Even more advantageous is an embodiment whereby the pins simultaneously fulfill the dual functions of actuator and receptor. In this way, the delimitation or labeling of a virtual key can be generated in an effective and space-saving manner (pins extended), whereby pressing (in) the pins enables detection of the contact on the one hand and the yielding or locking on the other. In addition, as a result of having the receptor and actuator functions in the same location, a more precise association between the detected contact point and the displayed virtual information is possible.

Piezoelectric elements are particularly suitable for drive purposes and for the detection of contacts since they are able to directly convert voltages (signals), generated by microprocessors for example, into pressure or movement and, in the opposite direction, pressure into voltages (signals) which can be immediately processed further by microprocessors.

Electromagnetic elements are known, just like the piezoelectric elements, for the implementation of text output for blind persons (Braille), and are, therefore, easily obtained.

One of the advantages of providing a sensor mat as the receptor is that the sensor mat can be procured cheaply as a mass-production item.

If the second layer is designed as a transparent sensor mat which, in addition, comes to be located immediately above the first layer, the mechanically flexible display medium is protected since it is no longer directly exposed to contact from a user. The life expectancy of the display medium, with its associated increased (procurement) costs when compared with the sensor mat, is increased.

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** shows a side view of the layer structure of a touch-sensitive display with tactile feedback in accordance with the teachings of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a side view of a display structured in three layers S_1, S_2 and S_3, whereby a transparent flexible sensor mat comes to be located in the first layer S_1.

This sensor mat is designed such that it detects contacts and generates at least one first signal which at least determines the location (Cartesian coordinates) of the contact.

Immediately above this first layer S_1 is located the second layer S_2 which is formed by a flexible plastic membrane and is designed using the technology known as electronic paper.

Electronic paper is the name used by experts for a technology which combines the advantages of flat screens and printer ink on paper, in which tiny color capsules containing at least two colors—(black and white, for example) are used and the one or the other of their sides is made to point upwards on a paper surface, depending on an electrical charge. So-called plastic transistors are intended for use in controlling the electrical field required for this purpose.

Alternative technologies known to experts are "organic electroluminescence membranes" or "microencapsulated electrophoretic displays" which similarly permit an embodiment in the form of flexible, extremely thin display media.

The use of this technology on a membrane which is designed to be mechanically flexible and elastic is intended for the arrangement according to the present invention in order that it can be mechanically manipulated in points so as to produce bulges on the surface of the membrane which are automatically returned to the normal state on termination of the mechanical manipulation.

Beneath the second layer S_2 is located the third layer S_3 which is formed by an area-covering matrix consisting of "knobs" $N_1 \ldots N_m$, designed as nylon or metal pins, which are arranged perpendicularly to the membrane surface and located so as to allow movement by piezoelectric operation.

In this situation, the three layers S_1, S_2 and S_3 are arranged in such a way that the piezoelectrically operated knobs $N_1 \ldots N_m$ are able to mechanically manipulate the first two layers S_1 and S_2 in points such that, in an initial state, keyboard delimitations and/or labels of a virtual keypad are generated on the surface of the second layer by knobs $N_1 \ldots N_m$ located beside one another, and can be felt by touch there. In this situation, the labeling can be generated in Braille in order for sighted users to have the opportunity to see a virtual keyboard and its functionality displayed on the display medium, where they are able to feel the keyboard delimitation, while at the same time visually impaired users have the capability to feel the keyboard functionality via the Braille generated by the knobs $N_1 \ldots N_m$.

At least the second layer S_2 and the third layer S_3 are connected to a control unit μP which is designed in such a way that it is implemented in an initial state, in other words a state in which no input has (yet) been made by contact; for example, a virtual keypad and/or a virtual menu bar resulting from the generation of at least one second signal, for controlling the knob matrix $N_1 \ldots N_m$. Furthermore, the control unit μP is designed in such a way that it generates at least one new second signal as a result of a contact on the sensor mat, whereby the contact must have taken place in a permitted area, in other words an area in which a virtual control element is displayed.

In addition, the control unit μP is also connected to another unit controlling the display, or forms a unit together with it, such that control signals for generating changes in the virtual control elements as a result of operator actions are also generated.

As an alternative to the sensor mat, a light grid also may be located in the second layer S_2.

Light grids generally consist of two transmitter strips arranged perpendicular to one another, each of which emits a number of light beams, and also receiver strips located opposite each transmitter strip, which detect the light beams. The light beams from the transmitter strips arranged perpendicular to one another cross in this situation and create a light grid. In the event of penetration of the light grid, the absence of at least one light beam on the receiver strips arranged perpendicular to one another is detected, in each case, in such a way that pairs of coordinates can be formed which serve to determine precisely the location of penetration. The coordinates ascertained then can be sent as a first signal to the control unit μP.

In this situation, the light grid is arranged in such a way above the first layer S_1 that the bulges in points on the display surface produced by the knob matrix $N_1 \ldots N_m$ do not interrupt any light beams.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the present invention as set forth in the hereafter appended claims.