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(54) Title: A METHOD OF GENERATING PREDETERMINED LUMINANCE LEVELS ACROSS AN ELECTRONIC VISUAL DISPLAY

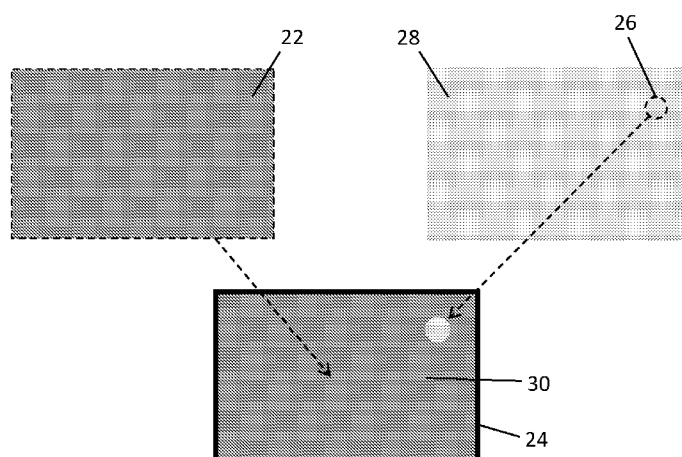


Fig. 5

(57) Abstract: A method of characterising an electronic visual display to substantially accurately and substantially precisely replicate a set of required luminance levels at any location across the electronic visual display is provided. The method comprises the steps of selecting a set of control points across the electronic visual display; selecting a colour-lightness levels (e.g. grey-level) range between 0 to 2^n-1 for a n-bit colour depth; measuring luminance at the selected control points and the selected colour-lightness levels; interpolating measured luminance levels at selected control points and the selected colour-lightness levels thereby deriving luminance at each pixel and each colour-lightness level of the display; generating a look-up-table, which comprises pairing colour-lightness levels to corresponding predetermined luminance levels. The method is applicable on both the grey and coloured light emitted by the EVD. A data acquisition rig for characterising an electronic visual display is also provided.





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**A METHOD OF GENERATING PREDETERMINED LUMINANCE LEVELS ACROSS AN
ELECTRONIC VISUAL DISPLAY**

FIELD OF THE INVENTION

The present invention relates to luminance characterisation and compensation for Electronic
5 Visual Displays (EVDs), for example including but not limited to liquid crystal displays (LCD),
cathode ray tube (CRT) displays, light emitting diode (LED) displays, organic light emitting
diode (OLED) displays and video projection devices. In particular, the present invention
relates to a purpose-specific method that characterises EVDs to accurately and precisely
replicate a set of required luminance levels at any location across the entire electronic visual
10 display. The technique is applicable on both the grey and coloured light emitted by an EVD.

BACKGROUND TO THE INVENTION

In modern society, Electronic Visual Displays (EVDs) are used in a wide range of
applications, from personal/portable devices, such as mobile phones and tablets, to
specialised applications, such as medical, industrial and commercial. Different applications
15 require a different set of characteristics from the EVD in use. Characteristics of common
interest include spatial and temporal resolution, brightness, contrast and colour-depth.

Display technology has improved considerably over the years; however, EVDs still suffer
from luminance non-uniformity, which is manifested as a variable set of luminances being
displayed across a display for a given, uniform colour-lightness level (e.g. grey-level). This
20 luminance non-uniformity across EVDs limits, and sometimes restricts, their suitability in
some specialised applications. For example, various visual field and other visual
performance tests, crucial in the management of a wide range of ophthalmic and
neurological disorders, as well as other vision research applications.

A common technique for visual field examination termed “differential light sensitivity” presents a series of light stimuli (grey or coloured) of known luminance on a uniform background. Stimuli are presented at predetermined locations across the visual field. By varying the luminance and location of the stimuli throughout the test, an accurate assessment of the visual field can be achieved. Currently, stimuli of known luminance are generated through the use of a projection system and a series of light-attenuation filters. Such systems are large, expensive and based on out-dated mechanical projection technologies.

The Humphrey Field Analyser (HFA) (Carl Zeiss), the Twinfield perimeter (Oculus) and the Goldmann and Octopus perimeters (Haag Streit International) are commonly used instruments for differential light sensitivity examinations. Luminance levels employed by these devices are expressed as attenuation levels, in decibels (dBs), with respect to a maximum luminance (0 dB). The required luminance difference between the background and light stimuli during differential light sensitivity examinations can be very small, for example, down to 0.10cd/m^2 are necessary. As such, accurate and precise representation of each luminance level is essential for an accurate and reliable visual field test.

More recently developed techniques, such as the Saccadic Vector Optokinetic Perimetry (SVOP), enable a user-friendly supra-threshold assessment of visual fields. SVOP utilises an EVD to display bright stimuli on a darker background. Suprathreshold SVOP is designed as a screening test to detect near absolute visual field defects and does not require representation of multiple luminance levels with high precision. In order for SVOP to detect subtle changes in visual field function (such as those associated with early stage glaucoma) it must be able to reliably produce accurate and precise representation of many luminance levels across a display screen. Threshold Saccadic Vector Optokinetic Perimetry (TSVOP) can utilise the method described in this patent to produce a reliable threshold perimetry test

suitable for detecting subtle changes from normal visual field function such as those found in early stage glaucoma.

