GREEN MEASUREMENT EDUCATION AND TRAINING WITH MOBILE SMART COMPUTERS

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Abstract: The **measurement tasks** for industrial and nonindustrial applications over long periods are constant. The **measurement solutions** are changing with the applicable technologies. Currently the influence of innovative smart computers and cloud computing receives enormous proportions. Smart computers and cloud computing are also the enablers for innovative **measurement education and training**.

Aim of the paper is to describe selected success stories of the so far unlimited innovative capabilities of smartphones with cloud computing for selected tasks in measurement engineering, education and training.

Keywords: mobile measurement education, training and applications.

1. INTRODUCTION

The **measurement tasks** for industrial and nonindustrial applications over long periods are constant. The **measurement solutions** are changing with the applicable technologies. Currently the influence of innovative smart computers and cloud computing receives enormous proportions. Smart computers and cloud computing are the enablers of innovative **measurement education and training** procedures.

Aim of the paper is to describe selected success stories of the so far unlimited capabilities of smartphones with cloud computing for selected tasks in measurement engineering, education and training.

2. MEASUREMENT EDUCATION

In conventional education the courses and their contents are offered at schools, universities and academies. So far the learners went to the teachers. Smart computers and cloud computing are the enablers for a reverse direction.

2.1 From Seminars to Webinars

Seminars are usually fixed concerning teachers, places and times. Webinars are flexible concerning teachers, places and times. The learners can organize their studies with the contents by themselves anywhere and anytime on demand (Fig. 2.1-02).

Fig. 2.1-01 Seminar	Fig. 2.1-02 Webinar

2.2 From Paper Books to Smart Books

Since centuries printed paper books are the sources for reliable knowledge transfer. But innovative smart computer technologies reinvent the reading habits. It becomes more convenient and reliable and affordable to acquire the freshest knowledge from a smart book (Fig. 2.2-01 and Fig. 2.2-02).
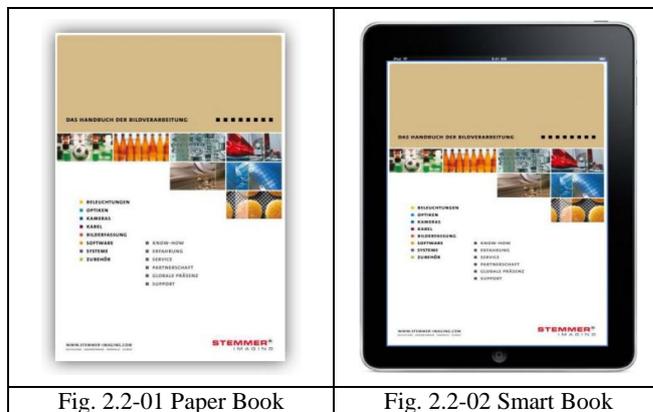

Fig. 2.2-01 Paper Book	Fig. 2.2-02 Smart Book

2.3 From Page Copies to Book Scans

Fundamental knowledge in paper books is valid for longer periods. To increase the individual flexibility it is usual to copy pages from paper books and work with it on demand. Now it is just as easy to copy a paper book and to turn it into a smart book (Fig. 2.3-01 and Fig. 2.3-02)
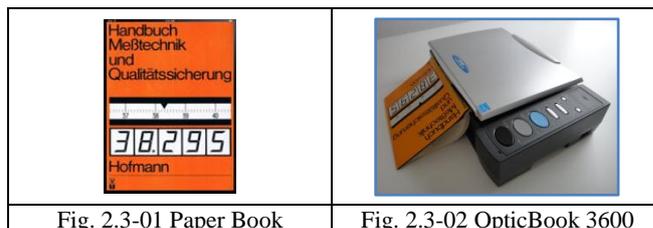

