IMAGE DISPLAY THAT MOVES PHYSICAL OBJECTS AND CAUSES TACTILE SENSATION

[0001] This invention relates to the field of image displays, and to displays that that can move or control physical objects at a surface of the display and that provide tactile sensation and feedback.

[0002] There are certain situations where it is required that physical objects at or near the surface of an image display be moved. Typically, such movement would be required within the bounds of the surface of the display.

[0003] Further, high precision moving forces may be useful as feedback for a user in a touch-sensitive image display, such as a computer-game control, and can be position related. Thus, the user could "feel" the grains in the wood of the displayed plank displayed on the image display.

[0004] Devices are known that provide tactile feedback to a user. For example, Franzen, U.S. Patent Application No. 2003/0179190, discloses a touch sensitive display that provides tactile feedback based on pins that move and down, the pins covered by a contact medium. However, the cited reference does not have the ability to move objects in a direction along the surface of the display and cannot give a finger that touches it the sensation of movement and texture.

[0005] Provided are a method, system, device, and apparatus that embodies or carries out the functions of image display system provided.

[0006] According to an embodiment of the present invention, provided is an image display including a set of actuators, each actuator including conductive rods attached together, such that each rod of the actuator may increase or decrease in size when current is applied to that rod to cause the actuator to bend toward a specified direction according to a received movement signal. Further, an object at a surface of the image display may be moved in the specified direction.

[0007] The rods may be made of piezo-electric ceramics or conductive polymers or a combination of these or other materials.

[0008] The actuator may be arranged between pixels of the image display. Such an image display may provide a haptic sensation or a motion of an object at the surface of the image display.

[0009] Moreover, the actuator may be made of three rods arranged such that responsive to application of a current to the rods, the actuator bends toward one of four or more specifiable directions.

[0010] The image display may be a touch sensitive display. The actuators may provide the touch sensitivity for the image display.

[0011] Also, an image display that can move an object near a surface of the image display is described. The image display includes a ball bearing assembly including a ball bearings that is arranged such that a rotation direction of the ball bearing may be controlled by magnets, to cause an object at a surface of the image display to be moved in a specified direction by the movement of the ball bearing along a rotation direction of the ball bearing.

[0012] The ball bearing may be arranged between pixels of the image display. The image display may be a touch sensitive image display. The ball bearings may provide the touch sensitivity for the image display.

[0013] Further, an image display that provides a motion of an object at the surface of said image display is provided. There is a hole layer that includes air holes. The air hole is tilted at an oblique angle with respect to the surface in one of four directions, such that air blown through the air hole creates directed air pressure at the surface in the direction toward which the hole is tilted. The air hole may be selectively opened and closed according to a movement signal received for moving an object at a surface of the image display in the direction of the directed air pressure.

[0014] Moreover, a control layer may be provided that has row electrodes and column electrodes, and a foil arranged such that the foil closes the hole responsive to an electric current passed through a row of electrodes.

[0015] There may be sets of four such air holes, such that each hole of the set may be located at a corner of an imaginary figure resembling a rectangle with no intervening holes as viewed from the surface, wherein each hole of the set of four holes is tilted in one of the four directions.

[0016] Further, an air inlet channel between holes may be formed. The holes may be arranged between pixels of the image display. The image display may be a touch sensitive image display.

[0017] Also described is an image display configured to cause a haptic sensation at a surface of the image display. Such an image display includes a pixel-actuator matrix including rods and a set of magnets arranged to be activated for a first activation by a first movement signal received and to be activated for a second activation by a second movement signal received. A rod may be arranged to move to an extended position with respect to the surface of the image display responsive to the first activation, and to move to a retracted position with respect to the surface of the image display responsive to the second activation, such that the haptic sensation is caused at the surface by the rod in the extended position. It may be formed such that at most one rod is provided between pixels. The image display may be a touch sensitive image display. The rods may provide the touch sensitivity for the image display.

[0018] FIG. **1** is a schematic view of a ball bearing assembly of an image display system according to a first embodiment of the present invention.

[0019] FIG. **2** is a schematic view of a rod assembly of an image display system according to a second embodiment of the present invention.

[0020] FIG. **3**A is schematic view of an image display system according to a third embodiment of the present invention.

[0021] FIG. **3**B is a schematic view of air pressure directions from air holes of an image display system according to the third embodiment of the present invention.

[0022] FIG. **3**C is a schematic view of an air intake channel of an image display system according to the third embodiment of the present invention.

[0023] FIG. **3**D is a cross-section view of an air pressure control system of an image display system according to the third embodiment of the present invention.

[0024] FIG. **3**E is a cross-section view of top layers of an image display system according to the third embodiment of the present invention.

[0025] FIG. **4**A is a perspective view of an image display according to the fourth embodiment of the present invention.