US6177915, US2011007090 and US2007132895 each detail a different approach to the compensation of non-uniformities across one example of electronic visual displays; namely computer Liquid Crystal Display (LCD) systems. In each case, characterisation and compensation of the non-uniformities is: (i) performed during the manufacturing process, and (ii) requires specialised hardware and signal processing on the original video signal. Similar approaches are currently employed by high-end display manufacturers in order to improve luminance non-uniformity across LCDs. However, such approaches are not of great use in a wide range of applications in vision testing (such as differential light sensitivity visual field assessment) and vision science research that require accurate and precise generation of predetermined luminance levels across flat panel displays. While they improve the luminance uniformity across the display to around 95%, the compensated displays still cannot offer sufficient level of luminance accuracy and precision for the intended application (up to 99% luminance uniformity). Furthermore, additional display characterisation would be necessary in order to match colour-lightness levels (display) to luminance-levels (application).

Much of the prior art in this area relates to image adjustment and correction for specific grey-levels and do not provide means of accurately, generating specific luminance levels across any display for specific applications which require this form of display output.

Accordingly, it is desirable to provide a system that can accurately generate specific luminance levels across any display for specific applications which require this form of display output.

It is also desirable to provide a system that is applicable on both grey and coloured light emitted by an EVD.

It is further desirable to provide a system that is capable of accurately and precisely generating specific luminance levels across an electronic visual display.

It is further desirable to provide a system that improves background luminance uniformity of EVDs.

- 5 It is further desirable to provide a system that facilitates expansion of the application of EVDs in a wider area of medical, scientific and ophthalmic applications.

It is further desirable to provide a system that does not require any specialised integrated hardware or dedicated signal processing requirements such that it is applicable to any EVD.

SUMMARY OF THE INVENTION

- 10 A first aspect of the present invention provides a method of characterising an electronic visual display to substantially accurately and substantially precisely replicate a set of required luminance levels at any location across the electronic visual display; the method comprises the steps of:

- a) selecting a set of Control Points (CPs) across the electronic visual display;
- 15 b) selecting a set of colour-lightness levels (e.g. grey-levels) between 0 to 2^n-1 for a n-bit colour depth;
- c) measuring luminance at the selected control points and colour-lightness levels ;
- d) interpolating measured luminance levels between selected control points and between each selected colour-lightness level thereby deriving luminance at each
20 pixel of the display and every possible colour-lightness levels ;
- e) generating a look-up-table, which comprises pairing colour-lightness levels (e.g. grey-levels) to corresponding predetermined luminance levels.

Colour lightness levels referenced above may comprise grey levels.

The method is applicable on both grey and coloured light emitted by the EVD.

In the above, substantially accurately and substantially precisely may be understood to mean towards 100% accuracy. More particularly, substantially accurately and substantially precisely may be understood to mean towards 98% to 99% accuracy.

The method may further comprise:

- f) Utilising the look-up-table to substantially accurately and substantially precisely generate application-specific luminance levels across a characterised electronic visual display

Selection of the set of Control Points may be across a regular grid. Alternatively or in addition the selection of the set of Control Points (CPs) may be positioned in a display specific arrangement. A display specific arrangement may require acquiring an image of a display and analysing the image. The image may be acquired by a camera. The analysis may comprise analysis of the acquired image and display gamma. Analysis of the image may further comprise low pass filtering and contrast enhancement such that unwanted noise can be removed.

A display specific arrangement of CPs provides an irregular sampling approach and thereby reduces acquisition and processing requirements by more than 60% compared with a regular sampling grid.

Step (c) measuring luminance at the selected control points may comprise a luminance meter. More particularly, step (c) measuring luminance at the selected control points may

comprise a scientific grade luminance meter. An example of a scientific grade luminance meter is a Konica Minolta LS-100.

An additional step before step (b) may comprise measuring an exhaustive set of luminance values for a greater number of colour lightness levels about the centre of the display in order
5 to determine the appropriate set of colour-lightness levels for any particular display (step (b)).

The method according to the present invention characterises an EVD in order to accurately and precisely replicate predetermined luminance levels at any location across the entire display. In addition to accurate replication of specific luminance levels, the present invention
10 may also achieve luminance uniformity in the region of 98-99% (depending on the initial quality of the characterised EVD). This is a marked improvement on existing methods, where luminance uniformity is generally a maximum of 95%-96%. As such, the method according to the present invention allows expansion of the use of existing commercial EVDs to specialised scientific applications, for example visual field tests and other vision research
15 applications, aiming at the assessment of glaucoma, cataract, stroke, brain tumours, etc.

Examples to which the method according to the present invention is therefore applicable is, for example, TSVOP technology for a reliable threshold perimetry test suitable for detecting early stage visual field loss, TSVOP is required to accurately (down to 1-2% non-uniformity) and precisely replicate any required stimuli luminance levels across the entire display.