Fig. 2.3-01 Paper Book	Fig. 2.3-02 OpticBook 3600

2.4 From Page Files to Smart Books

Over centuries it was inconvenient and expensive to create a paper book with accumulated knowledge. Now are inexpensive software packages available to transfer page files directly into smart books (Fig. 2.4-01 and Fig. 2.4-02)
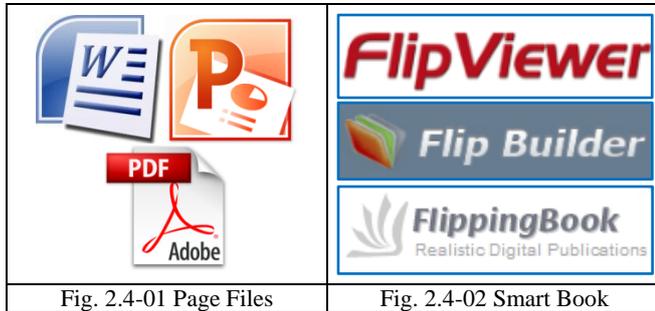

| Fig. 2.4-01 Page Files | Fig. 2.4-02 Smart Book |

2.5 From Images to Animations

Images say a thousand words. Animated images say much more. Therefore animated images in measurement education and training are very efficient. Paper books are generally unable for the animation of images. But smart books can (Fig. 2.5-01 and Fig. 2.5-02).
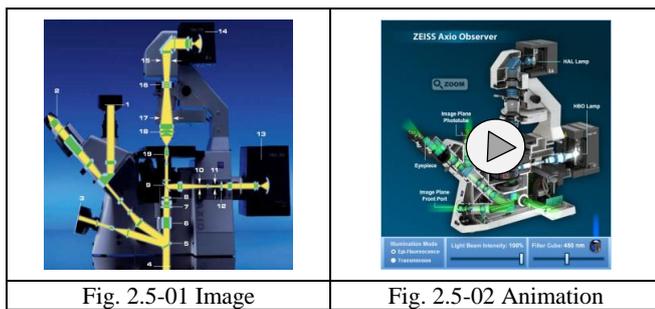

| Fig. 2.5-01 Image | Fig. 2.5-02 Animation |

2.6 From Black/White to Color

The information content of black/white images with grey scales is poor (up to 256 bit). The information content of color images is rich (up to 16 Mbit). Due to modern digital technologies it is simple and inexpensive to work with true color images (Fig. 2.6-01 and Fig. 2.6-02).
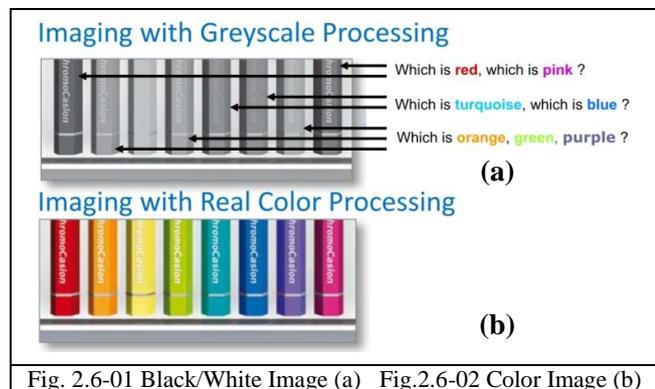

| Fig. 2.6-01 Black/White Image (a)   Fig.2.6-02 Color Image (b) |

2.7 From Paper Notes to Smart Notes

Over centuries it was usual to take a stylus to store information handwritten on a piece of paper. Innovative smart computers with note capabilities are the enabler for the direct conversion of handwritten notes into digital text

and to send edited text to Microsoft Word, to e-mail it or to save it as a picture file (Fig. 2.7-02).
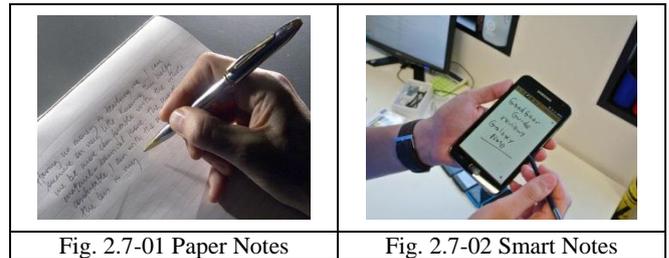

