

## Mobile Smart Specialization of Optodigital Shape, Color and Spectral Measurements in Industry, Biology and Medicine

D. Hofmann, P-G. Dittrich, E. Düntsch, D. Kraus, D. Görlich

SpectroNet c/o Technology- and innovation Park Jena GmbH, Jena, Germany,

Email: d.hofmann@spectronet.de

**Abstract.** Information specific topics in research and development, application and training are changing fairly quickly. The special task for researchers and developers as well as for users and trainers is to stay informed about new methods and technologies in their field of work. In the Internet there are many information sources for researchers and developers as well as for users and trainers. But it is difficult to find and filter the appropriate information anytime anywhere on demand. Smart factories and laboratories, the Internet of things and individualized medicine are on the way. Mobile smart optodigital measurements are essential links in their supply chains. Aim of the paper is to show that smart specialization is one method to increase the labour productivity in measurement theory and practice, education and training in the era of measurement 4.0. Practical examples are given for mobile smart optodigital shape, color and spectral measurements in industry, biology and medicine.

**Keywords:** Shape, Color, Spectral, Imaging, Industry, Biology, Medicine

### 1. Introduction

The computer market is changing. Miniaturization and mass production are in progress. The special advantages of smartphones and/or smartpads are their mobility and their multitouch user interfaces. Market leaders currently are Apple with iOS operation system and Google with Android operation system. Microsoft with Windows 8 operation system is a late follower (Fig. 1a). The innovative computers are equipped with consumerized interfaces for wired and/or wireless communications (Fig. 1b). Smartphones and/or smartpads are also equipped with powerful internal hardware apps for image acquisitions that are light sources, cameras, camcorders and scanners. Smartphones and smartpads are mobile because they are light weight and battery powered. In addition, the number, quality and diversity of external hardware apps for smartphones and/or smartpads are increasing. In the next chapters selected examples will be given for optodigital hardware apps and digital software apps which are applicable for industrial, biological and medical measurements as well as for scientific investigations or mobile education and training in measurements.



Fig. 1a Innovative mobile computers

	USB 2.0	USB 3.0	NFC	Bluetooth	WiFi	LTE
Transfer Rate	480 Mbit/s	2400 Mbit/s	0,424 Mbit/s	24 Mbit/s	600 Mbit/s	1000 Mbit/s
Range	5 m	4,5 m	4 cm	100 m	300 m	10 000 m
Wired	✓	✓	-	-	-	-
Wireless	-	-	✓	✓	✓	✓

Fig. 1b Innovative mobile interfaces

## 2. Mobile Optodigital Hardware Apps for Shape, Color and Spectral Measurements

In industrial, biological and medical measurements as well as in measurement science, measurement education and measurement training shape, color and spectrum are playing significant roles. Typical buzz words are microscopy, colormetry and spectrometry. Up to now it is usual to transfer the objects of interest for special investigations into laboratories. The fundamental reasons are the mass (weight) of the measuring instruments and their power supply. With smartphones and smartpads the situation can be changed enormously. Microscopes, colormeters and spectrometers with smartphones and smartpads can be directly applied in-field or at the point-of-care. Practical solutions for hardware apps are shown in the following figures (Fig. 2a, Fig. 2b, Fig. 2c, Fig. 2d). For easier use, the sources are indicated [1]. For biomedical measurements increasingly microfluidic components are used (Fig. 2e). Several practical examples have been compiled in the platform of the specialized international innovation cluster SpectroNet [2], [3], [4], [5].



Fig.2a Mobile optodigital scanner



Fig.2b Mobile optodigital microscope



Fig. 2c Mobile optodigital colormeter



Fig.2d Mobile optodigital spectrometer

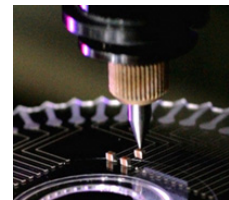


Fig.2e Mobile microfluidic module

## 3. Mobile Digital Software Apps for Shape, Color and Spectral Measurements

Smartphones and /or smart pads and cloud computing are unbeatable conditions for mobile software apps. These innovative conditions have never been existed before the year 2013 taking into account that most laboratory software packages are running under Microsoft Windows operation systems. It has been proved that multi-touch Windows 8 is in most cases downwards compatible. Practical solutions for software apps are shown in the following figures (Fig. 3a, Fig. 3b, Fig. 3c). For easier use, the sources are indicated [1].