20 Other applications that would benefit from the accurate and precise representation of a predetermined set of luminance levels, as provided by the method of the present invention, include, but are not limited to the following:

(i) vision science research employing psychophysical experimentation that usually rely on Cathode Ray Tube (CRT) displays to reproduce visual stimuli of specific luminance with
25 sufficient accuracy. However, it will be appreciated that CRTs are being phased out,

generally, because of the introduction and advancing development of other display devices which meet most mass market applications;

(ii) tests that assess vision, such as preferential looking and contrast sensitivity that are currently primarily performed by the use of printed cards;

5 (iii) multi-test platforms (visual tests) using portable computing devices for home visits by optometrists/ophthalmologists; and

(iv) any vision test or other application which requires the generation of specific luminance (background, stimulus or otherwise) at any particular screen locations.

The method may also allow extension of the application of the TSVOP technique to a wider
10 range of visual field tests. The TSVOP instrument, described above, utilises an EVD.

The display may have a colour-depth of 8-bit or higher (e.g. 10-bit, 12-bit, etc.)

By using a 10-bit display, the method (i) achieves higher levels of accuracy and precision in the generation of specific luminance levels, and (ii) achieves luminance uniformity in the region of 98-99%, which has not been achieved before.

15 A second aspect of the present invention provides a data acquisition rig, configured to characterise an electronic visual display device to substantially accurately and substantially precisely replicate a set of required luminance levels at any location across the electronic visual display.

The rig may comprise a luminance meter configured to perform a sequence of measurements
20 on selected control points across the electronic visual display device. The luminance meter may be a scientific grade luminance meter. An example of a suitable luminance meter is a Konica Minolta LS-100 model.

The rig may comprise positional control means configured to control position of the EVD relative to the luminance meter. The positional control means may comprise means to control linear translation, means to control level of the EVD and means to control angular position of the EVD relative to the luminance meter. The positional control means may comprise one or
5 more of the following: rails for linear translation, levelling device and a three-axis rotational device.

Aspects of the present invention provide a cost effective system which is applicable to a range of visual field, vision and psychophysics tests because the method according to the present invention facilitates the replacement of out dated technologies, for example cathode
10 ray tube displays, and facilitates replacement of expensive light projection systems, for example Humphrey Field Analyser and Octopus 300 instruments and also facilitates replacement of presently used expensive (circa £3000) LCD equipment that inherently has limited applicability in visual field testing.

The luminance non-uniformity characterisation and compensation method and system
15 according to aspects of the present invention shall therefore expand the usability of mid-range EVDs in specialised applications such as visual field tests normally associated with instruments such as the Humphrey Field analyser and the Octopus 300.

Screen luminance uniformity and the ability to create accurate stimuli are particularly important for applications such as visual field testing. The embodiments of the present
20 invention create a specialised display which enhances existing EVD technologies and expands their use to fields where previously EVDs would not have been considered appropriate.

The characterisation and compensation method and system according to embodiments of the present invention shall therefore enable a wider range of tests to be performed on a single
25 calibrated EVD without a requirement for integrated specialised hardware. For example, such

a calibrated EVD device can be used in applications that require a uniform luminance background and/or the accurate reproduction of stimuli with specific luminance, for example including but not limited to differential light sensitivity tests, vision science research employing psychophysics experimentation, which currently uses dated CRT displays and simple tests, such as preferential looking for infants and contrast sensitivity testing to assess various aspects of visual function e.g. cataract, which currently primarily use printed cards.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which:

10 Figure 1 illustrates a graphical representation of a data acquisition rig used in the application of the method of the present invention;

Figure 2 illustrates a graphical representation of the steps comprising the present invention;

Figure 3a illustrates a graphical representation of EVD gamma through multiple luminance measurements across the full range of colour-lightness levels (grey scale in the specific example) ($0-2^N-1$ for N-bit colour depth);

Figure 3b illustrates a graphical representation of a set of control points selected to characterise luminance non-uniformity across an EVD;

Figure 4a illustrates a graphical representation of interpolated non-uniformity across an assessed LCD. Representation is contrast enhanced for illustration purposes;

20 Figure 4b illustrates a graphical representation of dithered colour-lightness levels (e.g. grey levels) required to produce a uniform background luminance of 10cd/m^2 . Representation is contrast enhanced for illustration purposes;

Figure 4c illustrates a graphical representation of uniform background luminance reproduced by the compensated EVD. Representation is contrast enhanced for illustration purposes; and

Figure 5 illustrates a graphical representation of how specific luminance levels are utilised during a visual field differential light sensitivity test.

5 DETAILED DESCRIPTION

Embodiments of the present invention provide a purpose-specific method that characterises an electronic visual display (EVD), for example a liquid crystal display device to accurately and precisely replicate a set of required luminance levels at any location across the entire display. As such, the field of application for existing uncompensated EVDs can be expanded,
10 for example into areas of visual field testing normally associated with instruments such as the Humphrey Field Analyser and the Octopus 300.

