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(54) METHOD AND COMPUTER PROGRAM FOR EVALUATING THE COLOUR OUTPUT OF A DISPLAY DEVICE

(57) A display device is caused to display colours corresponding to colours in a palette of colours. A measure of the colours displayed by the display device is obtained using an image colour measuring device. The measure of the colours displayed by the display device is compared with a corresponding measure of colours displayed by a reference display device corresponding to the same colours in the same palette of colours.

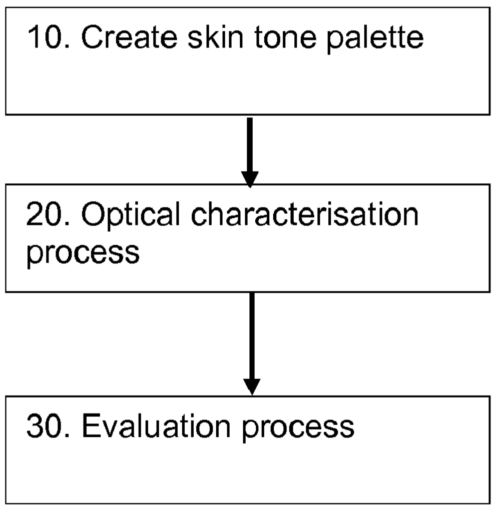

Fig. 1

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Description

Technical Field

[0001] The present disclosure relates to a method and a computer program for evaluating the colour output of a display device.

Background

[0002] During manufacture of a display device, such as a display screen or panel for a computer, a television set, for "signage" etc., currently a person (e.g. an engineer or technician) manually adjusts the picture/image design and calibration for the display device "by eye". That is, the person manually adjusts the display settings until the image displayed meets some requirements. Typically, the person compares the output of the display device with the output provided by a "golden sample" of the display device and adjusts the settings of the display device in an attempt to make the visual output of the display device match that of the golden sample. (A "golden sample" in this context is a display device that has been carefully set so that the output meets some specified characteristics, in particular optical and video / picture specifications.) This is however a laborious process and is very subjective, as it relies on a subjective comparison and subjective judgements being made by the person.

[0003] In addition, a particular display device may use different components from other display devices even though they are ostensibly the same type or model of display device. Also, owing to manufacturing variances, the same components may vary in their output or response to inputs. Accordingly, in principle at least, each display device that is manufactured has to be set up manually, which is very time-consuming and again currently relies on subjective judgements being made by the person.

Summary

[0004] According to a first aspect disclosed herein, there is provided a method of evaluating the colour output of a display device, the method comprising:

- causing the display device to display colours corresponding to colours in a palette of colours;
- using an image colour measuring device to obtain a measure of the colours displayed by the display device; and
- comparing the measure of the colours displayed by the display device with a corresponding measure of colours displayed by a reference display device corresponding to the same colours in the same palette of colours.

[0005] In examples, this enables the colour output of the display device to be evaluated in an objective and consistent and reproducible manner, and does not rely on a human attempting to evaluate the colour output "manually" (i.e. "by eye"). This in turn enables the display settings of the display device to be adjusted, for example during manufacture as part of a set-up step, to achieve a desired or optimum output in an objective and consistent and reproducible manner. Variations in components (such as in some cases different LED bar type, LED phosphors and LCD cells) or other variations giving rise to an optical spectral change can be compensated quantitatively and objectively for skin tone visual adjustment. used in different display devices being evaluated are easily accommodated, whether variations due to manufacturing tolerances within a specific type or model of component or variations due to the use of different types or models of component. At least these parts of the process may be carried out automatically and autonomously, under control of a computer program running on a processor for example.

[0006] The display device may be for example a display device as used in or with many different types of consumer apparatus, including for example television screens or monitors, computer displays or monitors, and displays for other computing devices, etc. The display device may be a display device as used in public environments in so-called "signage", for example, for displaying adverts or for information or entertainment that is of interest to a larger audience, including for outdoor use as well as indoor use.

[0007] In an example, the colours in the palette of colours are skin tone colours.

[0008] In an example, the measure of the colours displayed by the display device and the reference display device include one or more of (i) a measure of a spectrum for one or more colour filters of the display device, (ii) a measure of the gamma of display cells of the display device, and (iii) a measure of spectrum for a backlight unit of the display device.

[0009] In an example, the method comprises adjusting one or more parameters of the display device based on the results of the comparison of the measure of the colours displayed by the display device with the corresponding measure of colours displayed by a reference display device.

[0010] In an example, the method comprises displaying the results of the comparison of the measure of the colours displayed by the display device with the corresponding measure of colours displayed by a reference display device for viewing by a viewer.

[0011] According to a second aspect disclosed herein, there is provided a computer program comprising instructions such that when the computer program is executed on a computing device, the computing device is arranged to:

- cause a display device to display colours corresponding to colours in a palette of colours;
- obtain a measure of the colours displayed by the

display device; and
compare the measure of the colours displayed by the display device with a corresponding measure of colours displayed by a reference display device corresponding to the same colours in the same palette of colours.

Brief Description of the Drawings

[0012] To assist understanding of the present disclosure and to show how embodiments may be put into effect, reference is made by way of example to the accompanying drawings in which:

Figure 1 shows schematically an overview of an example of a method as described herein;

Figure 2 shows schematically an example of creation of a skin tone palette;

Figure 3 shows schematically an example of an optical characterisation process;

Figure 4 shows schematically an example of an evaluation process;

Figure 5 shows schematically an example of selection of colours of a skin tone palette;

Figure 6 shows examples of the spectrum response for two different brands of LED bar;

Figure 7 shows examples of the spectrum response for two LED bars having different phosphor types;

Figure 8 shows examples of colour filter characteristics for two different TFT cells;

Figure 9 shows a table of xyY values for various colours input to a display device; and

Figure 10 shows a table of HSV values for skin tone colours input to the display device and the results of a comparison with reference HSV values.

