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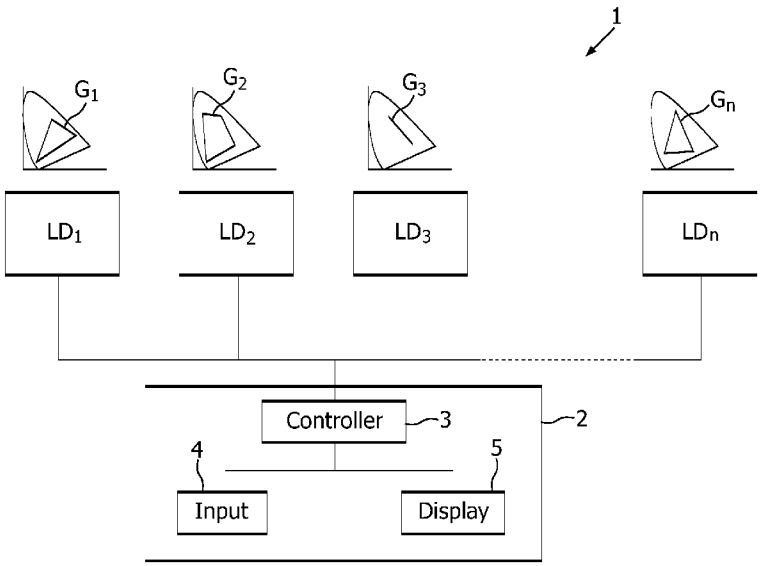
(54) Title: A CONTROLLER FOR A VARIABLE COLOR LIGHTING SYSTEM



(57) Abstract: A controller (3), for a variable color lighting system (1) comprising a plurality of lighting devices (LD_{1-n}), the controller (3) comprising means (10) for receiving a request (S_r) for an output color to be emitted by the variable color lighting system (1), and communication means (12) adapted to send control signals (C_1, C_2) indicative of the request to at least one of the lighting devices (LD_{1-n}), thereby enabling emission of the output color. The controller (3) further includes processing means (13) adapted to access data indicative of color gamuts (G_1, G_2) of at least two of the lighting devices (LD_1, LD_2), and determine a color emission capability (G_{tot}) based on the accessed data.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A controller for a variable color lighting system

The present invention relates to a controller for a variable color lighting system, a control system including such a controller and a variable color lighting system.

The invention further relates to a method for controlling color output of a variable color lighting system.

A current trend in lighting is that light is more and more used for creating an atmosphere rather than for simple illumination. Lighting solutions suitable as "atmosphere providers" need to be capable of emitting light of different colors as well as being variable in intensity (dimmable). Ideally, such lighting solutions should be variable over the entire color triangle (for example in the xy-plane of the CIE XYZ-system) perceptible by a human eye. In reality, however, a color variable lighting solution can span only a part of the color triangle. For a particular color variable lighting solution, this part of the color triangle is referred to as the color gamut of the lighting solution. Moreover, different lighting solutions generally have different color gamuts.

For a variable color lighting system constituted by a group of adjustable lighting devices, it is desirable to be able to individually control the lighting devices as well as to be able to control the group as a whole.

In order to enable user control of such a variable color lighting system in the form of a group of adjustable lighting devices, a control system having a suitably designed user interface should be provided.

In WO 02/061330 one such control system is disclosed, wherein an illumination spectrum is presented to the user and the user is allowed to select desired colors for illumination of a content of a swimming pool. Signals are then transmitted from the control system to light sources in order to produce the selected color.

The control system according to WO 02/061330 appears, however, not to be capable of handling a situation where several different lighting devices, having different color gamuts are to be controlled through the user interface. With the control system disclosed in WO 02/061330, the user may unintentionally select a color, which can be

emitted by some of the connected light sources but not by others. This may lead to undesirable illumination effects.

For alleviating the above problems connected with prior art, there is thus a need for an improved control system for a variable color lighting system.

In view of the above-mentioned and other drawbacks of prior art, a general object of the present invention is to provide an improved control system for a variable color lighting system and a variable color lighting system comprising such a control system.

A further object of the present invention is to enable control of a variable color lighting system comprising lighting devices having non-identical color gamuts.

According to a first aspect of the invention, these and other objects are achieved by a controller, for enabling user control of a variable color lighting system comprising a plurality of lighting devices, the controller comprising means for receiving a request for an output color to be emitted by the variable color lighting system, and communication means adapted to send control signals indicative of the request to at least one of the lighting devices, thereby enabling emission of the output color, wherein the controller further includes processing means adapted to access data indicative of color gamuts of at least two of the lighting devices, and to determine a color emission capability based on the accessed data.

