Amended claims with markings to show changes made

Please cancel claims **30**, **42**, **47**, **69** and **81** without prejudice.

1. (amended) A touch screen comprising:

a housing;

a display mounted in said housing;

a first plurality of ~~collimating~~ lenses mounted in said housing along ~~two opposite edges~~ a common edge of said display ~~and arranged along the two edges so as to be shift-aligned relative to one another~~;

a plurality of light pulse emitters mounted in said housing that ~~are spaced apart from and transmit~~ emit wide light pulses through said ~~collimating~~ first plurality of lenses ~~of one of the two edges~~ over said display;

a second plurality of lenses mounted in said housing and arranged so as to be shift-aligned relative to said first plurality of lenses, such that wide light pulses transmitted through *N* neighboring ones of said first plurality of lenses overlap and enter a common shift-aligned one of the second plurality of lenses, when *N* is a number at least two;

a plurality of light pulse receivers mounted in said housing that ~~are spaced apart from and~~ receive the wide light pulses transmitted through said ~~collimating~~ second plurality of lenses, and output received light intensities in accordance with the portions of the wide light pulses that they receive ~~of the opposite of the two edges~~; and

a calculating unit, mounted in said housing and connected to said receivers, that ~~determines~~ calculates a coordinate, along a first dimension, of a location of a pointer [[on]] touching said display that partially blocks [[the]] overlapping wide light pulses transmitted ~~by said emitters, based on outputs of said receivers~~ through at least two neighboring ones of said first plurality of lenses from entering the common shift-aligned one of the second plurality of lenses, by assigning coordinates corresponding to each of the overlapping wide light pulses, and by calculating a

weighted average of the assigned coordinates, wherein each coordinate's weight in the average is non-zero and corresponds to a degree of blockage of its corresponding light pulse.

2. The touch screen of claim **1**, wherein said emitters and receivers are arranged in opposing rows, and wherein said emitters are shift-aligned relative to said receivers.

3. (amended) The touch screen of claim **1**, wherein said ~~collimating~~ first and second pluralities of lenses comprise a plastic frame surrounding said display.

4. (amended) The touch screen of claim **1** further comprising a light guide for guiding light pulses, the light guide comprising micro-lenses for multi-directional collimation of light pulses, and wherein said ~~collimating~~ first and second pluralities of lenses comprise a portion of said light guide.

5. (amended) The touch screen of claim **4** wherein said micro-lenses are comprised within said ~~collimating~~ first and second pluralities of lenses.

6. (amended) The touch screen of claim **4** wherein said micro-lenses are not comprised within said ~~collimating~~ first and second pluralities of lenses.

7. (amended) The touch screen of claim **1** further comprising:

a first light guide for guiding light pulses, comprising:

a first substantially parabolic reflective surface for reflecting the wide light pulses ~~transmitted~~ emitted by said emitters; and

a first substantially elliptical refractive surface, positioned substantially above said first substantially parabolic reflective surface, for refracting the reflected light pulses over said display to a second light guide; and

a second light guide for guiding light pulses, comprising:

a second substantially elliptical refractive surface for further refracting the refracted light pulses; and

a second substantially parabolic reflective surface, positioned substantially below said second substantially elliptical refractive surface, for reflecting the further refracted light pulses onto said receivers,

wherein said emitters and said receivers are positioned beneath said display, and wherein said ~~collimating~~ first and second pluralities of lenses comprise ~~a portion~~ respective portions of said first and said second light guides.

8. (amended) The touch screen of claim **7**, wherein said first substantially parabolic reflective surface and said first substantially elliptical surface have the same focal location, and wherein said second substantially parabolic reflective surface and said second substantially elliptical surface have the same focal ~~location~~ location.

9. (amended) The touch screen of claim **1**, wherein said ~~collimating~~ first and second pluralities of lenses are rigidly mounted in said housing, wherein said display is flexibly mounted in said housing, and wherein said calculating unit further determines that the pointer is performing a hard touch, based on increases in the outputs of said receivers.

10. (amended) The touch screen of claim **1** further comprising a plurality of inter-fitting infra-red transmissible plastic emitter units mounted in said housing, each said unit comprising:

at least one of said ~~collimating~~ first plurality of lenses; and

at least one of said emitters, which ~~transmit~~ emit wide light pulses through said at least one of said ~~collimating~~ first plurality of lenses.

11. (amended) The touch screen of claim **10**, wherein said at least one ~~collimating~~ lens in each of said units ~~receives~~ transmits wide light pulses received from said unit's at least one emitter and from a neighboring unit's at least one emitter.

12. The touch screen of claim **10**, wherein said units are pre-manufactured, prior to being assembled in the touch screen.

13. The touch screen of claim **10**, wherein each of said units further comprises micro-lenses for multi-directional collimation of the light pulses.

14. (amended) The touch screen of claim **1**, further comprising a plurality of inter-fitting infra-red transmissible plastic receiver units mounted in said housing, each said unit comprising:

at least one of said ~~collimating~~ second plurality of lenses; and

at least one of said receivers, which receive wide light pulses transmitted through said at least one of said ~~collimating~~ second plurality of lenses.

15. (amended) The touch screen of claim **14**, wherein said at least one receiver in each of said units receives wide light pulses transmitted through said unit's at least one ~~collimating~~ lens, and also receives light pulses transmitted through a neighboring unit's at least one ~~collimating~~ lens.

16. The touch screen of claim **14**, wherein said units are pre-manufactured, prior to being assembled in the touch screen.

17. The touch screen of claim **14**, wherein each of said units further comprises micro-lenses for multi-directional collimation of the light pulses.

18. (withdrawn) A touch screen comprising:

a housing;

a display mounted in said housing;

two light guides mounted in said housing and arranged along two opposite edges of said display, each light guide comprising micro-lenses for refracting incoming light in multiple directions;

a plurality of light pulse emitters mounted in said housing that transmit light pulses through a first one of said light guides over said display;

a plurality of light pulse receivers mounted in said housing that receive light pulses through the other one of said light guides; and

a calculating unit, mounted in said housing and connected to said receivers, to determine a location of a pointer on said display that partially blocks the light pulses refracted by said micro-lenses in the first light guide transmitted by said emitters, based on outputs of said receivers corresponding to light pulses refracted by said micro-lenses in said second light guide.

19. (withdrawn) The touch screen of claim **18** further comprising two additional light guides mounted in said housing and arranged along the remaining two edges of said display, the four light guides comprising a single unit surrounding said display.

20. (withdrawn) A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of light pulse emitters mounted in said housing below said display;

a plurality of light pulse receivers mounted in said housing below said display;

a first light guide, mounted in said housing along a first edge of said display, comprising:

a first substantially parabolic reflective surface for reflecting light pulses transmitted by said emitters; and

a first substantially elliptical refractive surface, positioned substantially above said first substantially parabolic reflective surface, for refracting the reflected light pulses over said display;

a second light guide, mounted in said housing along an opposite edge of said display, comprising:

a second substantially elliptical refractive surface for further refracting the light pulse refracted by the first substantially elliptical refractive surface; and

a second substantially parabolic reflective surface, positioned substantially below said second substantially elliptical refractive surface, for reflecting the further refracted light pulses to said receivers; and

a calculating unit, mounted in said housing and connected to said receivers, to determine a location of a pointer on said display that partially blocks the light pulses refracted by said first light guide, based on outputs of said receivers corresponding to light pulses refracted by said second light guide.

21. (withdrawn) The touch screen of claim **20** wherein said first substantially parabolic reflective surface and said first substantially elliptical refractive surface have the same focal location, and wherein said second substantially parabolic reflective surface and said second substantially elliptical refractive surface have the same focal location.

22. (withdrawn) The touch screen of claim **20** further comprising two additional light guides mounted in said housing and arranged along the remaining two edges of said display, the four light guides comprising a single unit surrounding said display.

23. (withdrawn) The touch screen of claim **20**, wherein said first and second light guides comprise a portion of a screen glass covering said display.

24. (withdrawn) The touch screen of claim **20** further comprising a screen glass covering said display, the screen glass comprising a painted frame on the screen glass inner surface, surrounding a rectangular viewing window, and wherein said first and second light guides each comprise a daylight filter sheet aligned with said painted frame.

25. (withdrawn) The touch screen of claim **20** further comprising a screen glass covering said display, the screen glass comprising a painted frame on the screen glass inner surface, surrounding a rectangular viewing window,

wherein said first and second light guides each comprises an infra-red transparent portion that is colored like said painted frame and aligned with said painted frame.

