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(54) **MULTI-DIMENSIONAL CONTROL OF LIGHTING PARAMETERS**

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G06F 7/00	(2006.01)
G08B 29/00	(2006.01)
H04B 1/00	(2006.01)
H04Q 1/00	(2006.01)

(52) **U.S. Cl.** **340/5.64**; 340/5.1; 340/4.61; 340/12.5; 340/13.24

(58) **Field of Classification Search** 340/5.64, 340/5.1, 4.61, 12.5, 13.24; 700/17; 315/292; 362/231, 249.12, 85

See application file for complete search history.

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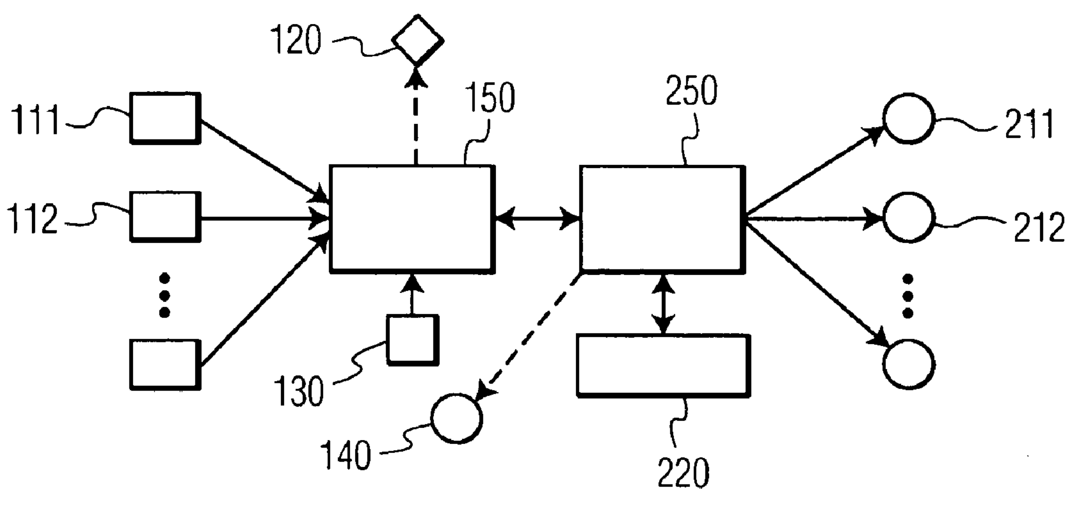
Primary Examiner — Nam V Nguyen

(57) **ABSTRACT**

A multi-dimensional controller (**150**) controls the multiple parameters of a lighting system (**250**). A track-ball (**100**) that provides three axes of rotation (**101-103**), for example, is used to control each of three lighting parameters, such as chrominance, luminance, and saturation. In like manner, intensity, direction, and diffusion control may be controlled by a device with three degrees of freedom/control. Force-feedback (**120**) is optionally provided to indicate divergence from established presets (**220**) or recommended operating conditions. Switches (**130**) and other control elements are also provided to store or recall pre-set parameters (**220**), override scheduled lighting settings, and so on.