Detailed Description

[0013] In examples described herein, the colour output of a display device is evaluated by causing the display device to display colours corresponding to colours in a palette of colours. A measure of the colours displayed by the display device is obtained using an image colour measuring device. The measure of the colours displayed by the display device is compared with a corresponding measure of colours displayed by a reference display device corresponding to the same colours in the same palette of colours.

[0014] As mentioned in examples, this enables the colour output of the display device to be evaluated in an objective and consistent and reproducible manner, and does not rely on a human attempting to evaluate the colour output "manually" (i.e. "by eye"). This in turn enables the display settings of the display device to be adjusted, for example during manufacture as part of a set-up step, to achieve a desired or optimum output in an objective and consistent and reproducible manner. Variations in components (such as in some cases different LED bar type, LED phosphors and LCD cells) or other variations giving rise to an optical spectral change can be compensated quantitatively and objectively for skin tone visual adjustment. used in different display devices being evaluated are easily accommodated, whether variations due to manufacturing tolerances within a specific type or model of component or variations due to the use of different types or models of component. At least these parts of the process may be carried out automatically and autonomously, under control of a computer program running on a processor for example.

[0015] The display device may be for example a display screen or display panel, which may be a display screen or panel for a computer, a television set, for "signage" etc.

[0016] The colours in the palette of colours may be skin tone colours. It is very important to display skin tone colours correctly as incorrect skin colours are typically very noticeable to viewers. Nevertheless, in some examples, the colours in the palette of colours may be other than skin tone colours, such as magenta, cyan, etc.

[0017] Some specific examples will now be described with reference to the accompanying drawings. As will be clear, one objective is to eliminate subjective picture quality adjustments, particularly in relation to skin tone colours, that can otherwise arise during human evaluation and different optical characters of different display devices. In general, the examples can be used for any display device.

[0018] The specific examples are principally given in respect of display devices, such as LCD (liquid crystal display) devices, that have backlights which illuminate the individual (liquid crystal) cells which in turn are controlled to pass or block light according to whether or not the corresponding pixel of the image is to be displayed. Currently, such backlights may use LEDs (light emitting diodes) as the light sources, though backlights may alternatively use cold cathode fluorescent lamps or other light sources. Examples described herein may also be applied to other types of display devices, including display devices in which the controllable cells generate the light themselves, such as in OLED (organic light-emitting diode) display devices.

[0019] Moreover, whilst some specific examples of certain colour spaces are discussed below, and certain specific colour spaces are mentioned as being used for particular stages in the process, it will be understood that the examples may be applied to and/or use different colour spaces, including for example CIE (International

Commission on Illumination) colour spaces, RGB colour spaces (e.g. BT.2020 (ITU-R Recommendation BT.2020, also known as Rec. 2020) and BT.709 (ITU-R Recommendation BT.709, also known as Rec. 709)), cylindrical transformations (e.g. HSV, HSL, etc.), HDR (high dynamic range) colour spaces, etc. (In simple terms, HDR expands the range of both contrast and colour significantly. HDR may use for example a greater number of bits to specify the brightness of a pixel. Bright parts of the image can be made much brighter, so the image seems to have more "depth". Colours can be expanded to show brighter reds, blues and greens (and all other colours). HDR processing may use a so-called electro-optical transfer function (EOTF) to specify the brightness of a pixel that is displayed. HDR processing may use wide colour gamut (WCG) to make colours more vivid, again using for example a greater number of bits to specify the colour of a pixel.) The colour space that is used at any particular stage may be selected based on for example convenience and/or practical considerations as well as on for example processing efficiency. For example, much video processing software is most suited for, and indeed is written for, use with HSV values. As another example, certain measuring equipment may output RGB values by default.

[0020] Referring to Figure 1, in overview a specific example can be regarded as comprising three main stages: creation of skin tone palette 10, an optical characterisation process 20 and an evaluation process 30.

[0021] The skin tone palette effectively forms a set of reference skin tone colours which are used in the subsequent stages. In the optical characterisation process 20, one or more reference display devices are fed the reference skin tone colours of the colour palette and the performance of the or each reference display device is measured (using for example a colorimeter or spectroradiometer or the like). A "standard" specification is then produced from a scoring of how closely the display device(s) reproduce(s) the skin tone colours. Then, in the evaluation process 30, the skin tone palette is fed to a display device that is to be set up or calibrated. The results output by the display device are compared with the standard specification and scored. The settings on the display device may then be adjusted (manually or automatically) as necessary to achieve an output that is closer to the standard specification.

[0022] Referring to Figure 2, in an example of creation of a skin tone palette 10, first a number of skin tone colours to be used in the palette are selected 12. This will typically be a manual process, with the colours being selected "by eye". One option for this is for a person to select a number of skin tone colours that are being displayed by a "golden sample" of a display device to be used in the palette. A better option, which is likely to produce better results, is for the skin tone colours to be used in the palette to be selected by studying a (large) number of images of people and selecting the main skin tone colours from those. The images should ideally represent a wide range of peoples and skin tone colours. Moreover, selecting a greater number of skin tone colours for the palette is likely to produce better results, though a greater number of skin tone colours will increase processing time and requirements: a balance between these factors should be achieved. Different types of display devices, which use different technology (e.g. vertical alignment (VA) or in plane switching (IPS) for LCD (liquid crystal display) devices having backlights) may benefit from having more skin tone colours in the palette whereas for other types, a smaller number of skin tone colours may be sufficient.