26. (amended) A method of determining a touch coordinate on a touch screen, comprising:

providing (i) a display, (ii) a plurality of collimating lenses along two opposite edges of the display, ~~the collimating lenses being arranged along the two edges so as to be shift-aligned relative to one another,~~ (iii) a plurality of light pulse emitters, denoted *E*, that transmit light pulses through the collimating lenses of a first of the two edges and over the display, and (iv) a plurality of light pulse receivers, denoted *R*, that receive the light pulses through the collimating lenses of the opposite of the two edges, and that output values, denoted *OUT(E, R)*, representing the ~~received~~ light pulses received by receiver *R* from emitter *E*, ~~wherein light pulses emitted by each emitter are detected by at least two of the receivers, wherein each receiver detects light pulses emitted by at least two emitters, and~~ wherein each ~~receiver~~ emitter-receiver pair *(E, R)* has an expected ~~values for emitter-receiver pairs~~ receiver output value, denoted *EXP(E, R)*, when light pulses are not blocked, and wherein the collimating lenses are arranged in a shift-aligned fashion such that (a) light pulses emitted by each emitter are detected by at least two of the receivers, and (b) each receiver detects light pulses emitted by at least two emitters;

selecting ~~receiver output values for~~ two or more emitter-receiver pairs ~~that~~ $(E_1, R_1), \ldots, (E_n, R_n)$ for which their actual receiver output values, $OUT(E_1, R_1), \ldots, OUT(E_n, R_n)$, deviate significantly from ~~corresponding receiver~~ their expected receiver output values~~, wherein the selected values indicate at least (i) that~~ $EXP(E_1, R_1), \ldots, EXP(E_n, R_n)$, because either (A) light pulses transmitted by each of two emitters are being blocked from reaching [[one]] a common receiver, or ~~(ii) that~~ (B) light pulses transmitted by [[one]] a common emitter are being blocked from reaching each of two receivers;

associating [[a]] respective screen ~~coordinate~~ coordinates, denoted $X(E_1, R_1), \ldots, X(E_n, R_n)$, along a first screen axis with [[each]] the selected ~~receiver output~~ emitter-receiver pairs; and

calculating a touch coordinate, denoted XT, by interpolating the associated screen coordinates

$$XT = \Sigma W_i * X(E_i, R_i)$$

with weights W_i according to the respective deviations, $OUT(E_i, R_i) - EXP(E_i, R_i)$, between the ~~selected receivers'~~ actual receiver output values and ~~corresponding~~ the expected receiver output values.

27. (amended) The method of claim **26**, comprising further providing (v) a second plurality of collimating lenses along the other two opposite edges of the display, ~~the second plurality of collimating lenses being arranged along the other two opposite edges so as to be shift-aligned relative to one another,~~ (vi) a second plurality of light pulse emitters, denoted *EE*, that transmit light pulses through the collimating lenses of a first of the other edges over the display, and (vii) a second plurality of light pulse receivers, denoted *RR*, that receive the light pulses through the collimating lenses of the opposite of the other edges, ~~and that output values representing the received light pulses,~~ wherein light pulses emitted by each emitter are detected by at least two of the receivers, wherein the second collimating lenses are arranged in a shift-aligned fashion such that (a) light pulses emitted by each emitter *EE* are detected by at least two of the receivers *RR*, and (b) each receiver *RR* detects light pulses emitted by at least two emitters *EE*~~, and wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked~~;

further selecting ~~a receiver output value for a receiver emitter pair, for a receiver from the second plurality of receivers, that~~ emitter-receiver pairs *(EE, RR)*, for which their actual receiver output values significantly ~~deviates~~ deviate from ~~the corresponding receiver~~ their expected ~~value~~ receiver output values;

~~further associating a screen~~ calculating another touch coordinate, denoted *YT*, along a second screen axis [[with]] from the further selected ~~receiver output value~~ emitter-receiver pairs; and

~~further calculating~~ updating each screen coordinate $X(E_i, R_j)$ ~~along the first screen axis, for each selected receiver output value,~~ according to the intersection of a line connecting the emitter-receiver pair (E_i, R_j) ~~associated~~ with the ~~selected receiver output and~~ line at coordinate *YT* with respect to the second screen axis ~~coordinate~~.

28. (amended) The method of claim **26** wherein said selecting ~~receiver output values~~ emitter-receiver pairs comprises selecting three ~~receiver output values for~~ emitter-receiver pairs~~, which indicate that light pulses transmitted by~~ from two emitters ~~are blocked from reaching~~ and two receivers.

29. (amended) The method of claim **28** wherein said selecting ~~receiver output values~~ emitter-receiver pairs comprises:

identifying ~~and selecting a receiver output value for~~ an emitter-receiver pair, for which its actual receiver output value deviates from its ~~corresponding~~ expected receiver output value by more than the amounts by which actual receiver output values for other emitter-receiver pairs deviate from their ~~corresponding~~ expected receiver output values; and

further ~~selecting a receiver output value for~~ identifying an emitter-receiver pair ~~to the left of~~ adjacent on one side to the thus-identified emitter-receiver pair ~~corresponding to the identified receiver output value~~, and ~~a receiver output value for~~ an emitter-receiver pair ~~to the right of~~ adjacent on another side to the thus-identified emitter-receiver pair, wherein adjacent emitter-receiver pairs are pairs that have a common emitter and adjacent receivers, or pairs that have a common receiver and adjacent emitters ~~corresponding to the identified receiver output value~~.

30. (canceled)

31. (amended) The method of claim **[[30]] 26** wherein said calculating further comprises:

providing a reference touch coordinate, denoted *XRT*; and

computing a temporally filtered touch coordinate, based on ~~the computed weighted average~~ *XT* and ~~the reference touch coordinate~~ *XRT*.

32. (amended) The method of claim **31** further comprising updating the reference touch coordinate *XRT* with either (i) the temporally filtered touch coordinate, or (ii) a combination of the temporally filtered touch coordinate and the reference touch coordinate.

33. (withdrawn) A method of determining a touch coordinate on a touch screen, comprising:

providing a display, a touch detector associated with the display, the touch detector being operable to register a plurality of touch locations in response to a single touch on the display,

each registered touch location having a normalized touch value between 0 and 1, and a respective screen coordinate; and

calculating a touch coordinate comprising interpolating the registered touch locations' screen coordinates according to the registered touch locations' normalized touch values.

34. (withdrawn) The method of claim **33** further comprising:

identifying and selecting a first registered touch location whose normalized value is greater than the normalized values of other registered touch locations; and

further selecting registered touch locations that surround the first touch location, the surrounding touch locations having normalized touch values significantly greater than 0,

wherein said interpolating comprises interpolating the surrounding registered touch locations' screen coordinates according to the surrounding registered touch locations' normalized touch values.

35. (withdrawn) The method of claim **33** wherein said interpolating comprises computing a weighted average of the screen coordinates.

36. (withdrawn) The method of claim **33** wherein said calculating further comprises:

providing a reference touch coordinate; and

computing a temporally filtered touch coordinate, based on the calculated touch coordinate and the reference touch coordinate.

37. (withdrawn) The method of claim **36** further comprising updating the reference touch coordinate with either (i) the temporally filtered touch coordinate, or (ii) a combination of the temporally filtered touch coordinate and the reference touch coordinate.

38. (amended) A method of ~~pairing~~ disambiguating unpaired *x*- and *y*- coordinate values [[in]] detected by a touch screen system in response to two simultaneous touches, comprising:

providing (i) a display, (ii) ~~a plurality of collimating lenses along two opposite edges of the display, the collimating lenses being arranged along the two edges so as to be shift-aligned relative to one another, (iii)~~ a plurality of light pulse emitters that transmit light pulses ~~through the collimating lenses of one of the two edges~~ over the display, and ~~(iv)~~ (iii) a plurality of light pulse receivers that receive the light pulses ~~through the collimating lenses of the opposite of the two edges~~, and that output values representing the received light pulses, ~~wherein light pulses transmitted by each emitter are detected by at least two receivers, wherein each receiver detects light pulses transmitted by at least two emitters, and~~ wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked;

detecting two different *x*-coordinates ~~and two different y-coordinates~~ corresponding to two simultaneous touches, based on significant deviations between actual receiver output values for receiver-emitter pairs ~~along the two opposite display edges~~ and corresponding ~~receiver~~ expected receiver output values;

separately detecting two different *y*-coordinates corresponding to the two simultaneous touches;

determining which one of the two *x*-coordinates is associated with a touch that is nearer to an edge of the display, based on ~~comparing~~ the deviations corresponding to the *x*-coordinates; and

pairing ~~one of the x-coordinates~~ the thus-determined *x*-coordinate with ~~an appropriate one of the y-coordinates, based on said comparing~~ the *y*-coordinate that is closer to that one edge.

39. (amended) The method of claim **38** wherein said ~~comparing comprises comparing~~ determining is based on a comparison of relative deviations.

40. (amended) The method of claim **38** wherein said ~~comparing comprises comparing~~ determining is based on a comparison of absolute deviations.

41. (amended) The method of claim **38** wherein said ~~comparing comprises comparing~~ determining is based on patterns of emitter-receiver pairs that indicate a touch for each coordinate.

42. (canceled)

43. (amended) A method of discriminating clockwise gestures from counter-clockwise gestures in a touch screen system, comprising:

providing (i) a display, (ii) ~~a plurality of collimating lenses along two opposite edges of the display, the collimating lenses being arranged along the two edges so as to be shift aligned relative to one another, (iii)~~ a plurality of light pulse emitters that transmit light pulses ~~through the collimating lenses of a first of the two edges~~ over the display, and ~~(iv)~~ (iii) a plurality of light pulse receivers that receive the light pulses ~~through the collimating lenses of the opposite of the two edges~~, and that output values representing the received light pulses, ~~wherein light pulses transmitted by each emitter are detected by at least two receivers, wherein each receiver detects light pulses transmitted by at least two emitters, and~~ wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked;

performing a series of touch detections over time at times $t_1, \ldots, t_n$, each touch detection at a given time t detecting two different x-coordinates, $x_1(t)$ and $x_2(t)$, corresponding to two touches, and separately detecting two different y-coordinates, $y_1(t)$ and $y_2(t)$, corresponding to the two touches, the touch detections being based on significant deviations between actual receiver output values for receiver-emitter pairs ~~along the two opposite display edges~~ and corresponding ~~receiver~~ expected receiver output values;

~~separately evaluating each series of~~ determining which of the two series of detected x-coordinates, $(x_1(t_1), \ldots, x_1(t_n))$ and $(x_2(t_1), \ldots, x_2(t_n))$, is associated with a touch approaching a display edge, by comparing the deviations ~~for the~~ corresponding to neighboring x-coordinates ~~over time~~; and

discriminating a gesture as being clockwise or counter-clockwise ~~comprising~~ by pairing ~~one of~~ the thus-determined series of the x-coordinates with ~~an appropriate~~ that one of the series of [[the]] detected y-coordinates, $(y_1(t_1), \ldots, y_1(t_n))$ and $(y_2(t_1), \ldots, y_2(t_n))$, that is also approaching that display edge ~~based on said separately evaluating~~.