A "lighting device" should, in the context of the present application, be understood as a device capable of emitting visible light. A lighting device may comprise one or several light-sources and may be adjustable in intensity and/or color.

The "color emission capability" of the variable color lighting system is the capability of the variable color lighting system to emit variably colored light. This capability may, for example, be illustrated as a certain area in a chromaticity diagram, such as an xy-diagram in the CIE XYZ-system.

The communication means may be configured to send signals to at least one of the lighting devices by means of wired or wireless communication.

Data indicative of color gamuts of lighting devices included in the lighting system may be accessed from the lighting devices or from a memory, which may be local or remote to the controller.

Through the provision of a controller according to the invention, a user may be guided to select an output color, which the variable color lighting system is capable of emitting. Thereby, unwanted color variations among the lighting devices comprised in the variable color lighting system may be avoided.

The controller according to the present invention is especially useful for situations when the variable color lighting system to be controlled comprises different types of lighting devices, such as light-emitting diode (LED) based and fluorescent-based lighting devices potentially having rather different color gamuts. The controller of the invention is, however, also useful for handling differences among lighting devices of the same type due to different manufacturing conditions or operational conditions etc. An additional effect obtained by means of the controller according to the present invention is that the determination of the color emission capability may be updated following changing conditions of the variable color lighting system, such as changes in which lighting devices are connected to the controller and/or the condition of the connected lighting devices. These updates may be performed automatically, without user intervention.

The controller according to the present invention may advantageously comprise means for providing a signal indicative of the color emission capability of the variable color lighting system.

Such a signal may, for example, be presented to a user via a user interface in a control system. Alternatively, the signal may be used in the control system to automatically adapt a user request to the color emission capability of the variable color lighting system.

Through the provision of a signal indicative of the color emission capability of the variable color lighting system, a user may be given clear guidance to which colors are available and how various configurations of the lighting system potentially yield different color emission capabilities. Unwanted color variations may thereby be avoided.

According to one embodiment of the controller according to the present invention, the communication means may further be adapted to receive signals from the at least two lighting devices, and the data indicative of the color gamuts of the at least two lighting devices may be accessed through the communication means.

By accessing color gamut data from lighting devices through the communication means, a plug-and-play lighting system may be realized. Upon adding a new lighting device to the variable color lighting system or replacing a lighting device with another, color gamut data may be accessed by the controller. Thereby, an updated determination of a modified color emission capability of the variable color lighting system

may automatically be performed following a modification of the lighting system. Additionally, a signal indicative of this modified color emission capability may be provided to the user.

Preferably, the controller according to the invention may further include a memory configured to store data indicative of the determined color emission capability.

Through the provision of a memory for storage of data indicative of the color emission capability of the variable color lighting system, color gamut data may be accessed from the lighting devices a very limited number of times. Following such an access, the color emission capability may be determined and the relevant data may be stored in the provided memory.

For example, color gamut data may be accessed at times such as following initial installation, upon modifications of the variable color lighting system and at regular predetermined intervals.

Obviously, the accessed color gamut data may be stored in the memory in addition to or instead of the data indicative of the color emission capability of the lighting system.

Advantageously, the processing means may further be adapted to de-saturate an out-of-gamut request.

Even though a signal indicative of the color emission capability of the variable color lighting system may be provided, a user may be allowed to request a color beyond this color emission capability. Such a request is here referred to as an "out-of-gamut request".

In order to handle such an out-of-gamut request in an acceptable manner, the processing means may be adapted to de-saturate the requested color to a color point within the color emission capability of the variable color lighting system. Such a de-saturation or approximation may be performed by, in a chromaticity diagram, linearly translating the requested color point towards a suitable point within the color gamut of the variable color lighting system.

De-saturation may also be performed locally in the lighting devices comprised in the lighting system.

According to one embodiment of the controller according to the present invention, the color emission capability of the variable color lighting system may be determined by forming a section of the color gamuts of the at least two lighting devices.

Through the determination of the color emission capability in this way, a color emission capability may be indicated, which is accessible to all of the at least two lighting

devices. Thereby, it is ensured that light at a requested color within the indicated color emission capability can be emitted by these lighting devices. Such a color emission capability may be formed by the section of all of the lighting devices comprised in the lighting system or of a sub-group of lighting devices.