Figure 1 provides a graphical representation of a data acquisition rig 10, configured to characterise an EVD 12. In the illustrated example an 8-bit EVD 12 is characterised using grey-level information. However, the technique is applicable to displays with higher colour
15 depths (e.g. 10bit or more) and can characterise light of various chromaticity levels.

The rig 10 comprises a scientific luminance meter 14, for example a Konica Minolta model no LS100. The luminance meter 14 performs a sequence of measurements on a number of control points across the EVD being assessed (see Figure 3b).

Linear translation of the EVD 12 relative to the luminance meter 14 is controlled by two rails
20 16. Levelling devices 18, such as spirit levels, were employed together with a three-axis rotating stage 20 to ensure that the measurement axis was perpendicular to the EVD.

All of the data acquisition parameters are set in accordance with Video Electronics Standards Association's (VESA) Flat Panel Display Measurements Standard (FPDM) Version 2.0. Luminance measurements are performed in darkroom conditions with ambient light below

VESAs suggested upper limit. However, could be performed in other conditions more relevant to the intended end-purpose of the luminance generation technique Figure 2 provides a graphical representation of the steps used in the method according to embodiments of the present invention.

- 5 Step 1 100 includes the selection of a set of control points across the EVD as well as across the entire grey-level range (0 to 2^n-1 for n-bit colour depth). A regular and/or a display-specific control point grid or arrangement may be employed. The method according to the present invention includes, but it is not limited to, a display-specific sampling approach which accurately and efficiently represents luminance variations across the display over a range of
- 10 grey levels (0 to 2^n-1), from the darkest black (0) to the brightest white (2^n-1).

To determine an optimal set of grey levels, which upon interpolation accurately represent the display gamma (nonlinear operation used to code and decode luminance), an exhaustive set of luminance measurements are performed at the centre of the display as illustrated in Figure 3a, and an algorithm is used to identify an optimal set of grey levels.

- 15 Starting from grey level 0 and progressing to grey level 2^n-1 , the algorithm automatically identifies the largest step for which the difference between the original and interpolated gamma curves is less than 20% of the corresponding inter-level step.

- To determine an optimal set of control points which, upon interpolation, accurately represents luminance non-uniformity across the EVD (see Figure 3b) an image of the display at a
- 20 suitable fixed grey level, for example $2^n/2$ (i.e. 128 for 8-bit EVD), is acquired using a suitable camera, for example a 24.2MPixel camera, This image is then low-pass filtered and contrast enhanced to further remove unwanted noise and highlight areas with high non-uniformity, enabling the selection of a representative set of control points across the EVD as illustrated in Figure 3b.

The process could be iterative and control point selection can be refined in regions demonstrating large differences between the original acquired image and the interpolated image.

While, a regular control point sampling grid may be employed in Step 1, a display-specific, irregular sampling arrangement reduces the acquisition and processing requirements, for example greater than 60% reduction in the total number of samples, and also enhances the accuracy of the interpolated profiles, for example greater than 60% reduction on maximum difference between the original and the interpolated profiles.

Referring to Figure 2, in step 2 110 a sequence of luminance measurements, required to characterise the EVD, were performed on the control points and grey-levels derived through the above. It will be appreciated that alternative processes could be adopted to derive the control points and the grey levels.

At each control point luminance measurements were performed at the identified specific grey-levels over the 0 to 2^n-1 range. The data acquisition rig illustrated in Figure 1 is employed for the data acquisition.

In step 3 120 (see Figure 2) interpolating splines are used to derive all intermediate luminance values amongst the sample grid. Initially, one-dimensional interpolating cubic b-splines are used to derive the Gamma corresponding to each control point across the EVD as illustrated in Figure 3a.

Given control points P_1 to P_n , a set of points S_i are derived defining a *relaxed uniform cubic B-Spline* interpolating through P_1 to P_n :

$$\begin{pmatrix} 4 & 1 & 0 & 0 & 0 \\ 1 & 4 & 1 & 0 & 0 \\ 0 & 1 & 4 & 1 & 0 \\ 0 & \dots & & 1 & \\ & & & & 4 \end{pmatrix} \times \begin{pmatrix} S_2 \\ S_3 \\ S_4 \\ \dots \\ S_{n-1} \end{pmatrix} = \begin{pmatrix} 6P_2 - P_1 \\ 6P_3 \\ 6P_4 \\ \dots \\ 6P_{n-1} - P_n \end{pmatrix} \quad (1)$$

with $S_1 = P_1$ and $S_n = P_n$. Subsequently, a set of two-dimensional interpolating b-splines are used to derive the luminance at each pixel across the display and for each grey-level.

$$T = \sum_{l=0}^3 B_l(u) S_{i+l} \quad (2)$$

5 where $i = \{1, \dots, n\}$, $u \in \{0, \dots, 1\}$ and B_l represented the l -th basis function of the B-Spline.

Such cubic splines generate smooth, 2nd order continuous interpolations providing closer representations of the actual gamma curves, and luminance non-uniformity across the assessed EVD, when compared to the corresponding linear interpolations. Fig. 4a illustrates the interpolated luminance variability across the assessed display for a given, uniform grey-
10 level. In Figure 4a the graphical representation is contrast enhanced for illustration purposes.

