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(54) FORCE SENSITIVE INPUT DEVICES AND METHODS

KRAFTEMPFINDLICHE EINGABEVORRICHTUNGEN UND VERFAHREN

DISPOSITIFS ET PROCÉDÉS D'ENTRÉE SENSIBLES À UNE FORCE

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Patent Application Serial No. 13/804,779, filed March 14, 2013.

TECHNICAL FIELD

[0002] The present disclosure relates, generally, to input devices and methods and, more particularly, to force sensitive input devices and methods.

BACKGROUND

[0003] One common input device used in interfacing with a computing device is the digital switch or button. Digital switches typically include a physical electrical contact designed to present a low electrical resistance when the switch is activated and an open circuit when the switch is not activated. Such switches generally have a binary output (i.e., on or off, high or low). Many types of physical mechanisms, with different behaviors, may be used for digital switches. For example, rocker switches, toggle switches, tactile switches, and sliding switches are all examples of switches that take discrete on or off values. Some digital switches can represent more than two values (e.g., via multiple positions) by connecting some combination of three or more contacts. However, all of these switches have the significant limitation of only being able to take a discrete number of positions and, thus, only being able to represent a limited set of possible user intents.

[0004] Analog sensors may also be used in interfacing with a computing device to achieve more granularity along a continuum of user intent. As analog sensors typically measure a physical behavior or phenomenon that can vary continuously under the control of the user, they generally have a continuous range of output values. One example of an analog sensor is a potentiometer (i.e., variable resistor) coupled to a slider or knob that is manipulated by a user. The user may adjust the slider or knob to set the resistance of the potentiometer along a continuum of values, and this resistance may be measured by an appropriate circuit. Prior analog sensors, such as those based on variable resistors, have suffered from poor response time due to the measurement methods used and/or the relaxation time required by the materials utilized. Prior analog sensors have also provided poor tactile, or haptic, response that does not feed back the performance of the sensor to the user or provide reassurance that the input would be what the user expected.

[0005] When used in an input device, a sensor must fit into the form factor needed for the particular application. One common form factor used for interfacing with a computing device is the keyswitch (or "key"), which has been used in personal computer keyboards, gaming controllers, control panels of computer-numerically controlled (CNC) industrial equipment (e.g., lathes, saws, milling machines, and the like), and other computing devices. The key typically includes a resilient component (e.g., a metal coil spring, a rubber dome, etc.) that returns a keycap to a home state when a user is not interacting with the key. For many analog sensors, the incorporation of the additional circuitry used to measure the subject physical behavior or phenomenon into the form factor of a standard key is impractical. For instance, in an analog sensor utilizing a potentiometer (as described above), the potentiometer may not fit within the form factor of a standard key.

[0006] Gaming controllers used as input devices are often used to control the movement and/or actions of a character in an electronic game (e.g., a computer game). Gaming controllers typically include a number of digital switches or buttons. As described above, the digital buttons of such gaming controllers typically have a binary output that results in a character either moving at a constant speed or not moving at all. While controlling a character using four digital buttons (e.g., up, down, left, and right buttons) may result in a precise direction of movement, the magnitude or speed of movement is fixed. Some gaming controllers also include an analog joystick to allow more granular control of character movement and/or actions. Typically, analog sensors in the gaming controller determine how far the joystick is displaced from a center position along both an x-axis and a y-axis (simultaneously). Thus, in contrast to digital buttons, an analog joystick is able to control character movement in any direction (i.e., 360 degrees) and at different magnitudes (based on how far the joystick is moved from the center position). Unlike digital buttons, however, a user is not able to precisely control the direction of character movement (e.g., at exactly 90 degrees) with an analog joystick.

[0007] JP H11110127 discloses calculating a moving direction and a moved distance of a cursor on a display screen by touching a propagation pass of surface acoustic waves which are excited on a piezoelectric substrate.

SUMMARY

[0008] The present invention comprises one or more of the features recited in the appended claims and/or the following features which, alone or in any combination, may comprise patentable subject matter:

[0009] According to one aspect, an input device may comprise a first input key configured to output a first analog signal as a function of force applied to the first input key, a second input key configured to output a second analog signal as a function of force applied to the second input key, a third input key configured to output a third analog signal as a function of force applied to the third input key, a fourth input key configured to output a fourth analog signal as a function of force applied to the fourth input key, and a controller configured to output movement data including both direction and magnitude in response to the first, second, third, and fourth analog signals.

[0010] In some embodiments, the controller may comprise an analog-to-digital converter configured to convert the first, second, third, and fourth analog signals into digital signals. The input device may further comprise a low-pass filter configured to reduce noise in at least one of the first, second, third, and fourth analog signals before the analog signal is received by the analog-to-digital converter of the controller.

[0011] In some embodiments, the controller may be configured to format the movement data for presentation to a driver of a computing device. The controller may be configured to format the movement data to a scale expected by the driver of the computing device. The controller may be configured to format the movement data according to either the DirectInput protocol or the XInput protocol.

[0012] In some embodiments, the movement data may include an x-axis component and a y-axis component. The x-axis component may be a function of the first and second analog signals, and the y-axis component may be a function of the third and fourth analog signals. The x-axis component may represent a first distance from a resting point, where the first distance is proportional to a force applied to one of the first and second input keys. The y-axis component may represent a second distance from the resting point, where the second distance is proportional to a force applied to one of the third and fourth input keys. In some embodiments, the input device may further comprise a number of binary input keys, each of the binary input keys being configured to output a digital signal indicating whether or not the binary input key has been pressed.

[0013] In some embodiments, the first, second, third, and fourth input keys may each comprise a button movable along a respective axis between a first end position and a second end position, the button including a reflective surface, a resilient component biasing the button toward the first end position, and a reflectance sensor configured to emit light that impinges upon the reflective surface, to measure an amount of the light that is reflected from the reflective surface, and to output the respective analog signal in response to the measured amount of the reflected light, where the light travels generally parallel to the respective axis.

[0014] In some embodiments, the button of each of the first, second, third, and fourth input keys may comprise a keycap configured to be pressed by a user to move the button along the first axis toward the second end position and a plunger supporting the keycap, where the plunger engages the resilient component. The reflective surface of the button may be spaced apart from a portion of the plunger that engages the resilient component. The portion of the plunger that engages the resilient component may be configured to move along the respective axis and the reflective surface may be configured to move along a parallel axis. The reflective surface may be perpendicular to the parallel axis.

[0015] In some embodiments, each of the first, second, third, and fourth input keys may further comprise an opaque housing defining a respective chamber, where the reflective surface and the reflectance sensor are disposed in the respective chamber. When the button is in the second end position, the button may contact the opaque housing to block further movement of the button along the respective axis away from the first end position. The reflectance sensor may comprise a light-emitting diode configured to emit the light and a phototransistor configured to receive the amount of the light that is reflected from the reflective surface.

[0016] In some embodiments, the resilient component of each of the first, second, third, and fourth input keys may be configured to allow a displacement of the button from the first end position that is proportional to a force applied to the button by a user. The amount of the light that is reflected from the reflective surface may be monotonically related to the displacement of the button from the first end position.

[0017] In some embodiments, the controller may be configured to calculate a first vector having a first magnitude based on a value of the first analog signal, calculate a second vector having a second magnitude based on a value of the second analog signal, calculate a third vector having a third magnitude based on a value of the third analog signal, and calculate a fourth vector having a fourth magnitude based on a value of the fourth analog signal. The direction and the magnitude of the movement data may represent a vector addition of the first, second, third, and fourth vectors.

[0018] According to another aspect, a method may comprise biasing a button that is movable along a first axis between a first end position and a second end position toward the first end position using a resilient component, illuminating a reflective surface of the button with light that travels generally parallel to the first axis, measuring, while the button is displaced from the first end position toward the second end position, an amount of the light that is reflected from the reflective surface and that travels generally parallel to the first axis, and determining a force applied to the button as a function of the measured amount of the light.

[0019] In some embodiments, illuminating the reflective surface of the button may comprise emitting light from a light-emitting diode facing the reflective surface. Measuring the amount of the light that is reflected from the reflective surface may comprise receiving light using a phototransistor. The phototransistor may output an analog signal that is a function of the amount of the light that is reflected from the reflective surface. The method may further comprise converting the analog signal into a digital signal that represents the amount of the light that is reflected from the reflective surface. Determining the force applied to the button may comprise calculating the force using a mathematical function that takes a value of the digital signal as an input. Determining the force applied to the button may comprise consulting a look-up table that relates a value of the digital signal to a force value.