44. (amended) The method of claim **43** wherein said ~~separately evaluating comprises comparing~~ determining is based on a comparison of relative deviations over time.

45. (amended) The method of claim **43** wherein said ~~separately evaluating comprises comparing~~ determining is based on a comparison of absolute deviations over time.

46. (amended) The method of claim **43** wherein said ~~separately evaluating comprises comparing~~ determining is based on patterns of emitter-receiver pairs that indicate a touch over time.

47. (canceled)

48. (withdrawn) A method of calibrating optical components in a light-based touch screen, comprising:

providing (i) a display, (ii) a row of light pulse emitters that sequentially transmit light pulses over the display according to calibrated pulse current and pulse duration controls, and (iii) a row of light pulse receivers that receive the light pulses and that output values representing the received light pulses, each receiver having expected values for emitter-receiver pairs when the light pulses are not blocked;

determining if each receiver output value for a receiver-emitter pair is within a respective designated range from the corresponding receiver expected value; and

when a receiver output value for a receiver-emitter pair is outside the designated range, comprising:

recalibrating the emitter, comprising adjusting at least one of the emitter pulse current and pulse duration such that subsequent receiver output values are within the designated range; and

updating the receiver expected value for the receiver-emitter pair based on subsequent output values of the receiver.

49. (withdrawn) The method of claim **48** further comprising determining that light pulses are not being blocked based on the deviation between receiver output values and expected values, prior to said recalibrating.

50. (withdrawn) The method of claim **49**, wherein said determining that light pulses are not being blocked comprises comparing deviations between receiver output values for neighboring emitter-receiver pairs and corresponding receiver expected values.

51. (withdrawn) The method of claim **48** further comprising determining that receiver output values for the emitter-receiver pair are stable over a time duration, prior to said recalibrating.

52. (withdrawn) A method of updating receiver expected values in a light-based touch screen, comprising:

providing (i) a display, (ii) a row of light pulse emitters that sequentially transmit calibrated light pulses over the display, and (iii) a row of light pulse receivers that receive the light pulses and that output values representing the received light pulses, each receiver having expected values for emitter-receiver pairs when the light pulses are not blocked;

determining which receivers detect a touch event on the display that partially blocks the light pulses, based on deviations between receiver output values for some receiver-emitter pairs, and corresponding receiver expected values; and

updating receiver expected values for remaining receiver-emitter pairs, based on corresponding receiver output values.

53. (withdrawn) The method of claim **52** further comprising determining that receiver output values for the remaining receiver-emitter pairs are stable over a time duration, prior to said updating.

54. (withdrawn) The method of claim **52** further comprising determining that receiver output values for the remaining receiver-emitter pairs are within a designated range of their expected values, prior to said updating.

55. (withdrawn) The method of claim **52**, wherein said determining comprises comparing deviations between receiver output values for neighboring emitter-receiver pairs and corresponding receiver expected values.

56. (withdrawn) A pressure-sensitive touch screen comprising:

a housing;

at least one light receiver rigidly mounted in said housing;

a display flexibly mounted in said housing substantially above said at least one receiver, which depresses in response to pressure of a touch; and

a calculating unit connected to said at least one light receiver for receiving outputs indicating amounts of received light by said at least one receiver, and for determining that said display is being depressed based on an increase in an output of said at least one receiver.

57. (withdrawn) The pressure-sensitive touch screen of claim **56** further comprising a touch detector connected to said calculating unit, wherein said calculating unit determines that said display is being depressed only when said touch detector detects a touch on said display.

58. (withdrawn) The pressure-sensitive touch screen of claim **57** wherein the outputs of said at least one receiver (i) indicate the presence of a touch on said display based on a receiver output value that deviates significantly from a receiver expected value when said display is not being touched, and (ii) indicate that said display is being depressed based on a receiver output value that deviates significantly from an expected value of the receiver when said display is not depressed.

59. (withdrawn) The pressure-sensitive touch screen of claim **58** wherein the outputs of said at least one receiver indicate the presence of a touch on said display based on a receiver output value that is significantly less than the receiver expected value of the receiver when said display is not being touched.

60. (withdrawn) The pressure-sensitive touch screen of claim **59** wherein the outputs of said at least one receiver indicate that the display is being depressed based on a receiver output value that is significantly greater than the receiver expected value when said display is not depressed.

61. (withdrawn) The pressure-sensitive touch screen of claim **56** wherein said calculating unit determines an amount of pressure being applied to the display based on the deviation between a receiver output value and an expected value of the receiver when said display is not depressed.

62. (withdrawn) A method of attaching a component to a substrate, comprising:

providing a component guide attached to a substrate, the component guide having a cavity substantially conforming to contours of a portion of a component;

attaching a first solder pad to the component;

inserting the component into the guide cavity;

providing a second solder pad, offset from the first solder pad and near the cavity;

inserting the component, the component guide and the substrate into an oven heating the solder pads, wherein the component is drawn further into the guide cavity by a capillary effect of the heated solder pads.

63. (withdrawn) The method of claim **62** further comprising providing a plurality of notches in the component guide outside of the cavity, for guiding the component into the cavity during the capillary effect.

64. (withdrawn) The method of claim **62**, wherein the component guide is removably attached to the substrate and is detached for subsequent use when the substrate is removed from the oven.

65. (withdrawn) The method of claim **62**, wherein the component comprises a light emitter and the component guide comprises a lens for directing light emitted by the emitter.

66. (withdrawn) The method of claim **62**, wherein the component comprises a light receiver and the component guide comprises a lens for directing light onto the receiver.

67. (amended) A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing and arranged along a first edge of said display;

a plurality of light pulse emitters mounted in said housing that are spaced apart from and serially transmit light pulses through said collimating lenses over said display;

[[a]] an elongated light guide mounted in said housing ~~along~~ near the edge of said display opposite the first edge, comprising:

an outer surface portion for receiving the light pulses~~, the light guide comprising~~ transmitted over said display by all of said light pulse emitters; and

a scatterer strip that scatters light pulses that enter the light guide from said outer surface portion, to reach one end of the light guide;

a reflective strip that reflects light pulses transmitted over said display by said light pulse emitters to ~~one end of the light guide~~ said outer surface portion;

a light pulse receiver mounted in said housing near the one end of said light guide, for receiving the ~~reflected~~ light pulses scattered by said scatterer strip; and

a calculating unit, mounted in said housing and connected to said light pulse receiver, for determining a location of a pointer on said display that partially blocks light pulses transmitted by said emitters, based on outputs of said light pulse receiver.

68. (amended) The touch screen of claim **67**, wherein said light guide further comprises a collimating lens for collimating ~~received~~ light pulses that enter said light guide from said outer surface, onto said ~~receiver~~ scatterer strip.

69. (canceled)

70. (amended) The touch screen of claim **67**, wherein said ~~reflective strip reflects~~ scatterer strip scatters the ~~received~~ light pulses that enter said light guide from said outer surface to reach both ends of said light guide, the touch screen further comprising a second light pulse receiver mounted in said housing near a second end of said light guide for receiving the ~~reflected~~ light pulses scattered by said scatterer strip, and wherein said calculating unit is also connected to said second light pulse receiver and determines the location of the pointer on said display based on outputs of said first and second light pulse receivers.

71. The touch screen of claim **70**, wherein said first and second light pulse receivers are activated serially.

72. The touch screen of claim **70**, wherein said first and second light pulse receivers are activated in parallel.

73. (amended) A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing along a first edge of said display;

a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses;

[[a]] an elongated light guide mounted in said housing ~~along a~~ near the edge of said display opposite the first edge ~~of said display~~, the light guide ~~comprising~~ comprising:

an outer surface portion; and

a scatterer strip that scatters light such that light pulses that enter the light guide from one end of the light guide, exit the light guide through said outer surface portion;

a reflective strip that reflects light pulses ~~received at one end of the~~ that exit said light guide through said outer surface portion, over said display to all of said light pulse receivers;

a light pulse emitter mounted in said housing near the one end of said light guide, for transmitting light pulses ~~through~~ into said light guide~~, wherein said reflective strip reflects the light pulses over said display; a plurality of collimating lenses mounted in said housing along the edge of said display opposite the first edge; a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses~~; and

a calculating unit, mounted in said housing and connected to said light pulse receivers, for determining a location of a pointer on said display that partially blocks the light pulses ~~transmitted by said emitter~~ reflected by said reflective strip, based on outputs of said light pulse receivers.

