DOI: 10.2352/ISSN.2470-1173.2016.7MOBMU-298

Digital Photonic Measurements for High Tech Strategy 2020

Paul-Gerald Dittrich, Dietrich Hofmann, SpectroNet c/o Technology and Innovation Park Jena GmbH, Jena, Thuringia/Germany

Abstract
Aim of the paper is to illustrate a paradigm shift in photonic measurements inaugurated by clustered mobile digital measurements with cloud-supported image processing for shapes, colors and spectra in visual (VIS) and non-visual ultraviolet (UV) as well as non-visual infrared (IR) ranges.

The Task
Recently, many labor forces are working for an increasingly number of technological processes, products and services

- to recognize normal and / or critical situations,
- to understand present measurement results and
- to apply, if appropriate, controlling and / or regulating measures for quality assurance.

It is known, that about 80% of subjectively identified situations are identified by the eyes and processed by the brains accompanied by experiences [1].

This is valid especially for photonic measurements of shapes, colors and spectra in industry, biology / medicine, agriculture / environmental protection and administration, as well as in security.

The employment of labor forces in technical systems is usually uncomfortable, unreliable and expensive. Therefore, it is desirable to replace the subjective assessment of situations with eyes, brains and experiences by objective measurements and quality controls of technological situations by technical means. This is especially true if mobile photonic measurements with digital image processing for shapes, colors and spectra are applicable for the re-oriented High Tech Strategy 2020 [2].

The Substantiation
The re-orientation of the High Tech Strategy 2020 focuses on the following core elements:

1. Value creation and quality of life
2. Networking and transfer
3. Innovation dynamics in business
4. Innovation-friendly environment
5. Transparency and participation.

For sustainable implementation of the core elements of the re-oriented High-Tech Strategy 2020, it is necessary to design clustered mobile digital photonic shape, color and spectral vision systems with digital image processing and to implement their sustained applications.

The Implementation
Sub target mobile digital measuring
The mobile digitalization of vision and comprehension with photonic micro sensors and digital image processing for measurement engineering and quality assurance will evolve into a new key-technology with outstanding importance for employment, labor productivity and competitiveness in the digital society. This enables industry biology / medicine, agriculture / environmental protection and business administration as well as security to be equipped with technological intelligence.

Sub target mobile digital cross-clustering
The mobile digital cross-clustering of businesses, research institutions and technical equipment results in a paradigm shift. Tasks, which previously had been resolved by labor forces with visual inspections and manual actions can be resolved in future ubiquitously by machines. These measures are increasing labor productivity and economic growth.

Sub target mobile digital globalization
The continuing global collaboration is a fundamental enabler in the development of the labor productivity. Mobile digital photonic measurement engineering and quality assurance and mobile digital cross-clustering facilitate the globalization in digital societies.

The Measures
For the implementation of the above-mentioned sub targets the following measures are necessary:

- all-embracing miniaturization and modularization in the digitalization of photonic measurements
- replacement of conventional lamps by energy-saving miniaturized LEDs and OLEDs,
- replacement of conventional compact sensors for photonic measurements by miniaturization & standardization of sensors for the united measurements of
  - single and multi-dimensional shapes
  - natural and technical colors as well as
  - multi, hyper-, ultra- and full spectra in the visible (VIS) and non-visible (UV, IR) ranges of electromagnetic waves,
- modularization and standardization of software tools for digital image processing to evaluate the measurement results of shapes, colors and spectra
- increasing the uniformity and accuracy of photonic measurements by metrological traceability of measurements to metrological standards,
- replacement of conventional stationary computers by mobile smart microcomputers,
- standardization of interfaces to increase the compatibility and flexibility of hardware and software modules for applications
- institutionalization of digitized collaboration structures,
- encouraging the creation of start-ups by digital guidance and consulting services,
- opening of potential foreign markets,
- harmonization of the structural and content fragmented nature of SMEs,
- permanent support of photonic innovation processes,

DOI: 10.2352/ISSN.2470-1173.2016.7MOBMU-298

- accelerated commercialization of research results through cross-clustering
- localized and mobilized digital education and training for learners, producers, distributors and users.

The presentation discussed selected details in the history of photonic measurements as well as recent and future developments of clustered mobile digital photonic measurements with

- lightings, modularized LED and OLED,
- micro sensors, for points and n-dimensional shapes, for RGB and XYZ colors as well as for multi, hyper, ultra and full spectra,
- smart microcomputers,
- cloud-supported modularized image processing software tools and with
- metrological standards.

Practical examples complement the theoretical considerations.