Fig. 3a Software apps for shape measurements



Fig. 3b Software apps for color measurements



Fig. 3c Software apps for spectral measurements

## 4. Modularized Applications for Shape, Color and Spectral Measurements

In combination of the contents of chapter 1, 2 and 3 now the practical solutions for innovative mobile modularized hybrid measuring instruments can be shown (Fig. 4, Fig. 4b and Fig. 4c). A very special solution is the immunoassay (Fig. 4d) which has been explained in detail in source [1].



Fig. 4a Mobile smart shape measurements

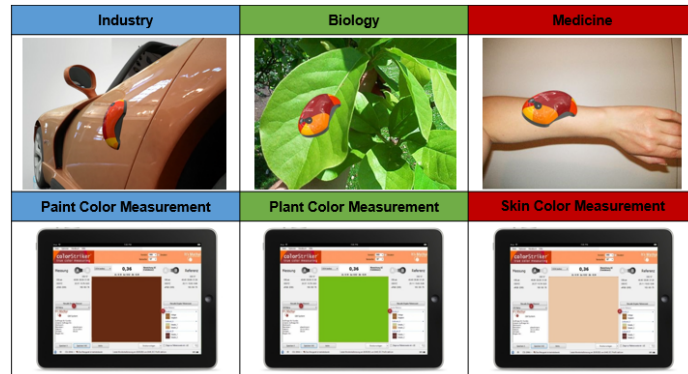


Fig. 4b Mobile smart color measurements

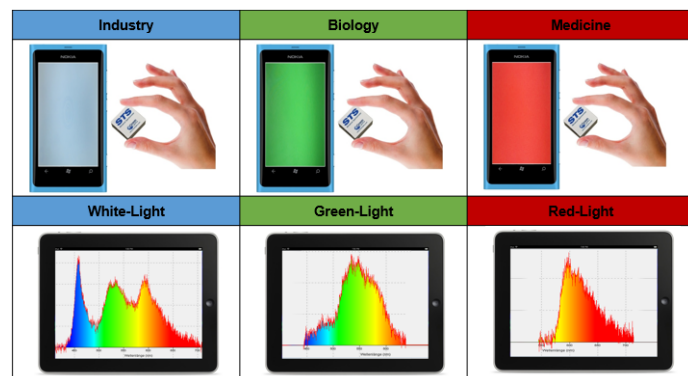


Fig. 4c Mobile smart spectral measurements

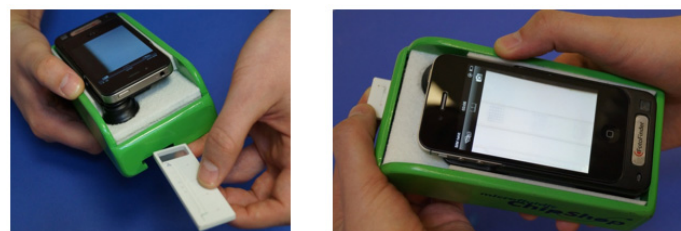


Fig. 4d Colorimetric immunological detection

## 5. Mobile Smart Education and Training for Shape Color and Spectral Measurements

In modern education and training are the actuality and applicability of the biggest challenges. Networking and web services are recommendable. For these purposes optodigital papers and presentations, trailers and videos in the field of shape, color and spectral measurements have been stored for open use in [www.spectronet.de](http://www.spectronet.de) (Fig. 5a). Supplementary optodigital channels with companies, experts and keywords in the fields of optodigital shape, color and spectral measurements have been elaborated (Fig. 5b and Fig. 5c) [6], [7], [8].

