(19) **United States**

(12) **Patent Application Publication** (10) Pub. No.: **US 2025/0258280 A1**

Wilkerson et al. (43) **Pub. Date:** **Aug. 14, 2025**

(54) **LIDAR SYSTEMS FOR NEAR-FIELD AND FAR-FIELD DETECTION, AND RELATED METHODS AND APPARATUS**

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(57) **ABSTRACT**

A light detection and ranging (LiDAR) method may include generating, by a first transmitter, a first light illumination signal; generating, by a second transmitter, a second light illumination signal; receiving first return signals corresponding to the first light illumination signal; receiving second return signals corresponding to the second light illumination signal; and sampling the first return signals or the second return signals during a short-range sampling period, such that the short-range sampling period avoids a period of dazzle.

100

FIG. 1

LONG RANGE

MEDIUM RANGE

210

206

208

204

203

205

202

Last Return

Strongest Return

FIG. 2A

FIG. 2B

300

112

Emitted Light Signal
110

Return Light Signal
114

312

310

314

| (First)
Transmitter 104 | (Second)
Transmitter 304 | Receiver
106 |

Control & Data
Acquisition 108

302

116

Data Analysis
& Interpretation

109

FIG. 3A

300

110

330

310

342

344

304

332

Optical Components

252

256

104

308

FIG. 3B

304

330

310

344

342

Diffuser 306

Emitter 302

FIG. 3C

400

FIG. 4

<u>500</u>

```
┌─────────────────────────────┐
│  Emit first illumination signal │
│             510              │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│   Detect first return signal(s)  │
│             520              │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│ Emit second illumination signal │
│             530              │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│  Detect second return signal(s)  │
│             540              │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│  Sample short-range return data  │
│             550              │
└─────────────────────────────┘
```