[0020] In some embodiments, the amount of the light that is reflected from the reflective surface may be monotonically related to the force applied to the button. The method may further comprise generating movement data including both direction and magnitude in response to the determined force. The method may further comprise mapping the determined force to a scale expected by a driver of a computing device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The concepts described in the present disclosure are illustrated by way of example and not by way of limitation in the accompanying figures. For simplicity and clarity of illustration, elements illustrated in the figures are not necessarily drawn to scale. For example, the dimensions of some elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, the same reference labels or similar reference labels (e.g., reference labels ending in the same two digits) have been repeated among the figures to indicate corresponding or analogous elements. The detailed description particularly refers to the accompanying figures in which:

FIG. 1 is a cross-sectional view of one illustrative embodiment of a force sensitive input device;

FIG. 2 is a perspective view of one illustrative embodiment of an input device including a number of force sensitive input keys and a number of binary input keys;

FIG. 3 is a partially-exploded perspective view of several components of the input device of FIG. 2;

FIG. 4 is a cross-sectional view of another illustrative embodiment of a force sensitive input key that may be used in the input device of FIG 2; and

FIG. 5 is a simplified flow diagram showing one illustrative embodiment of a force sensitive input method.

DETAILED DESCRIPTION OF THE DRAWINGS

[0022] While the concepts of the present disclosure are susceptible to various modifications and alternative forms, specific exemplary embodiments thereof have been shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the concepts of the present disclosure to the particular forms disclosed, but, on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

[0023] In the following description, numerous specific details, such as types and interrelationships of circuit components, are set forth in order to provide a more thorough understanding of the present disclosure. It will be appreciated, however, by one skilled in the art that embodiments of the disclosure may be practiced without such specific details. In other instances, various circuit components have not been shown in detail (or not labeled in every instance) in order to not obscure the invention. Those of ordinary skill in the art, with the included descriptions, will be able to implement appropriate functionality without undue experimentation.

[0024] References in the specification to "one embodiment," "an embodiment," "an illustrative embodiment," etcetera, indicate that at least one embodiment described may include a particular feature, structure, or characteristic, but not every embodiment necessarily includes the particular feature, structure, or characteristic. The scope of the invention is defined in the appended claims. Any reference to "embodiment(s)", "illustrative embodiment(s), "example(s)" or "aspect(s) of the invention" in this description not falling under the scope of the claims should be interpreted as illustrative example(s) for understanding the invention.

[0025] Referring now to FIG. 1, one illustrative embodiment of a force sensitive input device 10 is shown in cross-section. In this illustrative embodiment, the input device 10 generally includes a button 12, a resilient component 14, a reflectance sensor 16, and a housing 18. In some embodiments, such as that shown in FIG. 1, a bottom side of the housing 18 may be open, allowing the input device 10 to be secured to a support surface, such as a printed circuit board (PCB) 20. It is contemplated that, in other embodiments, the input device 10 may contain additional or different components to those illustrated in FIG. 1.

[0026] The button 12 of the input device 10 includes a surface 22 that is exposed through the housing 18 and is designed to be pressed by a user. The button 12 is movable relative to the housing 18 along an axis 24 between two end positions. The button 12 is illustrated in FIG. 1 in a top end position. When the surface 22 of the button is pressed by a user, the button 12 may move along the axis 24 (downward in FIG. 1) until the button 12 reaches a bottom end position. In the illustrative embodiment, a bottom surface 26 of the button 12 will be proximate to the PCB 20 when the button 12 is in the bottom end position. As the button 12 is an analog mechanism, the button 12 is positionable at an infinite number of positions between the top and bottom end positions.

[0027] The button 12 includes a reflective surface 28 that partially or fully reflects some or all types of light. By way of example, the reflective surface 28 may reflect light of a particular wavelength or spectrum of wavelengths. In the illustrative embodiment, the reflective surface 28 is a surface of the button 12 (i.e., the reflective surface 28 is integrally formed with the button 12). In other embodiments, the reflective surface 28 may be coupled to the button 12 after the button 12 has been formed. By way of example, the reflective surface 28 may be applied to a surface of the button 12 as a reflective coating.

[0028] The resilient component 14 of the input device

10 biases the button 12 toward the top end position. As shown in FIG. 1, the resilient component 14 is illustratively embodied as a metal coil spring 14. One end of the spring 14 is engaged with the button 12, while the other end of the spring 14 is engaged with the PCB 20. In the illustrative embodiment of FIG. 1, the spring 14 has a generally cylindrical shape, and the button 12 and the PCB 20 each include a cylindrical feature that is received within one end of the spring 14 to maintain engagement with the spring 14. The resilient nature of the spring 14 allows the button 12 to move along the axis 24 when a force is applied to the button 12 by a user, but causes the button 12 to return to the top end position, shown in FIG. 1, when the force is no longer applied by the user. This configuration of the button 12 and the spring 14 provides haptic feedback that allows a user to feel the amount of input (i.e., force) that the user is applying to the button 12. Furthermore, the spring 14 may be designed with a fast, robust response that requires very little relaxation time. It will be appreciated that, in other embodiments, the resilient component 14 may be any type of component that allows movement of the button 12 along the axis 24, but biases the button 12 toward the top end position (e.g., a rubber dome).

[0029] The reflectance sensor 16 of the input device 10 is configured to emit light that impinges upon the reflective surface 28. An amount of the light that impinges upon the reflective surface 28 will be reflected back toward the reflectance sensor 16 and will be measured by the reflectance sensor 16. As shown in FIG. 1, the light emitted from the reflectance sensor 16 that is reflected by the reflective surface 28 and then returns to the reflectance sensor 16 generally travels along an axis 30 that is parallel to the axis 24. In the illustrative embodiment, the reflective surface 28 is generally perpendicular to the axis 30. As the button 12 moves along the axis 24 (e.g., when a force is applied to the button 12 by a user), the reflective surface 28 of the button 12 will move along the axis 30.

[0030] As the distance between the reflectance sensor 16 and the reflective surface 28 of the button 12 changes, the amount of light that is reflected from the reflective surface 28 back to the reflectance sensor 16 will also change (for instance, when the reflective surface 28 and the reflectance sensor 16 are farther apart, more scattering will occur and less light will return to the reflectance sensor 16). In particular, the amount of light that is reflected from the reflective surface 28 is monotonically related to the displacement of the button 12 from the top end position (i.e., the distance the button 12 travels along the axis 24, which is also the distance the reflective surface 28 travels along the axis 30). As such, by measuring the amount of light that is reflected from the reflective surface 28, the reflectance sensor 16 is able to indirectly measure the distance between the reflectance sensor 16 and the reflective surface 28 of the button 12.

[0031] The measurement by the reflectance sensor 16 of the amount of light that is reflected from the reflective surface 28 is related not only to the distance between the reflectance sensor 16 and the reflective surface 28 but also, as a result of the spring 14, to the force applied to the button 12 by a user. The particular properties of the spring 14 (or other resilient component 14) used in the input device 10 will result in a particular relationship between the amount of force applied to the button 12 and the displacement of the button 12 allowed by the spring 14. In the illustrative embodiment, the spring 14 is configured to allow a displacement of the button 12 from the top end position that is proportional to the force applied to the button 12. As the displacement of the button 12 is proportional to the force applied, and the amount of light reflected from the reflective surface 28 is monotonically related to the displacement of the button 12, the amount of the light that is reflected from the reflective surface 28 is also monotonically related to the force applied to the button 12. As such, by measuring the amount of light that is reflected from the reflective surface 28, the reflectance sensor 16 is also able to indirectly measure a force applied to the button 12 by a user.

[0032] In the illustrative embodiment, the reflectance sensor 16 includes a light-emitting diode (LED) configured to emit the light and a phototransistor configured to receive and measure the amount of the light that is reflected from the reflective surface 28. In particular, the reflectance sensor 16 is illustratively embodied as a QRE1113 Minature Reflective Object Sensor, commercially available from Fairchild Semiconductor Corporation of San Jose, California. As shown in FIG. 1, the reflectance sensor 16 may be soldered to the PCB 20 with the LED and the phototransistor facing the reflective surface 28. When energized, the LED of the reflectance sensor 16 emits infrared light toward the reflective surface 28. Infrared light returning from the reflective surface 28 to the reflectance sensor 16 impinges upon the phototransistor. In the illustrative embodiment, the phototransistor of the reflectance sensor 16 is a bipolar junction transistor (BJT) with a light sensitive base. As such, the phototransistor will output an analog signal (e.g., of varying voltage) that is a function of the amount of the light that is reflected from the reflective surface 28 back to the reflectance sensor 16. This analog signal may be processed to determine a force applied to the button 12, as further described below. It is contemplated that, in other embodiments, the reflectance sensor 16 may have other configurations that include different light sources and/or light sensors.

