Color and Spectral Inspections with Smartphones

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Summary. The invitation to the 16th workshop for color image processing says, that the continuous recording, processing and analysis of color or multichannel images for years is becoming more important due to the improved technical capabilities of nanoelectronics and the increasing demands from research & industry, food & medicine, transport & environment, security & administration. Up to this year's workshop, the improved technology has been developed so fundamentally, that **smartphones** can be successful used for color and spectral inspections. In principle these are innovative solutions for old problems. Aim of the paper is to illustrate practical examples for color image processing and spectral imaging with smartphones and to demonstrate the convenience and simplicity of see & click operation instructions to overcome the acceptance threshold for complex measuring tasks.

1. Smartphone's sales and revenue

Smartphones are bulk commodity. Mobile Internet and touch screen operations have prevailed. The mobile nanocomputer became a personal companion in any pocket. With GHz processors and high-resolution cameras, smartphones became platforms for the solution of complex image processing algorithms in mobile use (**Fig. 01**) [01]

2. Direct objective determination of color characteristics

Due to physiological reasons the results of assessments of a colored object are different for various human inspectors. With modern smartphones, the color characteristics can be determined convenient, reliable and affordable in an objective manner (**Fig. 02**) [02]

3. Indirect objectified determination of color characteristics

In adverse conditions such as large objects, large object distances, more complex object access, etc., it may be convenient to accomplish an indirect objectification of color characteristics by subjective comparison with known displayed standards (**Fig. 03**) [03]

4. Object detection with different colored lights

Concerning quality assurance it is well known that different colored lights create different object detections. For this purpose, smartphones can be used as sources for different colored light (**Fig. 04**) [04]

5. Simplified reading of smartphones

The small size of smartphone screens are inconvenient for human perception. The screen of smartphones can be magnified by smartphone projectors (**Fig. 05**) [05]

6. Simplified programming of smartphones

To ease the tests concerning suitability and quality capability of modern smartphones for color measurement emulated simulators are helpful. In the shown example the operating system of Google Android smartphones is emulated by a Windows operating system on standard PC's, laptops or netbooks (**Fig. 06**) [06]

7. Simplified operating of smartphones

To overcome the acceptance threshold in use of smartphones for color imaging problems the so called See & Click operation manuals have been successful (**Fig. 07**) [07]

8. Simplified performing of statistical analysis

In many cases it is expected that the measurement results are evaluated and verified by statistical treatments. Even then modern smartphones are extremely powerful (**Fig. 08**) [08]

9. Simplified performing of mobile applications

Smartphones according to their original purpose are very well prepared for mobile use with the interfaces for WiFi, Bluetooth, infrared, GSM / (E) GPRS, UMTS / HSDPA, Edge. Through Internet and browsers, voice over IP and cloud computing the hitherto dominant linguistical communication can be extended without difficulty to written and graphic communication (**Fig. 09**) [09].

10. Qualification with scripts and books

For conventional qualification usually scripts and textbooks are used. The procurement of textbooks for training is simpler and cheaper with smartphones. Smartphones can be used as barcode reader to get a good bargain, to identify the nearest shop and to be led to the shop by the smartphone navigation system (**Fig. 10**) [10]

11. Qualification with touch screen and cloud computing

For modern qualification increasingly mobile on-demand solutions with touch screen and cloud computing are used. Practical examples are given in www.spectronet.de -> Akademie. (**Fig. 11**) [11]

12. Selected applications for smartphone color and spectral imaging

- HALCON embedded runs on the Nokia N900 mobile phone **[SYMBIAN]** (**Fig. 12a**) [12a]
- Qualification via mobile with WebEx smartphone applications **[RIM]** (**Fig. 12b**) [12b]
- Measurement news of IOP Science as iPhone application (**Fig. 12c**) [12c]
- Spectral imaging with color bug and iPod or iPhone **[IPHONE OS]**(**Fig. 12d**) [12d]
- Health Monitoring with HIT Ltd's mobile software (**Fig. 12e**) [12e]
- Fluorescent Imaging with smartphone at University of California, Berkeley (**Fig. 12f**) [12f]
- Office 2010 on Windows Smartphone **[WINDOWS PHONE 7]** (**Fig. 12g**) [12g]
- Barcode Reader Shop Savvy **[GOOGLE ANDROID]** (**Fig. 12h**) [12h]