According to another embodiment of the controller according to the present invention, the color emission capability may be determined by forming a union of the color gamuts of the at least two lighting devices. In this way, the color gamut of the variable color lighting system typically becomes bigger than that of the individual lighting devices comprised in the lighting system. Hereby, light of colors covering a large area of the chromaticity diagram may be emitted by the lighting system by intentionally selecting lighting devices with at least partly complementary color gamuts.

The controller according to the present invention may advantageously be included in a control system, for enabling user control of a variable color lighting system, further comprising input means adapted to enable the user to input a request for an output color to be emitted by the variable color lighting system.

The control system may further include indication means configured to indicate to the user a color emission capability of the variable color lighting system.

The indication means may, for example, include a display, such as a computer display or a small LCD-display, differently colored indicators, a printed color chart, or combinations thereof.

The user input means may, for example, be provided in the form of one or several actuators, such as buttons, touch-pads, sliders or knobs. The user input means may be separated from, or integrated with the indication means. The user input means may further include computer connected input means, such as a keyboard, a mouse, a touch-pad or a touch-screen.

According to a second aspect of the invention, the above-mentioned and other objects are achieved by a variable color lighting system comprising a plurality of lighting devices and the above-mentioned control system.

According to a third aspect of the invention, the above-mentioned and other objects are achieved by a method, for controlling color output of a variable color lighting system comprising a plurality of lighting devices, the method comprising the steps of accessing data indicative of color gamuts of at least two of the lighting devices, determining a color emission capability of the variable color lighting system based on the accessed data, receiving, from a user interface, a request for an output color to be emitted by the variable

color lighting system, and sending, to at least one of the lighting devices, control signals indicative of the request, thereby enabling emission of the requested output color.

Advantageously, the method according to the present invention may further comprise the step of providing, to the user interface, a signal indicating the color emission capability.

Further effects obtained through this third aspect of the present invention are largely analogous to those described above in connection with the first aspect of the invention.

According to a fourth aspect of the invention, the above-mentioned and other objects are achieved by a computer program module adapted to run on a controller in a variable color lighting system, to perform the method of the present invention.

For examplifying purposes, these and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing currently preferred embodiments of the invention, wherein:

Fig. 1 is a schematic illustration of a variable color lighting system according to the present invention.

Fig. 2a schematically shows a block diagram illustrating a preferred embodiment of a controller according to the present invention.

Fig. 2b schematically shows an example of a user interface of a control system according to the present invention.

Figs. 3a-b illustrate, in the xy-plane of the CIE XYZ-color space, two examples of relations between the determined color emission capability of the variable color lighting system according to the present invention and color gamuts of lighting devices comprised in the lighting system.

Fig. 4 is a flow chart illustrating a method according to a preferred embodiment of the present invention, for controlling color output of a variable color lighting system.

In the following description, the present invention is described with reference to a stand-alone control system for controlling a variable color lighting system. It should be noted that this by no means limits the scope of the invention, which is equally applicable to

control systems implemented in a variety of other ways, such as by means of a personal computer or similar.

In Fig. 1, a variable color lighting system 1 according to the present invention is schematically illustrated where a control system 2 is connected to n lighting devices LD_{1-n}, each capable of emitting light of colors within a respective color gamut G_{1-n}. The control system 2 comprises a controller 3, user input means 4 and indication means represented by a display 5.

A preferred embodiment of the controller 3 will now be described in greater detail with reference to Fig. 2a. In Fig. 2a, a controller 3 for enabling user control of a variable color lighting system 1 is shown. The controller 3 has a first interface 10 for enabling communication with a user interface comprising user input means 4 and indication means 5 (Fig. 1), communication means in the form of a second interface 12, a processor 13 and a memory 14.

The processor 13 is configured to access data indicative of color gamuts of lighting devices LD_{1-n} (Fig. 1) that are connected to the controller 3.

This data, which may for example be provided in the form of primary color co-ordinates and flux characteristics of the lighting devices LD_{1-n}, may be accessed from the lighting devices LD_{1-n} via the second interface 12, from the user interface, via the first interface 10, from a recordable medium, such as a CD-ROM or equivalent, via the internet or from the memory 14. In order to provide plug-and-play functionality for the variable color lighting system 1, the processor 13 is, in the present examplary embodiment, adapted to access data from the lighting devices LD_{1-n} via the second interface 12 and to store this data indicative of the color gamuts of the respective lighting devices LD_{1-n} in the memory 14.