The following figures and table facilitate the comprehension of the messages (Figure 1 to Figure 6 and Table 1):

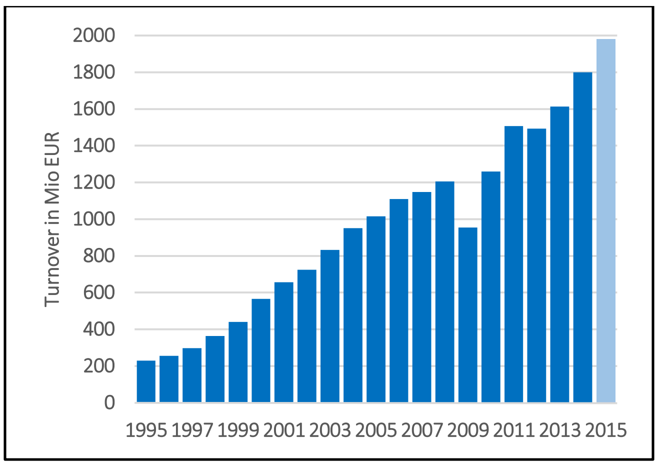

Figure 1. Economic development of digital image processing [3].

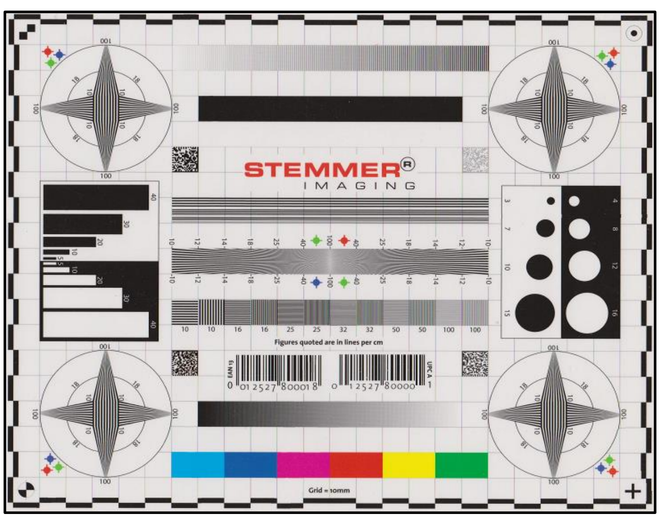

Figure 2. Metrological standards for shapes and colors [4],

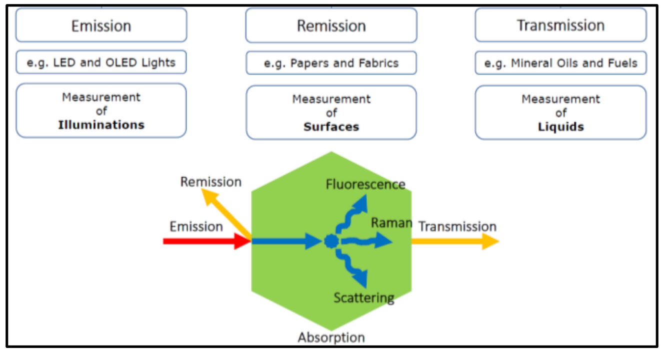

Figure 3. Photonic measurement methods [5],

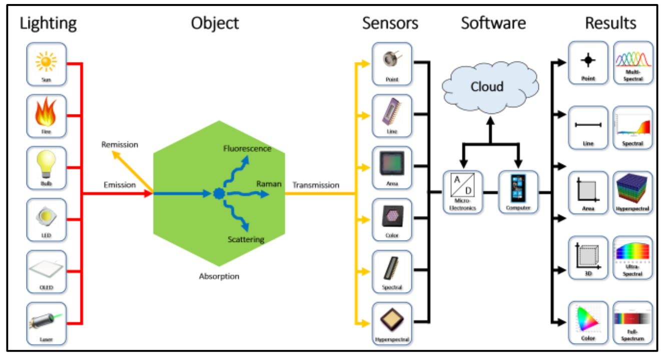

Figure 4. Photonic measurement systems [6],

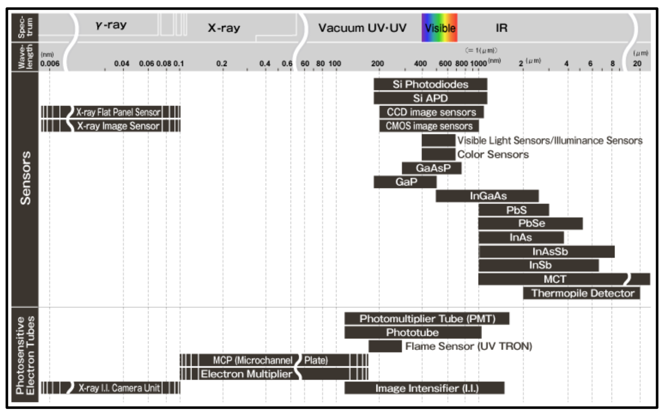

Figure 5. Selection of materials for photonic micro-sensors [7],

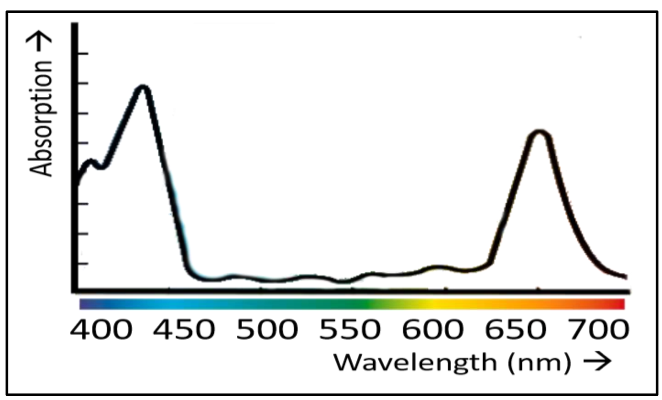

Figure 7. Absorption spectrum of chlorophyll in visible light [8],

Table 1. Current boundary conditions for image acquisition and image processing – modified in accordance to [9]

