

**[0013]** In accordance with a still further aspect thereof the exemplary embodiments of this invention provide an apparatus that includes a display to visualize information; a sensor arrangement that is responsive to the user executing a gesture with a user-manipulated physical object in the vicinity of a surface of the apparatus, the sensor arrangement having an output to provide data descriptive of the presence of the user-manipulated object when executing the gesture; and a unit having an input coupled to the output of the sensor arrangement and operating to interpret the data to identify the executed gesture, and to interpret the identified gesture as pertaining in some manner to visualized information.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]** The foregoing and other aspects of the teachings of this invention are made more evident in the following Detailed Description, when read in conjunction with the attached Drawing Figures, wherein:

**[0015]** FIG. 1A shows a device that incorporates a plurality of ultrasonic transducers (USTs) as user input devices;

**[0016]** FIG. 1B is a simplified block diagram of the device of FIG. 1A;

**[0017]** FIG. 2A shows a further exemplary embodiment of this invention where the USTs are incorporated into a device that embodies a mini-projector;

**[0018]** FIG. 2B is a simplified block diagram of the mini-projector device of FIG. 2A;

**[0019]** FIGS. 3A, 3B, collectively referred to as FIG. 3, FIGS. 4A-4D, collectively referred to as FIG. 4, FIGS. 5A, 5B, collectively referred to as FIG. 5, and FIG. 6 depict exemplary finger-based gestures that may be used to select various commands for execution in accordance with exemplary embodiments of this invention;

**[0020]** FIG. 7 shows the principles of the ultrasonic observation of finger distance;

**[0021]** FIGS. 8A-8D, collectively referred to as FIG. 8, show exemplary finger-based gestures that may be used to select various commands for execution in accordance with further exemplary embodiments of this invention;

**[0022]** FIG. 9 is a logic flow diagram depicting an exemplary finger detection process executed by the device shown in FIG. 10B, and that is suitable for capturing the finger-based gestures shown in FIG. 8 and 10A;

**[0023]** FIG. 10A shows an example of the sensing of multiple points of simultaneous touch detected by device of FIG. 10B;

**[0024]** FIG. 10B is a simplified block diagram of a device having a display capable of generating an image of one or more fingertips; and

**[0025]** FIG. 11 is a logic flow diagram that depicts a method in accordance with the exemplary embodiments of this invention.

#### DETAILED DESCRIPTION

**[0026]** Reference is made to FIGS. 1A and 1B, collectively referred to as FIG. 1, that show a device 10, such as a display dominated device having at least one visual display 12 capable of visualizing information, that incorporates a plurality of ultrasonic transducers (USTs) 14A, 14B and 14C (collectively referred to as USTs 14) as user input devices, while FIG. 1B is a simplified block diagram of the device of FIG. 1A. Note in FIG. 1B that the device 10 is assumed to include a data processor (DP) coupled to a memory (MEM)

18 that stores a program 18A that is suitable for use in implementing this exemplary embodiment of the invention. The device 10 may be or may include, as non-limiting examples, a PDA, a wireless communications device, a gaming device, an Internet appliance, a remote control device (such as one suitable for use with a TV set or with public interactive billboards), a music storage and playback device, projectors, a video storage and playback device, a multimedia device, a computer such as a desktop or a laptop computer, or in general any type of electronic device that includes a user interface for presenting information to a user (such as a display screen or display surface) and for receiving commands and/or input information from the user.

**[0027]** In the exemplary embodiment of FIG. 1 the three USTs 14 are arrayed on a surface 10A of the device 10 and enable the use of triangulation to detect the locations in three dimensional space of the user's fingers 20A, 20B (referred to also as finger a, finger b). The device 10 exploits the ultrasonic field established in the vicinity of the surface of the device 10 by the USTs 14 to provide a perception technology that enables the device 10 to perceive and react to finger position, and possibly movement, in real time.

**[0028]** In general, a given UST 14 uses high frequency sound energy to conduct examinations and make measurements. To illustrate the general principle, a typical pulse/echo set-up configuration is shown in FIG. 7. A typical UST system includes several functional units, such as a pulser/receiver 15A and the ultrasonic transducer 15B. The pulser/receiver 15A is an electronic device that can produce mechanical movement and/or an electrical pulse, respectively. Driven by the pulser portion the transducer 15B generates high frequency ultrasonic energy. The sound energy is introduced and propagates through the air in the form of waves. When there is a discontinuity (such as a finger movement) in the wave path, part of the energy is reflected back from the discontinuity. The reflected wave signal is transformed into an electrical signal by the transducer 15B and is processed to provide distance from the transducer 15B to the discontinuity (based on a round trip time-of-flight measurement, as is well known). The reflected signal strength may be displayed versus the time from signal generation to when an echo was received. Both phase and intensity change of the reflected signal may also be exploited to measure finger-transducer distances.

**[0029]** When the user's finger(s) or more generally hand (s) enter the scanned field in front of the device 10 the UST 14 system measures the distances to the individual fingers. The three UST 14 sensors (which in some exemplary embodiments may have a fixed relative position on the CT) are capable of providing individual finger-sensor distance measurements (a1, a2, a3, b1, b2, b3). Note that the device 10 maybe implemented with less than three UST 14 sensors, however by providing the third UST sensor it is possible to use finger movement for execution and basic operational commands (such as, but not limited to, Select; Copy; Paste; Move; Delete) by observation of a change in direction of the finger movement in three dimensional (3D) space. The device 10 may also be implemented using more than three UST 14 sensors in form of, for example, a UST sensor array when/if higher spatial detection resolution is needed.

**[0030]** In general, it is typically desirable to limit the range of the detection mechanism so that it encompasses a fairly limited volume of space (which may be considered to define a 'working envelope') in the vicinity of the sensing surface