedicated stand-alone tools makes it easy to take care of all aspects of a typical telecentric setup (focusing, alignments, distortion calibration) which, if not properly addressed, can negatively affect the results of measurements.

The software suite helps to improve the quality of the system, providing the best possible images for the chosen metrology software in order to obtain the best achievable measurement results. In fact, any edge detection, pattern matching, and calibration software will be more accurate and reliable if based on well-aligned, homogeneously backlit, undistorted images.

Tclib includes:

- dedicated tools to take care of the basics of a measurement system setup: alignment of telecentric lens and collimated light, alignment of the object plane, best focus (Tclip-App);
- a set of algorithms (C++ library) to calculate the distortion map of a system and correct in live mode every new image acquired by the system, plus all the functions developed in the app.

The stand-alone tools and the distortion calibration functions are used offline when the initial optimization and calibration of the machine is required. The distortion correction, on the other hand, is based on fast and reliable algorithms which allow the system to stream adjusted images in live mode.

The detailed functionalities of the graphical tools in the app are:

Aligning of Lens and Collimated Light Source

This tool assists the operator in achieving the most homogeneous illumination possible. Getting the best homogeneity of the illumination is the first fundamental step for a good measurement system, since this spec affects the reliability of any set of edge detection algorithms. The tool works in live mode, giving a visual feedback on the alignment. The FOV is divided in ROIs, each one having a color feedback regarding the alignment

Aligning the Object Plane

A good alignment of the object plane with the optical axis is essential. There are two main consequences of misalignment: In a backlighting condition we are looking at the object projection, not at its actual profile, hence the image might be affected by some compressions along certain directions. Also, some features might not be in the best focus at the same time, thus compromising the quality of the edge for the measurement.

Best Focus Tool

This tool gives a numeric index for every image, indicating the proximity to the best focus. It's based on two main algorithms, allowing the user to choose depending on the object features under inspection.

One of the most innovative tools in the library is the distortion correction function. This tool allows to eliminate the residual optical distortion from the telecentric lens – this value must be as close to zero as possible to achieve optimum results. From a single picture of a chessboard pattern covering the whole FoV (such as the Opto Engineering PT series), we receive all the information necessary to get rid of distortion.

The procedure is as follows:

- a single image of the calibration pattern is acquired (offline);
- from the picture a distortion map is created (offline);
- the distortion map is saved on a reference file;
- the distortion is eliminated on every new image acquired, recalling the saved distortion map (online).

Steps 1 and 2 are needed to calibrate the system, hence they have to be carried out only once. Step 4 is repeated on every new image acquired. All of the functions are integrated in the library .dll file and in a demo stand-alone software. The demo application can be used for test purposes or to obtain the distortion map, whereas for the actual online correction the integration of the .dll file is recommended. ■

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