finger's proximity to the screen surface, when the finger blocks a portion of light beams X.

[0185] ii. Mobile Phone Handsets

[0186] The touch screens of the present invention are particularly suitable for small mobile phones. Phones that have these touch screens do not required keypads, since the screens themselves may serve as touch-based keypads. The touch screens serve as input devices, for receiving touch-based user inputs, and as output devices, for displaying data generated by a phone modem.

[0187] US Publication No. 2008/007533 A1 entitled INFORMATION MANAGEMENT SYSTEM WITH AUTHENTICITY CHECK by Ericson et al. describes a system for identifying the location of a pen above a sheet of paper, whereby the pen includes a camera that captures images of a varying pattern on the sheet of paper. A computer unit analyzes a captured image and determines therefrom the location of the pen. Further, by analyzing a sequence of images captured by the camera as the pen is moved over the pattern, the computer unit identifies strokes made by the pen.

[0188] In one embodiment, the present invention provides a similar system for a touch screen. Instead of providing a pattern on a sheet of paper, a light pattern is projected over the touch screen. When a finger or other object is positioned above the touch screen, the finger or other object reflects a portion of the projected light pattern. Only the reflected portion of the projected pattern is substantially visible.

[0189] A camera communicatively coupled with the touch screen captures an image of space above the touch screen. The captured image shows the pattern reflected by the finger or other object. The captured image is transmitted to a controller that determines the location of the finger or other object over the touch screen by analyzing the captured image. Further, by providing a sequence of images captured as the finger or other object moves over the touch screen, the controller identifies a stroke or gesture made by the finger or other object.

[0190] Reference is now made to FIG. **30**A, which is a simplified illustration of a handset **600** with a touch screen **100**, in accordance with an embodiment of the present invention. Handset **600** includes a projector **610**, a barrier **613** that blocks portions of light projected by projector **610**, and a lens **617** that spreads the light over a specific angle, denoted by θ. Barrier **613** may be implemented as an etched metal plate that only allows light to penetrate through the etched openings. Barrier **613** may alternatively be implemented as a material that has transparent portions and non-transparent portions. The transparent portions may be in the form of digital, letters, dots, or such other shape. Barrier **613** may alternatively be a grating, with openings through which light projected by projector **610** passes. When projector **610** projects light at barrier **613**, a light pattern **620** is generated above touch screen **100**.

[0191] Handset **600** further includes a camera **630** which captures images of projected pattern **620**. When an object, such as a user's finger **640**, is within range of projected pattern **620**, portions of pattern **620** are reflected by finger **640**. In turn, the images captured by camera **630** show the reflected portions of pattern **620**, from which distance and position information of finger **640** is derived. Since finger **640**, or such other reflecting object such as a stylus or pen, is not a flat surface, the reflected portion of pattern **620** is warped or otherwise distorted when viewed from an angle other than the angle of projection. By aligning camera **630** with projector **610**, the images of finger **640** are captured at substantially the angle of projection, as a result of which the reflected portion of pattern **620** is not significantly distorted.

[0192] Reference is now made to FIG. **30**B, which is a simplified illustration of a pattern of dots projected into the space above screen **100**, in accordance with an embodiment of the present invention. The pattern of dots shown in FIG. **30**B may be generated by a barrier **613** that is implemented as a metal plate having holes etched therein. A portion of the dot pattern, shown as black dots, is reflected by finger **640**; and a portion of the dot pattern, shown as white dots, is not reflected by finger **640**. By analyzing the pattern of dots reflected by finger **640**, the touch screen controller determines the three-dimensional position of finger **640** relative to touch screen **100**.

[0193] Finger **640** in FIG. **30**B reflects a pattern of seven dots. As finger **640** moves to the right or to the left, different dot patterns appear on finger **640**, based on the dots shown in FIG. **30**B to the right and to the left of finger **640**, respectively. Similarly, when finger **640** moves up or down, different dot patterns appear on finger **640**, based on the absence of dots above finger **640** and the dots shown below finger **640**. As such, the dot pattern on finger **640** determines the height of finger **640** above touch screen **100**, along the z-axis, and the position of finger **640** along the width of touch screen **100**, along the x-axis.

[0194] The position of finger **640** along the length of touch screen **100**, along the y-axis, is determined from the scale of the image reflected by finger **640** or, equivalently, by the sizes of the elements of the projected pattern. Since projector **610** projects the pattern across a wide angle, as shown in FIG. **30**A, the closer finger **640** is to projector **610**, the denser is the reflected pattern. As such, the density of the reflected image determines the distance between finger **640** and projector **610**. In turn, this distance determines the position of finger **640** along the length of touch screen **100**, along the y-axis.

[0195] Reference is now made to FIG. **30**C, which is a simplified illustration showing how the density of pattern **620** projected by projector **610** in the space above touch screen **100**, and reflected by finger **640**, is dependent upon the distance of finger **640** from projector **610**, in accordance with an embodiment of the present invention. It is noted that the reflected pattern **620**, signified in FIG. **30**C by a "1" digit, scales larger the further it is from projector **610**. The protected pattern **620** is spread over an angle θ by lens **617**. The angle θ and the sizes of the captured pattern elements are used to determine the distance of the reflected pattern **620** from projector **610**.

[0196] In an alternative embodiment of the present invention, a second projector and barrier is situated along a second edge of touch screen **100**. The two sets of relative (x, z) position coordinates of finger **640**, determined by the two cameras, suffice to determine the y coordinate of finger **640**.

[0197] In accordance with an embodiment of the present invention, the distance and position information of finger **640** is used to further derive the location **650** on touch screen **100** where finger **640** is aimed. Touch screen **100** highlights location **650** so that a user can see the location to which finger **640** is aimed, and to adjust the position of finger **640** if necessary.

[0198] Reference is now made to FIG. **30**D, which is a simplified illustration of a pattern of digits projected into the space above screen **100**, in accordance with an embodiment of the present invention. The pattern of digits shown in FIG. **30**D may be generated by a barrier **613** that is implemented as a metal plate having the digits "1", "2" and "3" etched thereon