16 Claims, 3 Drawing Sheets



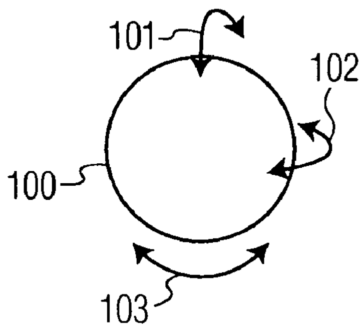


FIG. 1A

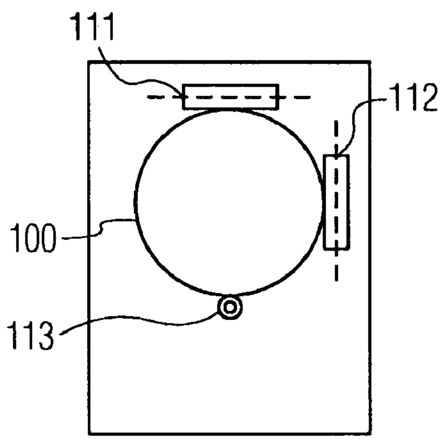


FIG. 1B

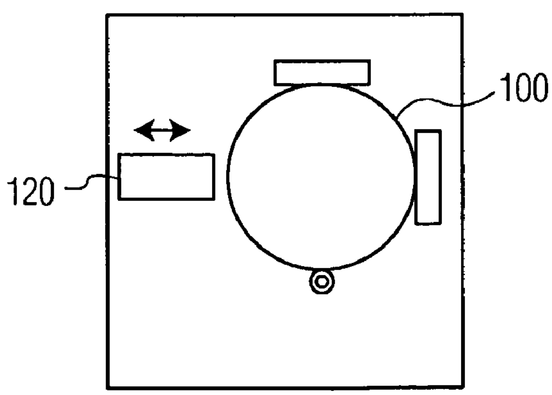


FIG. 1C

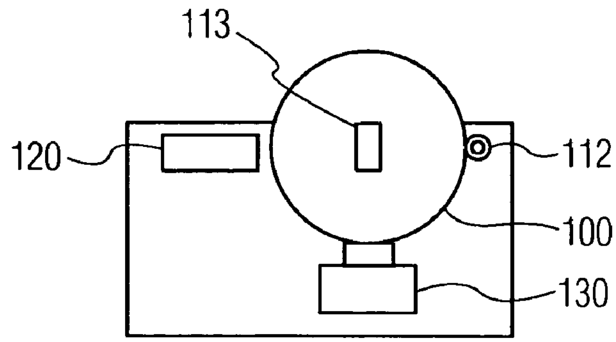


FIG. 1D

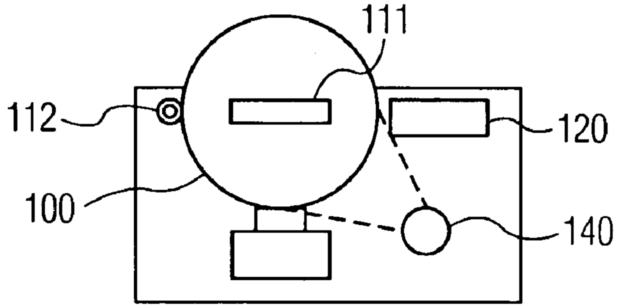


FIG. 1E

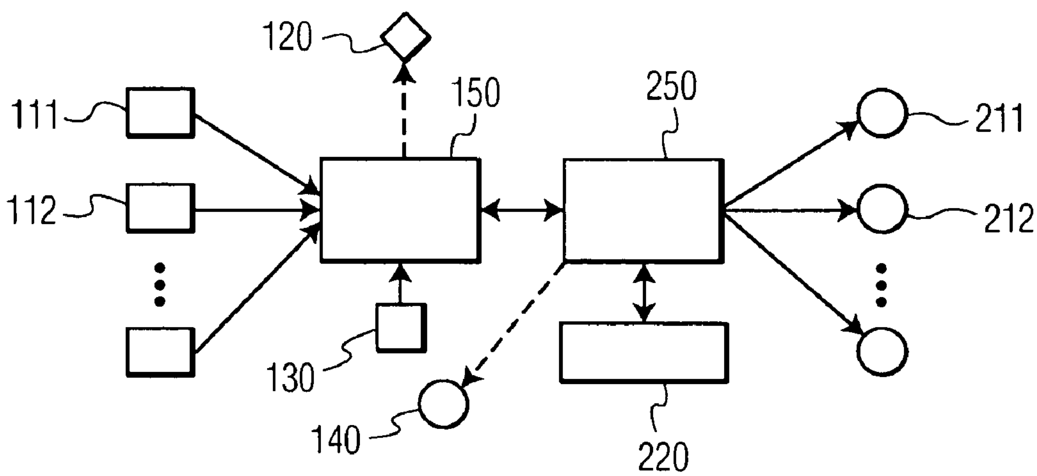


FIG. 2

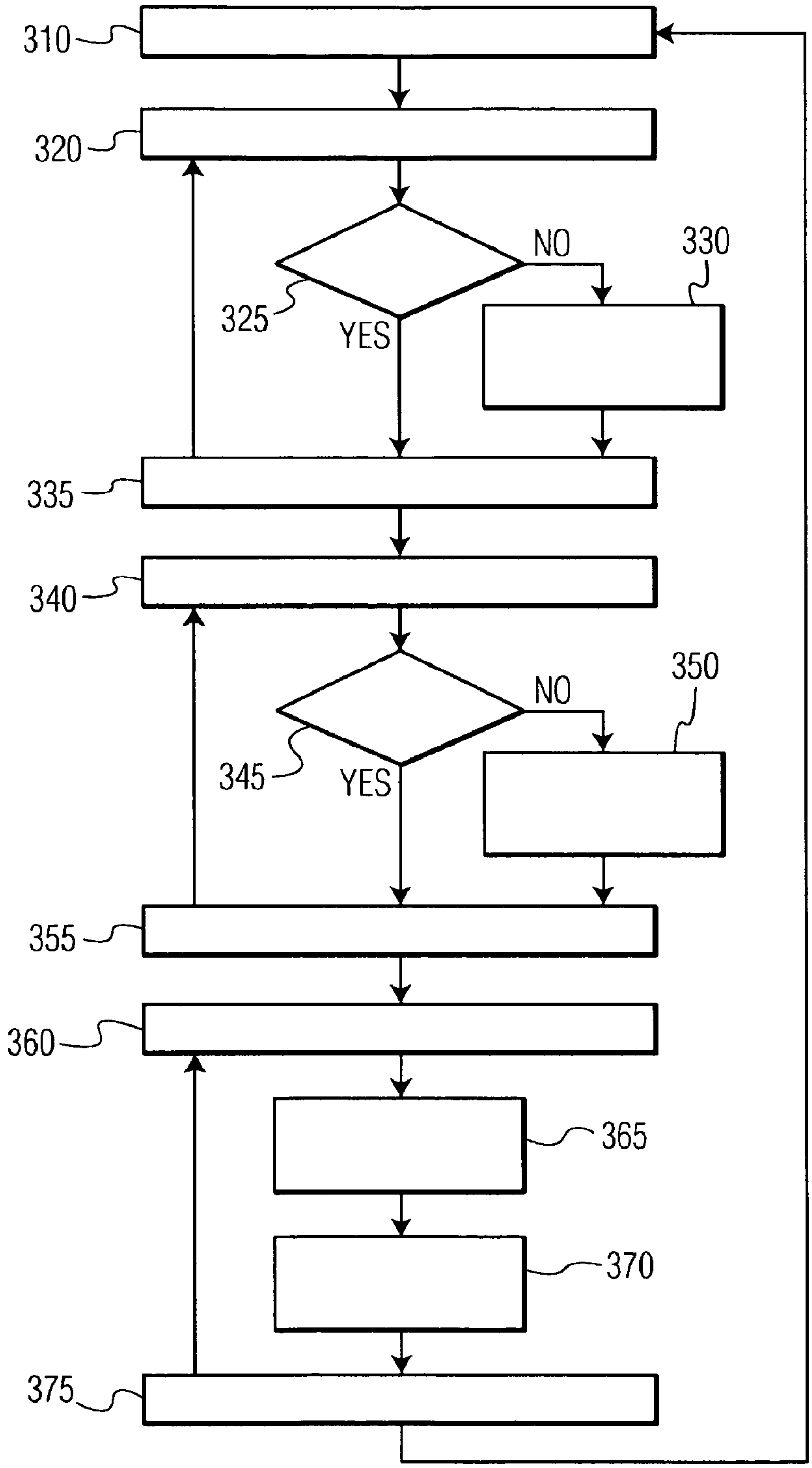


FIG. 3

MULTI-DIMENSIONAL CONTROL OF LIGHTING PARAMETERS

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. provisional application Ser. No. 60/629,798, filed Nov. 19, 2004, the entire subject matter of which is hereby incorporated by reference.

This invention relates to the field of lighting systems, and in particular to a multi-dimensional control system for varying lighting parameters.