Furthermore, the processor 13 is adapted to determine the color emission capability of the variable color lighting system 1 based on this accessed data. Signals indicative of the determined color emission capability may then be provided to a user interface through the first interface 10. In the user interface, the color emission capability may be indicated to the user in a variety of ways. For example, the color emission capability may be highlighted in one of various representations of color space. One examplary way of providing such an indication is described below in connection with Fig. 2b.

Guided by the information regarding the color emission capability, which is provided, through the first interface 10, the user requests color and/or intensity of light to be emitted by the variable color lighting system 1, or parts of it. The user requests are received through the first interface 10 and processed by the processor 13, which then sends signals

indicative of the request to at least one of the lighting devices LD_{1-n} (Fig. 1). The selected lighting device(s) is/are thereby caused to emit light of the requested color.

Obviously, variations of the above procedure exist. For example, the request signals received through the first interface 10 may be directly routed to the lighting devices LD_{1-n}, or an out-of-gamut request may be modified by the processor 13 such that signals indicative of a color within the respective gamuts of the at least one lighting devices LD_{1-n} are sent. Furthermore, referring to Fig. 1, the control system, 2 may provide the user with an out-of-gamut warning via the display 5 when an out-of-gamut request is received via the user input means 4.

Fig. 2b schematically shows an examplary embodiment of a user interface 20, comprised in the control system 2, with examplary indication means in the form of a color display 21 and examplary user input means in the form of a touch-sensitive surface 22 on the color display 21 and a slider 23.

In the present examplary embodiment, the color emission capability of the variable color lighting system 1 is indicated to the user in the form of an accessible area 24 in a circular color plane 25 according to the HSI-model. Guided by this indicated accessible area 24, the user may select a color to be emitted by touching the touch-sensitive surface 22 of the color display 21 in the appropriate location. The desired intensity may be selected using the slider 23.

As is apparent to the person skilled in the art, a user interface 20 similar to the above-described is readily implemented in an ordinary computer, in which case the color and intensity could be selected by clicking and/or dragging with a computer mouse in a graphical user interface.

Figs. 3a-b illustrates two alternative ways of forming the color emission capability of the variable color lighting system. For simplicity, the color emission capability, or color gamut, of the lighting system is here formed from color gamuts of two lighting devices. Of course, the illustrated principles are equally applicable to a larger number of lighting devices having different color gamuts.

As shown in Fig. 3a, the color emission capability G_{tot} of the variable color lighting system 1 may be formed as the section between color gamuts G_1, G_2 of lighting devices LD_1, LD_2. One is then ensured that light at a requested color within the indicated color emission capability G_{tot} can be emitted by the variable color lighting system 1.

In Fig. 3b, it is shown how the color emission capability G_{tot} of the variable color lighting system 1 may be formed as the union of color gamuts G_1, G_2 of lighting

devices LD_1, LD_2. The color emission capability G_{tot} of the lighting system 1 then becomes greater than the color emission capabilities G_1, G_2 of the constituting lighting devices LD_1, LD_2.

Fig. 4 is a flow chart illustrating the method according to the invention, for controlling color output of a variable color lighting system, where, in a first step 30, data indicative of color gamuts G_1, G_2 of at least two lighting devices LD_1, LD_2 comprised in the variable color lighting system 1 are accessed. In a subsequent step 31, the color emission capability G_{tot} of the variable color lighting system 1 is determined based on the accessed data. In a following step 32, a signal S_c indicating the determined color emission capability G_{tot} is provided to a user interface 20. In a subsequent step 33, a request S_r for an output color to be emitted by the variable color lighting system is received from the user interface 20, and in the next step 34, control signals C_1, C_2 indicative of this request are sent to at least one LD_1, LD_2 of the lighting devices LD_{1-n}.

CLAIMS:

1. A controller (3), for a variable color lighting system (1) comprising a plurality of lighting devices (LD_{1-n}), said controller (3) comprising:

means (10, 13) for receiving a request (S_r) for an output color to be emitted by the variable color lighting system (1); and

communication means (12) adapted to send control signals (C_1, C_2) indicative of said request to at least one of said lighting devices (LD_{1-n}), thereby enabling emission of said output color,

characterized in that said controller (3) further includes processing means (13) adapted to:

access data indicative of color gamuts (G_1, G_2) of at least two of said lighting devices (LD_1, LD_2); and

determine a color emission capability (G_{tot}) based on said accessed data.

2. A controller (3) according to claim 1, further comprising means (10, 13) for providing a signal (S_c) indicative of said color emission capability (G_{tot}) of the variable color lighting system (1).

3. A controller (3) according to claim 1 or 2, wherein said communication means (12) are further adapted to receive signals from said at least two lighting devices (LD_1, LD_2), and wherein said data is accessed through said communication means (12).