74. (amended) A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing along a first edge of said display;

a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses;

[[a]] an elongated light guide mounted in said housing ~~along a~~ near the edge of said display opposite the first edge ~~of said display~~, the light guide ~~comprising~~ comprising:

an outer surface portion; and

a scatterer strip that scatters light such that light pulses that enter the light guide from either end of the light guide, exit the light guide through said outer surface portion;

a reflective strip that reflects light pulses ~~received at either end of~~ that exit the light guide through said outer surface portion, over said display to all of said light pulse receivers;

a plurality of light pulse emitters mounted in said housing near each end of said light guide, for transmitting light pulses ~~through~~ into said light guide~~, wherein said reflective strip reflects the light pulses over said display; a plurality of collimating lenses mounted in said housing along the edge of said display opposite the first edge; a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses~~; and

a calculating unit, mounted in said housing and connected to said receivers, for determining a location of a pointer on said display that partially blocks the light pulses ~~transmitted by said emitters~~ reflected by said reflective strip, based on outputs of said light pulse receivers.

75. The touch screen of claim **74**, wherein said light pulse emitters are activated serially.

76. (amended) The touch screen of claim **75**, wherein said calculating unit computes ~~a deviation~~ deviations between an actual output value from each said light pulse receiver and [[an]]

first and second expected ~~value~~ output values for ~~each said~~ that light pulse receiver when [[the]] light pulses are not blocked, and wherein [[a]] the first expected output value corresponds to [[an]] the light pulse emitter at a first end of said light guide being activated, and [[a]] the second expected output value corresponds to [[an]] the light pulse emitter at the other end of said light guide being activated.

77. (amended) The touch screen of claim **76**, wherein the first and second expected output values for at least one of said light pulse receivers are different.

78. The touch screen of claim **74**, wherein said light pulse receivers are activated in parallel.

79. The touch screen of claim **74**, wherein said light pulse receivers are activated serially and in parallel.

80. (amended) The touch screen of claim **74**, wherein said light guide further comprises a collimating lens for collimating the ~~reflected~~ light pulses ~~over said display~~ scattered by said scattering strip and exiting said light guide through said outer surface portion.

81. (canceled)

Please add the following new claims.

82. (new) The touch screen of claim **1**, wherein said emitters are spaced apart from said first plurality of lenses.

83. (new) The touch screen of claim **1**, wherein said receivers are spaced apart from said second plurality of lenses.

84. (new) The touch screen of claim **1**, further comprising a controller, mounted in said housing and connected to said plurality of emitters, for activating said emitters individually one at a time.

85. (new) The touch screen of claim **1**, wherein each wide light pulse emitted by an emitter comprises a light intensity distribution with intensity varying in accordance with distance from such emitter.

86. (new) The touch screen of claim **1**, wherein said calculating unit assigns coordinates corresponding to each of the overlapping wide light pulses based on an estimated coordinate, along a second dimension, of the location of the pointer.

87. (new) The touch screen of claim **1**, wherein said calculating unit calculates the coordinate, along the first dimension, of the location of the pointer by temporally filtering a plurality of the weighted averages over time.

88. (new) The touch screen of claim **91**, wherein said calculating unit temporally filters the plurality of weighted averages based on at least one of: a velocity of the pointer, a scanning frequency, whether the pointer is moving in a straight line or not, and a size of the pointer.

89. (new) A touch screen comprising:

a housing;

a display mounted in said housing;

a first plurality of lenses mounted in said housing along a common edge of said display;

a plurality of light pulse emitters mounted in said housing that emit wide light pulses through said first plurality of lenses over said display;

a second plurality of lenses mounted in said housing and arranged so as to be shift-aligned relative to said first plurality of lenses, such that wide light pulses transmitted through one of said first plurality of lenses enter *N* neighboring ones of the second plurality of lenses, where *N* is a number at least two;

a plurality of light pulse receivers mounted in said housing that receive the wide light pulses transmitted through said second plurality of lenses, and output received light intensities in accordance with the portions of the wide light pulses that they receive; and

a calculating unit, mounted in said housing and connected to said receivers, that calculates a coordinate, along a first dimension, of a location of a pointer touching said display that partially blocks a wide light pulse transmitted through one of said first plurality of lenses from entering at least two neighboring ones of said second plurality of lenses, by assigning coordinates corresponding to portions of the wide light pulse that enter the neighboring ones of said second plurality of lenses, and by calculating a weighted average of the assigned coordinates, wherein each coordinate's weight in the average is non-zero and corresponds to a degree of blockage of its corresponding portion of the wide light pulse.

90. (new) The touch screen of claim **89** further comprising a light guide for guiding light pulses, the light guide comprising micro-lenses for multi-directional collimation of light pulses, and wherein said first and second pluralities of lenses comprise a portion of said light guide.

91. (new) The touch screen of claim **89**, wherein said calculating unit determines the degree of blockage of each corresponding portion from a separately activated wide light pulse that enters the at least two neighboring ones of said second plurality of lenses.

92. (new) The touch screen of claim **89**, wherein the portions of the wide light pulse that enter the second plurality of lenses comprise different light intensity distributions, with intensity varying in accordance with distance from an emitter of the wide light pulse.

93. (new) The touch screen of claim **89**, wherein said calculating unit assigns coordinates corresponding to portions of the wide light pulse that enter the neighboring ones of said second plurality of lenses based on an estimated coordinate, along a second dimension, of the location of the pointer.

94. (new) The touch screen of claim **89**, wherein said calculating unit calculates the coordinate, along the first dimension, of the location of the pointer by temporally filtering a plurality of the weighted averages over time.

95. (new) The touch screen of claim **94**, wherein said calculating unit temporally filters the plurality of weighted averages based on at least one of: a velocity of the pointer, a scanning frequency, whether the pointer is moving in a straight line or not, and a size of the pointer.

CLAIMS

What is claimed is:

1. A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing along two opposite edges of said display and arranged along the two edges so as to be shift-aligned relative to one another;

a plurality of light pulse emitters mounted in said housing that are spaced apart from and transmit light pulses through said collimating lenses of one of the two edges over said display;

a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive the light pulses through said collimating lenses of the opposite of the two edges; and

a calculating unit, mounted in said housing and connected to said receivers, that determines a location of a pointer on said display that partially blocks the light pulses transmitted by said emitters, based on outputs of said receivers.

2. The touch screen of claim **1**, wherein said emitters and receivers are arranged in opposing rows, and wherein said emitters are shift-aligned relative to said receivers.

3. The touch screen of claim **1**, wherein said collimating lenses comprise a plastic frame surrounding said display.

4. The touch screen of claim **1** further comprising a light guide for guiding light pulses, the light guide comprising micro-lenses for multi-

directional collimation of light pulses, and wherein said collimating lenses comprise a portion of said light guide.

5. The touch screen of claim **4** wherein said micro-lenses are comprised within said collimating lenses.

6. The touch screen of claim **4** wherein said micro-lenses are not comprised within said collimating lenses.

7. The touch screen of claim **1** further comprising:

a first light guide for guiding light pulses, comprising:

a first substantially parabolic reflective surface for reflecting light pulses transmitted by said emitters; and

a first substantially elliptical refractive surface, positioned substantially above said first substantially parabolic reflective surface, for refracting the reflected light pulses over said display to a second light guide; and

a second light guide for guiding light pulses, comprising:

a second substantially elliptical refractive surface for further refracting the refracted light pulses; and

a second substantially parabolic reflective surface, positioned substantially below said second substantially elliptical refractive surface, for reflecting the further refracted light pulses onto said receivers,

wherein said emitters and said receivers are positioned beneath said display, and wherein said collimating lenses comprise a portion of said first and said second light guides.

8. The touch screen of claim **7**, wherein said first substantially parabolic reflective surface and said first substantially elliptical surface have the same focal location, and wherein said second substantially parabolic reflective surface and said second substantially elliptical surface have the same focal location

9. The touch screen of claim **1**, wherein said collimating lenses are rigidly mounted in said housing, wherein said display is flexibly mounted in said housing, and wherein said calculating unit further determines that the pointer is performing a hard touch, based on increases in the outputs of said receivers.

10. The touch screen of claim **1** further comprising a plurality of inter-fitting infra-red transmissible plastic emitter units mounted in said housing, each said unit comprising:

at least one of said collimating lenses; and

at least one of said emitters, which transmit light pulses through said at least one of said collimating lenses.

11. The touch screen of claim **10**, wherein said at least one collimating lens in each of said units receives light pulses from said unit's at least one emitter and from a neighboring unit's at least one emitter.

12. The touch screen of claim **10**, wherein said units are pre-manufactured, prior to being assembled in the touch screen.

13. The touch screen of claim **10**, wherein each of said units further comprises micro-lenses for multi-directional collimation of the light pulses.

14. The touch screen of claim **1**, further comprising a plurality of inter-fitting infra-red transmissible plastic receiver units mounted in said housing, each said unit comprising:

at least one of said collimating lenses; and

at least one of said receivers, which receive light pulses through said at least one of said collimating lenses.

15. The touch screen of claim **14**, wherein said at least one receiver in each of said units receives light pulses through said unit's at least one collimating lens, and also receives light pulses through a neighboring unit's at least one collimating lens.

16. The touch screen of claim **14**, wherein said units are pre-manufactured, prior to being assembled in the touch screen.

17. The touch screen of claim **14**, wherein each of said units further comprises micro-lenses for multi-directional collimation of the light pulses.

18. A touch screen comprising:

a housing;

a display mounted in said housing;

two light guides mounted in said housing and arranged along two opposite edges of said display, each light guide comprising micro-lenses for refracting incoming light in multiple directions;

a plurality of light pulse emitters mounted in said housing that transmit light pulses through a first one of said light guides over said display;

a plurality of light pulse receivers mounted in said housing that receive light pulses through the other one of said light guides; and

a calculating unit, mounted in said housing and connected to said receivers, to determine a location of a pointer on said display that partially blocks the light pulses refracted by said micro-lenses in the first light guide transmitted by said emitters, based on outputs of said receivers corresponding to light pulses refracted by said micro-lenses in said second light guide.