13. Open technical issues

Recent realizations of application software for color image processing are focused on windows operation systems and designed for desktops, laptops and netbooks (**Fig. 13a**). Well established algorithms should also be adapted to hardware and operation systems of smartphones (**Fig. 13b**).

Summary & Conclusions

Modern smartphones can cope successfully with “bigger” microcomputers due to their increased technical capabilities in lighting, image recording, data processing and analysis for colored or multi-channel images. However, the best image-processing software packages for PCs are not yet applicable to smartphone operating systems. Smartphones should be considered much more by the image processing industry. Smartphones are convenient, reliable and affordable staple articles. Their application and business potential is almost unlimited.

Sources

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http://www.idc.com/getdoc.jsp?containerId=prUS22196610

[02] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

[03] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

[04] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

[05] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

[06] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

[07] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

[08] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

[09] http://spectronet.de/de/vortraege_bilder/vortraege_2010/7.-nemo-spectronet-collaboration-forum-nufringen_g8opk9bh.html

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[12b] http://www.webex.de/blackberry

[12c] http://iopscience.iop.org/info/page/latestnews

[12d] http://seachangeronline.com/html/colorbug.html

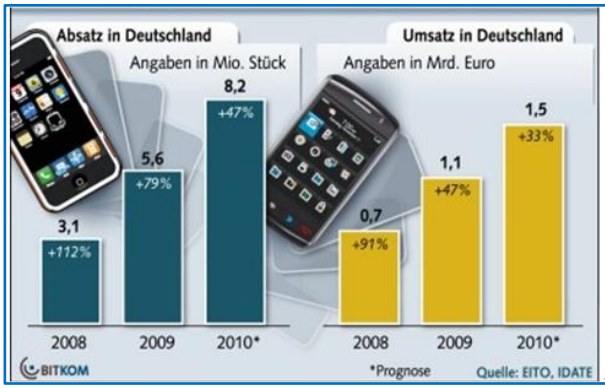
[12e] http://www.ehit.fi/index.jsp?pid=105

[12f] http://www.plosone.org/article/slideshow.action?uri=info:doi/10.1371/journal.pone

[12g] http://www.pocketpc.ch/windows-phone-7-allgemein/77920-windows-phone-7-series.html

[12h] http://www.appscout.com/2009/03/is_a_product_in_stock_nearby_a.php

Figures



Vendor	Shipments	Share
1. Nokia	67.7	38.9%
2. Research In Motion	34.5	19.8%
3. Apple	25.1	14.4%
4. HTC	8.1	4.6%
5. Samsung	5.7	3.3%
Others	33.1	19.0%
Total	**174.2**	**100.0%**

Fig. 01 Smartphone's sales and revenue [01]