4. A controller (3) according to any one of the preceding claims, further comprising a memory (14) configured to store data indicative of said determined color emission capability (G_{tot}).

5. A controller (3) according to any one of the preceding claims, wherein said processing means (13) are further adapted to de-saturate an out-of-gamut request.

6. A controller (3) according to any one of the preceding claims, wherein said color emission capability (G_{tot}) is determined by forming a section of the color gamuts (G_1, G_2) of said at least two lighting devices (LD_1, LD_2).

7. A controller (3) according to claim 1 to 5, wherein said color emission capability (G_{tot}) is determined by forming a union of the color gamuts (G_1, G_2) of said at least two lighting devices (LD_1, LD_2).

8. A control system (2) for enabling user control of a variable color lighting system (1) comprising a plurality of lighting devices (LD_{1-n}), said control system (2) comprising:

input means (4; 22) adapted to enable the user to input a request for an output color to be emitted by the variable color lighting system (1); and

a controller (3) according to claim 1 to 7.

9. A control system (2) according to claim 8, further comprising indication means (5; 21) configured to indicate to the user a color emission capability (G_{tot}) of the variable color lighting system (1).

10. A variable color lighting system (1) comprising a plurality of lighting devices (LD_{1-n}) and a control system (2) according to claim 8 or 9.

11. A method, for controlling color output of a variable color lighting system (1) comprising a plurality of lighting devices (LD_{1-n}), said method comprising the steps of:

accessing (30) data indicative of color gamuts (G_1, G_1) of at least two (LD_1, LD_1) of said lighting devices (LD_{1-n});

determining (31) a color emission capability (G_{tot}) of the variable color lighting system (1) based on said accessed data;

receiving (33), from a user interface (20), a request (S_r) for an output color to be emitted by the variable color lighting system (1); and

sending (34), to at least one (LD_1, LD_2) of said lighting devices (LD_{1-n}), control signals (C_1, C_2) indicative of said request, thereby enabling emission of said output color.

12. A method according to claim 11, further comprising the step of:

providing (32), to said user interface (20), a signal (S_c) indicating said color emission capability (G_{tot}).

13. A computer program module adapted to run on a controller in a variable color lighting system, to perform the steps of claim 11.

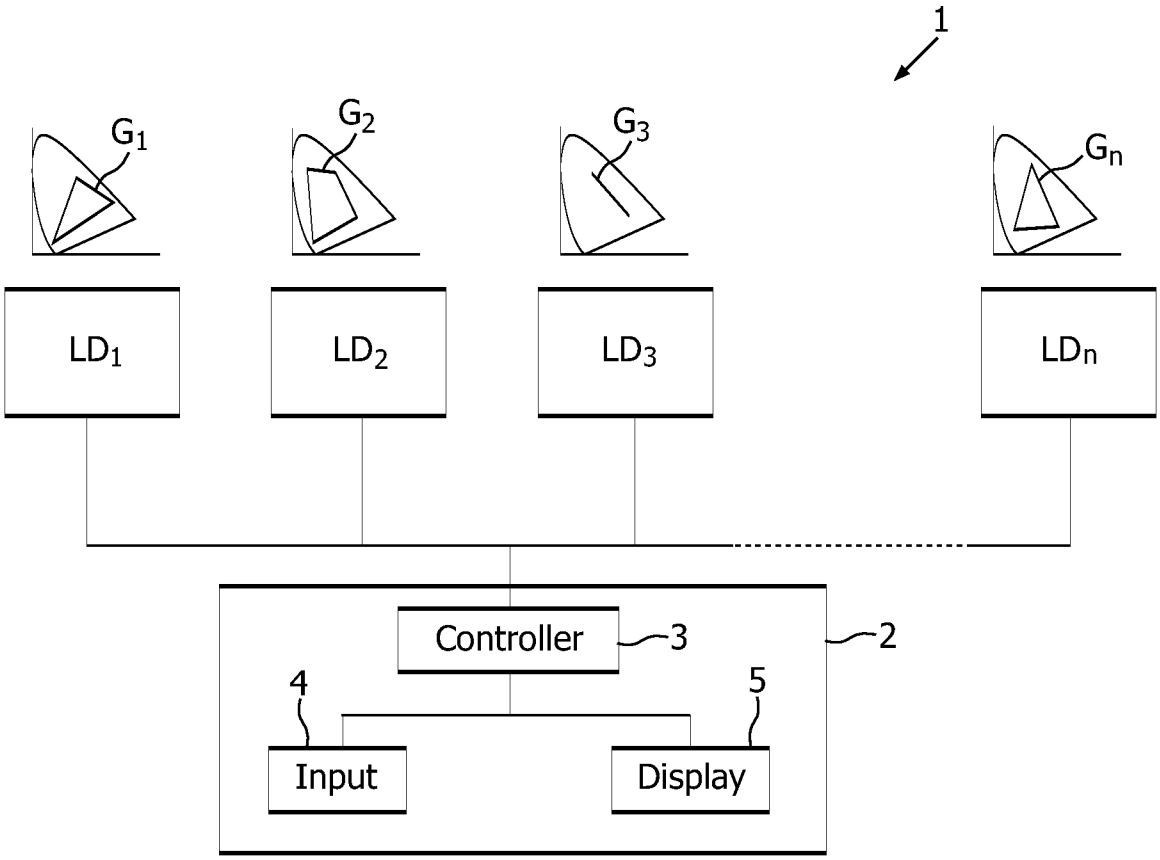
1
G1
G2
G3
Gn
LD1
LD2
LD3
LDn
Controller
3
2
4
5
Input
Display