By the end of the interpolation process, a luminance estimate is derived for each pixel and each grey-level across the display.

In step 4 130 (see Figure 2) a binary search is performed to identify the grey-levels that produced a uniform luminance representation to each luminance level required throughout
15 the characterised EVD for a specific application:

$$\arg \min_{i,j,k,N} |L_D(i, j, k) - L_H(N)| \quad (3)$$

where $L_H(N)$ corresponds to the N cd/m² luminance required during a specific application, while $L_D(i, j, k)$ denotes the luminance generated by the characterised EVD at pixel (i, j) and
20 grey-level $k \in [0: 2^n-1]$. At the end of the process, a sequence of 2D matrices (each with grey-level values for every pixel of the EVD) is generated, see Figure 4b. In Figure 4b the graphical representation is contrast enhanced for illustration purposes.

In step 5 140 (see Figure 2) the matrices generated in Step 4 130 provide a device, for example TSVOP, with the closest and most uniform representation of each required luminance level achievable. This uniform luminance representation is illustrated in Figure 4c.

A dithering algorithm, for example Floyd-Steingerg is employed to diffuse quantisation errors along the grey-level boundaries to neighbouring pixels generating visually smoother transitions. In Figure 4c the graphical representation is also contrast enhanced.

Figure 5 illustrates a graphical representation of how the specific luminance levels stored in look-up tables during Step 4 130 are utilised in Step 5 140 (described above with reference to Figure 2) during a visual field differential light sensitivity test. Background luminance 22 is displayed across the entire EVD 24. At the stimulus location 26, the stimulus luminance 28 is displayed generating an instant 30 during a differential light sensitivity test.

Quantitative assessment verifies the suitability of the present approach, demonstrating that compensated EVDs can provide the accuracy and precision required during visual field differential light sensitivity tests.

By employing the non-uniformity compensation approach described, the luminance-levels required for assessing visual fields are reproducible with a non-uniformity of $3.63\% \pm 0.42\%$ for mid-range 8-bit EVDs and less than 1% for high end 10-bit graphics EVDs. The non-uniformity is independent of the corresponding luminance level. The mean luminance across the compensated LCD provides a very accurate representation ($\pm 0.6\%$ of actual value) for each required luminance level.

The characterisation and the compensation approach provided by embodiments of the present invention has been clinically assessed.

Clinical testing demonstrated that a substantial decrease of luminance non-uniformity enables accurate and precise examination of visual field thresholds using a compensated display. Performing such threshold tests was previously not possible with current display technology.

The non-uniformity characterisation and the compensation approach according to
5 embodiments of the present invention utilised a mid-range 8-bit EVD as well as two high end graphics EVDs with native 10-bit support (1024 grey-levels). Characterising a display that provides a native 10-bit support (1024 grey-levels) increases the available search-space enhancing the capabilities of the present approach and consequently and consequently increases the accuracy and precision of the visual field threshold examinations.

10 The luminance non-uniformity characterisation and compensation approach provided by embodiments of the present invention expands the use and application of EVD devices and therefore creates a new specialised display to meet a new requirement which has previously not been achievable using existing display technologies.

The luminance non-uniformity characterisation and compensation approach provided by
15 embodiments of the present invention enable off-the-shelf, mid-range EVDs, which cost in the region of £500 to achieve better uniformity than high-end medical displays, which can cost in excess of £3000. Furthermore, it enables higher-end 10-bit EVDs to accurately and precisely reproduce a set of luminance levels required for specialised visual field examinations and other vision tests.

20 Using the approach of the present invention shall enable a range of medical, scientific and ophthalmic tests to be performed on a single computing device, along with a calibrated EVD without the need for additional hardware. For example: visual field differential light sensitivity tests, vision science research employing psychophysics experimentation, preferential looking test for infants and contrast sensitivity testing to assess various aspects of visual function e.g.

cataract, and any vision test or other application which requires the generation of specific luminance (background, stimulus or otherwise) at any particular screen locations.

The luminance characterisation and compensation approach provided by embodiments of the present invention can further improve the performance of high-end medical displays.

- 5 Although the description of the present invention refers specifically to the characterisation and derivation of luminance with grey levels, the present invention may also be applied (or extended) to the characterisation and derivation of other properties of colour on EVDs, for example hue, saturation and lightness.

- 10 Whilst specific embodiments of the present invention have been described above, it will be appreciated that departures from the described embodiments may still fall within the scope of the present invention.

CLAIMS

1. A method of characterising an electronic visual display to substantially accurately and substantially precisely replicate a set of required luminance levels at any location across the electronic visual display; the method comprises the steps of:

- 5 a) selecting a set of control points across the electronic visual display;
- b) selecting a set of colour-lightness levels between 0 to 2^n-1 for a n-bit colour depth;
- c) measuring luminance at the selected control points and lightness levels;
- d) interpolating measured luminance levels between selected control points and
10 between each selected lightness level thereby deriving luminance at each pixel of the display for every possible lightness level;
- e) generating a look-up-table, which comprises pairing colour lightness levels to corresponding predetermined luminance levels.