[0023] Referring briefly to Figure 5, this shows in the upper part two images, one showing a pair of hands and one showing a face. A number of skin tone colours are selected from these images (and ideally a number of other images, as mentioned) to give a range of typical representative skin tone colours. Those specific selected skin tone colours make up the palette of skin tone colours which is used in subsequent stages and which is illustrated schematically in the lower part of Figure 5. In this example, twenty-four (24) skin tone colours have been selected. (The images in Figure 5 may be presented in the attached drawings in black and white, it being understood that the actual images are in colour.)

[0024] Returning to Figure 2, once the skin tone colours have been selected 12, colour values for those individual selected skin tone colours are obtained 14. The colour values may be for example the RGB (red, green, blue) colour values for each of the individual selected skin tone colours. The (RGB) colour values may be obtained using for example a colorimeter or spectroradiometer or the like viewing actual representations of the skin tone colours. The colour values for each of the individual skin tone colours selected for the colour palette are then stored 16 for later use. The colour values that are stored may be HSV values as in general it is more straightforward to process and use HSV values than RGB values in the subsequent steps. As known, HSV (hue, saturation, value) is an alternative representation of the RGB colour model, designed to more closely align with the way human vision perceives colour-making attributes. If RGB colour values are obtained at 14, these may be converted to HSV values which are stored at 16. If on the other hand the colour values obtained at 14 are HSV values, then these values may be stored directly at 16. Other colour models, with different values, may be obtained at 14 and other colour models, with different values, may be stored at 16.

[0025] Referring to Figure 3, in an example of an optical characterisation process 20, one or more reference display devices are fed the colour palette. That is, one or more reference display devices are caused to display the skin tone colours in the palette. The one or more reference display devices are display devices that have already been set up and calibrated manually, by eye, to produce a desired or optimum output.

[0026] As mentioned, a main purpose of the optical characterisation process 20 is to obtain a "standard" specification from a scoring of how closely the reference display device(s) reproduce(s) the skin tone colours of the palette. If only a single reference display device is used, the results form the specification. If plural reference display devices are used, the results may be processed to obtain an average or mean of the results to form the specification.

[0027] In this example, the or each reference display device is a display device, such as an LCD (liquid crystal display) device, that has a backlight which illuminates the individual (liquid crystal) cells which in turn are controlled to pass or block light according to whether or not the corresponding pixel of the image is to be displayed. The cells may be for example TFT (thin film transistor) cells. The backlight of this example uses LEDs as the light sources, and is sometimes referred to as an LED bar or the like.

[0028] So, returning to Figure 3, at 22 the colour filter spectrum and the gamma for the TFT or other cells of the or each reference display device are measured when the display device is displaying the colours in the skin tone palette. At 24, the backlight unit spectrum of the or each reference display device is measured when the display device is displaying the colours in the skin tone palette. The meaning and purpose of these stages will be described below. The measurements may be made using for example a colorimeter or spectroradiometer or the like.

[0029] Referring to Figures 6 and 7, different backlight units, such as LED bars, in general have different spectrum responses. That is, the radiance response of the backlight unit for different wavelengths over the visible light range may differ for the different backlight units. The radiance (the amount of light emitted) for two LED bars over the range of visible light wavelengths is shown in Figure 6. In these examples, the light is generated initially by blue LEDs, i.e. blue light is generated resulting in a large peak in the blue region of the spectrum as shown. The blue light passes through a phosphor which then typically outputs green and red light (i.e. yellow light) as seen in the mid and long wavelengths in Figure 6.

[0030] For different LED bars, the peak of the blue light and the FWHM (full width at half maximum) of the peak may be different, as illustrated in Figure 6. In addition, different phosphors lead to different responses at the longer wavelengths. This is illustrated in Figure 7 for two examples, one being an LED bar that uses a yellow phosphor (i.e. a blue LED used in conjunction with a broad spectrum yellow phosphor, such as for example cerium(III)-doped YAG ($YAG{:}Ce_3+$, or $Y_3Al_5O_{12}{:}Ce_3+$) to result in the emission of white light) and the other being an LED bar that uses a KSF (e.g. $K_2SiF_6{:}Mn4+$) phosphor. The spectrum responses in the mid and long wavelengths for the two different phosphors are very different.

[0031] When measuring the spectrum of the backlight unit, using for example a spectroradiometer or some other device, the measurements may be taken with no TFT or LCD cells present.

[0032] Referring to Figure 8, this shows the colour filter characteristics for two different TFT cells. In this regard, an LCD cell, such as a TFT LCD cell, is typically illuminated with white light and so is formed of three sub-cells or subpixels, which selectively transmit red, green or blue light respectively and thus act as colour filters. The individual subpixels are controlled according to the colour of the corresponding pixel of the image that is to be displayed. The red, green and blue subpixels within a cell have different transmission characteristics, clearly. However, the red, green and blue subpixels of different LCD cells may also respectively have different transmission characteristics (i.e. the red subpixels have different transmission characteristics from one another, etc.). This can be seen clearly in Figure 8. This may because the LCD cells and their subpixels are of a different type and/or because of variations that arise naturally during manufacture of the cells.

[0033] When measuring the transmittance of the LCD cells, using for example a spectroradiometer or some other device, the measurements may be taken using standard reference images, which may for example simply be full white, full red, full green and full blue images.

[0034] The gamma defines the relationship between a pixel's numerical value (the "input") and its actual luminance (the "output"). In particular, gamma is defined by $V_{out} = AV_{in}^{\mathbf{gamma}}$, where V_{out} is the output luminance value, V_{in} is the input/actual luminance value and A is some constant. The gamma or gamma response in general again varies between different display devices, using different components.

