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Colour Reproduction on Tablet Devices

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Abstract:

With the advent of Internet and mobile devices client services and other print production are migrating more and more to online platforms. In a recent technology changeover it has become obvious that there is a growing number of printers and customers who are interested in the print service providers to expand their business to online and mobile platforms. With this technological transition there are some open questions regarding the possibilities of using tablet devices for colour soft proofing and other colour related operations. There are large similarities with desktop display devices but its operating systems are not colour smart yet. There have been some initial attempts to characterize the colour reproduction on this type of devices and find the possibility of using them not just for information content but also for colour managed content. In this study we have tested several tablets (Apple iPad2,Asus Transformer TF101, Samsung Galaxy Tab 1) with different display and OS technology and a software which is intended for colour managed reproduction view. We have measured tablets colour reproduction with the digital version of the GretagMacbeth ColourChecker card and calculated colour differences between colour chart data and displayed data. We have calibrated the Ipad2 with the only existing colour management tool, the Spyder Gallery, and we also tested the chart display with and without software colour correction. We have found that there are differences in the colour reproduction of display technologies and that the possibilities of a real colour managed workflow have yet to be resolved on the OS level of tablet and mobile devices.

Keywords:

Colour Reproduction, Tablets, Display Technologies

1. Introduction

tablets can be defined as mobile computers which are mainly operated by touching the screen or stylus movements. The point of acceleration of the proliferation of the Tablets can be dated to 2010 when the Apple company introduced the first iPad. There were some models of tablet PCs before but the iPad changed the focus on media consumption and thus propelled the sale of the devices. The other major part of the tablet computer market share is held by the devices based on the Android OS, developed by Google Inc. As a recent study by IDC *(IDC, 2013)* shows, iPad had a 43.6% market share while others held the rest with minimal share based on Windows platform tablets. Other surveys like the Infotrends (Little and Yeager, 2012) point out that tablets and other devices are becoming more and more present. This presence of tablets and mobile phones creates the need for online and mobile business processes via telecommunication infrastructure. At the moment mobile devices are mainly used for communication and e-payments but there are vast opportunities to use them as soft proof devices with appropriate software. Soft proofing can be content-based (text compositions, placement of pictures), which can be dealt with by commenting tools similar to ones in other applications like Adobe Acrobat or online proofing systems like Dalim Twist or Dialogue. Some of these software items offer colour managed online based proofing process, which, of course, requires appropriate displays with the possibility of calibration and characterization, as well the necessary back end software infrastructure for colour management. The current state of technology enables static workstation workflow while mobile devices are currently unable to fully participate in the colour reproduction workflow. Despite the shift towards mobile displays with higher image quality and full colour, the core mobile displays requirements for low-power consumption. The colour gamut of mobile colour displays is compromised compared to the typical standards accepted for TV and computer monitors. This reduction in colour performance is a direct consequence of engineering compromises required to satisfy the core mobile display requirements noted above small form factor and low cost remain. It has only recently been recognized that the increased requirements for mobile display image quality and colour performance, combined with the requirements to display both still and video imagery, create the need for efficient colour management and image processing techniques compatible with the processing resources of mobile devices *(Silverstein, 2006)*. Even rudimentary methods and algorithms for remapping input data (e.g., sRGB) into the colour space of the mobile display can yield remarkable improvements in colour accuracy and image quality *(Langedijk & Klompenhouwer,2004)*.

2. Colour Reproduction on Tablet Mobile Devices

Colour reproduction on mobile and tablet devices is achieved via several display technologies, where in high end tablet devices the IPS (In-Plane Switching technology) is the dominant one. In-Plane Switching involves the arranging and switching of liquid crystal (LC) layer molecules between the glass substrates in a plane parallel to these glass plates. IPS is a variant of standard consumer LCD technology. This means that it consists of a TFT panel in front of a backlight and light spreader, with thousands of pixels which are in turn made of sub pixels of Red, Green and Blue (RGB). Each subpixel is given intensity corresponding to the value of the colour component at the corresponding full colour pixel location in the image. When the subpixels are small enough, they are not individually visible at a normal viewing distance, so that the viewer will only perceive the resulting colour (tristimulus value) for that location in the image: so-called 'colour blending' occurs. (Klompenhouwer&Haan, 2003).The enlarged subpixels of the tablet devices are shown in Figure 1.

Unlike traditional TN LCD panels (common in consumer technology), IPS panels have crystals which do not twist full 90 degrees. This means that in each crystal there are two transistors on each end.