| Fig. 2.7-01 Paper Notes | Fig. 2.7-02 Smart Notes |

2.8 From Teaching to Self-Learning

People learn in different ways. That ought to be obvious, even from personal experience, yet it is usual to expect that all learners achieve a standard proficiency regardless of whether they hear a lecture, see a video, read a technical manual, or complete a m-learning module. But only 30% of adults say they learn best by listening; another 30% report they would prefer to learn by reading and reflection [2.8-01]. Smart books are excellent enablers for self-learning by reading and listening (Fig. 2.8-02).
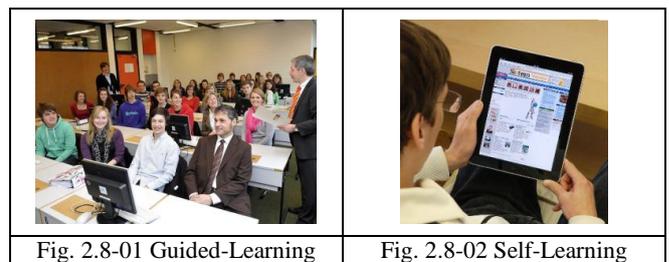

| Fig. 2.8-01 Guided-Learning | Fig. 2.8-02 Self-Learning |

3. MEASUREMENT TRAINING

Learning is often a gradual process that happens through a series of shaping activities, which are not always instructor initiated. This is sometimes called tacit learning. The coaching process recognizes this, and so do many hands-on courses where is expected that trainee skills will develop only over time and experience [3-01].

3.1 From Laboratory Work to Tele-Laboratory Work

Laboratories are stationary, expensive and not permanent opened. Tele-laboratories are organized as a collection of learning objects, i.e., modular didactic units designed following specific learning objectives within measurement engineering [3.1-01]. They are for the trainee flexible available, inexpensive and permanent open. The innovative technologies are changing the character of daily work for teachers and learners.
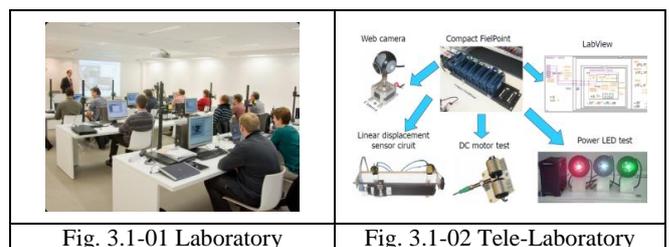

| Fig. 3.1-01 Laboratory | Fig. 3.1-02 Tele-Laboratory |

3.2 From Instrumentations to Simulators

A simulator is an imitation of a real instrument. Nowadays software simulators of hardware tools are playing the main role. Software simulators have the same graphical user interfaces like the original instruments. But the simulator is more convenient and more affordable especially for training purposes.



| Fig. 3.2-01 Instrument | Fig. 3.2-02 Simulator |
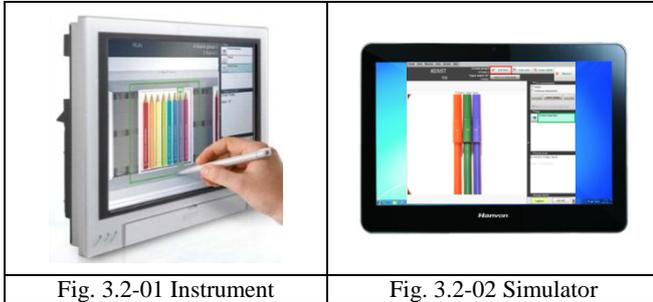
3.3 From Manuals to SSC-Instructions

Manuals are technical communication documents intended to give assistance to users to use for example measurement systems in the right way. Most manuals contain both a written guide and the associated images [3.3-01]. Practical experiences have shown that most real manuals are not directly usable as a guide to action. Therefore the so called see see & click manuals with simple and direct solution guarantee have been developed (Fig. 3.3-02).

| Fig. 3.3-01 Manuals | Fig. 3.3-02 SSC-Instruction |
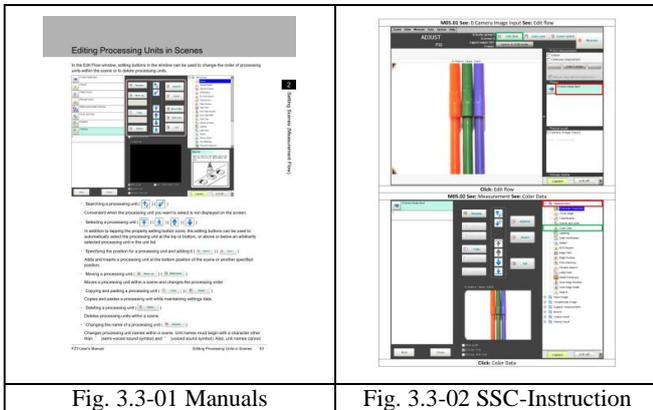
3.4 From Color Impressions to Measurements