[0033] The housing 18 may have any suitable shape for supporting the components of the input device 10. In the illustrative embodiment, the housing 18 defines a chamber 32 in an interior portion of the housing 18. As shown in FIG. 1, the reflectance sensor 16 is disposed in the chamber 32. A portion of the button 12 is also disposed in the chamber 32. In particular, the reflective surface 28 of the button 12 is disposed in the chamber 32. In the illustrative embodiment, the housing 18 is formed of an opaque material, such that the light emitted by the reflectance sensor 16 does not pass through the housing 18. The opaque housing 18 also prevents outside light from impinging upon and being measured by the reflectance sensor 16.

[0034] Referring now to FIGS. 2 and 3, one illustrative embodiment of an input device 100 is shown as a gaming controller, or game pad, 100. While the present disclosure generally describes applications involving electronic games (e.g., computer games), it will be appreciated that one or more features of the input device 100 may advantageously be incorporated into input devices for many applications in the fields of consumer, industrial, medical, and other electronics. It is contemplated that input devices similar to those described herein may be useful in translating user intent to a form interpretable by any type of computing device, including, but not limited to, personal computers, entertainment systems, industrial computing systems, stenography devices, medical computing systems, and other computing devices. By way of example, when an input device according to the present disclosure is used in a medical application (specifically, radiology), the force applied by a user to a force sensitive input key of the input device may control how fast a computerized tomography system changes between the displayed slices.

[0035] As shown in FIG. 2, the game pad 100 includes a number of force sensitive input keys 110 and a number of binary input keys 160. In particular, the illustrative embodiment of the game pad 100 includes six force sensitive input keys 110 that are arranged near the center of the game pad 100 and sixteen binary input keys 160 that surround the force sensitive input keys 110 (not all binary input keys 160 are labeled in FIG. 2). It is contemplated that, in other embodiments, the game pad 100 may include any number of force sensitive input keys 110 and any number of binary input keys 160 (including no binary input keys 160). As described below, an arrangement of at least four force sensitive input keys 110 may be advantageous for certain applications. The game pad 100 also includes a cover 150 to protect the internal electronic components of the game pad 100. The game pad 100 is shown in FIG. 3 with the cover 150 removed to expose several internal components of the game pad 100. It is contemplated that, in other embodiments, the game pad 100 may contain additional or different components to those illustrated in FIGS. 2 and 3.

[0036] Except as noted below, each of the force sensitive input keys 110 of the game pad 100 has a similar configuration and operation to the force sensitive input device 10 described above (with reference to FIG. 1). In the illustrative embodiment shown in FIGS. 2 and 3, the force sensitive input keys 110 (and the binary input keys 160) of the game pad 100 are each embodied in the form factor of a standard keyswitch. In particular, the button 112 of each force sensitive input key 110 has a two-part construction that includes a keycap 134 configured to be pressed by a user and a plunger 136 that engages a spring 114 within a housing 118. The housing 118, plunger 136, and spring 114 of each force sensitive input key 110 are illustratively embodied as an MX Series Desktop Profile 0.60 Inch Keyswitch (with linear actuation), commercially available from Cherry Corporation of Pleasant Prairie, Wisconsin. The button 162 of each binary input key 160 has a similar two-part construction that includes a key cap 184 and a plunger 186 that engages a spring 164 within a housing 168. The housing 168, plunger 186, and spring 164 of each binary input key 160 are illustratively embodied as an MX Series Desktop Profile 0.60 Inch Keyswitch (with pressure point click), also commercially available from Cherry Corporation. The housing 118 of each force sensitive input key 110 and the housing 168 of each binary input key 160 are secured to a PCB 120.

[0037] The majority of the keycaps 134, 184 have been removed in FIG. 3 to expose the housings 118, 168 and the plungers 136, 186 of the input keys 110, 160. One keycap 134 and one keycap 184 are shown in the partially-exploded view of FIG. 3 to indicate their relationships to the plunger 136 and the plunger 186, respectively. When the keycap 134 is coupled to the plunger 136, the plunger 136 supports the keycap 134. When assembled, the keycap 134 and plunger 136 move together along an axis 124 as the button 112 of the force sensitive input key 110. Similarly, when the keycap 184 is coupled to the plunger 186, the plunger 186 supports the keycap 184. When assembled, the keycap 184 and plunger 186 move together along an axis 174 as the button 162 of the binary input key 160.

[0038] As shown in FIG. 3, for each of the force sensitive input keys 110, the reflectance sensor 116 is positioned outside the housing 118 (rather than within the housing, like the illustrative embodiment of the force sensitive input device 10 shown in FIG. 1). In particular, the reflectance sensor 116 of each of the force sensitive input keys 110 is soldered to the PCB 120 in a position adjacent the housing 118. In the illustrative embodiment, the keycap 134 of each of the force sensitive input keys 110 includes a reflective surface 128. As shown in FIG. 3, the reflective surface 128 extends outwardly from the keycap 134 above the reflectance sensor 116. In the illustrative embodiment, the reflective surface 128 is integrally formed with the keycap 134 (i.e., the reflective surface 128 is a surface of the keycap 134). In other embodiments, the reflective surface 128 may be coupled to the keycap 134 after the keycap 134 has been formed. As the button 112 (including the keycap 134) moves along the axis 124, the reflective surface 128 will move along an axis that is generally parallel to the axis 124. In the illustrative embodiment, the reflective surface 128 is generally perpendicular to the axis 124 (and the axis of its travel).

[0039] Like the force sensitive input device 10 described above, each of the force sensitive input keys 110 of the game pad 100 is configured to output an analog signal that is a function of the force applied to that input key 110. In particular, the reflectance sensor 116 of each force sensitive input key 110 will generate an analog signal in response to the amount of reflected light measured. As described above, since the displacement of the button 112 (including the keycap 134 and its reflective surface 128) is proportional to the force applied to the keycap 134 and the amount of light reflected from the reflective surface 128 is monotonically related to the displacement of the button 112, the amount of the light that is reflected from the reflective surface 128 is also monotonically related to the force applied to the keycap 134. As such, by measuring the amount of light that is reflected from the reflective surface 128, the reflectance sensor 116 is also able to indirectly measure the force applied by a user.

[0040] The analog signal output by each of the force sensitive input keys 110 of the game pad 100 is transmitted to a controller 152 that determines a force applied to each of the force sensitive input keys 110 based on the respective analog signal. In the illustrative embodiment, the controller 152 of the game pad 100 is soldered to the PCB 120. In other embodiments, the controller 152 may be external to the game pad 100. The controller 152 is illustratively embodied as an ATmega16U4 8-Bit AVR Microcontroller with 16K Bytes of ISP Flash and USB Controller, commercially available from Atmel Corporation of San Jose, California. The controller 152 includes an analog-to-digital converter (ADC) configured to convert the analog signals received from the force sensitive input keys 110 into digital signals. In other words, the ADC of the controller 152 is configured to output a digital signal based upon each analog signal received from the force sensitive input keys 110. It is contemplated that, in other embodiments, the ADC may be separate from the controller 152 (i.e., a separate component soldered to the PCB 120). In the illustrative embodiment, the game pad 100 also includes one or more low-pass filters soldered to a backside of the PCB 120 (not shown). These one or more low-pass filters are positioned between the force sensitive input keys 110 and the ADC of the controller 152 and are configured to reduce noise in one or more of the analog signals from the force sensitive input keys 110 before the analog signals are received by the ADC.

[0041] Once the analog signals from the force sensitive input keys 110 have been converted into digital signals, the controller 152 of the game pad 100 may determine a force applied to each of the force sensitive input keys 110. As described above, the magnitude of each analog signal represents the amount of the light measured by each force sensitive input key 110, which is monotonically related to the force applied to the keycap 134 of that input key 110. As such, the controller 152 may calculate the force applied to one of the force sensitive input keys 110 using the value of the received analog signal (converted to a digital signal). The controller 152 may perform this calculation of the force applied using a mathematical function, a look-up table, or any other suitable calculation process. The controller 152 may then perform appropriate calibration, mapping, and/or scaling of the determined force into a format suitable for presentation to a driver of a computing device connected to the game pad 100.

[0042] In the illustrative embodiment, the controller 152 is configured to output movement data including both direction and magnitude in response to analog signals received from four of the force sensitive input keys 110 of the game pad 100. In particular, two of the force sensitive input keys 110 may be used to register user intent regarding movement along an x-axis (one input key 110 representing positive movement along the x-axis and one input key 110 representing negative movement along the x-axis). Likewise, two of the force sensitive input keys 110 may be used to register user intent regarding movement along a y-axis (one input key 110 representing positive movement along the y-axis and one input key 110 representing negative movement along the y-axis). Using the analog signals output by these four force sensitive input keys 110, the controller 152 may generate movement data that includes an x-axis component and a y-axis component. When any one of the four force sensitive input keys 110 is pressed by a user, the controller 152 may calculate a vector in the corresponding direction, where a magnitude of the vector is proportional to the force applied to that input key 110 by the user. Where multiple (e.g., two) force sensitive input keys 110 are pressed simultaneously, the controller 152 may add the calculated vectors to determine the overall direction and magnitude of movement intended by the user. In an electronic gaming application (e.g., a computer game), this movement data may be used to accurately and precisely control the movement and/or actions of a character in the game.