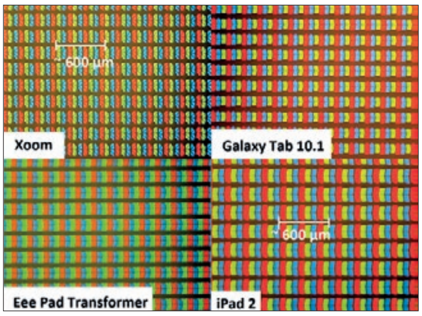

Figure 1. Colour filter matrix of tablet devices (Tom's Hardware, 2013)

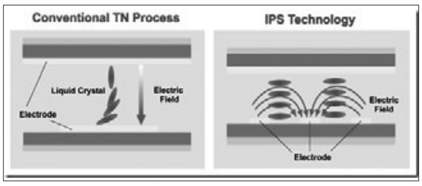

Figure 2. TN and IPS display technology

Two transistors instead of one means that there is more blocking of the light when penetrating the panel, and this means that a more intense backlight is needed to achieve the same brightness as a traditional TN panel. The other part of the colour reproduction system is the underlying software backend with a specific graphic engine for different operating systems. At the present moment neither the Android operating system (developed by Google) nor the iOS (developed by Apple) have system level colour management. The iOs version of the Quartz rendering engine, in contrast to desktop and laptop based MacOS, which also uses the Quartz rendering engine, lacks support for colour management and the ColourSync API is also missing from the system used on iPad. There are currently some solutions attempting to work around the lack of colour management like the Firefox web browser and some applications which use the application level of colour management. The only classic profiling setup via a colour measurement sensor is provided by Datacolour with the iOS application SpyderGallery *(Datacolor, 2013)*. Android tablets can use the software Colibri, which enables colour transform of ICC profiles and soft proof options to the colour transform on selected pictures, but without the basic instrument calibration these options are very rough and approximated.

3. Material and Methods

In this study we have tested two tablet devices running Android OS (Samsung Galaxy Tab 1, Asus Transformer TF101), and one tablet device running iOS (Ipad 2). The properties of the devices used are presented in Table 1.

Table 1. Properties of the measured devices (Displaymate,2013)

Categories	Apple iPad 2	Asus Transformer	Samsung Galaxy Tab
Display Technology	9.7 inch IPS LCD	10.1 inch IPS LCD	10.1 inch PLS LCD
Screen Shape	4:3 = 1.33 Aspect Ratio	16:10 = 1.60 Aspect Ratio	16:10 = 1.60 Aspect Ratio
OS Version for the Tests	iOS 4.3	Android 4.1	Android 4.1
Display Resolution	1024 x 768 pixels	1280 x 800 pixels 1280 x 752 active	1280 x 800 pixels 1280 x 752 active
Pixels Per Inch	132 ppi Good	149 ppi Good	149 ppi Good
Display Colour Depth	Full 24-bit colour 256 Intensity Levels No Dithering	18-bit colour with Dithering to 24-bit colour	Full 24-bit colour 256 Intensity Levels No Dithering
Photo Viewer Colour Depth	Full 24-bit colour No Dithering	16-bit colour with poor Dithering to 24-bit colour	Full 24-bit colour No Dithering

In order to test colour reproduction possibilities of the devices, we have used the digital version of the Xrite Colour Checker test chart, which was transferred to the devices in an untagged 8bit TIFF file format with values coded in Lab. The test chart was displayed at 100% of the Brightness values of all devices and colour patches were measured by means of XRite Eye One spectrophotometer with D50 and standard observer 2° with 45°/0° measurement geometry. In the beginning, the luminance and white point and emission spectrum of tablet devices was measured. The results are presented in Figure 2.

The luminance value of the iPad2 was 402 cd/m² with CCT (correlated colour temperature) of 6899 K, Samsung Galaxy Tab had the luminance value of 409 402 cd/m² and CCT of 7751K and the Asus Transformer had luminance value of 259 cd/m² with CCT 6785K.