The lighting of an environment has a significant effect on the ambiance associated with the environment. Environments conducive to reading are typically brightly lit; environments conducive to romance are typically dimly lit; and so on. In addition to the luminance level, the chromatic content also affects the ambiance of the environment. A yellow or red tinted light is generally considered to be "warmer" than a blue tinted light. Similarly, the saturation (white content) of the light and other parameters, such as the degree of dispersion of the light, will affect the ambiance.

Conventional lighting systems use variable control switches to set the parameters for the desired lighting effect. In a home environment, different on/off switches or variable dimmers are used to control each light or set of lights to achieve the desired effect. In a theatre environment, a control panel containing numerous sliding or rotating controls knobs is typically used to achieve the desired effect.

European Published Application 0192882, "LIGHT SOURCE HAVING AUTOMATICALLY VARIABLE HUE, SATURATION, AND BEAM DIVERGENCE", filed 30 Oct. 1985, discloses a light fixture wherein different filters and lenses can be oriented relative to a source of white light to vary the hue, saturation, and divergence of the projected light, and is incorporated by reference herein. As in typical embodiments of the era, the control panel for the variable light source includes sliding and rotating control knobs.

Increasingly, computers are being used to store sets of lighting parameters that can be recalled via a single command to achieve a desired effect.

U.S. Published Patent Application 2003/0057887, "SYSTEMS AND METHODS OF CONTROLLING LIGHT SYSTEMS", filed 13 Jun. 2002, discloses a multi-light system wherein the color and intensity of each light, or sets of lights, is controlled from a central controller via wireless communications, and is incorporated by reference herein. A graphic representation of the environment being controlled is preferably used to select and assign control parameters for each light or set of lights. These parameters are stored in a file, and "played back" (i.e. read from the file and communicated to the lights) when desired. The playback may be initiated directly by a user, or programmed to occur according to a defined schedule.

It is an object of this invention to provide an interface for controlling multiple parameters of a light source. It is a further object of this invention to provide an interface for controlling multiple parameters of a light source that is compatible with both manual and computer controlled lighting systems. It is a further object of this invention to provide an interface for controlling multiple parameters of a light source that is easy and intuitive to use, and optionally provides feedback during use.

These objects and others are achieved by providing a multi-dimensional controller for controlling the multiple parameters of a lighting system. A track-ball that provides three axes of rotation, for example, is used to control each of three lighting parameters, such as chrominance, luminance, and saturation. In like manner, intensity, direction, and diffusion control may be controlled by a device with three degrees of freedom/control. Force-feedback is optionally provided to indicate divergence from established presets or recommended operating conditions. Switches and other control elements are also provided to store or recall preset parameters, override scheduled lighting settings, and so on.

The invention is explained in further detail, and by way of example, with reference to the accompanying drawings wherein:

FIGS. **1**A-**1**E illustrate example embodiments of a three-dimensional track-ball for use in this invention.

FIG. **2** illustrates an example block diagram of a lighting control system in accordance with this invention.

FIG. **3** illustrates an example flow diagram of a lighting control system in accordance with this invention.

Throughout the drawings, the same reference numeral refers to the same element, or an element that performs substantially the same function. The drawings are included for illustrative purposes and are not intended to limit the scope of the invention.

The invention includes a multi-dimensional input device that is used to control multiple parameters in a lighting system. For ease of presentation and understanding, the invention is presented using a track-ball as a paradigm for a multi-dimensional input device. One of ordinary skill in the art will recognize that any of a variety of multi-dimensional input devices may be used, including, for example, a conventional joystick, mouse, and so on, as well as more advanced devices, such as virtual-reality (VR) gloves, suits, headgear, and so on. One of ordinary skill in the art will also realize that although a track-ball is a "relative location" or "motion-based" input device, like a mouse, the principles of this invention are equally applicable using an "absolute location" or "position-based" device, such as a graphics tablet wherein the absolute location of a pointing device on the surface of the tablet defines a two-dimensional coordinate. In like manner, the term "dimension" is used herein in the general sense, and includes any distinguishable aspect about which motion can be detected. For example, in a three-dimensional space, the dimensions may be up-down, left-right, and forward-back; in a spherical space, the dimensions may be roll, pitch, and yaw; in a fixed space, the dimensions may be stress and torque; and so on.