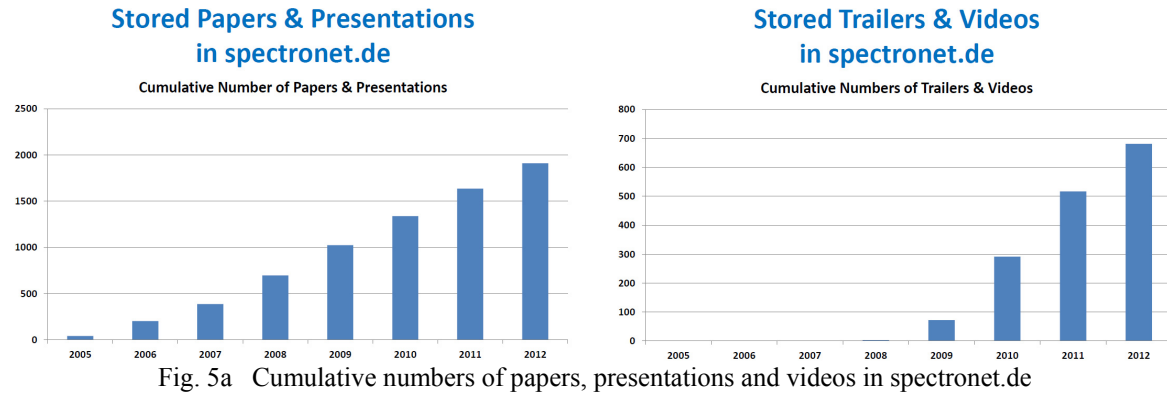


Fig. 5a Cumulative numbers of papers, presentations and videos in spectronet.de

**Unternehmen**

Hier finden Sie die Tag-List der Unternehmen in [www.spectronet.de](http://www.spectronet.de).

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

<p><b>A</b></p> <p>ABS Gesellschaft für Automatisierung, Bildverarbeitung und Software mbH <a href="http://www.abs-jena.de">www.abs-jena.de</a></p> <p>ADDITIVE Soft- und Hardware für Technik und Wissenschaft GmbH <a href="http://www.additive-net.de">www.additive-net.de</a></p> <p>Adopt Technology Inc. <a href="http://www.adopt.com">www.adopt.com</a></p> <p>AdiCash GmbH <a href="http://www.andasa.de">www.andasa.de</a></p> <p>Adimec Electronic Imaging Pte Ltd <a href="http://www.adimec.com">www.adimec.com</a></p> <p>Adobe Systems Inc. <a href="http://www.adobe.com/de">www.adobe.com/de</a></p> <p>Adobe Systems Romania SRL <a href="http://myadobe.ro">myadobe.ro</a></p>	<p><b>B</b></p> <p>BARCODAT GmbH <a href="http://www.barcod">www.barcod</a></p> <p>Basler AG <a href="http://www.basler">www.basler</a></p> <p>Batix Software GmbH <a href="http://www.batix.c">www.batix.c</a></p> <p>Baumer Inspection GmbH <a href="http://www.baume">www.baume</a></p> <p>Baumer Optronic GmbH <a href="http://www.baume">www.baume</a></p> <p>Bayerisches Cluster Sensorik <a href="http://www.sensor">www.sensor</a></p> <p>BEITEN BURKHARDT St. Petersburg <a href="http://www.bbblaw">www.bbblaw</a></p> <p>Benteler Maschinenbau GmbH <a href="http://www.bentel">www.bentel</a></p>
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A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

