sensing array, used for example in the jaws of a robotic gripper to determine simultaneously the stress applied to a gripped object, it's location between the jaws, as well as external forces applied to the object as in part assembly operation.

Employed in the field of computer input devices, the disclosed invention may be used in the form of a tactually responsive pad to determine the character of the contact of a user's finger pushing on the pad. For example, the centroid of the force field can be computed to determine the location of the contact, a summation over that field can be computed to determine the intensity of the contact, and a gradient over that field can be computed to determine the tangential component of the finger contact force.

An example of the manner in which the invention may be applied is provided by remote television control units. These units operate on batteries and typically include a array of buttons which a user may learn to use efficiently by tactile exploration. The invention can be used to replace a complete array of buttons by a single tactile stimulator coupled with one single motion specification device. The motion specification device is used by the user to displace a cursor in a visible or invisible space while the user is informed by the tactile display of movements of that cursor and of its location in the space. The information may be conveyed by certain tactile patterns associated with movement and other tactile pattern associated with location. The fact that the actual displacements occurring within the tactile stimulator may be minute dimension makes for very low power requirements.

Employed as part of an improved computer or appliance data input device, such as a hand-held remote control unit or portable telephone, the invention can provide controlled, tactile stimulation to facilitate the positioning of a cursor in a space, even in the absence of visual or audio feedback. The invention, because of its potential miniature size and modest power consumption is particularly useful for the enhancement of computer games, portable computing devices, cameras, inter alia. In the medical field, the invention can be used in a remote palpation device enabling a doctor to use touch to diagnose a patient at distance. It can be used to improve minimally invasive surgical instruments (laparoscopic instruments, canulae, endoscopes, catheters, etc.), to create or recreate tactile sensations not provided by their use. The invention can also serve in interpreting data which is normally accessible visually, as in the inspection and manipulation of complex medical images, inspecting and manipulating computer aided design models.

Another example is provided by an improvement for a minimally invasive surgical instrument. Many of these instruments incorporate a gun-like handle which permits simultaneous manipulation of the instrument and operation of a closing action with the index finger. The trigger-like lever on which the index finger acts could be equipped with an array display, in a line or over a surface, to inform the surgeon of the contact being made by the acting end of the instrument on the organ to be operated on. This contact can be sensed by means of tactile sensing transducers located at the acting end of the instrument. Other parts of the handle could be equipped with tactile displays to convey tactile signals to other fingers or parts of the hand.

As the device is a reversible transducer, appropriate electronics, for example based on rapid time multiplexing, can be employed so that bi-directional tactile information is relayed to and from a user and a computer. In such configuration, a most common operation is to move a cursor on a screen. This can be accomplished by causing the position or velocity of the cursor to depend on finger location, pressure applied and/or tangential force components, while at the same time, the computer can relay tactually to the user such events as the motion of the cursor in traversing or following boundaries, traversing regions, or encountering other digital objects stored in the computer, whether these are visible or not.

As an additional field of application, for example in medicine, the disclosed invention may be applied to enable a doctor to palpate a patient at distance since it can act as a tactile sensor and a display. In a particularly simple scenario, the patient simply follows the directives of the doctor over a telephone to run the device at the appropriate parts of her or his anatomy, while the tactile signals are transmitted over the telephone line to be experienced by the doctor.

Still in the field of medicine, the disclosed invention may be applied to enhance tactile sensations derived by palpation. In this application faint tactile sensations can be either employed or processed by enhancing filters, such as contrast enhancing filters, to make the doctor sensitive to faint tactually detectable symptoms such as tumors or cysts too small or too deep to be detected without assistance. Similarly, sensations derived from the flow of fluids in vessels and cavities can be amplified and processed to provide an enhanced presentation to a doctor.

CONCLUSION

The foregoing has constituted a description of specific embodiments showing how the invention may be applied and put into use. These embodiments are only exemplary. The invention in its broadest, and more specific aspects, is further described and defined in the claims which now follow.

These claims, and the language used therein, are to be understood in terms of the variants of the invention which have been described. They are not to be restricted to such variants, but are to be read as covering the full scope of the invention as is implicit within the invention and the disclosure that has been provided herein.

What is claimed is:

1. A tactile transducer comprising at least one pair of adjacent contactors, each contactor having a pair of skin engaging contacting tips each separated laterally by a gap from the adjacent contacting tip to permit both of said tips to be engaged with the skin of a single human finger without slippage, each of said contactors of said contactor pair being coupled to transducer means to effect or sense relative lateral displacement of said contactors and associated variation of the lateral gap distance between each of said contacting tips.

2. A transducer comprising a linear array of transducers wherein multiple transducers as in claim **1** define a sequence of gap distances between consecutive contactor tips, said contactor pairs being coupled to a multiple number of transducer means to effect or sense the variations in the inter-tip gap distances in said sequence of gap distances.

3. A transducer as in claim **2** wherein adjacent contactors are coupled to individual, shared transducer means.

4. A transducer having the form of a plurality of linear transducer arrays as in claim **2** defining an area array comprising gap areas, each gap area being surrounded by contactor tips, said contactors being coupled to said transducer means to effect or sense variations of gap areas.

5. A transducer comprising three interspersed sets of linear transducer arrays as in claim **2** defining an array of gap areas surrounded by triplets of contactor tips carried by