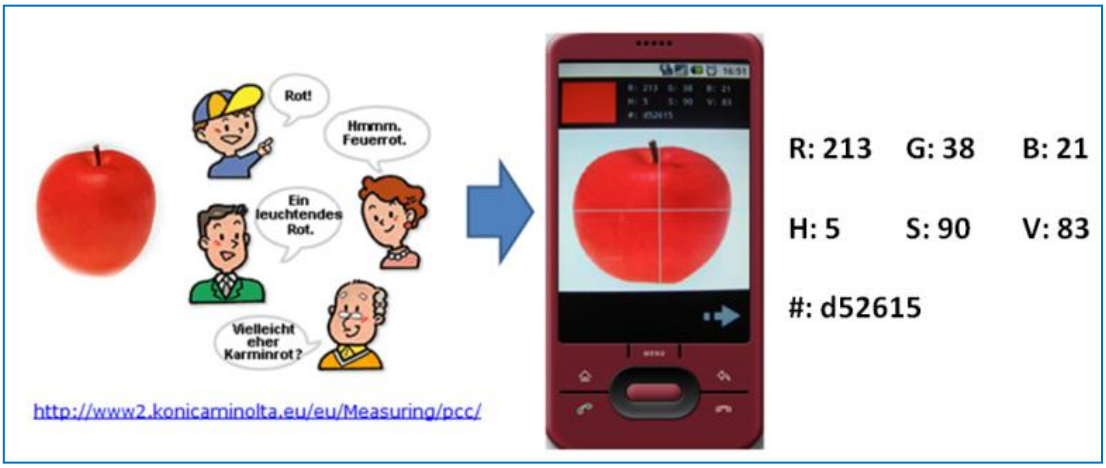


Fig. 02 Direct objective determination of color characteristics [02]

Fig. 03 Indirect objectified determination of color characteristics [03]

Fig. 04 Object detection with different colored lights [04]

Fig. 05 Simplified reading of smartphones [05]

Fig. 06 Simplified programming of smartphones [06]

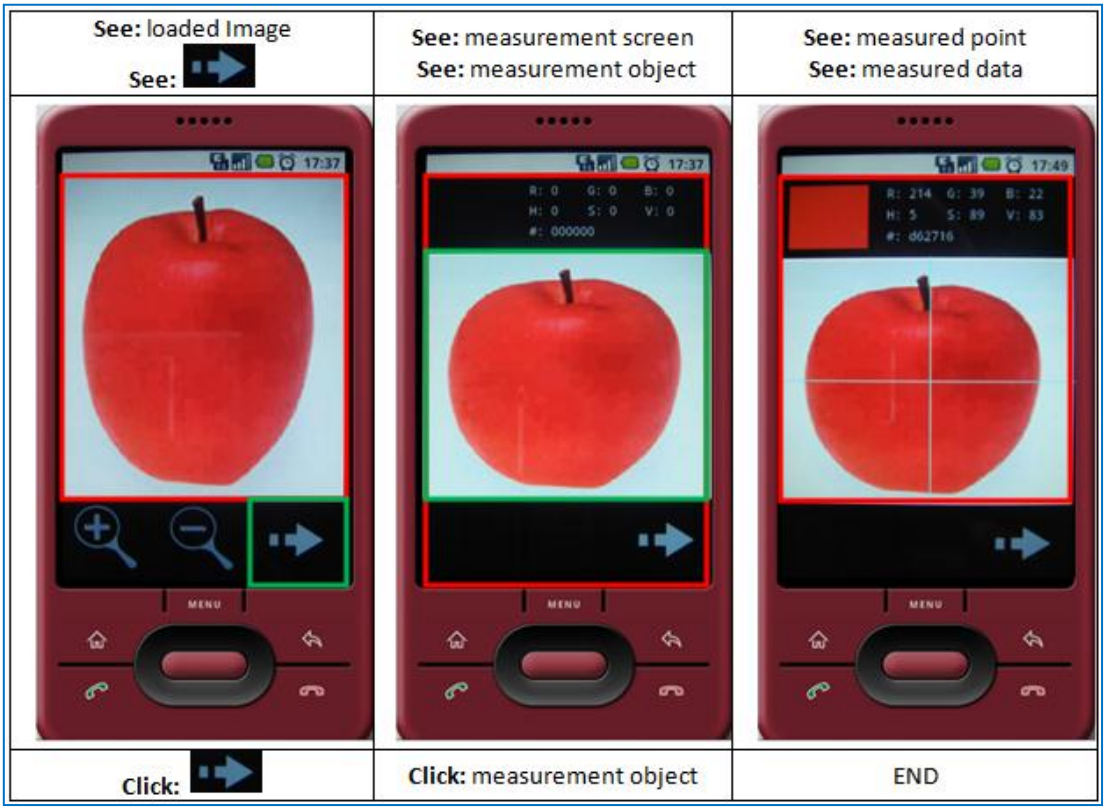


Fig. 07 Simplified operating of smartphones [07]

