SPECTRAL IMAGING FOR REAL-TIME IMAGING APPLICATIONS

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Guest Editorial

At the time when this journal was conceived, achieving real-time imaging was permissible mostly through hard-wired solutions that filled racks full of electronics. Storage capacity on discs or main memory was limited as well as computing power or data transmission bandwidth. Limits everywhere! Although expensive dedicated hardware allowed achieving real-time performance, off-the-shelf hardware was just sufficient for processing of binary or grey-value pixel data – of course only meeting real-time requirements when the algorithms were not too complex. Colour image processing was another luxury exception primarily used for representation purposes but not for real-time inspection in industrial environments. Image sequences could mostly be processed either by off-line or in-line processing but far off the video rate of standard cameras. Also, multi-band spectral data processing was reserved for very few applications such as remote sensing or military

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surveillance applications that enjoyed having considerable defense or space project budgets – more of a dream for industrial applications.

Today, one decade later it seems that all limits have been broken: memory, bandwidth, processing power and – miniaturization. Hardware compressed to the size of a notebook or within a small embedded smart camera is moving towards becoming standard in the next few years. Spectral imaging, formerly a dream due to limited industrial automation budgets, is just starting to become mature to allow real-time performance in industrial environments where the ratio of price and user benefit poses the prime constraint. This possibility has been mostly enabled by the improvements in computer technology but also because of developments in novel optical equipment such as Specim's ImSpector*. This dispersive optical component uses a prism-grating-prism (PGP) element that splits the light into its spectral bands. C-mounted between lens and CCD-camera, this set-up generates a spectrophotometer that delivers a new dimension in contact-free inspection techniques beyond simple visual analysis. In addition to spatial features like form, size, position, orientation or surface properties such as texture supplementary spectral data can be exploited for analysing ingredients and chemical components, i.e. spectral imaging captures both spatial and spectral properties within the specimen. Unfortunately, this leads to an increase in the dimensionality of data!

Recording image data by an aforementioned set-up involving a CCD-array camera as a detector the optical lens projects object reflections as dispersed light via the PGP-device and the slit of the aperture onto the sensor grid. Spatial data parallel to the slit are registered along the x-axis of the detector array while the spectral bands of the dispersed light are recorded along the y-axis. Up to this stage of processing the resulting sensor system could be denoted as a line camera providing full

* ImSpector is a product of SPECIM, Spectral Imaging Oy Ltd., Oulu, Finland

spectral information in each pixel of its line, delivering the spatial and spectral coincidence simultaneously. Moving either the object with respect to the spectral imaging system setup or a spectral imaging system setup with respect to the object perpendicular to the slit allows to record the 2^{nd} spatial dimension over time into a 3^{rd} dimension of a data array (data cube). Data values represent spectral intensities as the 4^{th} dimension in this representation, considerably increasing the volume of data compared to conventional grey-value or colour-value image processing.

Of course, objects, illumination, and sensors have to be selected carefully for a particular spectral analysis and coherent calibration of the set-up and normalization of data demands particular adaptations to the task and environmental conditions. Classification of spectral data has to address the extra dimensional semantics of the feature space and has to deal with various problems dedicated to the physical character of the acquired data.

All the aforementioned aspects motivated the Authors of Real-Time Imaging's Special Issue on Spectral Imaging to contribute some interesting articles dealing with particular approaches to solve problems ranging from calibration, hardware and real-time complexity considerations for competing classification schemes, to particular recycling and agricultural applications. Classical colour image signal processing can also be subsumed by the field of spectral imaging. Consequently, this issue also contains an article where data recorded by conventional RGB cameras are filtered for removing impulse noise. Of course, the following articles can only spot some aspects of this new and emerging field of spectral imaging for real-time applications.

Particular thanks are given to both the Authors and the Referees, who all contributed to this special issue on spectral imaging. This issue was made possible due to the Workshop on Spectral Imaging,

April 2003 in Graz (Austria). I would also like to acknowledge the valuable management done by the administrative office of Elsevier.

Looking forward to have this special issue providing a first step towards this new field, I encourage other authors to submit papers to Real-Time Imaging focussing on the subject of spectral imaging as related to the scope of this journal.

Yours

Guest editor

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