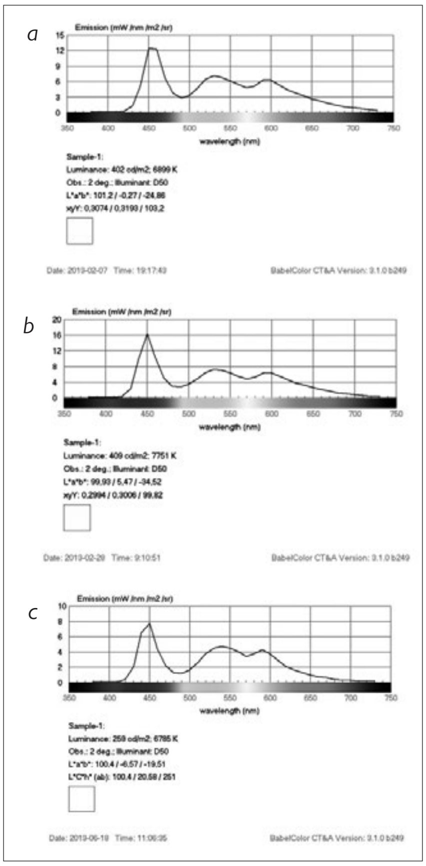

Figure 2. Emission spectrum of the measured white patches a) iPad2 b) Samsung Galaxy Tab I c) Asus Transformer TF101

After defining white point values of the devices, all the Colour Checker test patches were measured and the CIE94 colour difference values from the reference values of the test chart were calculated. The values are presented in Table 2.

Table 2. The colour differences of the Colour Checker patch measurements on different tablet devices

Colour Checker patches		Devices		
No.	Colour name	Ipad2	Asus TF101	Samsung Galaxy Tab I
1	dark skin	4.76	4.77	7.84
2	light skin	6.13	6.64	10.78
3	blue sky	3.54	5.87	9.75
4	foliage	15.29	4.23	6.10
5	blue flower	4.95	10.05	11.42
6	bluish green	18.85	8.09	14.57
7	orange	6.78	3.82	6.61
8	purplish blue	20.71	10.13	8.05
9	moderate red	12.23	6.51	3.44
10	purple	43.67	10.11	9.94
11	yellow green	26.84	2.67	6.92
12	orange yellow	14.39	3.47	7.47
13	blue	34.27	11.56	7.20
14	green	27.17	3.68	6.74
15	red	15.15	4.89	2.96
16	yellow	25.71	2.82	8.08
17	magenta	30.91	12.56	8.47
18	cyan	23.27	8.34	14.46
19	white 9.5 (.05 D)	4.75	17.05	26.12
20	neutral 8 (.23 D)	5.22	14.38	23.50
21	neutral 6.5 (.44 D)	5.56	11.38	19.99
22	neutral 5 (.70 D)	5.00	9.57	15.94
23	neutral 3.5 (1.05 D)	4.21	7.55	12.77
24	black 2 (1.5 D)	4.37	6.64	13.45

In Table 2. we can observe that the largest colour difference on all of the devices measured was on the purple patch when measured on iPad 2 (43,67). The Samsung tablet had a similar large colour difference value of 26,12 on the white patch which lead to larger colour differences in the grey patches. The Asus Transformer had the maximum colour difference of 17.05 also on the white patch. These differences are inherent to the native white point of the devices as the largest offset values on the -b scale which indicated a higher (more bluish) white than the Colour Checker patch. In average, Samsung Galaxy had an average colour difference value of 10.94 with median value of 9.1. Asus Transformer TF101 had an average colour difference of 7.78 with median value of 7.09. The Apple iPad 2 had on average 15.16 with median value of 13.31.

On the basis of measured data we have constructed ICC profiles of all displays. Display gamuts are presented in Figure 3.

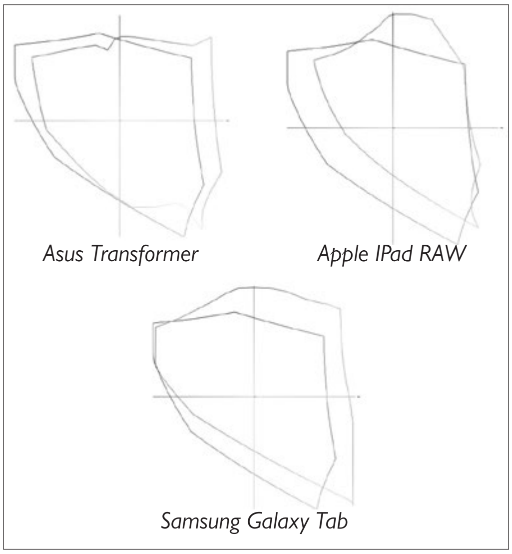

Figure 3. Colour gamuts of the measured tablets compared to the AdobeRGB

We have also used a free application from Datacolour SpyderGallery which is marketed as the first colour managed application for the iOS system (the Android version is yet to be released) (Datacolour,2013). The application offers two kinds of colour correction perceptual and saturation. The Apple iPad device needs to be calibrated with the Spyder colorimeter which is connected to a PC and placed on the touch screen of the iPad. The PC had an application which sent the correction data wirelessly to the tablet device since there is no possibility to connect directly the measurement device to the tablet. We have measured the XRite Colour Checker card with the two calibration setting and the differences between the uncalibrated and calibrated colour values are presented in Table 3.