2. A method according to claim 1, wherein step (b) selecting a colour-lightness level
15 between 0 to 2^n-1 for an n-bit colour depth, comprises analysis of an exhaustive colour-lightness level range across the electronic visual display.

3. A method according to claim 1 or 2, further comprising:

- f) Utilising the look-up-table to substantially accurately and substantially precisely
 generate application-specific luminance levels across the characterised electronic
20 visual display.

4. A method according to claim 1, 2, or 3, wherein step (a) selecting a set of control points across the electronic visual display is across a regular grid.

5. A method according to any preceding claim, wherein step (a) selecting a set of control points across the electronic visual display is across a display specific grid.

6. A method according to claim 5, wherein the display specific grid comprises further steps of acquiring an image of a display and analysing the image.
7. A method according to claim 6, wherein the image is acquired by a camera.
8. A method according to claim 6 or 7, wherein analysing the image may comprise
5 analysis of the acquired image and display gamma.
9. A method according to claim 8, further comprising low pass filtering and contrast enhancement of the acquired image.
10. A method according to any preceding claim, wherein step (c) measuring luminance at the selected control points comprises use of a luminance meter.
- 10 11. A method according to claim 10, wherein step (c) measuring luminance at the selected control points comprises a scientific grade luminance meter.
12. A method according to any preceding claim, wherein step (c) measuring luminance at the selected control points comprises an exhaustive set about the centre of the display.
13. A data acquisition rig, configured to characterise an electronic visual display device
15 to substantially accurately and substantially precisely replicate a set of required luminance levels at any location across the electronic visual display, the data acquisition rig comprises a luminance meter configured to perform a sequence of measurements on selected control points across the electronic visual display device and positional control means configured to control position of the EVD relative to the luminance meter.
- 20 14. A data acquisition rig according to claim 13, wherein the luminance meter is a scientific grade luminance meter.
15. A data acquisition rig according to claim 13 or 14, wherein the positional control means comprise means to control linear translation, means to control level of the EVD and means to control angular position of the EVD relative to the luminance meter.

16. A data acquisition rig according to claim 15, wherein the positional control means comprise one or more of the following: rails for linear translation, a levelling device and a three-axis rotational device.

17. A method of characterising an electronic visual display as hereinbefore described
5 and with reference to the accompanying drawings.

18. A data acquisition rig as hereinbefore described and with reference to the accompanying drawings.

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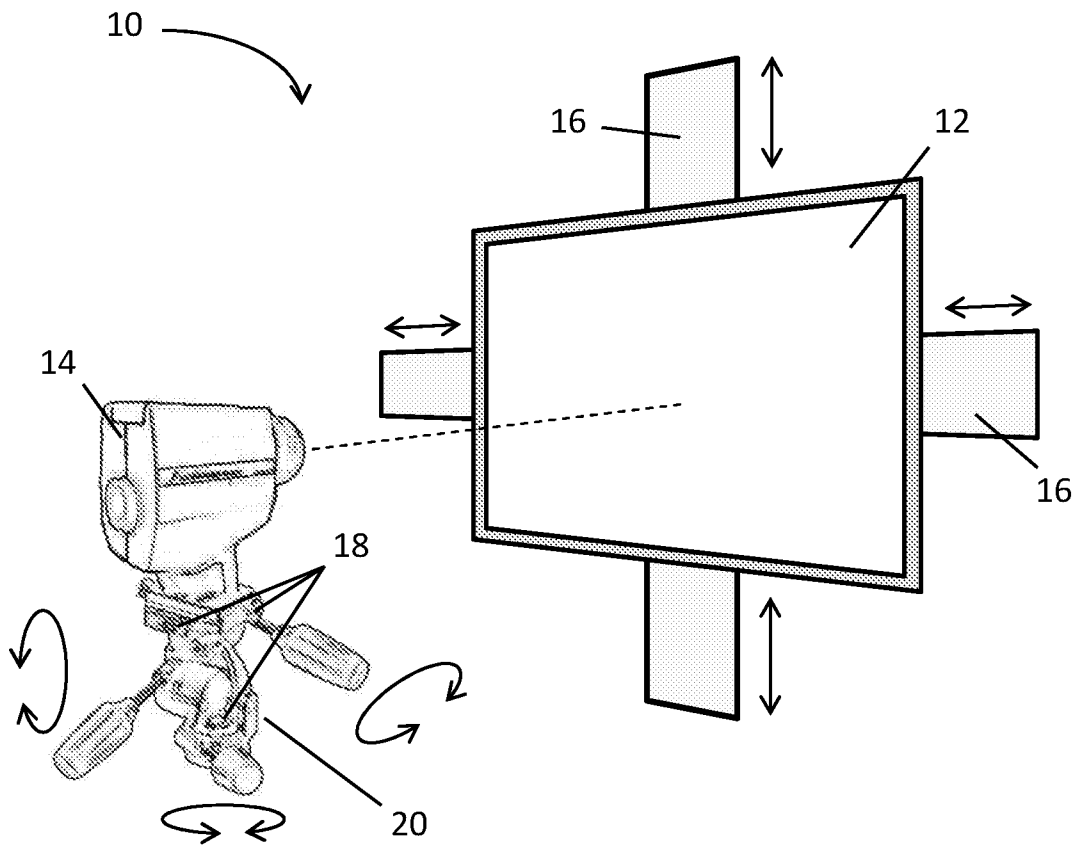