FIG. 1

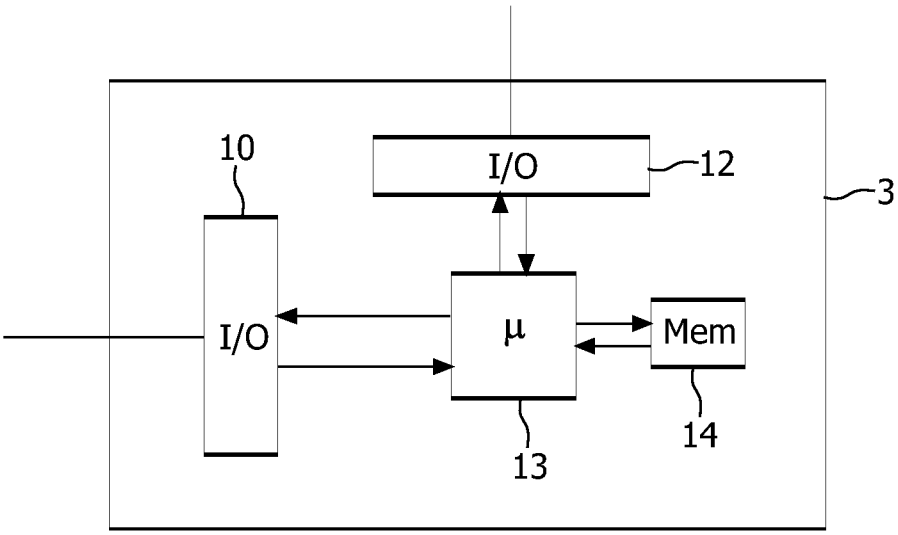
10
I/O
12
3
I/O
μ
Mem
13
14

FIG. 2a

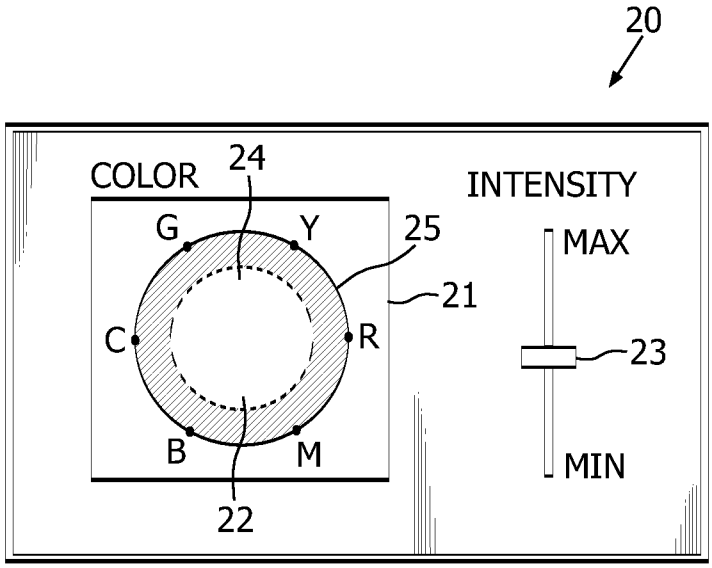
20
COLOR
24
INTENSITY
G
Y
25
MAX
21
C
R
23
B
M
MIN
22

