sizes, denoted by d, focal length, denoted by f, PD lens aperture, denoted by a, and distance between LED and PD lens surfaces, denoted by s. The PD lens aperture is approximately equal to the distance between neighboring PDs and to the distance between neighboring LEDs. Ideally, the LED projects over the PD lens aperture, which corresponds to the relationship d/a=f/s. Sample design parameters for a horizontal lens and for a vertical lens are provided in TABLE II. It is noted that the horizontal and vertical foci are significantly different. Ideally, the horizontal and vertical foci are directed away from the LED center, and towards the target PD, so that all light emanating from the LED lens arrives at the PD.

TABLE II

Design parameters for touch screen optics

parameter	symbol	horizontal lens	vertical lens
LED die size	d	0.3 mm	0.3 mm
PD die size	d	0.3 mm	0.3 mm
aperture	a	5 mm	1 mm
distance between LED and PD edges	s	30 mm	30 mm
focal length	f	1.8 mm	9 mm

3. Applications of Touch Screen **100**

[0174] Aspects of the present invention relate to applications for the touch screen described hereinabove. The ensuing discussion includes (i) user input based on finger motion, (ii) mobile phone handset, (ii) touch-screen as mouse-type input device for a computer, and (iii) touch-based storefront window.

[0175] i. User Input Based on Finger Motion

[0176] As indicated in FIGS. **6**A and **6**B, the output of PD receivers **140** is processed by controller **150**, to determine, from the measured light intensities, if one or more objects are positioned over touch screen **100**. The optical assembly of FIG. **25** enables measurements of light intensities at several heights above touch screen **100**; i.e., three-dimensional measurements at various heights over the surface of the touch screen **100**. In this regard, reference is now made to FIG. **27**, which shows three-dimensional measurements of light intensities over the surface of touch screen **100**, in accordance with an embodiment of the present invention. The top chart corresponds to measured light intensities at seven locations, when no finger is positioned on touch screen **100**. The bottom left chart corresponds to measured light intensities at the seven locations, when a finger is positioned over touch screen **100**. The bottom right chart also corresponds to measured light intensities when the finger is positioned over touch screen **100**. The bottom right chart corresponds to measurements taken slight after the measurements used for the bottom left chart were taken. The difference in charts indicates that the finger is moving downward, closer to the touch screen. As a result, light intensity is being blocked at lower z-values, i.e., heights.

[0177] It will thus be appreciated by those skilled in the art that the measurements of light intensities at various heights above touch screen **100** enables determination of both position and motion of an object on touch screen **100**. Referring to FIG. **27**, the distance between the finger positions from the bottom left chart and the bottom right chart, denoted by DIST, may be determined from the light intensity readings. Knowing the time difference between the measurements for the two charts enables determination of a finger velocity vector. If the velocity vector is substantially downward, then the magnitude of the velocity vector is an indication of how hard the finger is pressing on touch screen **100**. If the velocity vector is substantially rightward, then the finger is making a rightward gesture.

[0178] By determining motion information, touch screen **100** is able to distinguish between a variety of user inputs, including inter alia tap, press, and directional finger gesture, and to process them accordingly.

[0179] Reference is now made to FIG. **28**, which is an illustration of a touch screen with three-dimensional sensing functionality, in accordance with an embodiment of the present invention. Touch screen **100** functions as a three-dimensional sensor. Increases or decreases in light intensities measured by PD receivers are used to sense the presence of a finger or other object above the screen surface. As shown in FIG. **28**, a lens or array of lenses, distributes light emitted by an LED in a plurality of directions. Two groups of light beams are identified in FIG. **28**; namely, light beams denoted by X, which are directed along a plane substantially parallel to the screen surface, and light beams denoted by Y, which are directed diagonally across and upward to the screen surface.

[0180] When no object is near the screen surface, the PD receiver measures all of light beams X. When a finger or other object is positioned above the screen surface, it reflects a portion of light beams Y to the PD receivers, via a second lens or array of lenses. The PD receiver accordingly senses an increased light intensity corresponding to the sum of light beams X and Y. It will be appreciated by those skilled in the art that use of a reflective object, such as a silver pen, to point at the touch screen, enhances reflection of light beams Y.

[0181] Reference is now made to FIG. **29**, which is a graph illustrating different light intensities measured by a PD receiver corresponding to proximity of an object to a touch screen surface, in accordance with an embodiment of the present invention. The middle portion of the graph corresponds to light beams X, indicating that no object is obstructing light beams X, and none of light beams Y are reflected to the PD receiver. This portion of the graph is the default PD receiver intensity when no object is near the screen surface.

[0182] The signals shown in FIG. **29** rise and decline. When the PD current is activated, as shown at the bottom of FIG. **29**, the signals rise. When the PD current is terminated, the signals decline.

[0183] The highest portion of the graph corresponds to a finger or object reflecting a large portion of light beams Y to the PD receiver. As the finger or object is moved closer to the screen surface, the magnitude of measured light intensity changes, based on the amount of light beams Y directed to the PD receiver by the finger or object. The effect of increasing intensity of reflected light beams Y is similar to the effect of increasing intensity when a finger is brought close to a light bulb. Namely, as the finger approaches the light bulb, the intensity of light on the fingertip increases; i.e., more light is reflected by the fingertip.

[0184] When a finger or object is brought very close to the screen surface such that it blocks a portion of light beams X, the measured light intensity at the PD receiver drops to below its default value, and approaches zero as the object touches the screen and substantially completely blocks light beams X. Referring back to FIGS. **25**A, **26**A and **27** it is seen that the light intensity detected by a PD receiver is a function of a