<p><b>A</b></p> <p>Aach, Til</p> <p>Abbondanzieri, Melanie</p> <p>Aderhold, Jochen</p> <p>Adolf, Stephanie</p> <p>Afanasyeva, Anna</p> <p>Aguilar, Juan José</p> <p>Ahlemeyer-Stubbe, Andrea</p> <p>Albrecht, Dirk</p>	<p><b>B</b></p> <p>Baartz, Friedrich - J.</p> <p>Babyuk, Irina</p> <p>Balke, Eric</p> <p>Balthasar, Dirk</p> <p>Banthen, Caspari, Markus</p> <p>Bargenda, Jörg</p> <p>Barthelmä, Frank</p> <p>Bas, Gökcen</p>	<p><b>C</b></p> <p>Canali, E. A.</p> <p>Cantner, Uwe</p> <p>Carey, Eric</p> <p>Carvalho, Caspari, Markus</p> <p>Chaberski, Chaoge, Wang</p> <p>Chazan, Pierre</p>	<p><b>D</b></p> <p>Dahms, Steffe</p> <p>Damhaut, Mar</p> <p>Davies, Anche</p> <p>Deblauwe, Deckwart, Ror</p> <p>DeLuca, Micha</p> <p>Demant, Chris</p> <p>Dengler, Fran</p>
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Fig. 5b Opt digital channels with companies and experts

Accessories Acquisition Biology Cabling Cameras Education & Training (E&T) Embedded Illuminations Industry Interfaces Marketing & Sales (M&S) Medicine Microscopes Optics Papers 2005 Papers 2006 Papers 2007 Papers 2008 Papers 2009 Papers 2010 Papers 2011 Papers 2012 Products & Services (P&S) Research & Development (R&D) Software Spectrometers Systems Videos 2009 Videos 2010 Videos 2011 Videos 2012 Videos 2013 Vision Sensors

Fig. 5c Optodigital channels with keywords in spectronet.de

## 6. Conclusions

Smartphones and Smart pads became global mass products with great convenience, high reliability and affordable prices. These market developments enable a paradigm shift in industrial, biological and medical measurements. With modular hardware apps and software apps new classes of hybrid measurement instruments can be created. Modular hardware apps and software apps are reducing development time, cost & risk. Smartphones & smart pads are revolutionary game changers in lifestyle and work style. Miniaturization & consumerization inspire each other with increasing speed. Field instrumentations will be based on re-invented laboratory instrumentations. First steps on innovative routes are already gone successfully. An interesting convergence of measurements in industry, biology and medicine can be expected.

## References

- [1] [http://spectronet.de/portals/visqua/story\\_docs/vortraege\\_2013/130202\\_photonics\\_west/130202\\_hofmann\\_spectronet.pdf](http://spectronet.de/portals/visqua/story_docs/vortraege_2013/130202_photonics_west/130202_hofmann_spectronet.pdf)
- [2] [http://spectronet.de/portals/visqua/story\\_docs/vortraege\\_2013/130202\\_photonics\\_west/130202\\_01\\_becker\\_mfcs.pdf](http://spectronet.de/portals/visqua/story_docs/vortraege_2013/130202_photonics_west/130202_01_becker_mfcs.pdf)
- [3] [http://spectronet.de/portals/visqua/story\\_docs/vortraege\\_2013/130202\\_photonics\\_west/130202\\_02\\_becker\\_mfcs.pdf](http://spectronet.de/portals/visqua/story_docs/vortraege_2013/130202_photonics_west/130202_02_becker_mfcs.pdf)
- [4] [http://spectronet.de/portals/visqua/story\\_docs/vortraege\\_2013/130202\\_photonics\\_west/130202\\_03\\_becker\\_mfcs.pdf](http://spectronet.de/portals/visqua/story_docs/vortraege_2013/130202_photonics_west/130202_03_becker_mfcs.pdf)
- [5] [http://spectronet.de/portals/visqua/story\\_docs/vortraege\\_2013/130202\\_photonics\\_west/130202\\_ozcan\\_ucla.pdf](http://spectronet.de/portals/visqua/story_docs/vortraege_2013/130202_photonics_west/130202_ozcan_ucla.pdf)
- [6] <http://spectronet.de/de/unternehmen/>
- [7] <http://spectronet.de/de/experten/>
- [8] <http://spectronet.de/de/keywords/>