FIG. 2b

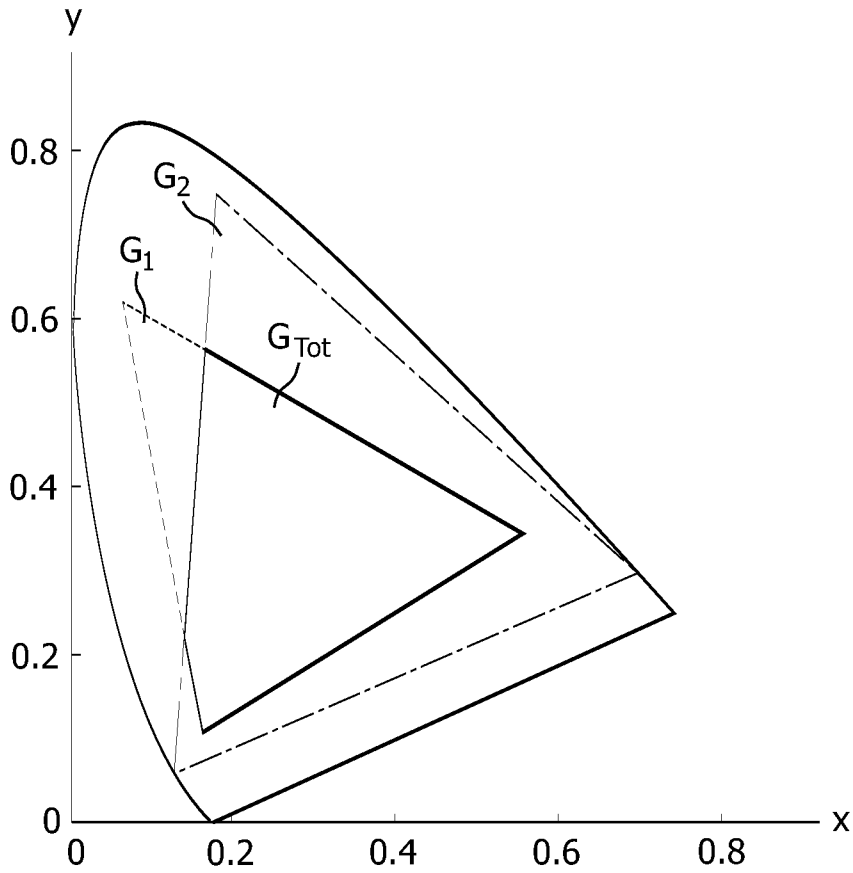
y
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
x
G2
G1
GTot