[0043] As mentioned above, the controller 152 may format the determined movement data for presentation to a driver of a computing device connected to the game pad 100. For instance, the movement data may be formatted according to a Universal Serial Bus (USB) protocol (e.g., by a USB controller included in the controller 152) where the game pad 100 is coupled to the computing device via a USB cable. In other embodiments, the controller 152 may format the movement data according to the Direct Input protocol, the X-Input protocol, or any other protocol expected by a driver of a particular computing device. In some embodiments, the formatting performed by the controller 152 may be adjustable by a user. For instance, the user may set how different forces applied to one of the force sensitive input keys 110 of the game pad 100 are mapped to a 256-value scale. This configurability may allow more users (e.g., of different abilities) to effectively use the game pad 100. In some embodiments, the user may also be able to instruct the game pad 100 to interpret the analog signal(s) from one or more of the force sensitive input keys 110 like a binary input key 160 (i.e., treat any force exceeding an adjustable threshold as a binary "on" and treat all other forces applied as a binary "off"). In the illustrative embodiment, the binary input keys 160 of the game pad 100 are configured to output a digital signal that indicates whether or not the binary input key has been pressed.

[0044] Referring now to FIG. 4, another illustrative embodiment of a force sensitive input key 110 that may be used in the game pad 100 (or other input devices 100) is shown in cross-section. The illustrative embodiment of the force sensitive input key 110 shown in FIG. 4 is similar in configuration and operation to the force sensitive input keys 110 shown in FIGS. 2 and 3, except that (like the force sensitive input device 10 of FIG. 1) the reflectance sensor 116 is disposed in a chamber 132 defined within the housing 118. As shown in FIG. 4, the button 112 of the force sensitive input key 110 has a two part construction that includes a keycap 134 (with a surface 122 configured to be pressed by a user) and a plunger 136 that engages a spring 114 within the housing 118. The plunger 136 is movable along an axis 124 when a force is applied to the keycap 134 by a user. The plunger 136 is illustrated in FIG. 4 in a top end position. When the surface 122 of the keycap 134 is pressed by a user, the keycap 134 and the plunger 136 may both move along the axis 124 (downward in FIG. 4) until the button 112 reaches a bottom end position.

[0045] In the illustrative embodiment of FIG. 4, the plunger 136 includes a plunger arm 138 that extends into the chamber 132 defined in the housing 118. The reflective surface 128 of the button 112 is included on the plunger arm 138 and faces the reflectance sensor 116. In the illustrative embodiment, the reflective surface 128 is integrally formed with the plunger 136 (i.e., the reflective surface 128 is a surface of the plunger 136). In other embodiments, the plunger arm 138 and/or the reflective surface 128 may be coupled to the plunger 136 after the plunger 136 has been formed. As the button 112 (including the plunger 136) moves along the axis 124, the reflective surface 128 will move along an axis 130 that is generally parallel to the axis 124. In the illustrative embodiment, the reflective surface 128 is generally perpendicular to the axis 130 (as well as the axis 124). In the illustrative embodiment, the housing 118 may be formed of an opaque material, such that light is not able to escape and/or enter the chamber 132.

[0046] Referring now to FIG. 5, one illustrative embodiment of a force sensitive input method 200 is shown as a simplified flow diagram. The method 200 may be used with the force sensitive input device 10 of FIG. 1, with the force sensitive input keys 110 of FIGS. 2-4, and/or with any other suitable force sensitive input device(s). The method 200 begins with block 202 in which a button 12 that is movable along an axis 24 between two end positions is biased toward one of the two end positions using a resilient component 14. As described above, the button 12 may be biased toward one of the two end positions using a spring 14. While the spring 14 allows displacement of the button 12 along the axis 24 (as described below), the spring 14 continually biases the button 12 toward one of the two end positions (i.e., the block 202 is performed throughout the method 200).

[0047] The method 200 continues with block 204 in which a reflective surface 28 of the button 12 is illuminated with light that travels generally parallel to the axis 24. In some embodiments, block 204 may involve illuminating the reflective surface 28 of the button 12 by emitting light from an LED of a reflectance sensor 16 that faces the reflective surface 28. In particular, block 204 may involve emitting infrared light from the LED of the reflectance sensor 16. It is contemplated that, in other embodiments, other types of light sources and/or other types of light may be used to illuminate the reflective surface 28 of the button 12. The block 204 may be performed either continuously or intermittently throughout the method 200.

[0048] After block 204, the method 200 continues to block 206 in which the button 12 is displaced from one end position (specifically, the end position toward which it is biased in block 202) toward the other end position. In some embodiments, block 204 may involve a user applying a force to the button 12 to cause movement of the button 12 along the axis 24. During block 206, the method 200 also involves block 208 in which an amount of the light that is reflected from the reflective surface 28 and that travels generally parallel to the axis 24 is measured by the reflectance sensor 16. In some embodiments, block 204 may involve receiving and measuring the reflected light using a phototransistor of the reflectance sensor 16. During block 208, the phototransistor of the reflectance sensor 16 may output an analog signal that is a function of the amount of the light that is reflected from the reflective surface 28. As described above, the amount of the light that is reflected from the reflective surface 28 (and, hence, the magnitude(s) of the generated analog signal) may be monotonically related to the force applied to the button 12 in block 206.

[0049] After blocks 206 and 208, the method 200 continues to block 210 in which the force applied to the button 12 in block 206 is determined as a function of the amount of light measured in block 208. In some embodiments, block 210 may involve a controller 152 receiving the analog signal output by the phototransistor in block 208 and calculating the force applied to the button 12 using this analog signal, as described above. In such embodiments, block 210 may involve converting the analog signal output by the phototransistor into a digital signal using an ADC of the controller 152. In some embodiments, block 210 may also involve reducing noise in the analog signal using a low-pass filter, prior to the analog signal being converted by the ADC.

[0050] After block 210, the method 200 may continue to block 212 in which the controller 152 generates movement data in response to the force determined in block 210. As described above, where the method 200 is used with one or more force sensitive input devices 10 and/or force sensitive input keys 110, the movement data generated by the controller 152 may include both direction and magnitude of movement. In some embodiments, block 212 may involve formatting the movement data for presentation to a driver of a computing device and transmitting the formatted data to the computing device.

[0051] While the disclosure has been illustrated and described in detail in the drawings and foregoing description, such an illustration and description is to be considered as exemplary and not restrictive in character, it being understood that only illustrative embodiments have been shown and described and that all changes and modifications that come within the scope of the disclosure are desired to be protected. There are a plurality of advantages of the present disclosure arising from the various features of the apparatus, systems, and methods described herein. It will be noted that alternative embodiments of the apparatus, systems, and methods of the present disclosure may not include all of the features described yet still benefit from at least some of the advantages of such features. Those of ordinary skill in the art may readily devise their own implementations of the apparatus, systems, and methods that incorporate one or more of the features of the present invention and fall within the scope of the present disclosure as defined by the appended claims.

Claims

1. An input device (10) comprising:

a first input key (110) configured to output a first analog signal as a function of force applied to the first input key (110);
a second input key (110) configured to output a second analog signal as a function of force applied to the second input key (110);
a third input key (110) configured to output a third analog signal as a function of force applied to the third input key (110);
a fourth input key (110) configured to output a fourth analog signal as a function of force applied to the fourth input key (110); and
a controller (152) configured to calculate a first vector having a first magnitude based on a value of the first analog signal, calculate a second vector having a second magnitude based on a value of the second analog signal, calculate a third vector having a third magnitude based on a value of the third analog signal, calculate a fourth vector having a fourth magnitude based on a value of the fourth analog signal, and output movement data including both direction and magnitude that represent a vector addition of the first, second, third, and fourth vectors.

2. The input device (10) of claim 1, wherein the controller (152) comprises an analog-to-digital converter configured to convert the first, second, third, and fourth analog signals into digital signals.

3. The input device (10) of claim 2, further comprising a low-pass filter configured to reduce noise in at least one of the first, second, third, and fourth analog signals before the analog signal is received by the analog-to-digital converter of the controller.

4. The input device (10) of any preceding claim, wherein the controller (152) is configured to format the movement data according to either the DirectInput protocol or the XInput protocol.

5. The input device (10) of any preceding claim, wherein the movement data includes an x-axis component and a y-axis component, the x-axis component being a function of the first and second analog signals, and the y-axis component being a function of the third and fourth analog signals.

6. The input device (10) of claim 5, wherein:

the x-axis component represents a first distance from a resting point, the first distance being proportional to a force applied to one of the first and second input keys (110); and
the y-axis component represents a second distance from the resting point, the second distance being proportional to a force applied to one of the third and fourth input keys (110).