Fig. 08 Simplified performing of statistical analysis [08]

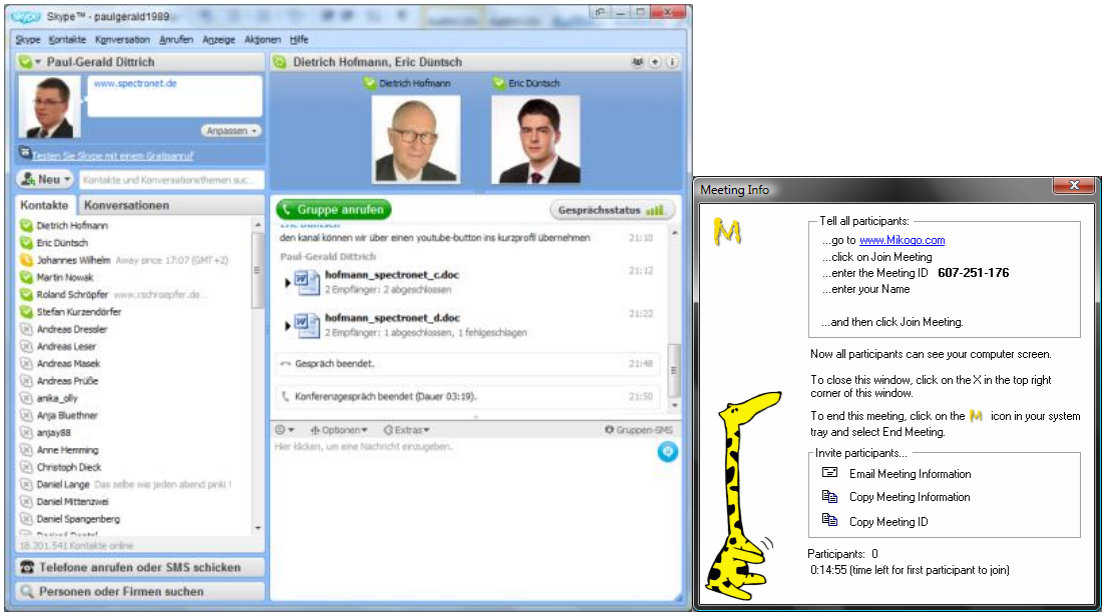


Fig. 09 Simplified performing of mobile applications [09]

Fig. 10 Qualification with scripts and books [10]

Fig. 11 Qualification with touch screen and cloud computing [11]

Fig.12a HALCON embedded runs on the Nokia N900 mobile phone **[SYMBIAN]** [12a]

Fig. 12b Qualification with WebEx smartphone applications **[RIM]** [12b]

