APPARATUS TO REPRODUCE TACTILE SENSATIONS

FIELD OF THE INVENTION

The present invention relates to a general method to record and to artificially reproduce tactile sensations experienced while touching and sliding a finger or other tactilely sensate objects over a surface.

BACKGROUND TO THE INVENTION

It is well known that scenes and objects can be imaged in such manner that the resulting images may be recorded or projected for simultaneous or subsequent viewing using a refreshable screen, locally or at distance. Imaging is normally achieved by measuring illumination coming from many directions within a viewing angle. It is also well known that rapid sequences of still images give rise to the impression of continuous motion, therefore, moving scenes can be recorded and projected. Similarly, sound waves can be picked up by measuring the air velocity or the air pressure at one or several locations and transforming these quantities into a signal that can be recorded for differed reproduction or amplified for immediate reproduction by a loudspeaker, locally or at distance. It is thus natural to desire similar functions for tactile sensations.

To date, this has been achieved by measuring the net movement of—and/or the net force applied to—an object which is made to come into contact with a surface and then to reproduce these signals using a device capable of reproducing them. Such device, as it is well known, is termed a haptic device because it combines sensitivity to the user's movements and production of signals in return of these movements. These devices are however limited by the necessity to consider an intervening object between the skin of the user and the surface being touched, both during recording and reproduction.

This limitation was addressed in the past by providing artificial tactile sensors that performed a function similar to that of the natural skin. These devices specifically operated by measuring the distributed deformation of a deformable surface which is brought into contact with the surface of an external object, typically by means of an array of pressure sensitive sites and by recording their individual responses. These responses were reproduced by a tactile display device which reproduced the original deformation using another array of pressure causing and/or deformation causing contactors. The present state of the art is limited by the manufacturing difficulties of both artificial tactile sensors and tactile displays. Hence, there is a need to provide an improved method to record and reproduce tactile sensations.

Returning to the analogy of recording and reproducing visual or audio signals, it is observed that optical waves or sound waves can be picked up with instruments which are disconnected from the persons experiencing the results of this signals. Appropriate recordings can be made without the need of directly measuring the image projected on the retina or by directly measuring the waves taking place in the cochlea. In these two cases, instruments such a cameras and microphones can be constructed to accomplish substantially similar functions as eyes and ears. However, constructing devices which accomplish a similar function as that of the skin is difficult and onerous. Appropriate visual or auditory reproduction can be accomplished using screens that are viewed or speakers which are listen to and are which are disconnected from the persons using them. Tactile sensations differ from these cases because they originate from the contact of the skin with the surface of objects. Hence recordings which depend on the knowledge of the deformation of the skin while it is in contact with objects is conveniently done by measuring skin deformation over time directly. Then, reproduction can be done by causing deformations that are similar to those that were recorded. Thus it is the object of the present invention to provide for methods and devices to accomplish both skin deformation measurements over time and to recreate similar deformations over time.

The applications of the present invention include but are not limited to human machine interfaces, games and entertainment, computer peripherals, training simulators, virtual simulators, remote operations, telepresence, rehabilitation, sensory substitution, sensory amplification, data mining, vehicle driving and piloting, e-commerce, musical instruments, records making, documentation, document browsing, medical diagnosis, scientific instruments, pleasure inducing devices, biometry, among many other possible uses.

The invention in its general form will first be described, and then its implementation in terms of specific embodiments will be detailed with reference to the drawings following hereafter. These embodiments are intended to demonstrate the principle of the invention, and the manner of its implementation. The invention in its broadest and more specific forms will then be further described, and defined, in each of the individual claims which conclude this Specification.

According to one aspect of the invention, advantage is taken of a new tactile stimulation display transducer which is preferably made of a single plate of piezoelectric bimorph. The plate is cut in a comb shape. The bimorph has two outer electrodes, one on each side. These are cut such that each tooth's electrodes are isolated from those of the next tooth. Each tooth can be independently actuated to transfer forces to a finger in contact with their free tip. Many such transducers can be combined to form a larger array of skin engaging tips.

SUMMARY OF THE INVENTION

According to this aspect, the invention may be used in conjunction with a tactile sensing transducer comprising:

a) a contacting surface to receive and deform the surface of human skin;

b) skin surface imaging means position for viewing and providing an output image signal corresponding to said deformed skin surface, and

c) electronic processing means connected to said imaging means for providing an output skin deformation signal corresponding to the deformation of said skin

for delivery of the output skin deformation signal to a storage means for storing said output signal, or to a tactile stimulation display transducer to form on the surface of skin presented to said display transducer deformations that correspond to the deformations represented by said skin deformation signal.

The invention may be applied to the case where the skin is the pad of a finger that presents a fingerprint pattern whereby the image includes an image of the fingerprint pattern and the skin deformation signal corresponds to the deformation of the skin. Or the skin may be overlaid with a visible pattern that presents an image visible to the skin surface imaging means to provide the skin deformation signal. The invention may be applied to the case where the