Haptic systems may sense particular stimuli, change one or more characteristics of a shape change element, or both. Haptic systems may perform sensing functions and actuating functions at the same time. In some embodiments, haptic systems may be coupled to a display screen, audio system, device software, device hardware or other system to provide for any combination of tactile, visual, and audio interactions. Actuation may occur, in some embodiments, substantially normal to a substantially planar surface, which may allow for three dimensional contouring of the planar surface.

[0029] In some embodiments, shape change elements may have different properties which may provide for relatively different responses. For example, shape change elements of a particular size may provide for a particular range of displacement, force, sensing any other suitable physical response, or any combinations thereof. Shape change elements of relatively smaller size may provide finer resolution in displacement, force, sensing any other suitable physical response, or any combinations thereof. Shape change elements of relatively larger size may provide coarser resolution in displacement, force, sensing any other suitable physical response, or any combinations thereof. Various scales of haptic response may be used to provide diverse tactile interaction. For example, large displacements may be achieved by using one or more arrays of relatively large shape change elements. One or more arrays of relatively small shape change elements may be stacked with the one or more arrays of larger elements to provide for finer haptic response while allowing for large displacements. In some embodiments, multiple layers of arrays may be used, which each may have a particular size of shape change elements. Such arrangements may allow for varied response over large temporal and spatial ranges of tactile response and interaction.

[0030] In some embodiments, a tiered haptic response approach may be used in which one or more arrays of shape change elements may provide tactile interaction via an elastic screen interface. A suitable display screen may be included in the elastic screen interface. For example, stacked, planar arrays of piezoelectric elements may be used to provide variable actuation, sensing, or both. In some arrangements, each array may include, for example, piezoelectric elements of a particular size, providing multi-scale control in actuation and sensing. In some arrangements, a particular type of shape change element may be included in each array. In some embodiments, different types of shape change elements may be included within a particular array. Shape change elements may provide any type of actuation such as, for example, vibration, net displacement, bending, deforming, any other suitable actuation mode, or any suitable combinations thereof.

[0031] For example, a stacked haptic arrangement may include a particular array, which may include electromechanical elements (e.g., solenoids). Another array in the stacked haptic arrangement may include electroactive polymer elements. The shape change elements of the arrays of this illustrative stacked haptic arrangement may be controlled by any suitable control system, which may include circuitry for activating electromechanical actuators, electroactive polymers, or both. Stacked arrays may be used to create a contoured screen surface such as, for example, contour maps, shaped buttons, moving contours or shapes, or other surfaces with multi-scale features. In some embodiments, the stacked haptic arrangement may receive tactile stimuli on the screen surface. This stimuli may be received at any suitable time, including times when one or more shape changes elements of one or more arrays are activated.

[0032] For example, a stacked haptic arrangement may include one or more shape change elements of one or more arrays that may be activated to produce one or more screen surface features. The stacked haptic arrangement may receive a stimulus from software (e.g., software command), hardware (e.g., a stylus), a user (e.g., finger contact), any other suitable source, or any suitable combinations thereof. In some embodiments, a tactile interaction between a user and a device may be detected, processed, or both. The stacked haptic arrangement may receive a stimulus such as, for example, a touch by a user on some portion of the surface feature. The haptic arrangement may, in response to the tactile stimulus, execute one or more functions associated with the surface feature. For example, a stacked haptic arrangement may form a raised button corresponding to a particular media selection (e.g., a song in an iTunes® library) on the screen surface. In response to receiving a user selection of the button (e.g., touching the raised button), the stacked haptic arrangement may play the media selection. In a further example, a stacked haptic arrangement may form a contour map of a particular geological location on the screen surface. The stacked haptic arrangement may receive a particular tactile stimulus (e.g., user contact) to a particular region of the screen surface corresponding to a particular geographic region. In response to the tactile stimulus, the stacked haptic arrangement may reconfigure the screen surface to, for example, form a scaled contour map of the particular geographic region. The stacked haptic arrangement may form any suitable surface feature or contour on the screen surface, and may receive any suitable stimuli on the screen surface.

[0033] In some embodiments, an embedded haptic arrangement may be used in which one or more arrays of shape change elements may be embedded or inserted in an elastic screen interface. For example, an array of shape change elements embedded within an elastic screen sheet may be used to provide variable actuation, sensing, or both. In some embodiments, the elastic screen sheet may include one or more sunken reliefs (e.g., blind holes, patterned grooves, etched surfaces) or cavities (e.g., etched cavities, internal cavities), in which shape change elements may be positioned. In some arrangements, an elastic screen sheet may include one or more arrays of shape change elements, which may vary in size and shape. In some arrangements, in which more than one array is used, a particular type of shape change element may be included in each array. In some arrangements, within a particular array there may be different types of shape change elements of any suitable size or shape.

[0034] In some embodiments, an embedded haptic arrangement may be combined with a stacked haptic arrangement. For example, a stacked haptic arrangement may include one or more arrays of shape change elements and an elastic screen sheet that may include embedded shape change elements. The disclosed haptic arrangements may include any suitable combination of shape change elements and elastic sheets to provide tactile interaction.

[0035] Although piezoelectric elements may be referred to herein in examples and discussion for purposes of brevity and clarity, it will be understood that any suitable shape change element or combination of elements may be used in accordance with the present disclosure. Shape change elements may include piezoelectrics, shape memory alloys, shape memory polymers, electroactive polymers, electromechani-