FIGS. **1**A-**1**E illustrate example embodiments of a three-dimensional track-ball for use in this invention. FIG. **1**A illustrates an example ball **100** that can rotate in any combination of directions **101**, **102**, **103**. This ball **100** may contain internal inertial sensors that report movement of the ball **100**, but in a more traditional embodiment, the ball **100** is mounted in a base **110** that includes sensors **111**, **112**, and **113** that are configured to report motion in each of the directions **101**, **102**, **103**, respectively, as illustrated in FIG. **1**B. The example sensors **111**, **112**, and **113** include rollers that are tangent to the ball **100**, and rotate in each of three orthogonal directions, and sensing devices, such as optical pickups that communicate pulses or other signals corresponding to the rotation. A controller (**150** of FIG. **2**), discussed further below, receives these signals, from which a magnitude of movement of the ball **100** can be determined.

FIG. **1**C illustrates another aspect of this invention, wherein a feedback element **120** is included in the multi-dimensional input device. For ease of understanding, the feedback element **120** is illustrated as being movable in a direction perpendicular to the surface of the ball **100**, so as to exert a force that provides resistance to the rotation of the ball. One of ordinary skill in the art will recognize that other arrangements can be used to provide more selective feedback; for example, an arrangement that resists motion of the ball in a particular direction or combination of directions. In like manner, if a VR-glove is used as the multi-dimensional input device, the tension on elements of the glove can be selectively controlled to resist, or assist, motion in particular directions.

FIG. **1**D illustrates another aspect of this invention, wherein a switch device **130** is included in the multi-dimensional input device. In this example, the switch device **130** may be a microswitch that is located beneath the ball **100**, and reacts to vertical pressure being exerted on the ball by a user. Other switch arrangements will be obvious to one of ordinary skill in the art, including switches that are independent of the ball **100**.

FIG. **1**E illustrates another aspect of this invention, wherein a light element **140** is included in the multi-dimensional input device. In this example, the ball **100** is translucent, and the light element **140** is configured to project light to the ball **100** based on parameters determined by motion of the ball **100**. Preferably, the projected light corresponds to the lighting effects that the multi-dimensional input device is producing, or will produce, in an actual environment.

FIG. **2** illustrates an example block diagram of a multi-dimensional light controller in accordance with this invention. A controller **150** receives signals from motion sensors **111**, **112**, etc. in a multi-dimensional input device. Note that although the reference numerals correspond to the motion sensors in the example track-ball of FIG. **1**, for ease of understanding, these sensors in FIG. **2** correspond to any sensor in a multi-dimensional input device, such as inertial sensors, tension sensors, proximity sensors, and the like.

The controller **150** processes the signals from the sensors **111**, **112**, as well as from any switches **130**, as discussed further below with respect to FIG. **3**, to determine light-parameter values corresponding to the signals from the input device. The controller **150** communicates these parameters to a light controller **250** that is configured to apply the appropriate control to one or more lights **211** corresponding to these parameters. For example, rotating the ball **100** of FIG. **1**A in direction **101** may control the brightness or luminance of the lights, rotating the ball in direction **102** may control the color or chrominance of the lights, and rotating the ball in direction **103** may control the whiteness or saturation of the lights. If there are more controllable features on the lights than dimensions available on the multi-dimensional input device, a switch **130** may be configured to reassign the mapping of the input signals to particular light-parameter values. For example, a set of inputs that control the flashing, blinking, or sequencing of the lights may be enabled by controlling a switch on the input device.

The communication between the controller **150** and the controller **250** may be via any of a variety of wired or wireless means, including direct connection, radio, infrared, and so on. In a preferred embodiment of this system, the input device and the lighting system are each compatible with a home-networking protocol, and the controllers **150**, **250** communicate via a corresponding home-network. In a self-contained system, the controllers **150**, **250** may be included within the same device, and, in some embodiments, the controllers **150**, **250** are embodied as a single processing device, and the 'communication' of the parameters is via registers or memory elements within the processor as each functional block of software code is executed.