19. The touch screen of claim **18** further comprising two additional light guides mounted in said housing and arranged along the remaining two edges of said display, the four light guides comprising a single unit surrounding said display.

20. A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of light pulse emitters mounted in said housing below said display;

a plurality of light pulse receivers mounted in said housing below said display;

a first light guide, mounted in said housing along a first edge of said display, comprising:

a first substantially parabolic reflective surface for reflecting light pulses transmitted by said emitters; and

a first substantially elliptical refractive surface, positioned substantially above said first substantially parabolic reflective surface, for refracting the reflected light pulses over said display;

a second light guide, mounted in said housing along an opposite edge of said display, comprising:

a second substantially elliptical refractive surface for further refracting the light pulse refracted by the first substantially elliptical refractive surface; and

a second substantially parabolic reflective surface, positioned substantially below said second substantially elliptical refractive surface, for reflecting the further refracted light pulses to said receivers; and

a calculating unit, mounted in said housing and connected to said receivers, to determine a location of a pointer on said display that partially blocks the light pulses refracted by said first light guide, based on outputs of said receivers corresponding to light pulses refracted by said second light guide.

21. The touch screen of claim **20** wherein said first substantially parabolic reflective surface and said first substantially elliptical refractive surface have the same focal location, and wherein said second substantially parabolic reflective surface and said second substantially elliptical refractive surface have the same focal location.

22. The touch screen of claim **20** further comprising two additional light guides mounted in said housing and arranged along the remaining two edges of said display, the four light guides comprising a single unit surrounding said display.

23. The touch screen of claim **20**, wherein said first and second light guides comprise a portion of a screen glass covering said display.

24. The touch screen of claim **20** further comprising a screen glass covering said display, the screen glass comprising a painted frame on the screen glass inner surface, surrounding a rectangular viewing window, and wherein said first and second light guides each comprise a daylight filter sheet aligned with said painted frame.

25. The touch screen of claim **20** further comprising a screen glass covering said display, the screen glass comprising a painted frame on the screen glass inner surface, surrounding a rectangular viewing window, wherein said first and second light guides each comprises an infra-red transparent portion that is colored like said painted frame and aligned with said painted frame.

26. A method of determining a touch coordinate on a touch screen, comprising:

providing (i) a display, (ii) a plurality of collimating lenses along two opposite edges of the display, the collimating lenses being arranged along the two edges so as to be shift-aligned relative to one another, (iii) a plurality of light pulse emitters that transmit light pulses through the collimating lenses of a first of the two edges over the display, and (iv) a plurality of light pulse receivers that receive the light pulses through the collimating lenses of the opposite of the two edges, and that output values representing the received light pulses, wherein light pulses emitted by each emitter are detected by at least two of the receivers, wherein each receiver detects light pulses emitted by at least two emitters, and wherein each receiver has expected values for emitter-receiver pairs when light pulses are not blocked;

selecting receiver output values for emitter-receiver pairs that deviate significantly from corresponding receiver expected values,

wherein the selected values indicate at least (i) that light pulses transmitted by two emitters are blocked from reaching one receiver, or (ii) that light pulses transmitted by one emitter are blocked from reaching two receivers;

associating a screen coordinate along a first screen axis with each selected receiver output; and

calculating a touch coordinate by interpolating the associated screen coordinates according to the respective deviations between the selected receivers' output values and corresponding expected values.

27. The method of claim **26**, comprising further providing (v) a second plurality of collimating lenses along the other two opposite edges of the display, the second plurality of collimating lenses being arranged along the other two opposite edges so as to be shift-aligned relative to one another, (vi) a second plurality of light pulse emitters that transmit light pulses through the collimating lenses of a first of the other edges over the display, and (vii) a second plurality of light pulse receivers that receive the light pulses through the collimating lenses of the opposite of the other edges, and that output values representing the received light pulses, wherein light pulses emitted by each emitter are detected by at least two of the receivers, wherein each receiver detects light pulses emitted by at least two emitters, and wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked;

further selecting a receiver output value for a receiver-emitter pair, for a receiver from the second plurality of receivers, that significantly deviates from the corresponding receiver expected value;

further associating a screen coordinate along a second screen axis with the further selected receiver output value; and

further calculating each screen coordinate along the first screen axis, for each selected receiver output value, according to the intersection of a line connecting the emitter-receiver pair associated with the selected receiver output and the second screen axis coordinate.

28. The method of claim **26** wherein said selecting receiver output values comprises selecting three receiver output values for emitter-receiver pairs, which indicate that light pulses transmitted by two emitters are blocked from reaching two receivers.

29. The method of claim **28** wherein said selecting receiver output values comprises:

identifying and selecting a receiver output value for an emitter-receiver pair, which deviates from its corresponding expected value by more than receiver output values for other emitter-receiver pairs deviate from their corresponding expected values; and

further selecting a receiver output value for an emitter-receiver pair to the left of the emitter-receiver pair corresponding to the identified receiver output value, and a receiver output value for an emitter-receiver pair to the right of the emitter-receiver pair corresponding to the identified receiver output value.

30. The method of claim **29** wherein said interpolating comprises computing a weighted average of the screen coordinates according to each selected receiver output value's deviation from its corresponding expected value.

31. The method of claim **30** wherein said calculating further comprises:

providing a reference touch coordinate; and

computing a temporally filtered touch coordinate, based on the computed weighted average and the reference touch coordinate.

32. The method of claim **31** further comprising updating the reference touch coordinate with either (i) the temporally filtered touch coordinate, or (ii) a combination of the temporally filtered touch coordinate and the reference touch coordinate.

33. A method of determining a touch coordinate on a touch screen, comprising:

providing a display, a touch detector associated with the display, the touch detector being operable to register a plurality of touch locations in response to a single touch on the display, each registered touch location having a normalized touch value between 0 and 1, and a respective screen coordinate; and

calculating a touch coordinate comprising interpolating the registered touch locations' screen coordinates according to the registered touch locations' normalized touch values.

34. The method of claim **33** further comprising:

identifying and selecting a first registered touch location whose normalized value is greater than the normalized values of other registered touch locations; and

further selecting registered touch locations that surround the first touch location, the surrounding touch locations having normalized touch values significantly greater than 0,

wherein said interpolating comprises interpolating the surrounding registered touch locations' screen coordinates according to the surrounding registered touch locations' normalized touch values.

35. The method of claim **33** wherein said interpolating comprises computing a weighted average of the screen coordinates.

36. The method of claim **33** wherein said calculating further comprises:

providing a reference touch coordinate; and

computing a temporally filtered touch coordinate, based on the calculated touch coordinate and the reference touch coordinate.

37. The method of claim **36** further comprising updating the reference touch coordinate with either (i) the temporally filtered touch coordinate, or (ii) a combination of the temporally filtered touch coordinate and the reference touch coordinate.

38. A method of pairing x- and y- coordinate values in a touch screen system in response to two simultaneous touches, comprising:

providing (i) a display, (ii) a plurality of collimating lenses along two opposite edges of the display, the collimating lenses being arranged along the two edges so as to be shift-aligned relative to one another, (iii) a plurality of light pulse emitters that transmit light pulses through the collimating lenses of one of the two edges over the display, and (iv) a plurality of light pulse receivers that receive the light pulses through the collimating lenses of the opposite of the two edges, and that output values representing the received light pulses, wherein light pulses transmitted by each emitter are detected by at least two receivers,

wherein each receiver detects light pulses transmitted by at least two emitters, and wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked;

detecting two different x-coordinates and two different y-coordinates corresponding to two simultaneous touches, based on significant deviations between receiver output values for receiver-emitter pairs along the two opposite display edges and corresponding receiver expected values;

comparing the deviations corresponding to the x-coordinates;

pairing one of the x-coordinates with an appropriate one of the y-coordinates, based on said comparing.

39. The method of claim **38** wherein said comparing comprises comparing relative deviations.

40. The method of claim **38** wherein said comparing comprises comparing absolute deviations.

41. The method of claim **38** wherein said comparing comprises comparing patterns of emitter-receiver pairs that indicate a touch for each coordinate.

42. The method of claim **38** further comprising:

further comparing deviations corresponding to the y-coordinates; and

further pairing one of the y-coordinates with an appropriate one of the x-coordinates, based on said comparing and said further comparing.

43. A method of discriminating clockwise gestures from counter-clockwise gestures in a touch screen system, comprising:

providing (i) a display, (ii) a plurality of collimating lenses along two opposite edges of the display, the collimating lenses being arranged along the two edges so as to be shift-aligned relative to one another, (iii) a plurality of light pulse emitters that transmit light pulses through the collimating lenses of a first of the two edges over the display, and (iv) a plurality of light pulse receivers that receive the light pulses through the collimating lenses of the opposite of the two edges, and that output values representing the received light pulses, wherein light pulses transmitted by each emitter are detected by at least two receivers, wherein each receiver detects light pulses transmitted by at least two emitters, and wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked;

performing a series of touch detections over time, each touch detection detecting two different x-coordinates and two different y-coordinates corresponding to two touches, the touch detections being based on significant deviations between receiver output values for receiver-emitter pairs along the two opposite display edges and corresponding receiver expected values;

separately evaluating each series of deviations for the x-coordinates over time; and

discriminating a gesture as being clockwise or counter-clockwise comprising pairing one of the series of the x-coordinates with an appropriate one of the series of the y-coordinates, based on said separately evaluating.