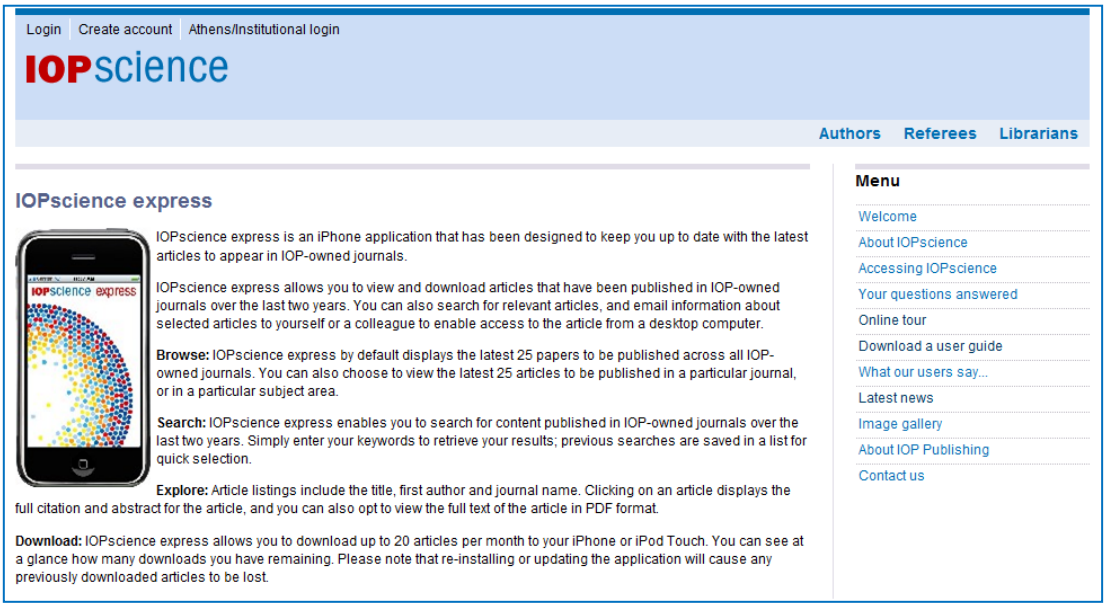


Fig. 12c Measurement news of IOP Science as iPhone application [12c]

Fig. 12d Spectral imaging with color bug from ocean optics on iPhone **[IPHONE OS]** [12d]

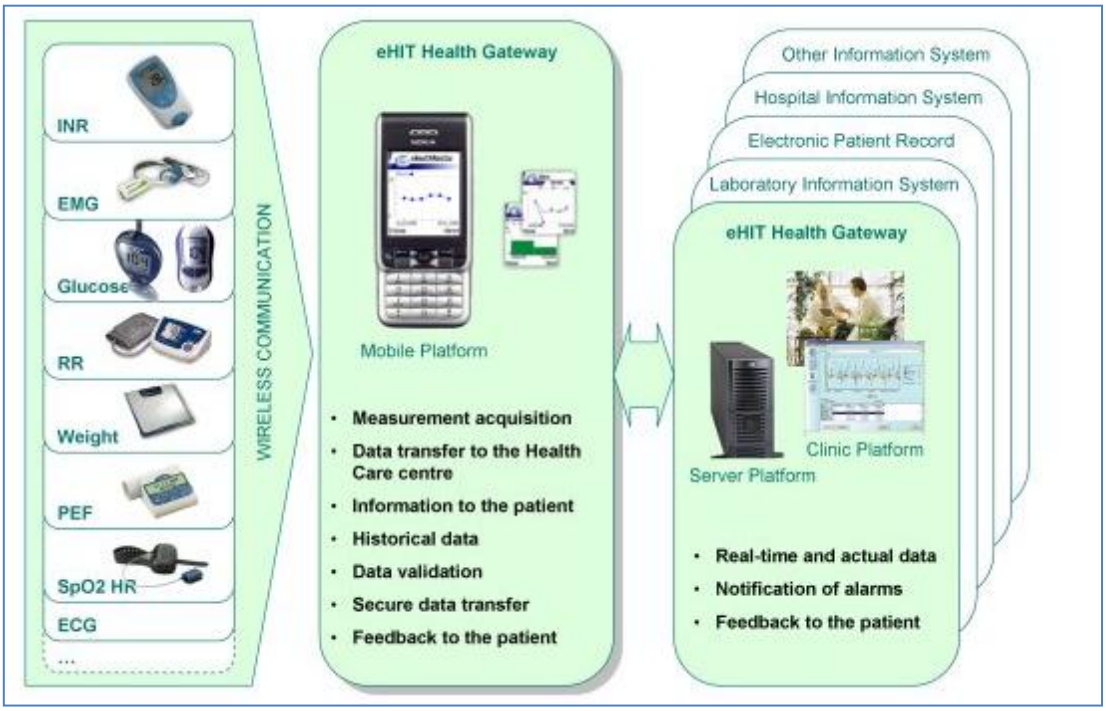


Fig. 12e Health Monitoring with HIT Ltd's mobile software [12e]