7. The input device (10) of any preceding claim, wherein the first, second, third, and fourth input keys (110) each comprise:

a button (12) movable along a respective axis between a first end position and a second end position, the button including a reflective surface (128);
a resilient component (14) biasing the button toward the first end position; and
a reflectance sensor (16) configured to emit light that impinges upon the reflective surface, to measure an amount of the light that is reflected from the reflective surface, and to output the respective analog signal in response to the measured amount of the reflected light, wherein the light travels generally parallel to the respective axis.

8. The input device (10) of claim 7, wherein the button (12) of each of the first, second, third, and fourth input keys (110) comprises:

a keycap (134) configured to be pressed by a user to move the button (12) along the first axis toward the second end position; and
a plunger (136) supporting the keycap, the plunger engaging the resilient component.

9. The input device (10) of claim 8, wherein, for each of the first, second, third, and fourth input keys (110), the reflective surface (128) of the button (12) is spaced apart from a portion of the plunger (136) that engages the resilient component (14).

10. The input device (10) of claim 9, wherein, for each of the first, second, third, and fourth input keys (110), the portion of the plunger (136) that engages the resilient component (14) is configured to move along the respective axis and the reflective surface (128) is configured to move along a parallel axis.

11. The input device (10) of claim 10, wherein, for each of the first, second, third, and fourth input keys (110), the reflective surface (128) is perpendicular to the parallel axis.

12. The input device (10) of any one of claims 7-11, wherein each of the first, second, third, and fourth input keys (110) further comprises an opaque housing (118) defining a respective chamber (132), the reflective surface (128) and the reflectance sensor (16) being disposed in the respective chamber.

13. The input device (10) of claim 12, wherein, for each of the first, second, third, and fourth input keys (110), when the button (12) is in the second end position, the button contacts the opaque housing (118) to block further movement of the button along the respective axis away from the first end position.

14. The input device (10) of any one of claims 7-13, wherein the reflectance sensor (16) of each of the first, second, third, and fourth input keys (110) comprises:

a light-emitting diode configured to emit the light; and
a phototransistor configured to receive the amount of the light that is reflected from the reflective surface.

15. The input device (10) of any one of claims 7-14, wherein the resilient component (14) of each of the first, second, third, and fourth input keys is configured to allow a displacement of the button (12) from the first end position that is proportional to a force applied to the button by a user.

Patentansprüche

1. Eingabevorrichtung (10), umfassend:

eine erste Eingabetaste (110), die für die Ausgabe eines ersten analogen Signals als eine Funktion der auf die erste Eingabetaste (110) ausgeübten Kraft gestaltet ist;
eine zweite Eingabetaste (110), die für die Ausgabe eines zweiten analogen Signals als eine Funktion der auf die zweite Eingabetaste (110) ausgeübten Kraft gestaltet ist;
eine dritte Eingabetaste (110), die für die Ausgabe eines dritten analogen Signals als eine Funktion der auf die dritte Eingabetaste (110) ausgeübten Kraft gestaltet ist;
eine vierte Eingabetaste (110), die für die Ausgabe eines vierten analogen Signals als eine Funktion der auf die vierte Eingabetaste (110) ausgeübten Kraft gestaltet ist; und
eine Steuereinheit (152), die gestaltet ist zur Berechnung eines ersten Vektors mit einer ersten Größe auf der Basis des ersten analogen Signals, zur Berechnung eines zweiten Vektors mit einer zweiten Größe auf der Basis des zweiten analogen Signals, zur Berechnung eines dritten Vektors mit einer dritten Größe auf der Basis des dritten analogen Signals, zur Berechnung eines vierten Vektors mit einer vierten Größe auf der Basis des vierten analogen Signals, und zur Ausgabe von Bewegungsdaten, die sowohl Richtung als auch Stärke aufweisen, die eine Vektoraddition des ersten, zweiten, dritten und vierten Vektors darstellen.

2. Eingabevorrichtung (10) nach Anspruch 1, wobei die Steuereinheit (152) einen Analog-Digital-Wandler umfasst, der zur Umwandlung des ersten, zweiten, dritten und vierten analogen Signals in digitale Signale gestaltet ist.

3. Eingabevorrichtung (10) nach Anspruch 2, die ferner einen Tiefpassfilter umfasst, der zur Reduzierung von Rauschen in wenigstens einem Signal des ersten, zweiten, dritten und vierten analogen Signals gestaltet ist, bevor das analoge Signal durch den Analog-Digital-Wandler der Steuereinheit empfangen wird.

4. Eingabevorrichtung (10) nach einem der vorstehenden Ansprüche, wobei die Steuereinheit (152) so gestaltet ist, dass sie die Bewegungsdaten gemäß dem DirectInput-Protokoll oder dem XInput-Protokoll formatiert.

5. Eingabevorrichtung (10) nach einem der vorstehenden Ansprüche, wobei die Bewegungsdaten eine X-Achsen-Komponente und eine Y-Achsen-Komponente aufweisen, wobei die X-Achsen-Komponente eine Funktion des ersten und des zweiten analogen Signals ist, und wobei die Y-Achsen-Komponente eine Funktion des dritten und des vierten analogen Signals ist.

6. Eingabevorrichtung (10) nach Anspruch 5, wobei:

die X-Achsen-Komponente einen ersten Abstand zu einem Ruhepunkt darstellt, wobei der erste Abstand proportional zu einer auf eine Taste der ersten und der zweiten Eingabetasten (110) ausgeübten Kraft ist; und
die Y-Achsen-Komponente einen zweiten Abstand zu dem Ruhepunkt darstellt, wobei der zweite Abstand proportional zu einer auf eine Taste der dritten und der vierten Eingabetasten (110) ausgeübten Kraft ist.

7. Eingabevorrichtung (10) nach einem der vorstehenden Ansprüche, wobei die erste, zweite, dritte und vierte Eingabetaste (110) jeweils folgendes umfassen:

einen Knopf (12), der entlang einer entsprechenden Achse zwischen einer ersten Endposition und einer zweiten Endposition beweglich ist, wobei der Knopf eine reflektierende Oberfläche (128) aufweist;
eine nachgiebige Komponente (14), die den Knopf an die erste Endposition vorbelastet; und
einen Reflexionssensor (16), der so gestaltet ist, dass er Licht emittiert, das auf die reflektierende Oberfläche auftrifft, um eine von der reflektierenden Oberfläche reflektierte Lichtmenge zu messen, und um das entsprechende analoge Signal als Reaktion auf die gemessene Menge des reflektierten Lichts auszugeben, wobei das Licht allgemein parallel zu der entsprechenden Achse verläuft.

8. Eingabevorrichtung (10) nach Anspruch 7, wobei der Knopf (12) jeder der ersten, zweiten, dritten und vierten Eingabetaste (110) folgendes umfasst:

einen Tastenüberzug (134), der zum Drücken durch einen Benutzer gestaltet ist, um den Knopf (12) entlang der ersten Achse in Richtung der zweiten Endposition zu bewegen; und
einen Kolben (136), der den Tastenüberzug stütz, wobei der Kolben mit der nachgiebigen Komponente eingreift.

9. Eingabevorrichtung (10) nach Anspruch 8, wobei für jede der ersten, zweiten, dritten und vierten Eingabetaste (110) die reflektierende Oberfläche (128) des Knopfs (12) einen Abstand zu einem Teil des Kolbens (136) aufweist, der mit der nachgiebigen Komponente (14) eingreift.

10. Eingabevorrichtung (10) nach Anspruch 9, wobei für jede der ersten, zweiten, dritten und vierten Eingabetaste (110) der Teil des Kolbens (136), der mit der nachgiebigen Komponente (14) eingreift, so gestaltet ist, dass er sich entlang der entsprechenden Achse bewegt, und wobei die reflektierende Oberfläche (128) so gestaltet ist, dass sie sich entlang einer parallelen Achse bewegt.

11. Eingabevorrichtung (10) nach Anspruch 10, wobei für jede der ersten, zweiten, dritten und vierten Eingabetaste (110) die reflektierende Oberfläche (128) senkrecht zu der parallelen Achse ist.

12. Eingabevorrichtung (10) nach einem der Ansprüche 7 bis 11, wobei jede der ersten, zweiten, dritten und vierten Eingabetaste (110) ferner ein opakes Gehäuse (118) umfasst, das eine entsprechende Kammer (132) definiert, wobei sich die reflektierende Oberfläche (128) und der Reflexionssensor (16) in der entsprechenden Kammer befinden.