Mode	Number of Spectral Bands	Spectral Resolution	Capability	Availability
Imaging	None	None	Image brightness	Now
Multi-spectral	Few to tens	Low	Detects solids and liquids	Now
Hyper-spectral	Hundreds to ~thousands	Medium	Detects and identifies solids and liquids	Now
Ultra-spectral	Thousands	High	Detects and identifies solids, liquids and gases	Emerging technology but very expensive and processor hungry
Full spectrum	Thousands to "continuous spectra" over full optical spectral range from UV to IR	Very High	Detects and identifies solids, liquids and gases	Proposed technology and data processing system

References

[1] N. G. e. i. Z. m. d. Z. f. K. u. M. K. (. Gemeinnützigen Hertie-Stiftung, "Sehen – (k)ein selbstverständliches Wunder," [Online]. Available: https://www.dasgehirn.info/wahrnehmen/sehen/sehen-2013-k-ein-selbstverstaendliches-wunder. [Accessed 07 August 2015].

[2] B. f. B. u. F. (BMBF), „Die neue Hightech-Strategie - Innovationen für Deutschland," [Online]. Available: http://www.bmbf.de/pub_hts/HTS_Broschure_Web.pdf. [Zugriff am 3 August 2015].

[3] F. I. B. VDMA Fachverband Robotik + Automation, "SpectroNet - Video: The VDMA Market Survey: Machine Vision Approaching New Sales Record," 3 August 2015. [Online]. Available: http://spectronet.de/de/videos_2014/the-vdma-market-survey-machine-vision-approaching-_i3t6yji8.html.

[4] STEMMER IMAGING GmbH, "Handbuch der Bildverarbeitung | STEMMER IMAGING," [Online]. Available: http://www.stemmer-imaging.de/de/handbuch-der-bildverarbeitung/. [Accessed 7 August 2015].

[5] S. c. T.-. u. I. J. G. Prof. Dr. Dietrich Hofmann, "Easier Usability of Photonic Micro Sensors & Digital Image Processing by Consumerization," [Online]. Available: http://www.spectronet.de/portals/visqua/story_docs/intern_spectronet/vortraege/150317_21_collab_vortraege/150317_30_hofmann_spectronet.pdf. [Accessed 7 August 2015].

[6] M. P.-G. D. Prof. Dr. Dietrich Hofmann, "SpectroNet - International Collaboration Cluster," SpectroNet c/o Technologie- und Innovationspark Jena GmbH, [Online]. Available: http://www.spectronet.de. [Accessed 07 August 2015].

[7] Hamamatsu Photonics K.K. , "Optical Sensors Hub | Hamamatsu Photonics," Hamamatsu Photonics K.K., [Online]. Available: http://www.hamamatsu.com/us/en/community/optical_sensors/index.html?utm_source=ps&utm_medium=banner2A&utm_campaign=hc-osh. [Accessed 7 August 2015].

[8] H. Ebert, "Algen - "deep under" Zonierung und Anpasssung an das Lichtklima," [Online]. Available: http://www.gorgonien-lexikon.com/algen-deep-under-zonierung-und-anpasssung-an-das-lichtklima.html. [Accessed 7 August 2015].

[9] G. P. L. John R. Gilchrist and S. I. L. Timo Hyvärinen, "Hyperspectral Imaging Spectroscopy - A Look at Real-Life Applications," Laurin Publishing Company, Inc., [Online]. Available: http://www.photonics.com/EDU/Handbook.aspx?Tag=Imaging&AID=25139. [Accessed 7 August 2015].

Authors Biographies

Paul-Gerald Dittrich received his M.Eng from the Ernst-Abbe-University in Jena (2014). Since then he is working in the SpectroNet Division of the Technology and Innovation Park Jena GmbH and at the Technical University of Ilmenau at the Department of Quality Assurance and Industrial Image Processing.

Dietrich Hofmann received his Dipl-Ing in Scientific Instrumentation from the Technical University of Dresden (1959), his Dr.-Ing. from the Electrotechnical University of St. Petersburg (LETI) (1964), his Habilitation from the Technical University of Dresden (1969) and he was full Professor for Measurement Engineering at Friedrich-Schiller-University of Jena (1970-1993). From 1993 through 1998 he was Director of the Centre for Micro Sensors in Erfurt. Since 1998 he is Cluster Manager for Measurement Engineering and Quality Assurance in Jena.