Fig. 1

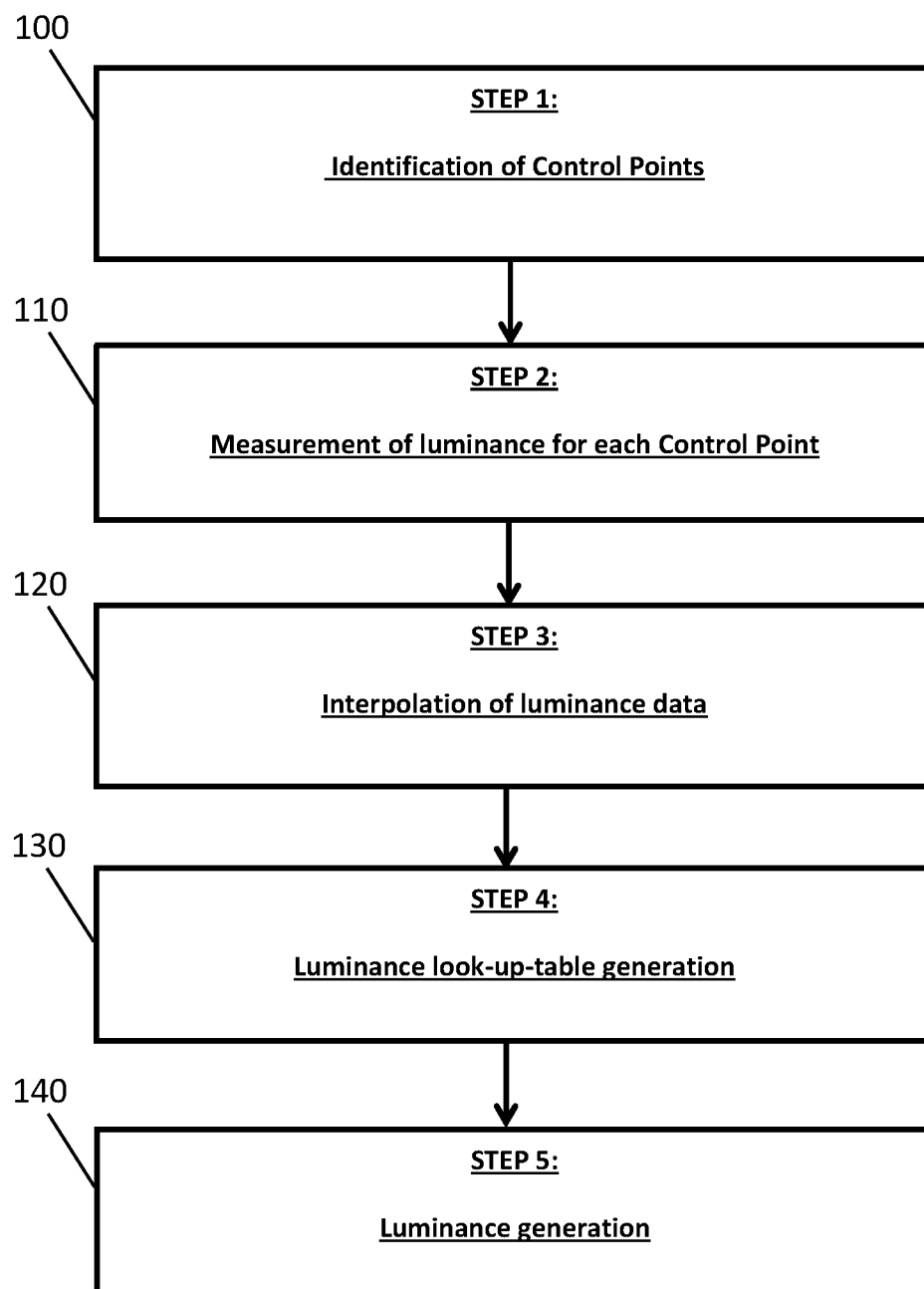


Fig. 2

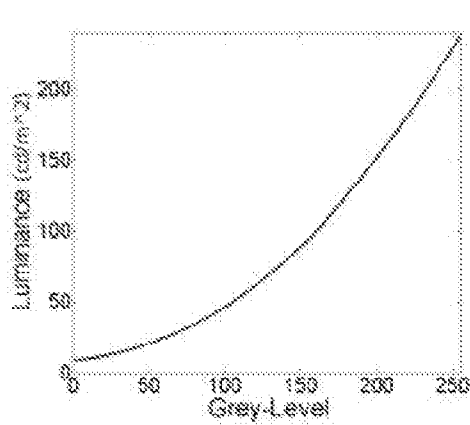


Fig. 3a

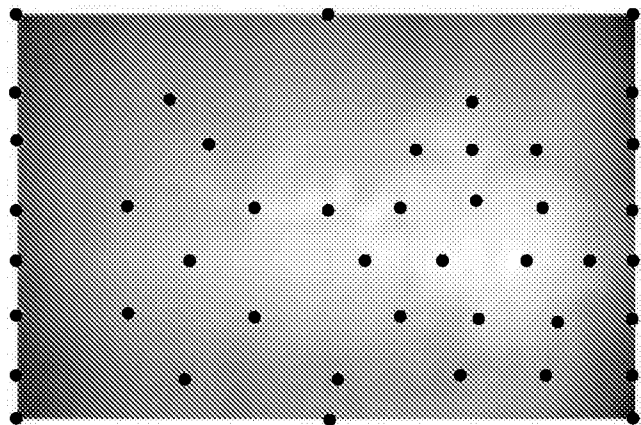


Fig. 3b