Color impressions derive from the spectrum of light interacting in the eyes with spectral sensitivities of the human light receptors red, green and blue. For technical quality assurance the color measurements can be realized by color sensors and smartphones [3.4-01], (Fig. 3.4-02).

| Fig. 3.4-01 Color Inspection | Fig. 3.4-02 Color Measurement |
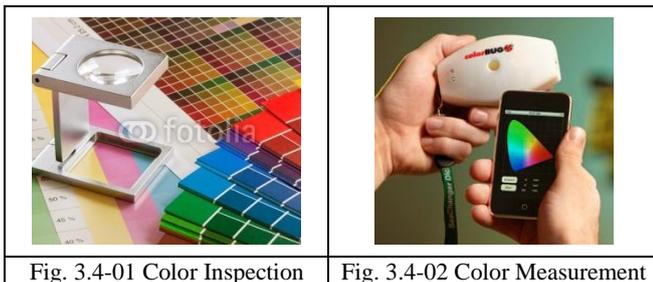
3.5 From Observation to Objectivation

Over centuries medical doctors for diagnostics had to rely on their eyes, their knowledge, and their memory only (Fig. 3.5-01). Now they got an innovative tool with smartphone to register what they have seen, to compare the results objectively over a longer period and to ask for a second opinion from a colleague over the internet (Fig. 3.5-02).

| Fig. 3.5-01 Observation | Fig. 3.5-02 Objectivation |
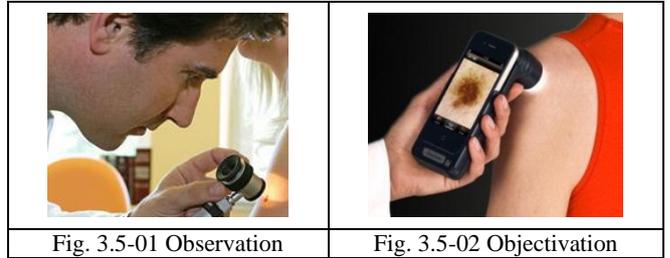
3.6 From Laboratory to In-Field Instrumentation

Over centuries analogue microscopes have been the fundamental equipment in industrial, biological, chemical and medical laboratories to investigate and measure objects with dimensions beyond the resolution of human eyes. The results have been dependent on the individual interpretation. The analogue microscopes have been stationary and expensive (Fig. 3.6-01). Innovative digital microscopes are convenient and affordable and have the advantages that images directly can be stored, processed and documented in smart computers (Fig. 3.6-02).

| Fig. 3.6-01 Analog Microscope | Fig. 3.6-02 Digital Microscope |

3.7 From Lab Training to Online Training

On complex topics people need to get comfortable, to "mess around" with the topic and the tools before they can understand it [3.7-01]. Self-training with appropriate digital tools (simulators, cloud computing, teleworking) is an innovative way for increased efficiency in acquisition of individual new knowledge and personal professional capabilities.

| Fig. 3.7-01 Training | Fig. 3.7-02 Online Training |

4. NEW MEASUREMENT APPLICATIONS

Consumer driven user behavior has enabled the usage of smartphones with cloud computing in education and training. Now new kinds of measurement hardware and software – based on small, mobile and linked devices also reinvent measurement applications in industry, biology and medicine.

Recently mobile measurement applications and solutions with smartphones and cloud computing are applicable for everyone. New kinds of measurement solutions are based on small, mobile and inter-connectable devices in industry, biology and medicine (Fig. 4.1-01, Fig 4.2-01 and Fig. 4.3-01).