The controller **150** is also optionally configured to control a feedback device **120**, as discussed further below.

In a preferred embodiment of this invention, sets of defined parameter values are stored as presets **220**, to allow a user to quickly set the lights **211** to achieve a predefined effect. This preset option may be provided within the multi-dimensional input device, or within the lighting control. In either embodiment, the multi-dimensional input device includes a control, typically a switch **130**, that allows the user to store the current parameters as a preset **220**. If multiple presets **220** are provided, the switch **130** may be configured to enable one of the dimensions of the input device to 'scroll' through each preset. As noted above, the input device may include a light **140** that is also controlled by the light control **250**. Optionally, the controller **250** can be configured to control the light **140** independently of the lights **211** while the user is scrolling through the presets, or otherwise searching for a desired effect. When the user signals that the desired effect has been achieved, as shown by the light **140**, the controller **150** enables the light controller **250** to apply the same settings to the lights **211**. The controller **150**, or the controller **250**, also optionally includes a scheduler that is configured to activate a preset **220** at a given time, or a sequence of presets **220** at scheduled times.

FIG. **3** illustrates an example flow diagram for use in a controller **150** in accordance with this invention. At **310**, the controller detects activity from one or more sensors or switches on a multi-dimensional input device.

When an activity is detected, the controller executes the loop **320-335** for each dimension of the input device. In a preferred embodiment of this invention, the controller allows a user to selectively enable one or more of the input dimensions, so that, for example, the user can choose to only affect the luminance of the lighting system, and keep the other lighting effects fixed at their current setting. At **335**, each dimension is checked to see if movements in that dimension are enabled to affect its corresponding parameter. If it is enabled, the lighting-parameter corresponding to the enabled direction is updated, based on any movement in the enabled direction.

After all of the input dimensions are processed, the controller processes each switch input, via the loop **340-355**. Depending upon the current mode of the input device, some switches may be disabled from affecting the operation of the input device. At **345**, each switch is checked to see if it is enabled, and if so, the operation controlled by the state of the switch is executed, at **350**. As noted above, a switch may effect the storing or recall of preset parameters, thereby storing or overriding the lighting-parameter values set at **330**.

After all of the switches, if any, are processed, each lighting-parameter is applied to the lighting system, via the loop **360-375**. At **365**, the lighting-effect corresponding to the parameter is controlled. As noted above, this control may affect the luminance, chrominance, saturation, etc. of the entire lighting system, or it may be limited to select lights, such as an optional light source in the input device, depending upon the current mode of the input device, or the current mode of the lighting system.

At **370**, the controller optionally controls one or more feedback devices based on one or more of the lighting-parameters. For example, the failure rate of most lights is dependent upon the luminance level. A feedback device could be configured to provide increasing resistance to a continued increase in luminance, to discourage high luminance levels. In another example, the resistance could increase based on the difference from a selected preset. Similarly, using an 'expert systems' approach, the resistance could be based on sets of rules provided by the user, or provided by third-party experts in lighting effects. Such an expert system approach is particularly well suited for use in a professional lighting setting, such as a theatre, to reduce the likelihood of errors, and/or to reduce the amount of skill or training required to operate the system.

After all of the parameters are applied to the lighting system and optional feedback system, the controller returns to **310** to receive the next input from the input device and to repeat the above process.

The foregoing merely illustrates the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements which, although not explicitly described or shown herein, embody the principles of the invention and are thus within the spirit and scope of the following claims.

In interpreting these claims, it should be understood that:

a) the word “comprising” does not exclude the presence of other elements or acts than those listed in a given claim;

b) the word “a” or “an” preceding an element does not exclude the presence of a plurality of such elements;

c) any reference signs in the claims do not limit their scope;

d) several “means” may be represented by the same item or hardware or software implemented structure or function;

e) each of the disclosed elements may be comprised of hardware portions (e.g., including discrete and integrated electronic circuitry), software portions (e.g., computer programming), and any combination thereof;

f) hardware portions may be comprised of one or both of analog and digital portions;

g) any of the disclosed devices or portions thereof may be combined together or separated into further portions unless specifically stated otherwise;

h) no specific sequence of acts is intended to be required unless specifically indicated; and

i) the term “plurality of” an element includes two or more of the claimed element, and does not imply any particular range of number of elements; that is, a plurality of elements may merely include two elements.