[0035] The measurements at steps 22 and 24 and discussed above provide radiometric (spectral) data which may be for example RGB values (i.e. the amount of red light, green light and blue light). In this example at 26 the radiometric values that are obtained are converted to photometric values (such as for example HSV values) for ease of use later (as will be discussed further below). The RGB values may instead be converted to other values for other colour models, including for example HSL (hue, saturation, lightness). The HSV values for the reference display(s) are then stored at 28.

[0036] To summarise the optical characterisation process 20 discussed more fully with reference to Figure 3, the result is a set of reference colour values (in this example HSV values) for each of the skin tone colours in the palette created at 10 and discussed more fully with reference to Figure 2 as displayed by the reference display device(s).

[0037] The skin tone colour palette can now be used in the evaluation process 30 for evaluating the display device under test, which may then be calibrated and set up as desired.

[0038] Referring now to Figure 4, a specific example of an evaluation process 30 will be described. At 32, similarly to the measurements made at 22 and 24 in the optical characterisation process 20 discussed above, the colour filter spectrum and the gamma for the TFT or other cells of the display device and the backlight unit spectrum of the display device are measured when the display device is displaying the colours in the skin tone palette. The measurements may be made using for example a colorimeter or spectroradiometer or the like.

[0039] The measurements at steps 32 again typically result in RGB values (i.e. the amount of red light, green light and blue light). In this example, similarly to 26 in the optical characterisation process 20 discussed above, the RGB values that are obtained are converted to HSV values at 34.

[0040] At 36, the HSV values for the display device being calibrated are compared with the reference HSV values obtained above. The results of the comparison may be presented as scores depending on for example how similar the respective values are to each other. (An example of this will be discussed with reference to Figure 10.) This enables the display being calibrated to be evaluated and the colour, brightness, contrast, etc. settings to be adjusted as necessary at 38 so that the displayed skin tone colours are closer to the skin tone colours of the reference display(s). Once the various settings have been adjusted, the evaluation process 30 may be repeated for the display device with the new settings.

[0041] Figure 9 shows a table of xyY values for various test colours which in an example are input to a display device that is being evaluated and calibrated. The xyY values are values of the known CIE xyY colour space, which are obtainable from the known CIE 1931 XYZ colour space. An equivalent colour space which may be used is the CIE 1976 (L*, u*, v*) colour space. Other colour spaces may be used.

[0042] In this example, the display device is fed first with white, red, green and blue patterns respectively. For each pattern feed, the colour filter spectrum and the gamma for the TFT or other cells of the display device and the backlight unit spectrum of the display device is measured. The measurements may be made using for example a colorimeter or spectroradiometer or the like.

[0043] Then, the display device is fed with the colours from the skin tone palette. Recalling that the specific example of the skin tone palette discussed above has 24 skin tone colours, the xyY values for the 24 test skin tone colours are indicated. The measurements of the colour filter spectrum and the gamma for the TFT or other cells of the display device and the backlight unit spectrum of the display device are made, using for example a colorimeter or spectroradiometer or the like, as discussed above with reference to step 32 of Figure 4. The measured (RGB) values are converted to HSV values, as discussed above with reference to step 34 of Figure 4. Finally, the sets of HSV values for the reference display device(s) and the display device being calibrated are compared, as discussed above with reference to step 36 of Figure 4.

[0044] Figure 10 shows a table of examples of HSV values for the 24 skin tone colours which are input to the display device and the results of the comparison with the reference HSV values. The results of the comparison are displayed in a simple form, here as scores or percentage points for each of the skin tone colours of the palette that is used. In one example, a score may be calculated by calculating the difference between the measured HSV values and the reference HSV values and dividing by the reference HSV values. A threshold may be set such that a match of say 75% or more is sufficient for the display device to be regarded as displaying the relevant skin tone colour correctly. A threshold, which may be the same (e.g. 75% in this example) or different (e.g. 85% in an example), is also set for an average of the thresholds for the 24 skin tone colours for the display device to be regarded as displaying all of the relevant skin tone colours correctly.

[0045] This therefore provides the user (e.g. the technician or engineer setting up the display device) with a very simple indication of whether the display device need to be adjusted and, if so, in relation to which specific skin tone colours. This is achieved in an objective and reproducible way, and does not rely on the user having to make personal judgements by eye, which can be very subjective. Indeed, the output as illustrated by the table in Figure 10 may be processed by a suitable computer program which can then automatically make adjustments to the display device to improve the representation of the skin tone colours as necessary.

[0046] It may be noted that the colours used in the skin tone colour palette, and therefore the different reference values which are used for the comparison, may be varied for different tests of different display devices. This may be useful for different geographical markets, particularly where for example the display device is part of a television set, as skin colours (at least on average) may be different in different geographical markets. This may also be useful as trends and fashions change, or to accommodate new technology for new components that are used in display devices.

[0047] It will be understood that the processor or processing system or circuitry referred to herein may in practice be provided by a single chip or integrated circuit or plural chips or integrated circuits, optionally provided as a chipset, an application-specific integrated circuit (ASIC), field-programmable gate array (FPGA), digital signal processor (DSP), graphics processing units (GPUs), etc. The chip or chips may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry, which are configurable so as to operate in accordance with the exemplary embodiments. In this regard, the exemplary embodiments may be implemented at least in part by computer software stored in (non-transitory) memory and executable by the processor, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware).

[0048] Although at least some aspects of the embodiments described herein with reference to the drawings comprise computer processes performed in processing systems or processors, the invention also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of non-transitory source code, object code, a code intermediate source and object code such as in partially compiled form, or in any other non-transitory form suitable for use in the implementation of processes according to the invention. The carrier may be any entity or device capable of carrying the program. For example, the carrier may comprise a storage medium, such as a solid-state drive (SSD) or other semiconductor-based RAM; a ROM, for example a CD ROM or a semiconductor ROM; a magnetic recording medium, for example a floppy disk or hard disk; optical memory devices in general; etc.