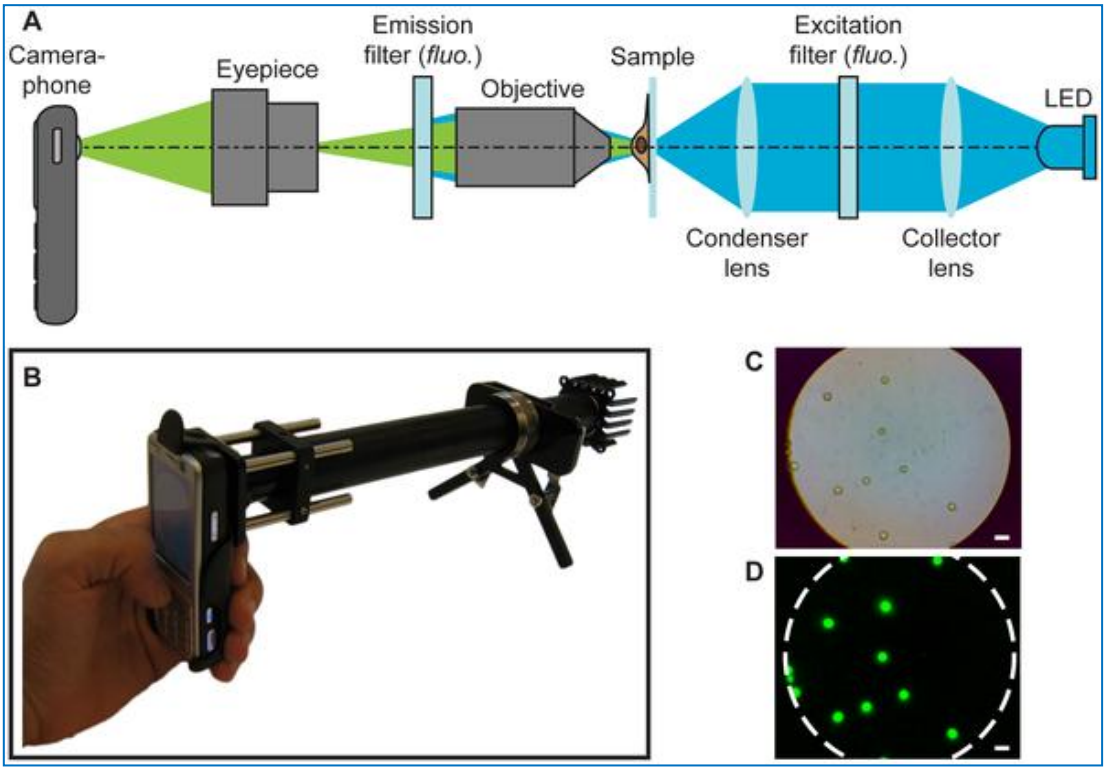


Fig. 12f Fluorescent imaging using smartphone from the University of California [12f]