44. The method of claim **43** wherein said separately evaluating comprises comparing relative deviations over time.

45. The method of claim **43** wherein said separately evaluating comprises comparing absolute deviations over time.

46. The method of claim **43** wherein said separately evaluating comprises comparing patterns of emitter-receiver pairs that indicate a touch over time.

47. The method of claim **46** further comprising further separately evaluating each series of deviations for the y-coordinates over time, wherein said discriminating a gesture as being clockwise or counter-clockwise further comprises pairing one of series of the y-coordinates with an appropriate one of the series of the x-coordinates, based on said further separately evaluating.

48. A method of calibrating optical components in a light-based touch screen, comprising:

providing (i) a display, (ii) a row of light pulse emitters that sequentially transmit light pulses over the display according to calibrated pulse current and pulse duration controls, and (iii) a row of light pulse receivers that receive the light pulses and that output values representing the received light pulses, each receiver having expected values for emitter-receiver pairs when the light pulses are not blocked;

determining if each receiver output value for a receiver-emitter pair is within a respective designated range from the corresponding receiver expected value; and

when a receiver output value for a receiver-emitter pair is outside the designated range, comprising:

recalibrating the emitter, comprising adjusting at least one of the emitter pulse current and pulse duration such that subsequent receiver output values are within the designated range; and

updating the receiver expected value for the receiver-emitter pair based on subsequent output values of the receiver.

49. The method of claim **48** further comprising determining that light pulses are not being blocked based on the deviation between receiver output values and expected values, prior to said recalibrating.

50. The method of claim **49**, wherein said determining that light pulses are not being blocked comprises comparing deviations between receiver output values for neighboring emitter-receiver pairs and corresponding receiver expected values.

51. The method of claim **48** further comprising determining that receiver output values for the emitter-receiver pair are stable over a time duration, prior to said recalibrating.

52. A method of updating receiver expected values in a light-based touch screen, comprising:

providing (i) a display, (ii) a row of light pulse emitters that sequentially transmit calibrated light pulses over the display, and (iii) a row of light pulse receivers that receive the light pulses and that output values representing the received light pulses, each receiver having expected values for emitter-receiver pairs when the light pulses are not blocked;

determining which receivers detect a touch event on the display that partially blocks the light pulses, based on deviations between

receiver output values for some receiver-emitter pairs, and corresponding receiver expected values; and

updating receiver expected values for remaining receiver-emitter pairs, based on corresponding receiver output values.

53. The method of claim **52** further comprising determining that receiver output values for the remaining receiver-emitter pairs are stable over a time duration, prior to said updating.

54. The method of claim **52** further comprising determining that receiver output values for the remaining receiver-emitter pairs are within a designated range of their expected values, prior to said updating.

55. The method of claim **52**, wherein said determining comprises comparing deviations between receiver output values for neighboring emitter-receiver pairs and corresponding receiver expected values.

56. A pressure-sensitive touch screen comprising:

a housing;

at least one light receiver rigidly mounted in said housing;

a display flexibly mounted in said housing substantially above said at least one receiver, which depresses in response to pressure of a touch; and

a calculating unit connected to said at least one light receiver for receiving outputs indicating amounts of received light by said at least one receiver, and for determining that said display is being depressed based on an increase in an output of said at least one receiver.

57. The pressure-sensitive touch screen of claim **56** further comprising a touch detector connected to said calculating unit, wherein said calculating unit determines that said display is being depressed only when said touch detector detects a touch on said display.

58. The pressure-sensitive touch screen of claim **57** wherein the outputs of said at least one receiver (i) indicate the presence of a touch on said display based on a receiver output value that deviates significantly from a receiver expected value when said display is not being touched, and (ii) indicate that said display is being depressed based on a receiver output value that deviates significantly from an expected value of the receiver when said display is not depressed.

59. The pressure-sensitive touch screen of claim **58** wherein the outputs of said at least one receiver indicate the presence of a touch on said display based on a receiver output value that is significantly less than the receiver expected value of the receiver when said display is not being touched.

60. The pressure-sensitive touch screen of claim **59** wherein the outputs of said at least one receiver indicate that the display is being depressed based on a receiver output value that is significantly greater than the receiver expected value when said display is not depressed.

61. The pressure-sensitive touch screen of claim **56** wherein said calculating unit determines an amount of pressure being applied to the display based on the deviation between a receiver output value and an expected value of the receiver when said display is not depressed.

62. A method of attaching a component to a substrate, comprising:

providing a component guide attached to a substrate, the component guide having a cavity substantially conforming to contours of a portion of a component;

attaching a first solder pad to the component;

inserting the component into the guide cavity;

providing a second solder pad, offset from the first solder pad and near the cavity;

inserting the component, the component guide and the substrate into an oven heating the solder pads, wherein the component is drawn further into the guide cavity by a capillary effect of the heated solder pads.

63. The method of claim **62** further comprising providing a plurality of notches in the component guide outside of the cavity, for guiding the component into the cavity during the capillary effect.

64. The method of claim **62**, wherein the component guide is removably attached to the substrate and is detached for subsequent use when the substrate is removed from the oven.

65. The method of claim **62**, wherein the component comprises a light emitter and the component guide comprises a lens for directing light emitted by the emitter.

66. The method of claim **62**, wherein the component comprises a light receiver and the component guide comprises a lens for directing light onto the receiver.

67. A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing and arranged along a first edge of said display;

a plurality of light pulse emitters mounted in said housing that are spaced apart from and serially transmit light pulses through said collimating lenses over said display;

a light guide mounted in said housing along the edge of said display opposite the first edge, for receiving the light pulses, the light guide comprising a reflective strip that reflects light pulses to one end of the light guide;

a light pulse receiver mounted in said housing near the one end of said light guide, for receiving the reflected light pulses; and

a calculating unit, mounted in said housing and connected to said receiver, for determining a location of a pointer on said display that partially blocks light pulses transmitted by said emitters, based on outputs of said receiver.

68. The touch screen of claim **67**, wherein said light guide further comprises a collimating lens for collimating received light pulses onto said receiver strip.

69. The touch screen of claim **68**, wherein said light guide further comprises a plurality of micro-lenses for multi-directional collimation of received light pulses onto said reflective strip.

70. The touch screen of claim **67**, wherein said reflective strip reflects the received light pulses to both ends of said light guide, the

touch screen further comprising a second light pulse receiver mounted in said housing near a second end of said light guide for receiving the reflected light pulses, and wherein said calculating unit is also connected to said second light pulse receiver and determines the location of the pointer on said display based on outputs of said first and second receivers.

71. The touch screen of claim **70**, wherein said first and second light pulse receivers are activated serially.

72. The touch screen of claim **70**, wherein said first and second light pulse receivers are activated in parallel.

73. A touch screen comprising:

a housing;

a display mounted in said housing;

a light guide mounted in said housing along a first edge of said display, the light guide comprising a reflective strip that reflects light pulses received at one end of the light guide;

a light pulse emitter mounted in said housing near the one end of said light guide, for transmitting light pulses through said light guide, wherein said reflective strip reflects the light pulses over said display;

a plurality of collimating lenses mounted in said housing along the edge of said display opposite the first edge;

a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses; and

a calculating unit, mounted in said housing and connected to said receivers, for determining a location of a pointer on said display that

partially blocks the light pulses transmitted by said emitter, based on outputs of said receivers.

74. A touch screen comprising:

a housing;

a display mounted in said housing;

a light guide mounted in said housing along a first edge of said display, the light guide comprising a reflective strip that reflects light pulses received at either end of the light guide;

a plurality of light pulse emitters mounted in said housing near each end of said light guide, for transmitting light pulses through said light guide, wherein said reflective strip reflects the light pulses over said display;

a plurality of collimating lenses mounted in said housing along the edge of said display opposite the first edge;

a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses; and

a calculating unit, mounted in said housing and connected to said receivers, for determining a location of a pointer on said display that partially blocks the light pulses transmitted by said emitters, based on outputs of said receivers.

75. The touch screen of claim **74**, wherein said light pulse emitters are activated serially.

76. The touch screen of claim **75**, wherein said calculating unit computes a deviation between an output value from each said receiver and an expected value for each said receiver when the light pulses are

not blocked, and wherein a first expected value corresponds to an emitter at a first end of said light guide being activated, and a second expected value corresponds to an emitter at the other end of said light guide being activated.

77. The touch screen of claim **76**, wherein the first and second expected values for at least one of said receivers are different.

78. The touch screen of claim **74**, wherein said light pulse receivers are activated in parallel.

79. The touch screen of claim **74**, wherein said light pulse receivers are activated serially and in parallel.

80. The touch screen of claim **74**, wherein said light guide further comprises a collimating lens for collimating the reflected light pulses over said display.

81. The touch screen of claim **74**, wherein said light guide further comprises a plurality of micro-lenses for multi-directional collimation of the reflected light pulses over said display.

82. A touch screen system comprising:

a reflective display surface;

a camera mounted so as to capture an image of (i) said reflective display surface, (ii) a pointer approaching said reflective display surface, and (iii) a reflection of the pointer on said reflective display surface; and

a processor coupled with said camera that determines a three-dimensional location of the pointer relative to said reflective display surface, based on the positions of the pointer and the reflection of the pointer in the image captured by said camera.

83. The touch screen system of claim **82**, wherein said processor determines the location of the pointer relative to said reflective display surface along at least one dimension, based on a mid-point between the pointer and the reflection of the pointer in the image captured by said camera.

84. The touch screen system of claim **82**, wherein said processor determines the location of the pointer relative to said reflective display surface along at least one dimension, based on a line connecting the pointer and the reflection of the pointer in the image captured by said camera.