[0049] The examples described herein are to be understood as illustrative examples of embodiments of the invention. Further embodiments and examples are envisaged. Any feature described in relation to any one example or embodiment may be used alone or in combination with other features. In addition, any feature described in relation to any one example or embodiment may also be used in combination with one or more features of any other of the examples or embodiments, or any combination of any other of the examples or embodiments. Furthermore, equivalents and modifications not described herein may also be employed within the scope of the invention, which is defined in the claims.

Claims

1. A method of evaluating the colour output of a display device, the method comprising:

causing the display device to display colours corresponding to colours in a palette of colours;
using an image colour measuring device to obtain a measure of the colours displayed by the display device; and
comparing the measure of the colours displayed by the display device with a corresponding measure of colours displayed by a reference display device corresponding to the same colours in the same palette of colours.

2. A method according to claim 1, wherein the colours in the palette of colours are skin tone colours.

3. A method according to claim 1 or claim 2, wherein the measure of the colours displayed by the display device and the reference display device include one or more of (i) a measure of a spectrum for one or more colour filters of the display device, (ii) a measure of the gamma of display cells of the display device, and (iii) a measure of spectrum for a backlight unit of the display device.

4. A method according to any of claims 1 to 3, comprising adjusting one or more parameters of the display device based on the results of the comparison of the measure of the colours displayed by the display device with the corresponding measure of colours displayed by a reference display device.

5. A method according to any of claims 1 to 4, comprising displaying the results of the comparison of the measure of the colours displayed by the display device with the corresponding measure of colours displayed by a reference display device for viewing by a viewer.

6. A computer program comprising instructions such that when the computer program is executed on a computing device, the computing device is arranged to:

cause a display device to display colours corresponding to colours in a palette of colours;
obtain a measure of the colours displayed by the display device; and
compare the measure of the colours displayed by the display device with a corresponding measure of colours displayed by a reference display device corresponding to the same colours in the same palette of colours.

7. A computer program according to claim 6, wherein the colours in the palette of colours are skin tone colours.

8. A computer program according to claim 6 or claim 7, wherein the measure of the colours displayed by the display device and the reference display device include one or more of (i) a measure of a spectrum for one or more colour filters of the display device, (ii) a measure of the gamma of display cells of the display device, and (iii) a measure of spectrum for a backlight unit of the display device.

9. A computer program according to any of claims 6 to 8, comprising instructions such that when the computer program is executed on a computing device, the computing device is arranged to adjust one or more parameters of the display device based on the results of the comparison of the measure of the colours displayed by the display device with the corresponding measure of colours displayed by a reference display device.

10. A computer program according to any of claims 6 to 9, comprising instructions such that when the computer program is executed on a computing device, the computing device is arranged to cause display of the results of the comparison of the measure of the colours displayed by the display device with the corresponding measure of colours displayed by a reference display device for viewing by a viewer.

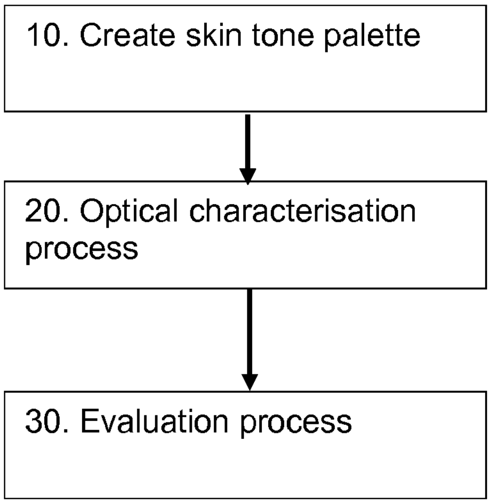
10. Create skin tone palette
20. Optical characterisation process
30. Evaluation process

Fig. 1

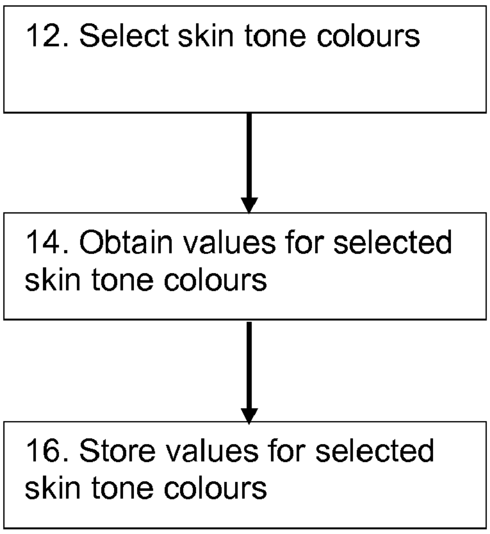
12. Select skin tone colours
14. Obtain values for selected skin tone colours
16. Store values for selected skin tone colours