13. Eingabevorrichtung (10) nach Anspruch 12, wobei für jede der ersten, zweiten, dritten und vierten Eingabetaste (110), wenn sich der Knopf (12) an der zweiten Endposition befindet, der Knopf das opake Gehäuse (118) berührt, um eine weitere Bewegung des Knopfs entlang der entsprechenden Achse von der ersten Endposition weggehend zu blockieren.

14. Eingabevorrichtung (10) nach einem der Ansprüche 7 bis 13, wobei der Reflexionssensor (16) jeder der ersten, zweiten, dritten und vierten Eingabetaste (110) folgendes umfasst:

eine Leuchtdiode, die so gestaltet ist, dass sie Licht emittiert; und
einen Fototransistor, der so gestaltet ist, dass er die von der reflektierten Oberfläche reflektierte Lichtmenge empfängt.

15. Eingabevorrichtung (10) nach einem der Ansprüche 7 bis 14, wobei die nachgiebige Komponente (14) jeder der ersten, zweiten, dritten und vierten Eingabetaste so gestaltet ist, dass sie einen Versatz des Knopfs (12) von der ersten Endposition ermöglicht, der proportional ist zu einer durch einen Benutzer auf den Knopf ausgeübten Kraft.

Revendications

1. Dispositif d'entrée (10) comprenant :

une première touche d'entrée (110) conçue pour délivrer en sortie un premier signal analogique en fonction de la force appliquée à la première touche d'entrée (110) ;
une deuxième touche d'entrée (110) conçue pour délivrer en sortie un second signal analogique en fonction de la force appliquée à la deuxième touche d'entrée (110);
une troisième touche d'entrée (110) conçue pour délivrer en sortie un troisième signal ana-

logique en fonction de la force appliquée à la troisième touche d'entrée (110);
une quatrième touche d'entrée (110) conçue pour délivrer en sortie un quatrième signal analogique en fonction de la force appliquée à la quatrième touche d'entrée (110) ; et
un dispositif de commande (152) conçu pour calculer un premier vecteur ayant une première amplitude basée sur une valeur du premier signal analogique, calculer un deuxième vecteur ayant une deuxième amplitude basée sur une valeur du deuxième signal analogique, calculer un troisième vecteur ayant une troisième amplitude basée sur une valeur du troisième signal analogique, calculer un quatrième vecteur ayant une quatrième amplitude basée sur une valeur du quatrième signal analogique, et délivrer en sortie des données de mouvement comprenant à la fois la direction et l'amplitude qui représentent une addition vectorielle des premier, deuxième, troisième et quatrième vecteurs.

2. Dispositif d'entrée (10) selon la revendication 1, le dispositif de commande (152) comprenant un convertisseur analogique-numérique conçu pour convertir les premier, deuxième, troisième et quatrième signaux analogiques en signaux numériques.

3. Dispositif d'entrée (10) selon la revendication 2, comprenant en outre un filtre passe-bas conçu pour réduire le bruit dans au moins un des premier, deuxième, troisième et quatrième signaux analogiques avant que le signal analogique ne soit reçu par le convertisseur analogique-numérique du dispositif de commande.

4. Dispositif d'entrée (10) selon l'une quelconque des revendications précédentes, le dispositif de commande (152) étant conçu pour formater les données de mouvement selon le protocole DirectInput ou le protocole XInput.

5. Dispositif d'entrée (10) selon l'une quelconque des revendications précédentes, les données de mouvement comprenant une composante d'axe x et une composante d'axe y, la composante d'axe x étant une fonction des premier et deuxième signaux analogiques, et la composante d'axe y étant une fonction des troisième et quatrième signaux analogiques.

6. Dispositif d'entrée (10) selon la revendication 5 :

la composante d'axe x représentant une première distance par rapport à un point de repos, la première distance étant proportionnelle à une force appliquée à l'une des première et seconde touches d'entrée (110) ; et
la composante d'axe y représentant une seconde distance par rapport au point de repos, la seconde distance étant proportionnelle à une force appliquée à l'une des troisième et quatrième touches d'entrée (110).

7. Dispositif d'entrée (10) selon l'une quelconque des revendications précédentes, les première, deuxième, troisième et quatrième touches d'entrée (110) comprenant chacune :

un bouton (12) mobile le long d'un axe respectif entre une première position d'extrémité et une seconde position d'extrémité, le bouton comprenant une surface réfléchissante (128) ;
un composant résilient (14) qui pousse le bouton vers la première position d'extrémité ; et
un capteur de réflectance (16) conçu pour émettre de la lumière qui frappe la surface réfléchissante, pour mesurer une quantité de lumière qui est réfléchie par la surface réfléchissante, et pour délivrer en sortie le signal analogique respectif en réponse à la quantité mesurée de la lumière réfléchie, la lumière se déplaçant généralement parallèlement à l'axe respectif.

8. Dispositif d'entrée (10) selon la revendication 7, le bouton (12) de chacune des première, deuxième, troisième et quatrième touches d'entrée (110) comprenant :

un dessus de touche (134) conçu pour être pressé par un utilisateur afin de déplacer le bouton (12) le long du premier axe vers la seconde position d'extrémité ; et
un piston (136) soutenant le dessus de touche, le piston venant en prise avec le composant résilient.

9. Dispositif d'entrée (10) selon la revendication 8, pour chacune des première, deuxième, troisième et quatrième touches d'entrée (110), la surface réfléchissante (128) du bouton (12) étant espacée d'une partie du piston (136) qui vient en prise avec le composant résilient (14).

10. Dispositif d'entrée (10) selon la revendication 9, pour chacune des première, deuxième, troisième et quatrième touches d'entrée (110), la partie du plongeur (136) qui vient en prise avec le composant résilient (14) étant conçue pour se déplacer le long de l'axe respectif et la surface réfléchissante (128) étant conçue pour se déplacer le long d'un axe parallèle.

11. Dispositif d'entrée (10) selon la revendication 10, pour chacune des première, deuxième, troisième et quatrième touches d'entrée (110), la surface réfléchissante (128) étant perpendiculaire à l'axe parallèle.

12. Dispositif d'entrée (10) selon l'une quelconque des revendications 7 à 11, chacune des première, deuxième, troisième et quatrième touches d'entrée (110) comprenant en outre un boîtier opaque (118) définissant une chambre (132) respective, la surface réfléchissante (128) et le capteur de réflectance (16) étant disposés dans la chambre respective.

13. Dispositif d'entrée (10) selon la revendication 12, pour chacune des première, deuxième, troisième et quatrième touches d'entrée (110), lorsque le bouton (12) est dans la seconde position d'extrémité, le bouton entrant en contact avec le boîtier opaque (118) pour bloquer tout autre mouvement du bouton le long de l'axe respectif à l'opposé de la première position d'extrémité.

14. Dispositif d'entrée (10) selon l'une quelconque des revendications 7 à 13, le capteur de réflectance (16) de chacune des première, deuxième, troisième et quatrième touches d'entrée (110) comprenant :

une diode électroluminescente conçue pour émettre la lumière ; et
un phototransistor conçu pour recevoir la quantité de lumière qui est réfléchie par la surface réfléchissante.

15. Dispositif d'entrée (10) selon l'une quelconque des revendications 7 à 14, le composant résilient (14) de chacune des première, deuxième, troisième et quatrième touches d'entrée étant conçu pour permettre un déplacement du bouton (12) à partir de la première position d'extrémité qui est proportionnel à une force appliquée au bouton par un utilisateur.