4.1 Industrial Measurement Applications

New applications based on small, mobile and linked devices for industrial usage solve measurement applications in 2D and 3D imaging, in VIS light and body colors and also in IR and UV (Fig. 4.1-01). Special instrumentation for smart and mobile 3D imaging in industry has been elaborated by GFMesstechnik GmbH with MikroCAD^{lite} Portable.
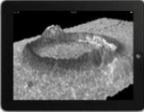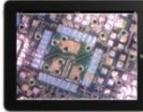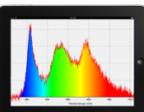
2D Imaging	3D Imaging	VIS Color Imaging
Micro Structure	Welding Point	Printed Board

VIS Spectral Imaging	Light-Color	Body-Color
White Light	White Light	Paint Color

IR Imaging	UV Imaging	Quality Assurance
Temp. Differences	Car Paint	Material Analysis

Fig. 4.1-01 Industrial Measurement Applications

4.2 Biological Measurement Applications

New applications based on small, mobile and linked devices for biological usage solve measurement applications in 2D and 3D imaging, in VIS light and body colors and also in IR and UV (Fig. 4.2-01). Special instrumentation for smart and mobile VIS spectral imaging in biology has been elaborated by Ocean Optics with STS spectrometers.

2D Imaging	3D Imaging	VIS Color Imaging
Daphne Fly	Leaf Surface	Stamens

VIS Spectral Imaging	Light-Color	Body-Color
Green-Light	Green-Light	Plant Color
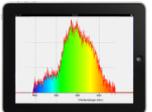
IR Imaging	UV Imaging	Quality Assurance
Temp. Differences	Flower Nectar	Leaf Analysis

Fig. 4.2-01 Biological Measurement Applications

4.3 Medical Measurement Applications

New applications based on small, mobile and linked devices for medical usage solve measurement applications in 2D and 3D Imaging, in VIS light and body colors and also in IR and UV (Fig. 4.3-01). Special instrumentation for smart and mobile IR imaging in medicine has been elaborated by FLIR with E-series infrared camera.

2D Imaging	3D Imaging	VIS Color Imaging
Skin Damage	Skin Structure	Inner Ear

VIS Spectral Imaging	Light-Color	Body-Color
Red-Light	Red-Light	Skin Color

IR Imaging	UV Imaging	Quality Assurance
Temp. Differences	Dental Prosthesis	Skin Analysis

Fig. 4.3-01 Medical Measurement Applications

5. FUTURE DEVELOPMENTS FOR EDUCATION AND TRAINING

5.1 From Storages to Clouds

Conventional data storages (Fig. 4.1-01) will be stepwise supplemented and replaced by cloud computing (Fig. 4.1-02).

Fig. 5.1-01 Storages	Fig. 5.1-02 Clouds

5.2 From Apps to Streams

Apps are thousands of smartphone applications for special purposes. They can be downloaded from markets. Streams in computing are understood as a sequence of data elements made available over time [5.2-01]. Conventional Apps will be stepwise supplemented and replaced by

streaming because it is more convenient, reliable and affordable (Fig. 5.2-02).

Fig. 5.2-01 Apps	Fig. 5.2-02 Streams

5.3 From Desktop to Smart Computer

Smart computer that means smartphones and smartpads are the key technologies for smart, mobile education and training anywhere, anytime and at anyplace on demand.

Fig. 5.3-01 Desktops	Fig. 5.3-02 Smart Computer

5.4 From Laboratory to In-Field

Education and training and also the applications in measurement engineering will be transformed from laboratory to in-field measurements.

Fig. 5.4-01 Laboratory	Fig. 5.2-02 In-Field

5.5 From SME to Networks

Small and medium enterprises SME are the dominant employers in the world. Their efficiency is limited by their size, equipment and equity. Innovative technologies like websites, tele-information and communication with flat rates, mobile smart computers and cloud computing are the enablers for nearly unlimited success stories of collaboration in socio-commercial competence networks. The most representative social network of today is facebook.

Fig. 5.5-01 SME members in www.spectonet.de	Fig. 5.5-02 Socio-commercial Network

6. CONCLUSIONS

Smart computers and cloud computing are changing our habits in work and life. Green technologies are reducing the consumption of matter, energy, information, capital and labour. That is also valid for measurement education and training as well as for measurement applications. Examples have been shown.