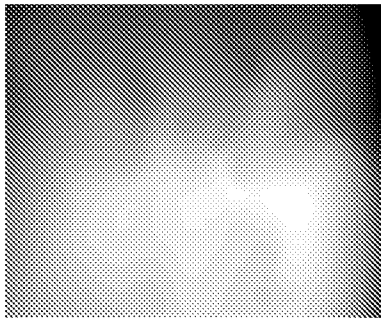


Fig. 4a

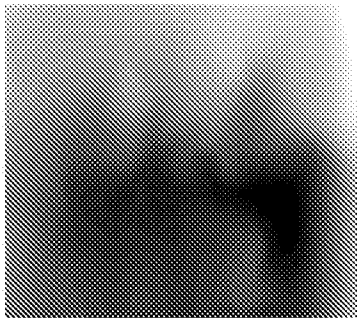


Fig. 4b

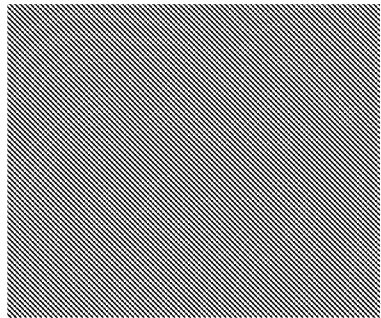


Fig. 4c

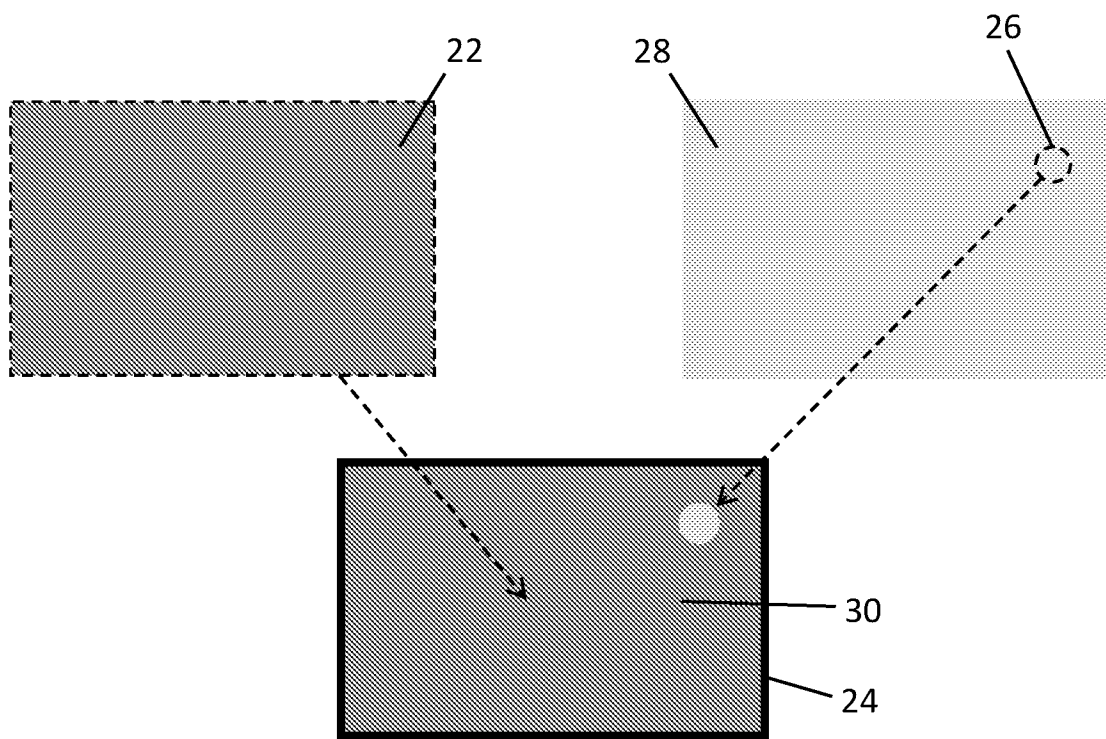


Fig. 5