Fig. 2

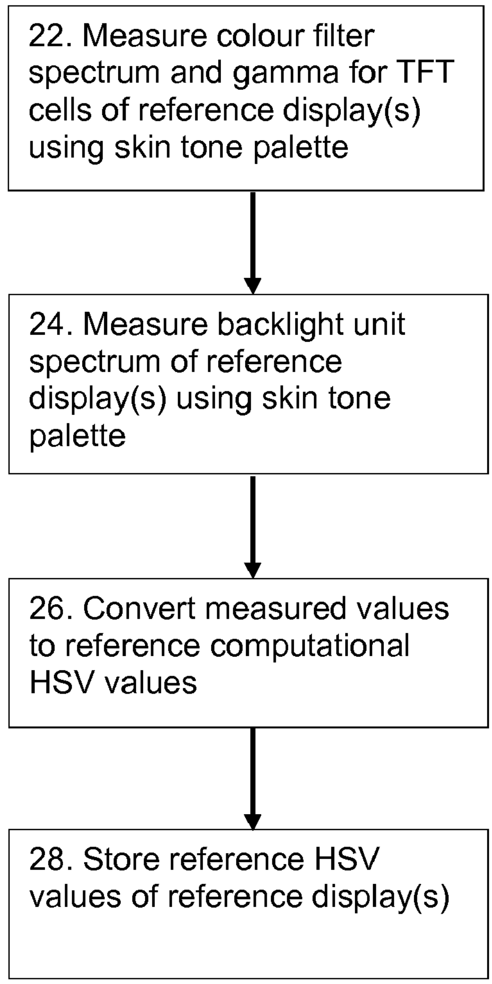
22. Measure colour filter spectrum and gamma for TFT cells of reference display(s) using skin tone palette
24. Measure backlight unit spectrum of reference display(s) using skin tone palette
26. Convert measured values to reference computational HSV values
28. Store reference HSV values of reference display(s)

Fig. 3

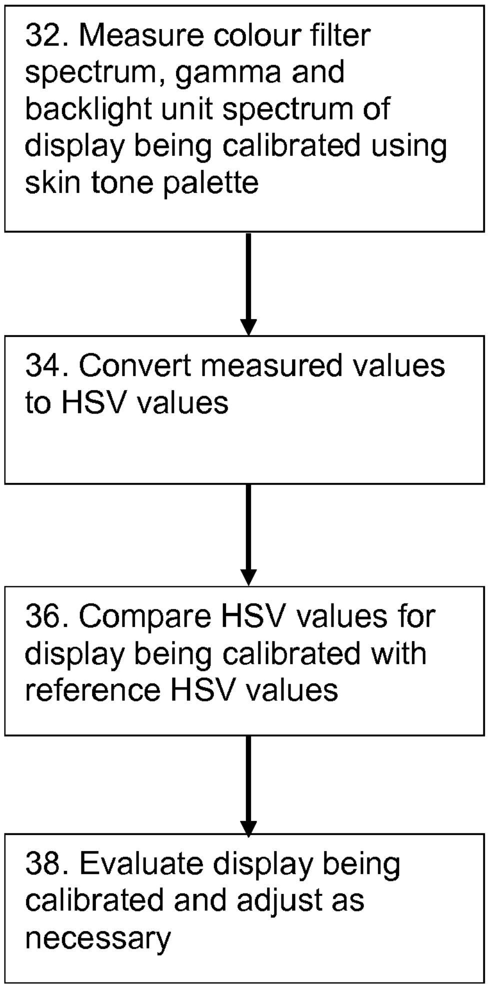
32. Measure colour filter spectrum, gamma and backlight unit spectrum of display being calibrated using skin tone palette
34. Convert measured values to HSV values
36. Compare HSV values for display being calibrated with reference HSV values
38. Evaluate display being calibrated and adjust as necessary