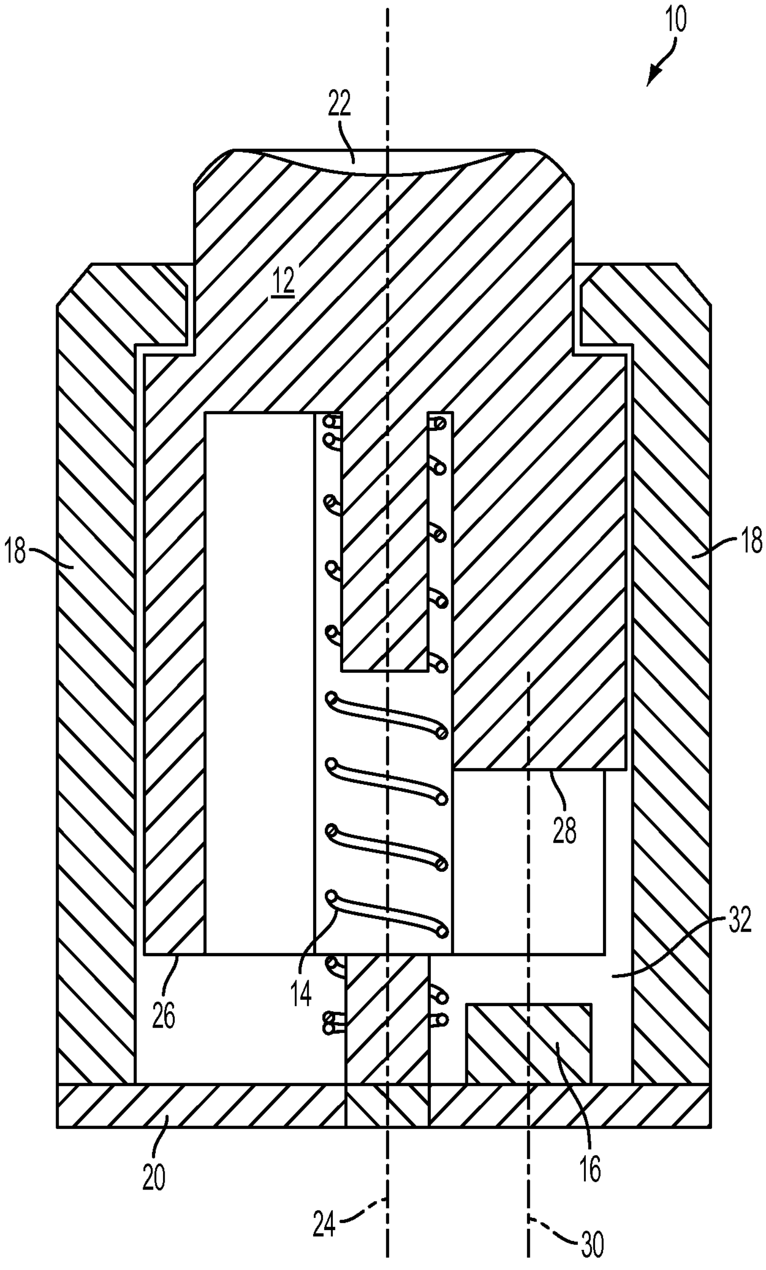
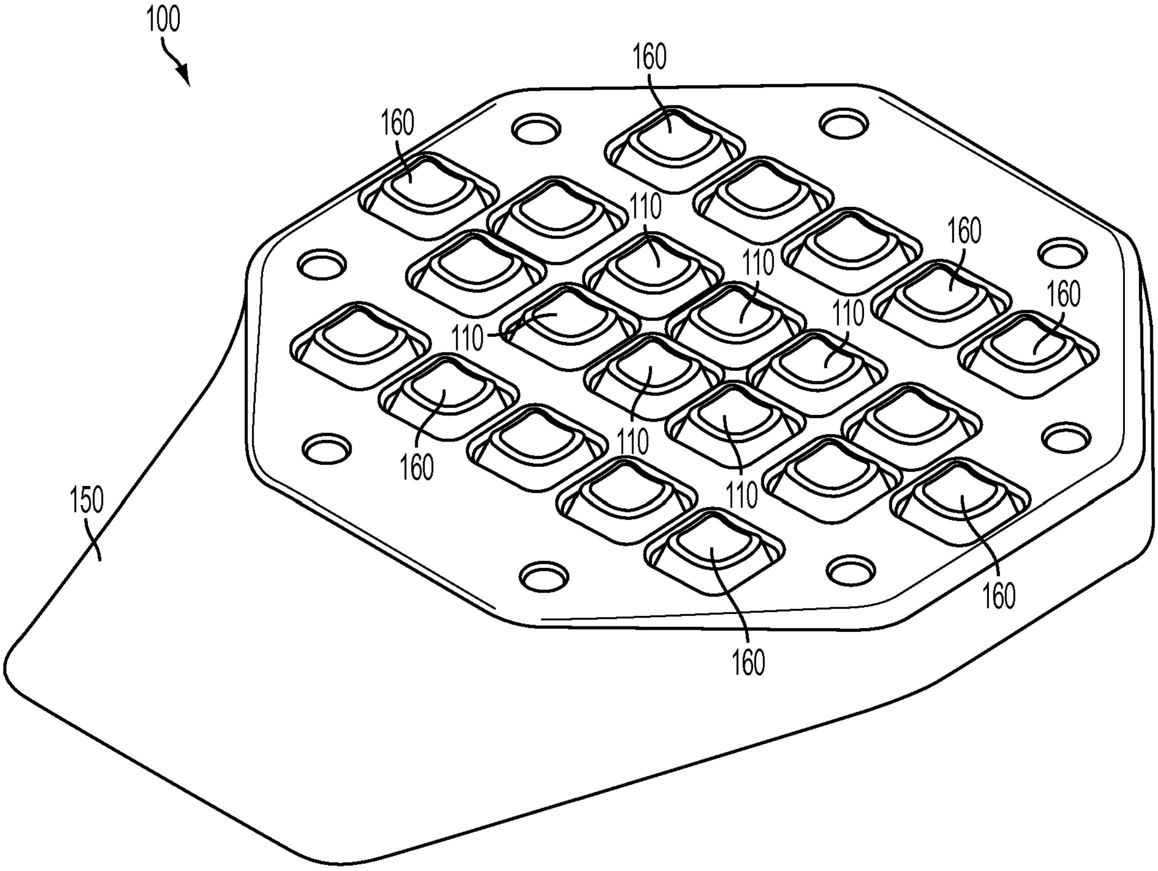


FIG. 1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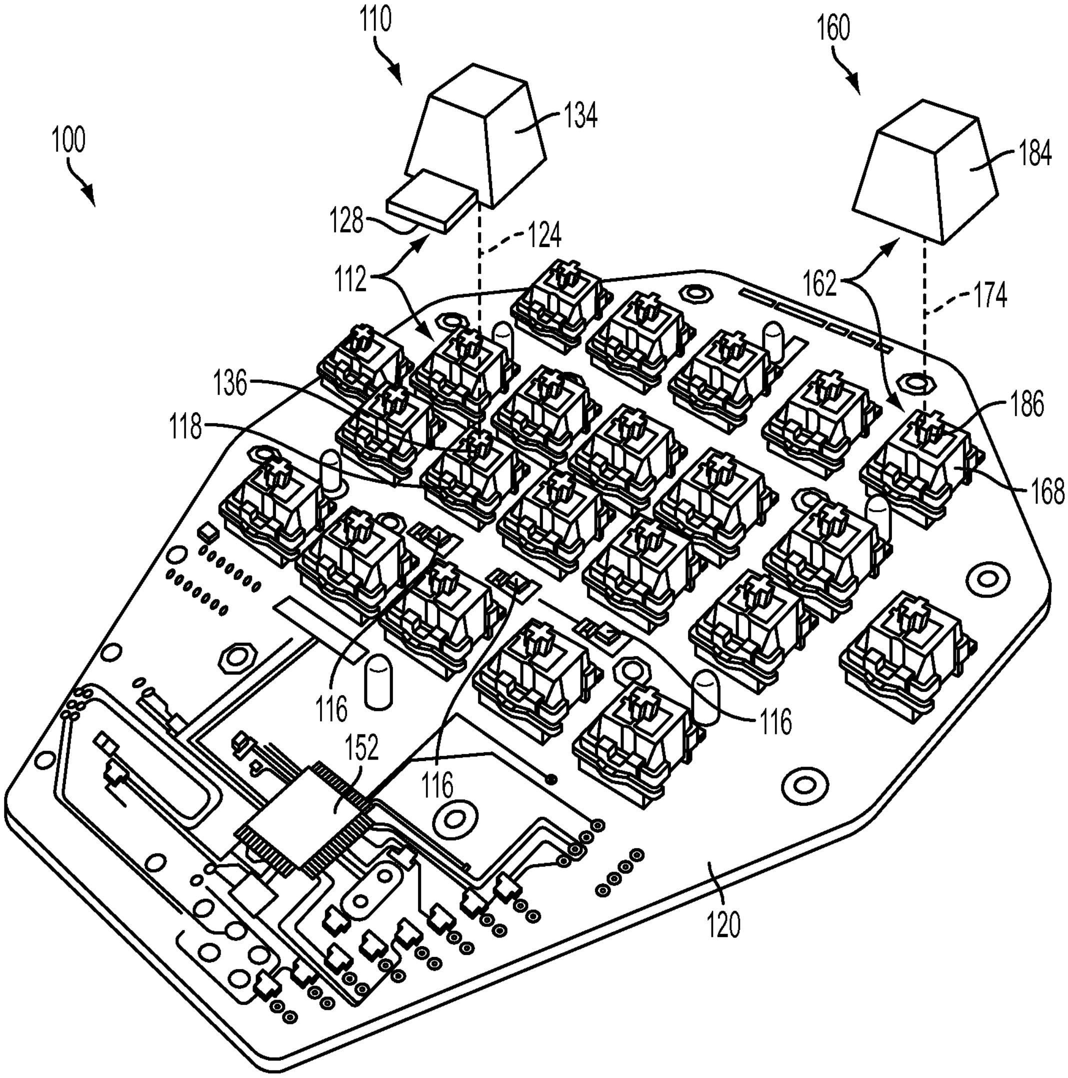
160