85. The touch screen system of claim **82**, wherein said processor determines a distance between the pointer and said reflective display surface, based on a distance between the pointer and the reflection of the pointer in the image captured by said camera.

CLAIMS

1. A touch screen comprising:

a housing;

a display mounted in said housing;

a first plurality of lenses mounted in said housing along a common edge of said display;

a plurality of light pulse emitters mounted in said housing that emit wide light pulses through said first plurality of lenses over said display;

a second plurality of lenses mounted in said housing and arranged so as to be shift-aligned relative to said first plurality of lenses, such that wide light pulses transmitted through *N* neighboring ones of said first plurality of lenses overlap and enter a common shift-aligned one of the second plurality of lenses, when *N* is a number at least two;

a plurality of light pulse receivers mounted in said housing that receive the wide light pulses transmitted through said second plurality of lenses, and output received light intensities in accordance with the portions of the wide light pulses that they receive; and

a calculating unit, mounted in said housing and connected to said receivers, that calculates a coordinate, along a first dimension, of a location of a pointer touching said display that partially blocks overlapping wide light pulses transmitted through at least two neighboring ones of said first plurality of lenses from entering the common shift-aligned one of the second plurality of lenses, by assigning coordinates corresponding to each of the overlapping wide light pulses, and by calculating a weighted average of the assigned coordinates, wherein each coordinate's weight in the average is non-zero and corresponds to a degree of blockage of its corresponding light pulse.

2. The touch screen of claim 1, wherein said emitters and receivers are arranged in opposing rows, and wherein said emitters are shift-aligned relative to said receivers.

3. The touch screen of claim 1, wherein said first and second pluralities of lenses comprise a plastic frame surrounding said display.

4. The touch screen of claim 1 further comprising a light guide for guiding light pulses, the light guide comprising micro-lenses for multi-directional collimation of light pulses, and wherein said first and second pluralities of lenses comprise a portion of said light guide.

5. The touch screen of claim 4 wherein said micro-lenses are comprised within said first and second pluralities of lenses.

6. The touch screen of claim 4 wherein said micro-lenses are not comprised within said first and second pluralities of lenses.

7. The touch screen of claim 1 further comprising:

a first light guide for guiding light pulses, comprising:

a first substantially parabolic reflective surface for reflecting the wide light pulses emitted by said emitters; and

a first substantially elliptical refractive surface, positioned substantially above said first substantially parabolic reflective surface, for refracting the reflected light pulses over said display to a second light guide; and

a second light guide for guiding light pulses, comprising:

a second substantially elliptical refractive surface for further refracting the refracted light pulses; and

a second substantially parabolic reflective surface, positioned substantially below said second substantially elliptical refractive surface, for reflecting the further refracted light pulses onto said receivers,

wherein said emitters and said receivers are positioned beneath said display, and wherein said first and second pluralities of lenses comprise respective portions of said first and said second light guides.

8. The touch screen of claim 7, wherein said first substantially parabolic reflective surface and said first substantially elliptical surface have the same focal location, and wherein said second substantially parabolic reflective surface and said second substantially elliptical surface have the same focal location.

9. The touch screen of claim 1, wherein said first and second pluralities of lenses are rigidly mounted in said housing, wherein said display is flexibly mounted in said housing, and wherein said calculating unit further determines that the pointer is performing a hard touch, based on increases in the outputs of said receivers.

10. The touch screen of claim 1 further comprising a plurality of inter-fitting infra-red transmissible plastic emitter units mounted in said housing, each said unit comprising:

at least one of said first plurality of lenses; and

at least one of said emitters, which emit wide light pulses through said at least one of said first plurality of lenses.

11. The touch screen of claim 10, wherein said at least one lens in each of said units transmits wide light pulses received from said unit's at least one emitter and from a neighboring unit's at least one emitter.

12. The touch screen of claim 10, wherein said units are pre-manufactured, prior to being assembled in the touch screen.

13. The touch screen of claim 10, wherein each of said units further comprises micro-lenses for multi-directional collimation of the light pulses.

14. The touch screen of claim 1, further comprising a plurality of inter-fitting infra-red transmissible plastic receiver units mounted in said housing, each said unit comprising:

at least one of said second plurality of lenses; and

at least one of said receivers, which receive wide light pulses transmitted through said at least one of said second plurality of lenses.

15. The touch screen of claim 14, wherein said at least one receiver in each of said units receives wide light pulses transmitted through said unit's at least one lens, and also receives light pulses transmitted through a neighboring unit's at least one lens.

16. The touch screen of claim 14, wherein said units are pre-manufactured, prior to being assembled in the touch screen.

17. The touch screen of claim 14, wherein each of said units further comprises micro-lenses for multi-directional collimation of the light pulses.

18. A method of determining a touch coordinate on a touch screen, comprising:

providing (i) a display, (ii) a plurality of collimating lenses along two opposite edges of the display, (iii) a plurality of light pulse emitters, denoted *E*, that transmit light pulses through the collimating lenses of a first of the two edges and over the display, and (iv) a plurality of light pulse receivers, denoted *R*, that receive the light pulses through the collimating lenses of the opposite of the two edges, and that output values, denoted *OUT(E, R)*, representing the light pulses received by receiver *R* from emitter *E*, wherein each emitter-receiver pair *(E, R)* has an expected receiver output value, denoted *EXP(E, R)*, when light pulses are not blocked, and wherein the collimating lenses are arranged in a shift-aligned fashion such that (a) light pulses emitted by each emitter are detected by at least two of the receivers, and (b) each receiver detects light pulses emitted by at least two emitters;

selecting two or more emitter-receiver pairs (E_1, R_1), ..., (E_n, R_n) for which their actual receiver output values, $OUT(E_1, R_1)$, ..., $OUT(E_n, R_n)$, deviate significantly from their expected receiver output values, $EXP(E_1, R_1)$, ..., $EXP(E_n, R_n)$, because either (A) light pulses transmitted by

each of two emitters are being blocked from reaching a common receiver, or (B) light pulses transmitted by a common emitter are being blocked from reaching each of two receivers;

associating respective screen coordinates, denoted $X(E_1, R_1)$, ..., $X(E_n, R_n)$, along a first screen axis with the selected emitter-receiver pairs; and

calculating a touch coordinate, denoted XT, by interpolating the associated screen coordinates

$$XT = \Sigma W_i * X(E_i, R_i)$$

with weights W_i according to the respective deviations, $OUT(E_i, R_i) - EXP(E_i, R_i)$, between the actual receiver output values and the expected receiver output values.

19. The method of claim 18, comprising further providing (v) a second plurality of collimating lenses along the other two opposite edges of the display, (vi) a second plurality of light pulse emitters, denoted *EE*, that transmit light pulses through the collimating lenses of a first of the other edges over the display, and (vii) a second plurality of light pulse receivers, denoted *RR*, that receive the light pulses through the collimating lenses of the opposite of the other edges, wherein light pulses emitted by each emitter are detected by at least two of the receivers, wherein the second collimating lenses are arranged in a shift-aligned fashion such that (a) light pulses emitted by each emitter *EE* are detected by at least two of the receivers *RR*, and (b) each receiver *RR* detects light pulses emitted by at least two emitters *EE*;

further selecting emitter-receiver pairs *(EE, RR)*, for which their actual receiver output values significantly deviate from their expected receiver output values;

calculating another touch coordinate, denoted *YT*, along a second screen axis [[with]] from the further selected emitter-receiver pairs; and

updating each screen coordinate $X(E_i, R_i)$ according to the intersection of a line connecting the emitter-receiver pair (E_i, R_i) with the line at coordinate *YT* with respect to the second screen axis.

20. The method of claim 18 wherein said selecting emitter-receiver pairs comprises selecting three emitter-receiver pairs from two emitters and two receivers.

21. The method of claim 20 wherein said selecting emitter-receiver pairs comprises:

identifying an emitter-receiver pair, for which its actual receiver output value deviates from its expected receiver output value by more than the amounts by which actual receiver output values for other emitter-receiver pairs deviate from their expected receiver output values; and

further identifying an emitter-receiver pair adjacent on one side to the thus-identified emitter-receiver pair, and an emitter-receiver pair adjacent on another side to the thus-identified emitter-receiver pair, wherein adjacent emitter-receiver pairs are pairs that have a common emitter and adjacent receivers, or pairs that have a common receiver and adjacent emitters.

22. The method of claim 18 wherein said calculating further comprises:

providing a reference touch coordinate, denoted *XRT*; and

computing a temporally filtered touch coordinate, based on *XT* and *XRT*.

23. The method of claim 22 further comprising updating the reference touch coordinate *XRT* with either (i) the temporally filtered touch coordinate, or (ii) a combination of the temporally filtered touch coordinate and the reference touch coordinate.

24. A method of disambiguating unpaired *x*- and *y*- coordinate values detected by a touch screen system in response to two simultaneous touches, comprising:

providing (i) a display, (ii) a plurality of light pulse emitters that transmit light pulses over the display, and (iii) a plurality of light pulse receivers that receive the light pulses, and that output values representing the received light pulses, wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked;

detecting two different x-coordinates corresponding to two simultaneous touches, based on significant deviations between actual receiver output values for receiver-emitter pairs and corresponding expected receiver output values;

separately detecting two different y-coordinates corresponding to the two simultaneous touches;

determining which one of the two x-coordinates is associated with a touch that is nearer to an edge of the display, based on the deviations corresponding to the x-coordinates; and

pairing the thus-determined x-coordinate with the y-coordinate that is closer to that one edge.