These examples follow simple roadmaps for value added and functionality in research & development, products & services and education and training. (Fig. 6-01 - Fig. 6-03)
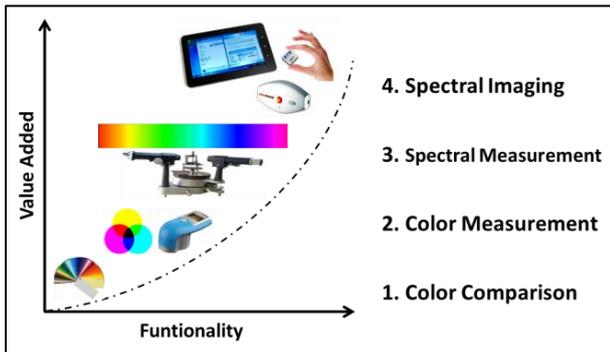

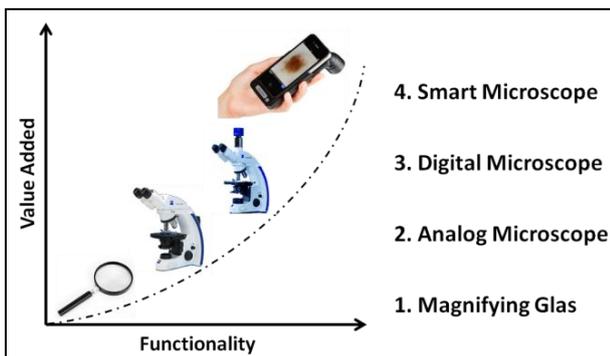Fig. 6-01 Research & Development Roadmap
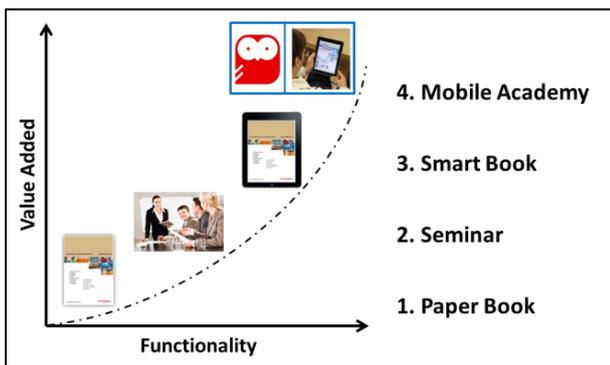