FIG. 2


110
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124
112
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136
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120

FIG. 3

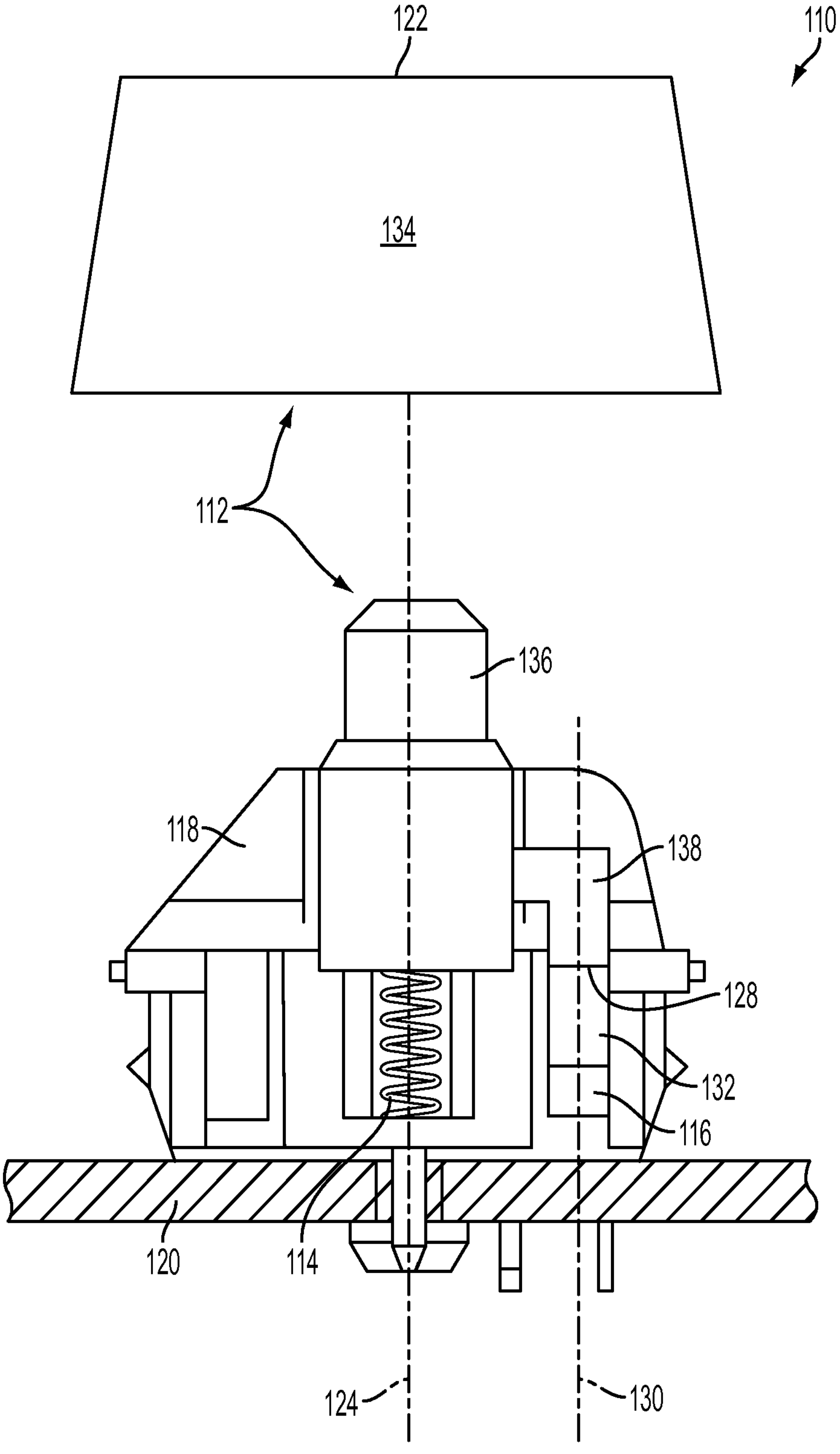

FIG. 4

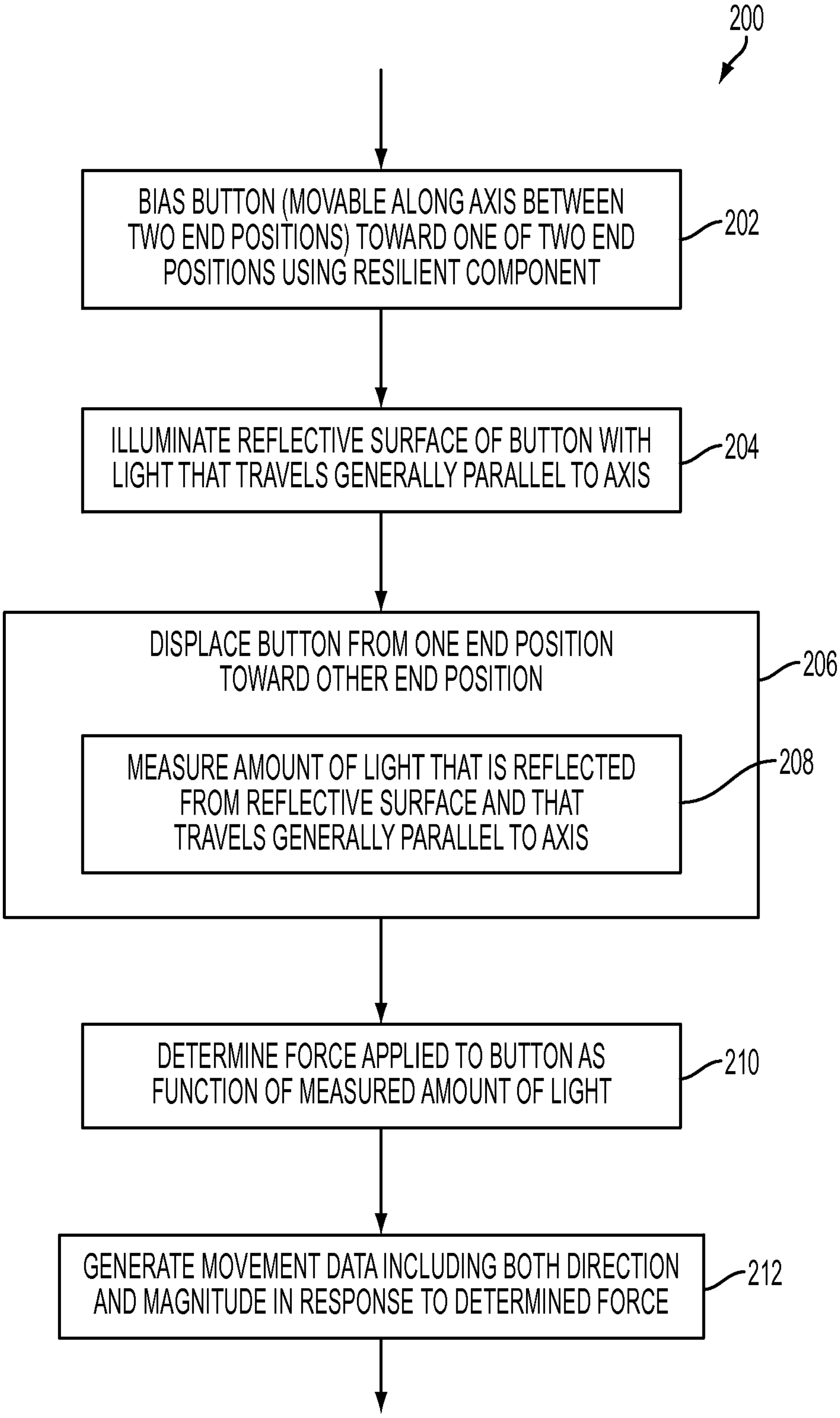
200
BIAS BUTTON (MOVABLE ALONG AXIS BETWEEN TWO END POSITIONS) TOWARD ONE OF TWO END POSITIONS USING RESILIENT COMPONENT
202
ILLUMINATE REFLECTIVE SURFACE OF BUTTON WITH LIGHT THAT TRAVELS GENERALLY PARALLEL TO AXIS
204
DISPLACE BUTTON FROM ONE END POSITION TOWARD OTHER END POSITION
206
MEASURE AMOUNT OF LIGHT THAT IS REFLECTED FROM REFLECTIVE SURFACE AND THAT TRAVELS GENERALLY PARALLEL TO AXIS
208
DETERMINE FORCE APPLIED TO BUTTON AS FUNCTION OF MEASURED AMOUNT OF LIGHT
210
GENERATE MOVEMENT DATA INCLUDING BOTH DIRECTION AND MAGNITUDE IN RESPONSE TO DETERMINED FORCE
212

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 80477913 **[0001]**
- JP H11110127 B **[0007]**