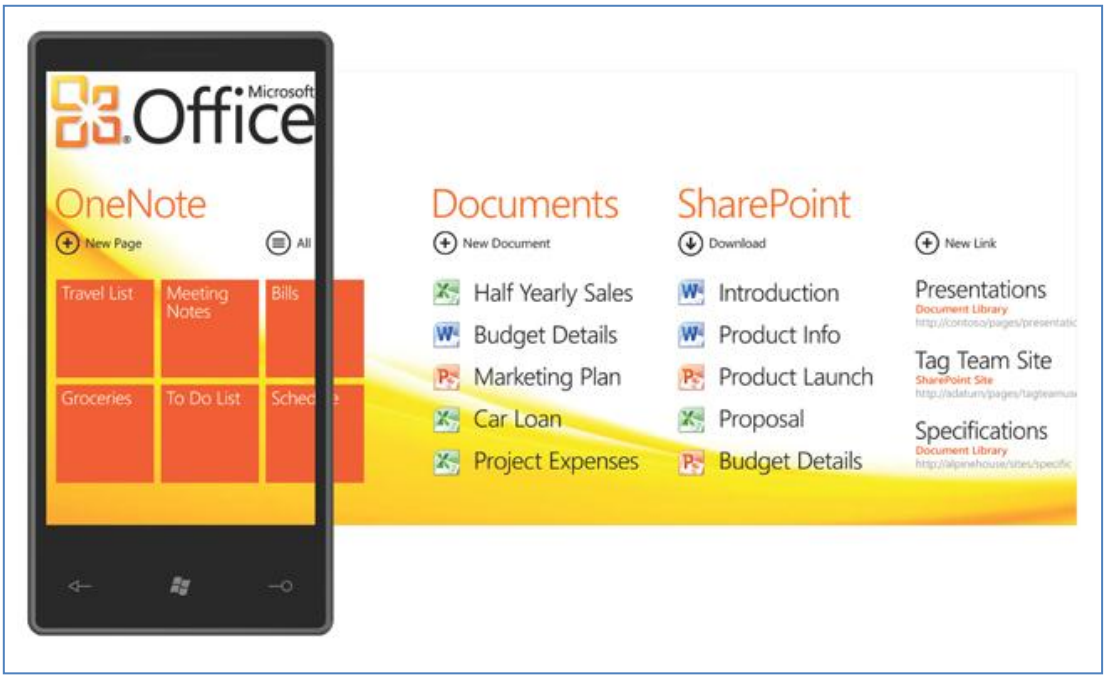


Fig. 12g Office 2010 on a Windows Smartphone **[WINDOWS PHONE 7]** [12g]

Fig. 12h Barcode Reader Shop Savvy **[GOOGLE ANDROID]** [12h]

Windows phone	http://www.windowsphone7.com
android	http://www.android.com
4.0	http://www.apple.com
RIM BlackBerry	http://www.rim.net
symbian	http://www.symbian.org

Fig. 13a Smartphone operating systems

NATIONAL INSTRUMENTS	https://lumen.ni.com/nicif/us/machinevisionbrochure/content.xhtml
heurisko®	http://www.heurisko.de/deutsch/produkte.html#demo
EyeSpector	http://www.evt-web.com/de/userbereich/login/
OMRON	http://www.omron-news.co.uk/form_9.aspx?pageid=7#
ActiVTools	http://www.activ-vision-tools.com
HALCON	http://www.mvtec.com/download/release/
Imaging Library	http://www.matrox.com/imaging/products/mil/home_overview.cfm
NEURO CHECK	http://www.neurocheck.de/forms.php?form=democdg
VIP TOOLKIT	http://www.zbs-ilmenau.de/intern/vip/toolkitd.php
SAC	www.sac-vision.net/download/coake/setup67206.exe
VISION&CONTROL	http://www.vision-control.com/uploads/media/vcwin2.7.98a_setup.zip
Development	http://stz-ilmenau.de/downloads/files/QID-Demo.exe
JETI	http://www.jeti.com/down/sw/limes_demo.zip
BLOX	http://www.commonvisionblox.de/pages/cvb/releases.php
COGNEX	http://www.cognex.com/global/ltmain.aspx?DP=VisionPro%205.2%20Trial.exe
SCORPION VISION SOFTWARE	http://www.scorpionvision.com/43.html
Open eVision	http://www.euresys.com/downloadarea/Download.asp

Fig. 13b Image-processing software packages