Table 3. The colour differences of Colour Checker after the application of calibration settings

Colour Checker patches		Calibration type		
No.	Colour name	Ipad2 raw	Ipad2 percept.	Ipad2 saturat.
1	dark skin	4.76	2.88	5.23
2	light skin	6.13	3.22	10.84
3	blue sky	3.54	4.54	5.23
4	foliage	15.29	4.70	7.11
5	blue flower	4.95	4.30	5.60
6	bluish green	18.85	1.50	4.04
7	orange	6.78	1.31	4.44
8	purplish blue	20.71	3.81	3.27
9	moderate red	12.23	1.67	4.47
10	purple	43.67	2.18	3.84
11	yellow green	26.84	1.99	5.43
12	orange yellow	14.39	0.40	2.48
13	blue	34.27	3.90	2.12
14	green	27.17	1.67	3.35
15	red	15.15	1.29	5.58
16	yellow	25.71	0.73	1.39
17	magenta	30.91	1.00	5.49
18	cyan	23.27	6.68	6.40
19	white 9.5 (.05 D)	4.75	4.62	5.27
20	neutral 8 (.23 D)	5.22	4.33	5.58
21	neutral 6.5 (.44 D)	5.56	4.00	5.37
22	neutral 5 (.70 D)	5.00	4.42	5.40
23	neutral 3.5 (1.05 D)	4.21	3.48	5.53
24	black 2 (1.5 D)	4.37	2.48	4.85

As we can observe from Table 3., after the calibration with Spyder 3 colorimeter there was a large decrease in the colour difference values. Before calibration the average colour difference value was 15.16 with median value of 13.31 while after the Perceptual calibration the average value decreased to 2.96 with median value of 3.05. When the saturation calibration was applied the colour difference was a little bit higher (4.93) with median value of 5.23. It can be observed that the colour values of primaries (red, green, blue and secondary colours cyan, magenta, yellow) are much better compared to non calibrated state of the display.

As the iOs does not supports the colour management workflow on the system level these settings are software specific and are applied only when the pictures are shown through the Spyder Gallery application. To examine the colour correction curves we have made ICC profiles of the "colour corrected files" to see the difference and the results are presented in Figure 4.

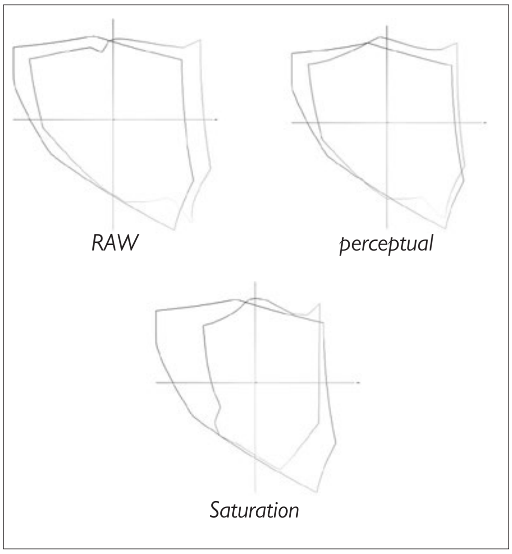

Figure 4. The colour gamut of the iPad2 tablet with different calibration settings

4. Conclusion

Tablets and mobile devices are taking over classic display technologies, such as desktop computers and notebooks for content viewing. Customers, content creators and contract makers use mobile devices for more efficient and quicker job delivery and control. The advent of new technologies with different OS systems has brought new possibilities but has also broken the well established ICC colour communication protocols and the manufacturers of measurement and calibration devices are still not offering solutions except for the mentioned SpyderGallery software. The measurement of tablet colour reproduction possibilities shows its ability to cover the already well established and used colour spaces (sRGB and Adobe RGB). One of the options is to use the sRGB colour profile on images, as almost all mobile devices cover it well. But without direct calibration controls (brightness, contrast and separate RGB channel modification) and the OS system based colour transforms, the rendered colour work is still far from accurate colour managed values of the classic colour reproduction workflow. It is expected that future versions of the Android and iOS operating systems in the collaboration of ICC will have implemented necessary options for mobile and tablet devices to offer colour management options.

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