FIG. 3a

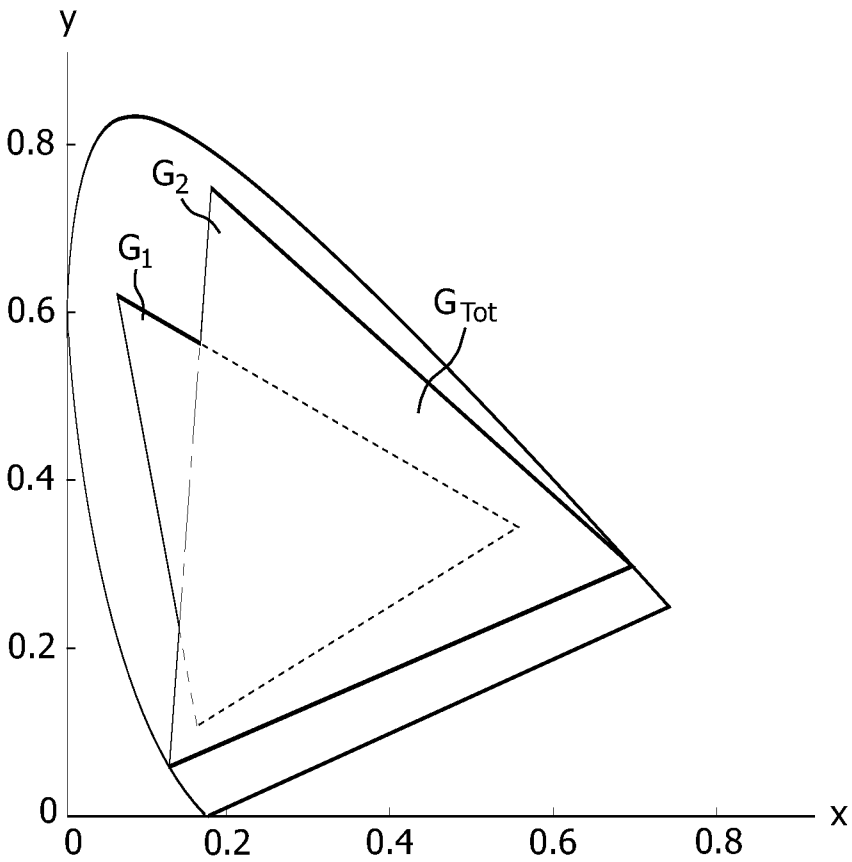

FIG. 3b

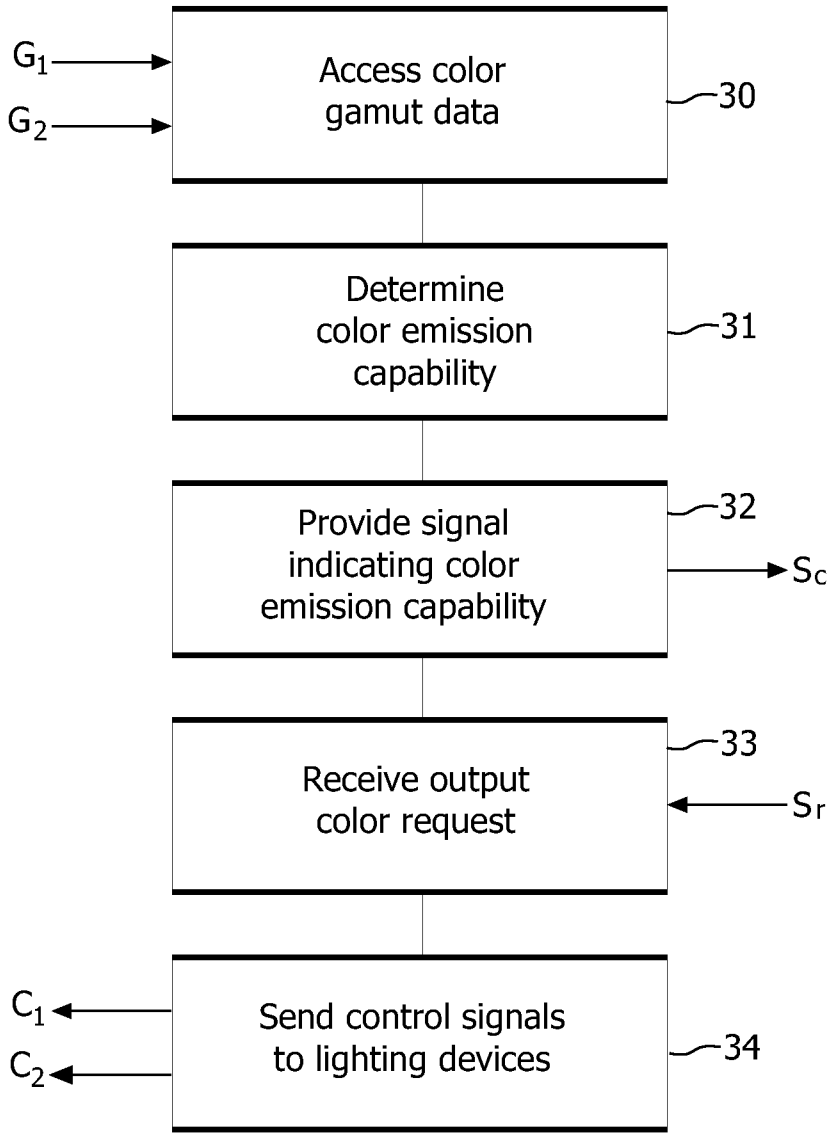
G1
G2
Access color gamut data
30
Determine color emission capability
31
Provide signal indicating color emission capability
32
Sc
Receive output color request
33
Sr
C1
C2
Send control signals to lighting devices
34

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/053959

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B37/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/105261 A1 (DUCHARME ALFRED D [US] ET AL) 3 June 2004 (2004-06-03) paragraphs [0097] - [0113] figures 6,9,22-25	1-13
P,X	EP 1 622 427 A (AGILENT TECHNOLOGIES INC [US]) 1 February 2006 (2006-02-01) the whole document	1-13
A	WO 2005/096258 A (KONINKL PHILIPS ELECTRONICS NV [NL]; DEURENBERG PETER H F [NL]; HOELEN) 13 October 2005 (2005-10-13) page 7 - page 13; figure 1	1-13
A	EP 1 587 347 A (ERCO LEUCHTEN [DE]) 19 October 2005 (2005-10-19) the whole document	1-13

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 March 2007	14/03/2007

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International application No
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