

to be in electronic communication with the device generating the visual display. In particular, the apparatus is well suited to use as an add-on device, perhaps sold as an after-market product. It is a distinct advantage, both in terms of compatibility and manufacturing, that the apparatus can interface with all types of displays, regardless of the source of the displayed image, the type computer system, operating system, input/output protocol, and other system specific variables.

[0053] Perhaps the only customization that the apparatus will need is the length and width dimensions of the apparatus in conjunction with an attachment member for aligning and securing the imaging means to the visual display. For intermittent use, it may be perfectly acceptable to have an over-sized apparatus that can be laid over various sizes of visual displays. However, it is preferred that the apparatus be secured to the visual display in a manner that does not deter from the portability or utility of the visual display, such as a PDA. Such attachment members may include clips, straps, hook and loop fasteners, adhesives, friction fits, screws and other known devices that facilitate securing the tactile device onto the visual display.

[0054] In an exemplary embodiment, the display means could be formed as a two dimensional grid (X-Y dimensions) on which the individual would place their hand, for example. The surface of the grid would be formed by the ends of rods which would be moved up or down (Z dimension) under control of the processing means.

[0055] In more detail, in one embodiment, there is provided a plurality of individually controlled miniature motors oriented in a grid, each of which responds to a portion of the processed electrical signals. A plurality of miniature rack and pinion gear assemblies are also provided, each of which is operatively connected to one of the miniature motors so that rotational motion of a pinion connected to a shaft of a miniature motor is converted into linear motion of a rack. A plurality of rods form the surface of the tactile display, each of which is connected to one of the racks, so that when the racks move linearly, the rods move linearly as well. The relative linear motion of the individual rods forms a "tactile image." The motors could be formed by micro or nano-motors to produce very high resolution tactile images.

[0056] The device could also have applications for users who are not visually impaired but find themselves in conditions where visibility is limited. The invention thus covers a wide range of applications where transforming from the visual to the tactile has use.

[0057] In the preferred embodiment, the touch screen display is an IBM Model 8516 touch screen. While this touch screen display detects touch by using strain gauge technology, other touch screens, such as those employing optical or electrostatic technology, could also be used and still fall within the spirit and scope of the invention. Processor, memory, storage, and speaker preferably are standard components of a personal computer system, such as an IBM PS/2, although they could also be standalone components.

[0058] It will be understood from the foregoing description that various modifications and changes may be made in the preferred embodiment of the present invention without departing from its true spirit. It is intended that this description is for purposes of illustration only and should not be

construed in a limiting sense. The scope of this invention should be limited only by the language of the following claims.

What is claimed is:

1. An apparatus for converting a visual image into a tactile image, comprising:

imaging means for converting incident light from a visual image into electrical signals that are proportional to the gray scale intensity of the incident light;

a tactile display device having a two-dimensional array of variable height pixels, wherein the height of each pixel in the tactile display is dynamically variable in proportion to the electrical signals from the imaging means.

2. The apparatus of claim 1, further comprising means for recognizing words in the visual image and displaying the Braille translation of the words.

3. The apparatus of claim 1, wherein the height of each pixel is inversely proportional to the gray scale intensity.

4. The apparatus of claim 3, wherein maximum height of a pixel is occurs when a corresponding pixel in the visual image is black.

5. The apparatus of claim 1, wherein the ratio of pixels in the tactile display device to pixels in the visual image is one or less.

6. The apparatus of claim 1, wherein the pixels of the tactile display device are pressure-sensitive for allowing touch-screen input.

7. The apparatus of claim 1, wherein the pixels of the tactile display means comprises:

a plurality of individually controlled miniature motors oriented in a grid, wherein each motor is coupled to one of the electrical signals;

a plurality of miniature rack and pinion gear assemblies, each of which is operatively connected to one of the miniature motors so that rotational motion of a pinion connected to a shaft of a miniature motor is converted into linear motion of a rack; and

a plurality of rods, wherein each rod is connected to one of the racks so that the rods move linearly with the racks.

8. The apparatus of claim 7, wherein the miniature motors move linearly in a Z dimension that is perpendicular to X and Y dimensions.

9. The apparatus of claim 1, further comprising:

attachment means for attaching the imaging means in alignment with a display screen.

10. The apparatus of claim 9, wherein the display screen is selected from a cathode ray tube, liquid crystal display, array of light emitting diodes, laser images, projections, and combinations thereof.

11. The apparatus of claim 9, wherein the display screen is a computer monitor.

12. The apparatus of claim 11, wherein the computer monitor forms part of a portable computer.

13. The apparatus of claim 12, wherein the portable computer is a handheld computer.

14. The apparatus of claim 13, wherein the handheld computer is a personal digital assistant.

15. The apparatus of claim 7, the pixels further comprising a strain gauge for sensing applied pressure.