Fig. 6-02 Products & Services Roadmap

Fig. 6-03 Education & Training Roadmap

7. LINKS & SOURCES

Fig.	Link
Fig. 2.1-01	www.wdr.de/wissen/wdr_wissen/themen/naturwissenschaften/dossier_forscherland/img/exzellenzini_02_400q_wdr_dfg.jpg
Fig. 2.1-02	spectronet.de/portals/visqua/story_docs/intern_spectronet/vortraege/111214_12_collab_vortraege/111214_30_hofmann_spectronet.pdf
Fig. 2.2-01	www.boyn-heilbronn.de/uploads/pics/kopierer-develop-d191f-detail_01.jpg
Fig. 2.2-02	plustek.com/de/products/knowledge-office-series/opticbook-3600/introduction.html
Fig. 2.3-01	www.stemmer-imaging.de
Fig. 2.3-02	www.stemmer-imaging.de
Fig. 2.4-01	office.microsoft.com/de-de/word/	office.microsoft.com/de-de/powerpoint/	get.adobe.com/de/reader/
Fig. 2.4-02	www.flipviewer.de/	www.flipbuilder.com/	page-flip.com/
Fig. 2.5-01	www.zeiss.de/C1256D18002CC306/0/6D5EB650E88FDC60C12574C8003F5F3D/$file/60-2-0015_e.pdf
Fig. 2.5-02	zeiss-campus.magnet.fsu.edu/tutorials/basics/axioobserver/index.html
Fig. 2.6-01	spectronet.de/portals/visqua/story_docs/vortraege_2011/110929_farbworkshop_konstanz/110930_20_hofmann_spectronet.pdf
Fig. 2.7-01	static.guim.co.uk/sys-images/Guardian/About/General/2010/5/28/1275041643248/A-hand-writing-with-a-pen-006.jpg
Fig. 2.7-02	cdn.idg.com.au/gim/id/46913/res/5
Fig. 2.8-01	www.ngz-online.de/polopoly_fs/1.278302.1295012376!/httpImage/282124834.jpg_gen/derivatives/rpoPanorama_786/282124834.jpg
Fig. 2.8-02	4.bp.blogspot.com/_TAm9S4IMSGg/TO6BmlVRuhI/AAAAAAAAGK8/YAoLHh12IKU/s1600/ipad.jpg
Fig. 3.1-01	www.stemmer-imaging.de/de/service/schulungen
Fig. 3.1-02	spectronet.de/portals/visqua/story_docs/vortraege_2010/100901_imeko/100901_03_varadi_london.pdf
Fig. 3.2-01	spectronet.de/portals/visqua/story_docs/intern_spectronet/vortraege/111214_12_collab_vortraege/111214_30_hofmann_spectronet.pdf
Fig. 3.2-02	industrial.omron.de/de/products/catalogue/sensing/vision_sensors_and_systems/flexible_vision_systems/xpectia_fz3/xpectia_simulator.html
Fig. 3.3-01	downloads.industrial.omron.de/IAB/Products/Sensing/Vision%20Sensors%20and%20Systems/Flexible%20vision%20systems/Xpectia%20FZ3/Z290/Z290-E1-04.pdf
Fig. 3.3-02	spectronet.de/services/dienstleistungen/qualifizierung-training---steinbeis--transfe_gcarq6pi.html
Fig. 3.4-01	t1.ftcdn.net/jpg/00/23/17/20/400_F_23172047_xC5CNfzAj1usknev8lrtEamcuZzpYsSM.jpg
Fig. 3.4-02	halmapr.com/news/oceanoptics/files/2008/12/colorbug-release-blog.jpg
Fig. 3.5-01	www.apotheken-umschau.de/multimedia/103/242/172/16918659089.jpg
Fig. 3.5-02	www.handyscope.net/
Fig. 3.6-01	www.rochmicroscope.com/index_files/biologicalmicroscope.jpg
Fig. 3.6-02	www.dnt.de/index.php?dir=shop/item&pid=52092
Fig. 3.7-01	www.stemmer-imaging.de/de/service/schulungen
Fig. 3.7-02	www.powerpapers.com/images/photos/distance_learning.jpg
Fig. 4.1-01	spectronet.de/portals/visqua/story_docs/intern_spectronet/vortraege/120417_13_collab_vortraege/120417_25_hofmann_spectronet.pdf
Fig. 4.2-01	spectronet.de/portals/visqua/story_docs/intern_spectronet/vortraege/120417_13_collab_vortraege/120417_25_hofmann_spectronet.pdf
Fig. 4.3-01	spectronet.de/portals/visqua/story_docs/intern_spectronet/vortraege/120417_13_collab_vortraege/120417_25_hofmann_spectronet.pdf
Fig. 5.1-01	spectronet.de/portals/visqua/story_docs/intern_spectronet/vortraege/111214_12_collab_vortraege/111214_30_hofmann_spectronet.pdf
Fig. 5.1-02	spectronet.de/de/vortraege_bilder/vortraege_2011/10-spectronet-collaboration-forum-jena_gmsxpnic.html
Fig. 5.2-01	spectronet.de/de/vortraege_bilder/vortraege_2011/10-spectronet-collaboration-forum-jena_gmsxpnic.html
Fig. 5.2-02	spectronet.de/de/vortraege_bilder/vortraege_2011/10-spectronet-collaboration-forum-jena_gmsxpnic.html
Fig. 5.3-01	www.weltdertechnik.de/technik/hp-pavilion-elite-m9600-desktop-pc
Fig. 5.3-02	dsl.1und1.de/DetailsSmartPad
Fig. 5.4-01	www.pro-4-pro.com/de/Labor-Biotechnik/Company-14953/Extrem_scharfes_hochaufloesendes_DigitalMikroskop_VHX-600.html
Fig. 5.4-02	www.dnt.de/DigiMicro-Mobile.2.html
Fig. 5.5-01	http://spectronet.de
Fig. 5.5-02	http://spectronet.de
Fig. 6-01	spectronet.de/de/vortraege_bilder/vortraege_2012/13-spectronet-collaboration-forum-konstanz_h1aixec0.html
Fig. 6-02	spectronet.de/de/vortraege_bilder/vortraege_2012/13-spectronet-collaboration-forum-konstanz_h1aixec0.html
Fig. 6-03	spectronet.de/de/vortraege_bilder/vortraege_2012/13-spectronet-collaboration-forum-konstanz_h1aixec0.html