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Editorial

Image sensors and cameras

When we look around us these days, there are cameras wherever you look: at home, on the street, at your office, in factories and even in your car.

The development of modern (video) cameras goes back to the 1950s when the first commercial television broadcasts started. Images were acquired using cathode ray tubes and processing was still analog using vacuum tubes. Cameras in the early days were therefore large, heavy, and expensive and had only limited resolution and sensitivity.

Advances in semiconductor technology and more particular the invention of silicon-based integrated circuits made it not only possible to reduce size and power of the circuits needed for processing of the video signal, but also provided a method to make solid state image sensors: a photodiode made out of silicon can convert photons in 350–1000 nm range into electrons and is therefore suited for imaging in the visible and near infrared range. Although this principle is simple, making image sensors with sufficient resolution and speed was not easy.

The first CCD (charge coupled device) image sensor was brought to the market in 1974 by RCA and had a resolution of 320 by 512 pixels. It took almost another decade until the first commercial CCD cameras became available – Sony launched their first CCD camera in 1983. Though there are applications where CCD image sensors are still to be preferred, complementary metal-oxide-semiconductor (CMOS) image sensors are taking over most markets.

CMOS technology has the advantage that is already in use for manufacturing of digital devices such as microprocessors and memories. Image sensors produced in CMOS technology therefore benefit from the developments that are taking place for the consumer markets. Also, it is possible to integrate more functionality on the same chip such as analog to digital conversion and digital image processing.

It took until the early 1990s until the first CMOS image sensors became available that was using a so-called active pixel array, but many innovations had to follow before the image quality could compete with CCD technology. For this reason the success of CMOS sensors started in applications that could benefit from the advantages of CMOS technology (small size, low power, low costs) and were willing to accept a lower image quality. Examples are cameras in cell phones and webcams.

Today's CMOS image sensors have an excellent image quality and can compete with CCDs in most applications.

This issue of *Advanced Optical Technologies* focusses on image sensors and cameras. We present a selection of papers that cover state-of-the-art imaging technologies for several applications.

The topical part of the issue starts with a tutorial 'Camera-based driver assistance systems' about the technology behind driver assistance systems and the most significant functionalities. This addresses the critical points bearing in mind when these systems are introduced in cars worldwide and the benefits in terms of safety.

Next follows a tutorial about various interfaces on today's digital cameras that are used in Machine Vision applications. It explains the many interfaces in use today, each with their own specific advantages and disadvantages, and gives an overview of the digital interfaces that were developed in the past 15 years and is intended to help with the selection of the best interface depending on the requirements of each application.

Camera systems play an important role in today's industrial safety systems – for example, they monitor an area around an industrial robot to ensure against collisions with obstacles or even humans. The article 'High dynamic range CMOS imagers for safety systems' describes two novel high dynamic range CMOS imagers with a logarithmic response and a stereo camera system for safe 3D zone monitoring.

Instead of using an image sensor with a logarithmic or piecewise linear response, one can also make high dynamic range images by combining several images with different exposures. For applications where an accurate color reproduction is very important, the article 'Color sensitivity of the multi-Exposure HDR imaging' studies the color accuracy of images that are acquired using the multi-exposure HDR technique.

Smart cameras are gaining popularity and are the topic of the next article. Traditional vision systems consist of many components like illumination, optics, camera, PC and software. Smart cameras combine all these parts in one module. Where standard cameras output image data, smart cameras output higher-level data like the number of products, positions, dimensions or simply accept/reject.

In 'Eight considerations when evaluating a smart camera' it is shown what are the important factors to consider when selecting a smart camera.

As we wrote earlier in this editorial, modern CMOS imagers can compete with sensors based in CCD technology. The article 'Global shutter pixels with correlated double sampling for CMOS imagers' is a proof of this statement. The author describes a CMOS sensor architecture that combines a very good global shutter with a low read noise level – a combination that was until recently only found in CCD imagers.

Finally, we as guest editors of the issue would like to thank the *AOT* team and all the authors for their cooperation.

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