Fig. 4

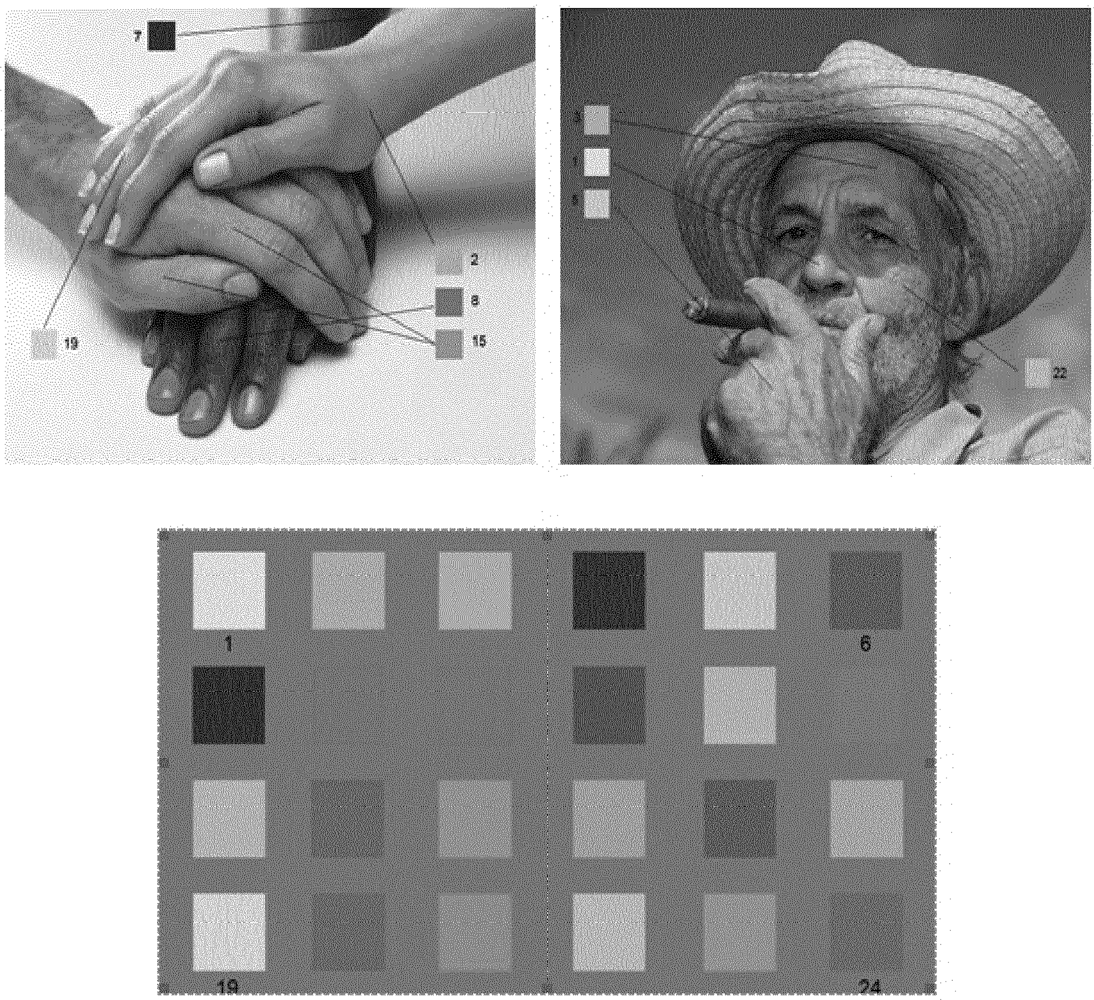

Fig. 5

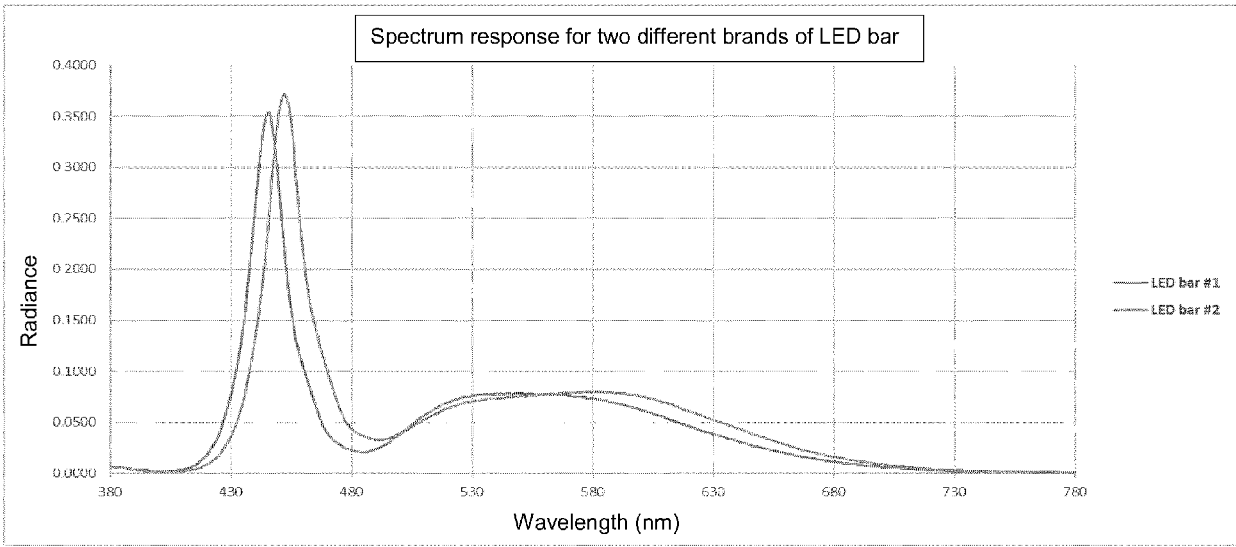
Spectrum response for two different brands of LED bar
Radiance
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
380
430
480
530
580
630
680
730
780
Wavelength (nm)
LED bar #1
LED bar #2

Fig. 6

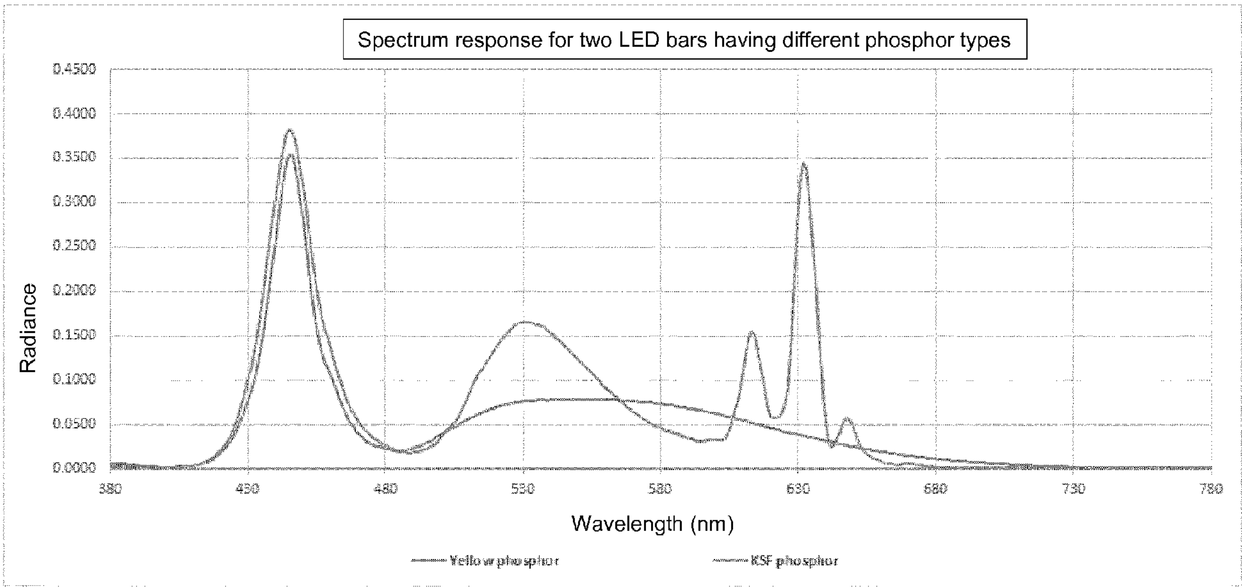
Spectrum response for two LED bars having different phosphor types
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
Radiance
380
430
480
530
580
630
680
730
780
Wavelength (nm)
Yellow phosphor
KSF phosphor