FIG. 5

FIG. 6A

FIG. 6B

Hybrid System Return

720

ADC Codes

300
250
200
150
100
50
0

FIG. 7B

0   200   400   600   800   1000   1200

Sample

FIG. 7A

725

700

710   715

FIG. 7B

Standard Return
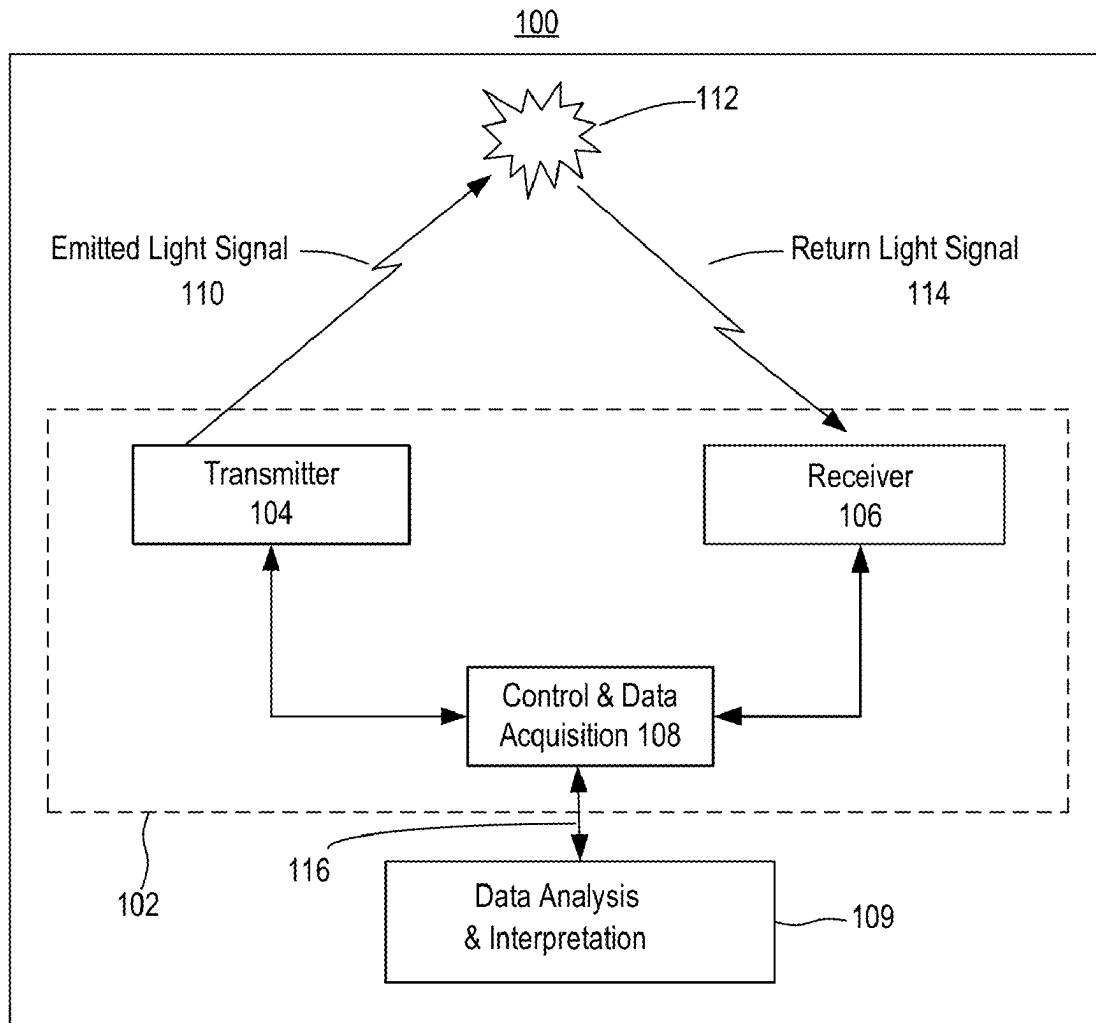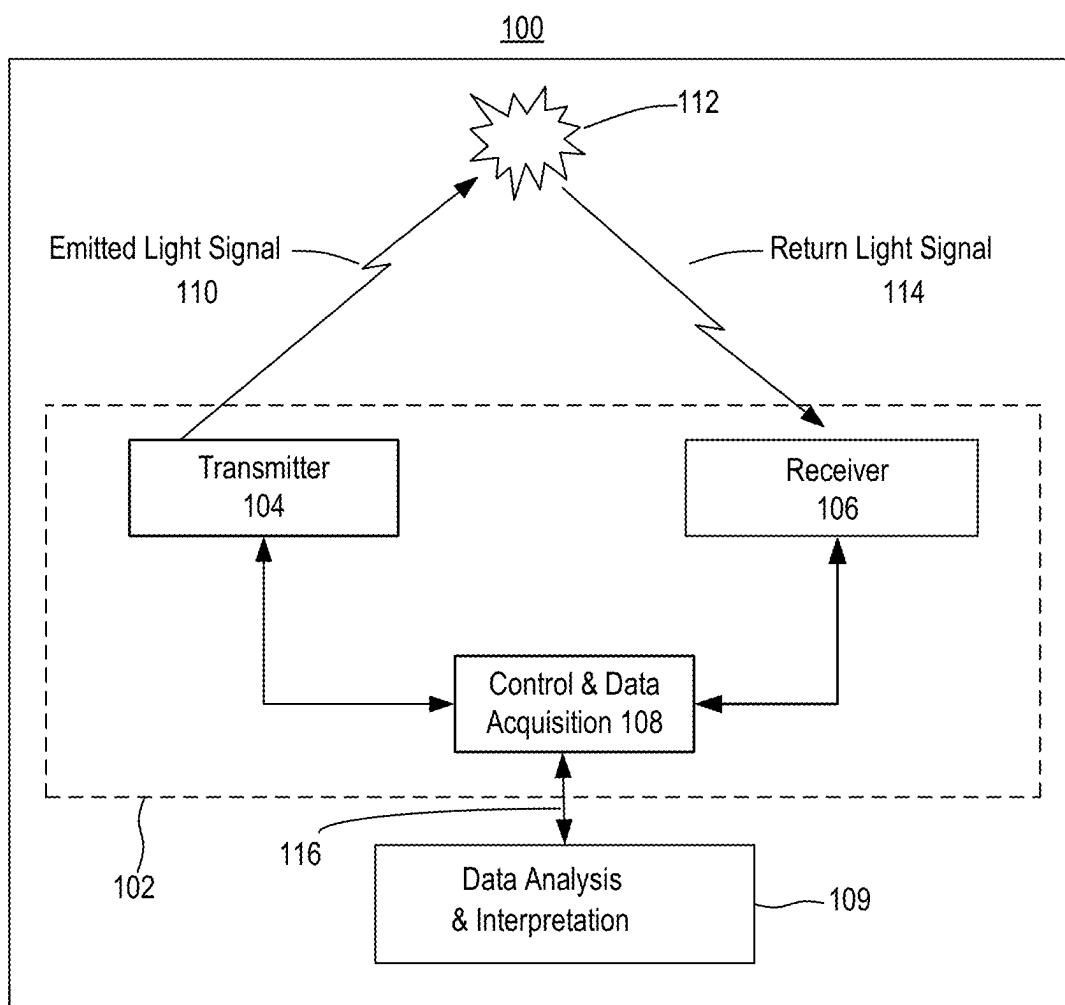