25. The method of claim 24 wherein said determining is based on a comparison of relative deviations.

26. The method of claim 24 wherein said determining is based on a comparison of absolute deviations.

27. The method of claim 24 wherein said determining is based on patterns of emitter-receiver pairs that indicate a touch for each coordinate.

28. A method of discriminating clockwise gestures from counter-clockwise gestures in a touch screen system, comprising:

providing (i) a display, (ii) a plurality of light pulse emitters that transmit light pulses over the display, and (iii) a plurality of light pulse receivers that receive the light pulses, and that output values representing the received light pulses, wherein each receiver has expected values for emitter-receiver pairs when the light pulses are not blocked;

performing a series of touch detections over time at times $t_1, \ldots, t_n$, each touch detection at a given time t detecting two different x-coordinates, $x_1(t)$ and $x_2(t)$, corresponding to two touches, and separately detecting two different y-coordinates, $y_1(t)$ and $y_2(t)$, corresponding to the two

touches, the touch detections being based on significant deviations between actual receiver output values for receiver-emitter pairs and corresponding expected receiver output values;

determining which of the two series of detected x-coordinates, $(x_1(t_1), \ldots, x_1(t_n))$ and $(x_2(t_1), \ldots, x_2(t_n))$, is associated with a touch approaching a display edge, by comparing the deviations corresponding to neighboring *x*-coordinates; and

discriminating a gesture as being clockwise or counter-clockwise by pairing the thus-determined series of the *x*-coordinates with that one of the series of detected *y*-coordinates, $(y_1(t_1), \ldots, y_1(t_n))$ and $(y_2(t_1), \ldots, y_2(t_n))$, that is also approaching that display edge.

29. The method of claim 28 wherein said determining is based on a comparison of relative deviations over time.

30. The method of claim 28 wherein said determining is based on a comparison of absolute deviations over time.

31. The method of claim 28 wherein said determining is based on patterns of emitter-receiver pairs that indicate a touch over time.

32. A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing and arranged along a first edge of said display;

a plurality of light pulse emitters mounted in said housing that are spaced apart from and serially transmit light pulses through said collimating lenses over said display;

an elongated light guide mounted in said housing near the edge of said display opposite the first edge, comprising:

an outer surface portion for receiving the light pulses transmitted over said display by all of said light pulse emitters; and

a scatterer strip that scatters light pulses that enter the light guide from said outer surface portion, to reach one end of the light guide;

a reflective strip that reflects light pulses transmitted over said display by said light pulse emitters to said outer surface portion;

a light pulse receiver mounted in said housing near the one end of said light guide, for receiving the light pulses scattered by said scatterer strip; and

a calculating unit, mounted in said housing and connected to said light pulse receiver, for determining a location of a pointer on said display that partially blocks light pulses transmitted by said emitters, based on outputs of said light pulse receiver.

33. The touch screen of claim 32, wherein said light guide further comprises a collimating lens for collimating light pulses that enter said light guide from said outer surface, onto said scatterer strip.

34. The touch screen of claim 32, wherein said scatterer strip scatters the light pulses that enter said light guide from said outer surface to reach both ends of said light guide, the touch screen further comprising a second light pulse receiver mounted in said housing near a second end of said light guide for receiving the light pulses scattered by said scatterer strip, and wherein said calculating unit is also connected to said second light pulse receiver and determines the location of the pointer on said display based on outputs of said first and second light pulse receivers.

35. The touch screen of claim 34, wherein said first and second light pulse receivers are activated serially.

36. The touch screen of claim 34, wherein said first and second light pulse receivers are activated in parallel.

37. A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing along a first edge of said display;

a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses;

an elongated light guide mounted in said housing near the edge of said display opposite the first edge, the light guide comprising:

an outer surface portion; and

a scatterer strip that scatters light such that light pulses that enter the light guide from one end of the light guide, exit the light guide through said outer surface portion;

a reflective strip that reflects light pulses that exit said light guide through said outer surface portion, over said display to all of said light pulse receivers;

a light pulse emitter mounted in said housing near the one end of said light guide, for transmitting light pulses into said light guide; and

a calculating unit, mounted in said housing and connected to said light pulse receivers, for determining a location of a pointer on said display that partially blocks the light pulses reflected by said reflective strip, based on outputs of said light pulse receivers.

38. A touch screen comprising:

a housing;

a display mounted in said housing;

a plurality of collimating lenses mounted in said housing along a first edge of said display;

a plurality of light pulse receivers mounted in said housing that are spaced apart from and receive light pulses through said collimating lenses;

an elongated light guide mounted in said housing near the edge of said display opposite the first edge, the light guide comprising:

an outer surface portion; and

a scatterer strip that scatters light such that light pulses that enter the light guide from either end of the light guide, exit the light guide through said outer surface portion;

a reflective strip that reflects light pulses that exit the light guide through said outer surface portion, over said display to all of said light pulse receivers;

a plurality of light pulse emitters mounted in said housing near each end of said light guide, for transmitting light pulses into said light guide; and

a calculating unit, mounted in said housing and connected to said receivers, for determining a location of a pointer on said display that partially blocks the light pulses reflected by said reflective strip, based on outputs of said light pulse receivers.

39. The touch screen of claim 38, wherein said light pulse emitters are activated serially.

40. The touch screen of claim 39, wherein said calculating unit computes deviations between an actual output value from each said light pulse receiver and first and second expected output values for that light pulse receiver when light pulses are not blocked, and wherein the first expected output value corresponds to the light pulse emitter at a first end of said light guide being activated, and the second expected output value corresponds to the light pulse emitter at the other end of said light guide being activated.

41. The touch screen of claim 40, wherein the first and second expected output values for at least one of said light pulse receivers are different.

42. The touch screen of claim 38, wherein said light pulse receivers are activated in parallel.

43. The touch screen of claim 38, wherein said light pulse receivers are activated serially and in parallel.

44. The touch screen of claim 38, wherein said light guide further comprises a collimating lens for collimating the light pulses scattered by said scattering strip and exiting said light guide through said outer surface portion.

45. The touch screen of claim 1, wherein said emitters are spaced apart from said first plurality of lenses.

46. The touch screen of claim 1, wherein said receivers are spaced apart from said second plurality of lenses.

47. The touch screen of claim 1, further comprising a controller, mounted in said housing and connected to said plurality of emitters, for activating said emitters individually one at a time.

48. The touch screen of claim 1, wherein each wide light pulse emitted by an emitter comprises a light intensity distribution with intensity varying in accordance with distance from such emitter.

49. The touch screen of claim 1, wherein said calculating unit assigns coordinates corresponding to each of the overlapping wide light pulses based on an estimated coordinate, along a second dimension, of the location of the pointer.

50. The touch screen of claim 1, wherein said calculating unit calculates the coordinate, along the first dimension, of the location of the pointer by temporally filtering a plurality of the weighted averages over time.

51. The touch screen of claim 1, wherein said calculating unit temporally filters the plurality of weighted averages based on at least one of: a velocity of the pointer, a scanning frequency, whether the pointer is moving in a straight line or not, and a size of the pointer.

52. A touch screen comprising:

a housing;

a display mounted in said housing;

a first plurality of lenses mounted in said housing along a common edge of said display;

a plurality of light pulse emitters mounted in said housing that emit wide light pulses through said first plurality of lenses over said display;

a second plurality of lenses mounted in said housing and arranged so as to be shift-aligned relative to said first plurality of lenses, such that wide light pulses transmitted through one of said first plurality of lenses enter *N* neighboring ones of the second plurality of lenses, where *N* is a number at least two;

a plurality of light pulse receivers mounted in said housing that receive the wide light pulses transmitted through said second plurality of lenses, and output received light intensities in accordance with the portions of the wide light pulses that they receive; and

a calculating unit, mounted in said housing and connected to said receivers, that calculates a coordinate, along a first dimension, of a location of a pointer touching said display that partially blocks a wide light pulse transmitted through one of said first plurality of lenses from

entering at least two neighboring ones of said second plurality of lenses, by assigning coordinates corresponding to portions of the wide light pulse that enter the neighboring ones of said second plurality of lenses, and by calculating a weighted average of the assigned coordinates, wherein each coordinate's weight in the average is non-zero and corresponds to a degree of blockage of its corresponding portion of the wide light pulse.

53. The touch screen of claim 52 further comprising a light guide for guiding light pulses, the light guide comprising micro-lenses for multi-directional collimation of light pulses, and wherein said first and second pluralities of lenses comprise a portion of said light guide.

54. The touch screen of claim 52, wherein said calculating unit determines the degree of blockage of each corresponding portion from a separately activated wide light pulse that enters the at least two neighboring ones of said second plurality of lenses.

55. The touch screen of claim 52, wherein the portions of the wide light pulse that enter the second plurality of lenses comprise different light intensity distributions, with intensity varying in accordance with distance from an emitter of the wide light pulse.

56. The touch screen of claim 52, wherein said calculating unit assigns coordinates corresponding to portions of the wide light pulse that enter the neighboring ones of said second plurality of lenses based on an estimated coordinate, along a second dimension, of the location of the pointer.

57. The touch screen of claim 52, wherein said calculating unit calculates the coordinate, along the first dimension, of the location of the pointer by temporally filtering a plurality of the weighted averages over time.

58. The touch screen of claim 57, wherein said calculating unit temporally filters the plurality of weighted averages based on at least one of: a velocity of the pointer, a scanning frequency, whether the pointer is moving in a straight line or not, and a size of the pointer.