Fig. 7

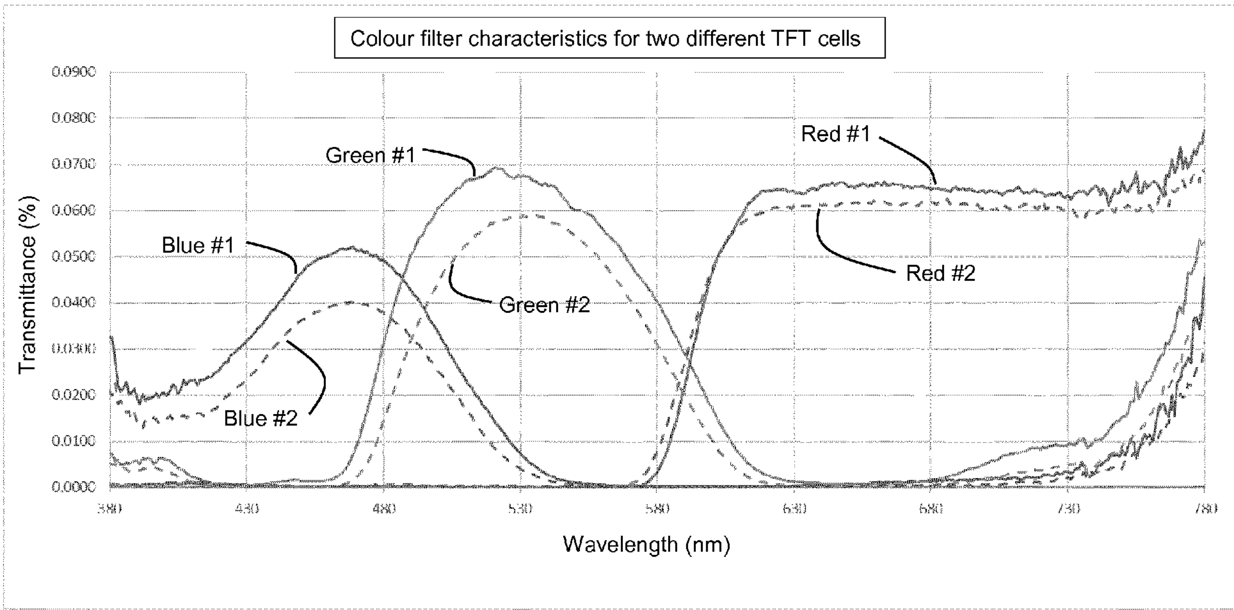
Colour filter characteristics for two different TFT cells
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
Transmittance (%)
380
430
480
530
580
630
680
730
780
Wavelength (nm)
Green #1
Red #1
Blue #1
Red #2
Green #2
Blue #2

Fig. 8

Test Colour Grades			
MB 26 100 Hz			
DATA			
	x	y	Y
100% white	0.28	0.30	400.41
100% red	0.64	0.34	76.67
100% yellow	0.29	0.62	276.12
100% blue	0.14	0.06	24.82
Test colour 01	0.32	0.32	304.91
Test colour 02	0.44	0.40	203.85
Test colour 03	0.42	0.37	203.53
Test colour 04	0.62	0.34	22.16
Test colour 05	0.37	0.35	254.70
Test colour 06	0.48	0.38	75.38
Test colour 07	0.55	0.38	11.15
Test colour 08	0.52	0.40	106.59
Test colour 09	0.55	0.37	78.62
Test colour 10	0.54	0.38	53.83
Test colour 11	0.36	0.32	216.59
Test colour 12	0.53	0.40	119.31
Test colour 13	0.37	0.33	227.86
Test colour 14	0.47	0.35	81.50
Test colour 15	0.43	0.37	168.24
Test colour 16	0.40	0.35	192.37
Test colour 17	0.47	0.37	78.37
Test colour 18	0.37	0.34	212.54
Test colour 19	0.38	0.40	276.99
Test colour 20	0.49	0.39	79.26
Test colour 21	0.55	0.42	140.89
Test colour 22	0.43	0.40	214.69
Test colour 23	0.44	0.37	161.71
Test colour 24	0.51	0.40	86.38

Fig. 9

HSV					
#	**H**	**S**	**V**	**% Point**	**OK/NOK (Not OK)**
1	19	0.21199486	1.002103813	90	OK
2	29	0.63700964	1.003751473	80	OK
3	22	0.53751692	1.003706118	85	OK
4	4	0.903918181	0.530622114	85	OK
5	25	0.392849979	1.003946612	75	OK
6	19	0.686541718	0.717320128	95	OK
7	15	0.81607028	0.339770941	0	NOK
8	23	0.801372416	0.866879117	100	OK
9	12	0.794084612	0.837675372	90	OK
10	17	0.812117619	0.677862113	95	OK
11	6	0.362588553	1.004436379	80	OK
12	21	0.806319307	0.930429474	95	OK
13	13	0.377204901	1.004926831	95	OK
14	10	0.623955178	0.771689417	90	OK
15	20	0.577514637	0.954594258	95	OK
16	17	0.493362063	0.983211886	95	OK
17	16	0.64969463	0.735471827	95	OK
18	17	0.382232453	0.955428167	90	OK
19	39	0.49048457	1.003859688	90	OK
20	21	0.704206637	0.730998821	100	OK
21	27	0.952711967	1.005838339	90	OK
22	30	0.610971875	1.004017977	85	OK
23	18	0.593921372	0.962575204	80	OK
24	21	0.772606679	0.78414673	100	OK
Evaluation (overall score)				**86**	**OK**

Fig. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 4530

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G09G

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	26 January 2018	Bader, Arnaud

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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26-01-2018

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