The invention claimed is:

1. A lighting control system comprising:

an input device that is configured to detect motion in a plurality of dimensions, and

a controller that is configured to:

map the motion in each of the plurality of dimensions to corresponding lighting-parameters, and

communicate one or more of the lighting-parameters to a lighting system, to effect a change of lighting-effects at one or more lights, corresponding to the one or more lighting-parameters;

wherein said input device includes one or more feedback elements that are configured to restrict the motion in one or more of the plurality of dimensions, and

the controller is further configured to control the one or more feedback elements based on the lighting-parameters;

said controller configured to control the one or more feedback elements based on one or more of:

one or more rules associated with one or more of the lighting-parameters, and

a difference between one or more of the lighting-parameters and one or more predefined lighting-parameters.

2. The system of claim **1**, further comprising the lighting system.

3. The system of claim **1**, further including:

one or more input switches, operably coupled to the controller.

4. The system of claim **3**, further including

a memory that is configured to store one or more sets of lighting-parameters,

wherein

the controller is configured to:

store the lighting-parameters to the memory based on a status of the one or more switches, and

recall the lighting-parameters from the memory based on the status of the one or more switches.

5. The system of claim **1**, further including one or more lights that are controlled by the lighting system.

6. The system of claim **5**, wherein the input device includes at least one of the one or more lights.

7. The system of claim **1**, wherein the input device includes a track-ball.

8. The system of claim **7**, wherein the track-ball is configured to detect motion in three dimensions.

9. A method of controlling a lighting system comprising:

receiving input from an input device that is configured to detect motion in a plurality of dimensions,

mapping the motion in each of the plurality of dimensions to corresponding lighting-parameters, and

communicating one or more of the lighting-parameters to the lighting system, to effect a change of lighting-effects at one or more lights, corresponding to the one or more lighting-parameters;

controlling one or more feedback elements that are configured to restrict the motion in one or more of the plurality of dimensions in the input device based on the lighting-parameters;

wherein said controlling the one or more feedback elements includes applying one or more rules associated with one or more of the lighting-parameters to determine an amount of restriction of the motion.

10. The method of claim **9**, further comprising receiving the one or more lighting-parameters at the lighting system, and changing the lighting-effects based on the one or more lighting-parameters.

11. The method of claim **9**, further including applying a force to the one or more feedback elements to restrict the motion.

12. The method of claim **9**, further including receiving an other input from the input device, and,

based on the other input, performing one of the following:

selectively storing the lighting-parameters, and

selectively retrieving the lighting-parameters.

13. The method of claim **9**, further including

controlling one or more lights in the input device based on the lighting-parameters.

14. The method of claim **9**, wherein the input device includes a track-ball.

15. The method of claim **9**, wherein

the input from the input device includes an indication of the motion in three dimensions.

16. A method of controlling a lighting system comprising:

receiving input from an input device that is configured to detect motion in a plurality of dimensions,

mapping the motion in each of the plurality of dimensions to corresponding lighting-parameters, and

communicating one or more of the lighting-parameters to the lighting system, to effect a change of lighting-effects at one or more lights, corresponding to the one or more lighting-parameters;

controlling one or more feedback elements that are configured to restrict the motion in one or more of the plurality of dimensions in the input device based on the lighting-parameters;

controlling the one or more feedback elements includes applying one or more rules associated with one or more of the lighting-parameters to determine an amount of restriction of the motion

controlling one or more feedback elements that are configured to restrict the motion in one or more of the plurality of dimensions in the input device based on the lighting-parameters

controlling the one or more feedback elements includes determining a difference between one or more of the lighting-parameters and one or more predefined lighting-parameters to determine an amount of restriction of the motion.

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