

the surface by the body member. The inventive technique may be further enhanced by power control functionality of the electric field being formed, for example. Utilization of some embodiments of the invention in the implementation of a proximity sensor may require a weaker electric field than what is required by causing the inventive sensory stimulus. Accordingly it may be beneficial to be able to vary the strength of the electric field depending on the currently needed functionality. Such variation may, for instance, involve strengthening the electric field such that a sense of touch or vibration is caused in the body member when it is brought sufficiently close to the electrode or insulator.

[0013] By way of example, the low-frequency component of the control signal being used in the inventive technique may be generated by modulating a high-frequency alternating current. The modulation signal may be continuous or pulsed, for example. The duration of individual pulses may be 0.01, 0.5 or 4 ms and the pause between pulses can be at least 1, 10 or 100 ms.

[0014] The low-frequency component of the control signal may have a frequency of at least 10, 50 or 100 Hz and at most 300, 500 or 1000 Hz. In one specific embodiment the control signal has an exemplary frequency of 120 Hz. In the inventive technique the alternating electric field, which causes the stimulus to be provided, may exhibit an intensity peak of at least 100 V/mm, 200 V/mm or 500 V/mm and at most 10 kV/mm, 30 kV/mm or 100 kV/mm. The field strength may be measured, for example, by means of a grounded electrode with a surface area of eg 1 cm² positioned 0.05 to 5 mm, preferably about 1 mm from the surface of the insulated electrode.

[0015] By way of example, the electric field generated by the electrode can be controlled according to a processing logic being executed in a computer or other electronic data processing apparatus. For example, the control logic can be used to control the variation frequency and/or intensity of the electric field generated by an individual electrode. Furthermore, the control logic can be used to pulse the varying electric field, for example. The control logic can also receive control information via a data network from another apparatus, such as another computer or data processing apparatus.

[0016] An inventive apparatus for sensory stimulation comprises at least one insulated electrode, wherein the apparatus is operable to apply a charge to the electrode such that the charge causes a stimulation of the Pacinian corpuscles. For humans this normally requires a voltage of at least 750 V. The apparatus further comprises means for varying the intensity of the charge-generated, capacitively-coupled electric field by utilizing a signal having a component with a frequency of at least 10 Hz and at most 1000 Hz.

[0017] Some embodiments of the inventive apparatus can be implemented, when so desired, without mechanically moving parts, and such embodiments do not pose similar restrictions on the mechanical characteristics of the materials as do actuators based on mechanical movement of the surface. Accordingly, some embodiments of the invention are applicable to a wide variety of surfaces of different shapes. For instance, the surface shape of the electrode and/or insulator attached to it may be planar, rounded, spherical or concave. Likewise, the insulator material can be selected from a variety of materials having characteristics particularly suitable for the chosen application. As regards mechanical characteristics, the surface material can be hard, soft, stiff, bending,

transparent or flexible. The surface, as well as the material being used as the conductor, can also be transparent.

[0018] An individual electrode of the apparatus and/or the insulator attached to the electrode can have a surface area of 0.1, 1, 10 or 100 cm² or more. The apparatus can comprise multiple insulated electrodes which can be arranged in an array forming an X-Y coordinate system. Each electrode of such a system can, when so desired, be controlled by a control logic according to some embodiments of the invention, for example. The electrodes can be fixedly mounted or movable.

[0019] The apparatus may comprise means for varying the variation frequency of the electric field, for example by modulating the high-voltage alternating current or by moving the electrodes of the MEMS device according to the control signal.

[0020] The insulator to be arranged between the electrode of the apparatus and the body member can have a thickness of at least 0.01 mm, 0.05 mm, 0.1 mm or 0.5 mm and at most 10 mm, 20 mm or 50 mm. The insulator material can be selected according to the intended use and/or voltage to be used, for example.

[0021] In some embodiments the insulator comprises multiple layers. For instance, the inventors have discovered that the bulk of the insulator layer between the electrode and the body part approaching or toughing it may comprise glass but glass is not optimal as the insulator's surface material. In the present context, optimal means an insulator material which best supports the creation of the electrosensory sensation. A glass insulator works much better if covered with a plastic film.

[0022] The inventive apparatus can be implemented such that its power consumption is low. For example, the power required to cause a sensory stimulus may be 1 mW, 5 mW or 10 mW or more. Power consumption can be measured on the basis of the electric power applied to the electrode when a human touches the apparatus surface or when a capacitively grounded 50 pF capacitor is connected to the apparatus surface.

[0023] The apparatus may comprise means for measuring the capacitance of the capacitive coupling being formed. The apparatus may further comprise means for adjusting the characteristics of the electric field, such as intensity or variation frequency, based on the obtained measurement information.

[0024] The inventive apparatus for sensory stimulation can be integrated as a part of some other apparatus or system. For instance, a prior art touch display can be complemented by apparatuses according to some embodiments of the present invention. This way it is possible to provide a touch display which produces a sensation of touch even if the display is not physically touched. Control components of the feedback system can be combined, or they may be arranged to exchange information with one another. An advantageous embodiment of the presently disclosed method and apparatus is a control device based on touch or proximity, such as a touch display that produces a feedback which can be sensed via the sense of touch.

[0025] In some embodiments of the invention, the local charge/field can be controlled by means of capacitive grounding. In various embodiments of the invention, it is possible to into account the fact that the dependence of the electric coupling on the insulated electrode, ie, capacitance, depends on several factors. The capacitance value affects the potential difference between the finger and electrode if the apparatus or subject (such as human) is not grounded, and their ground