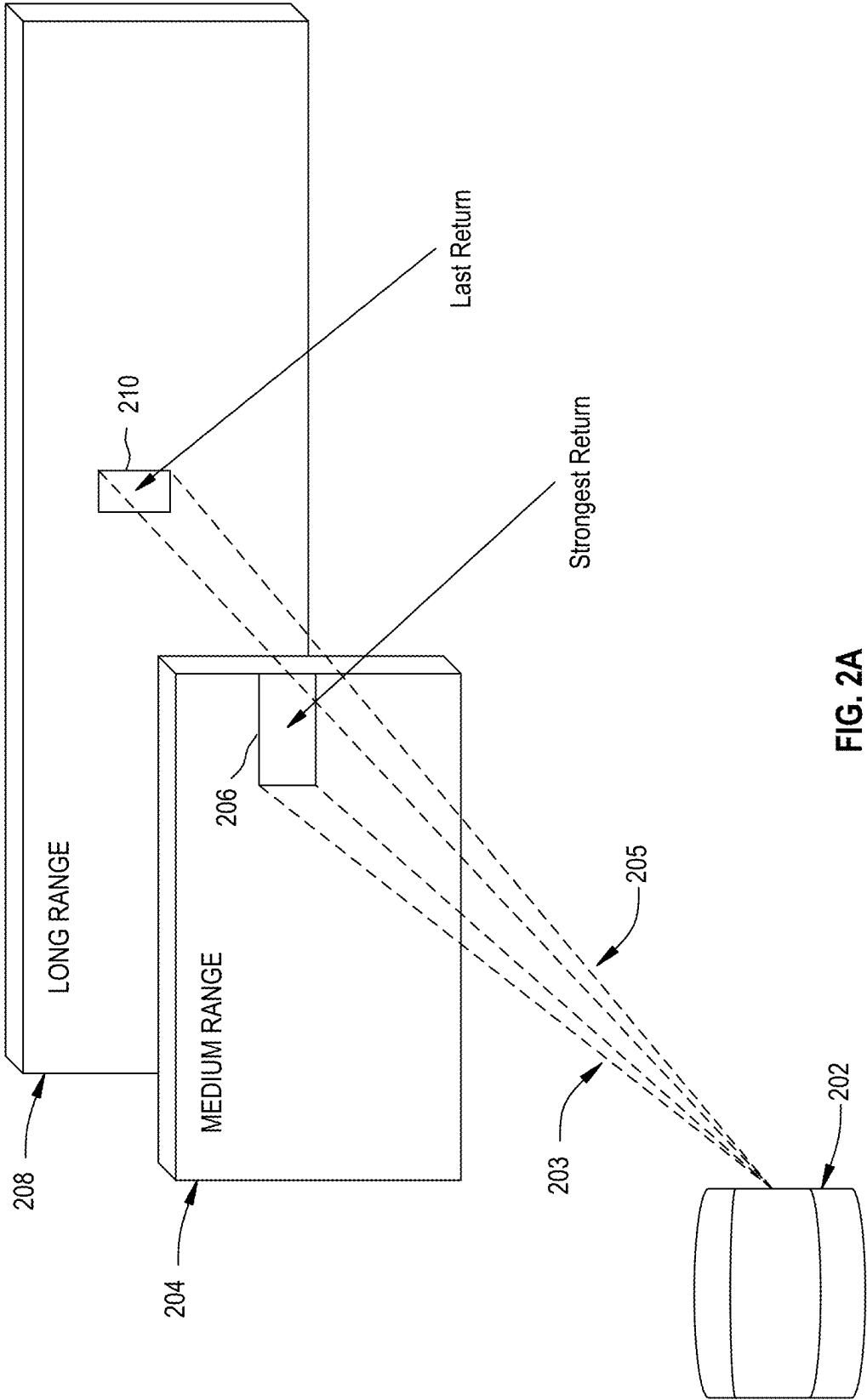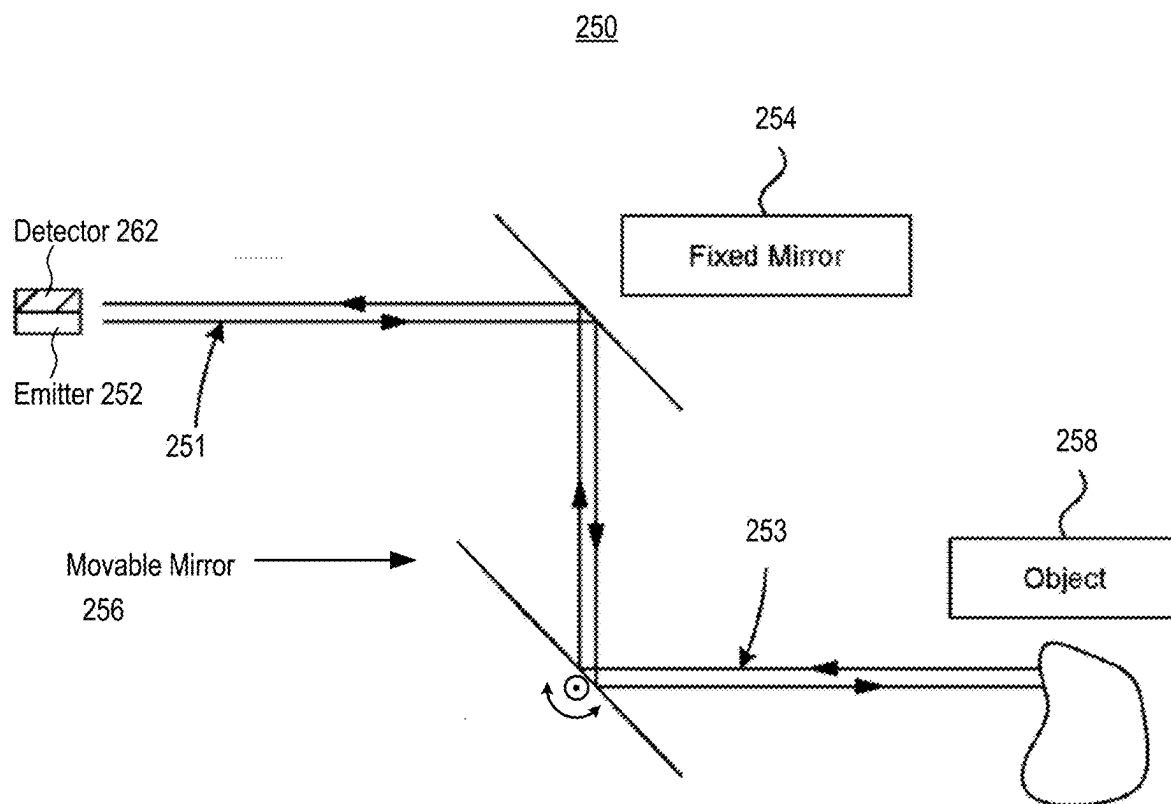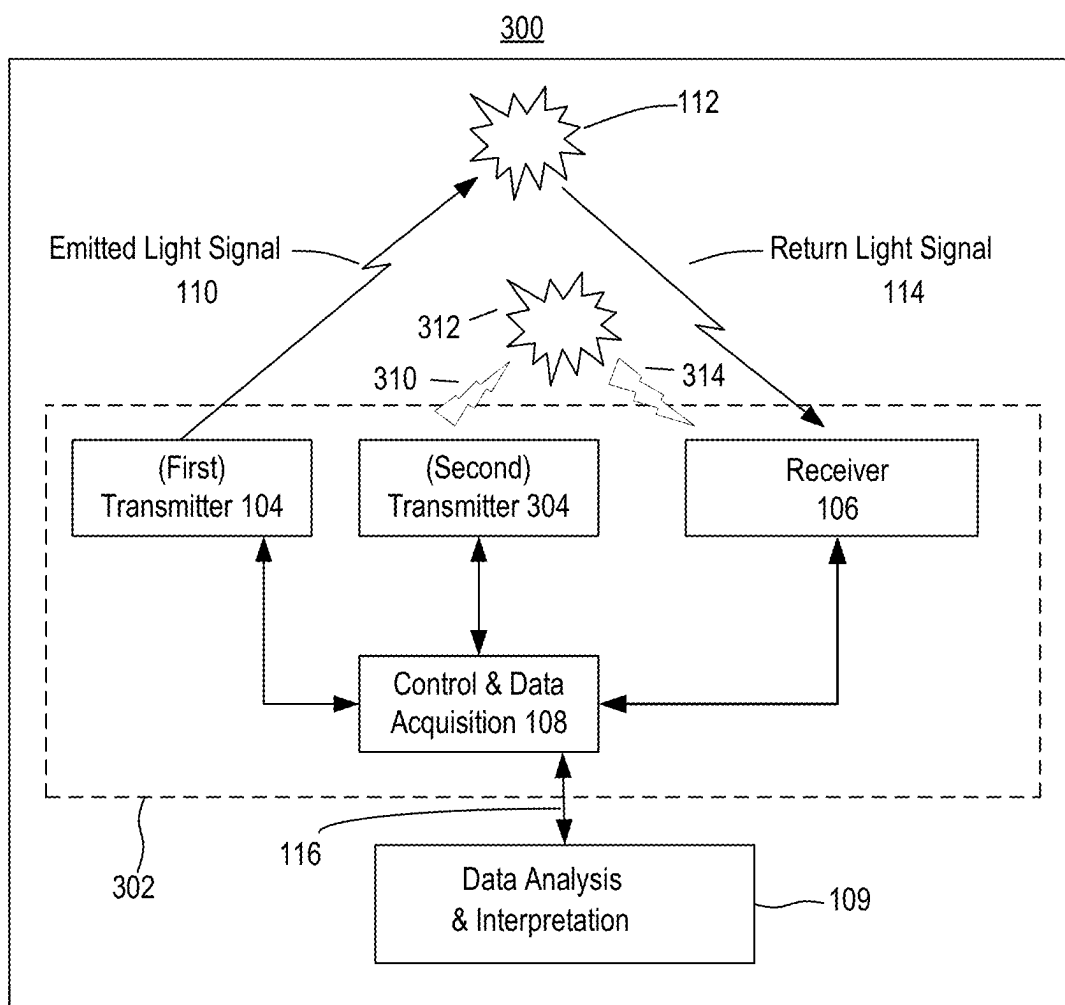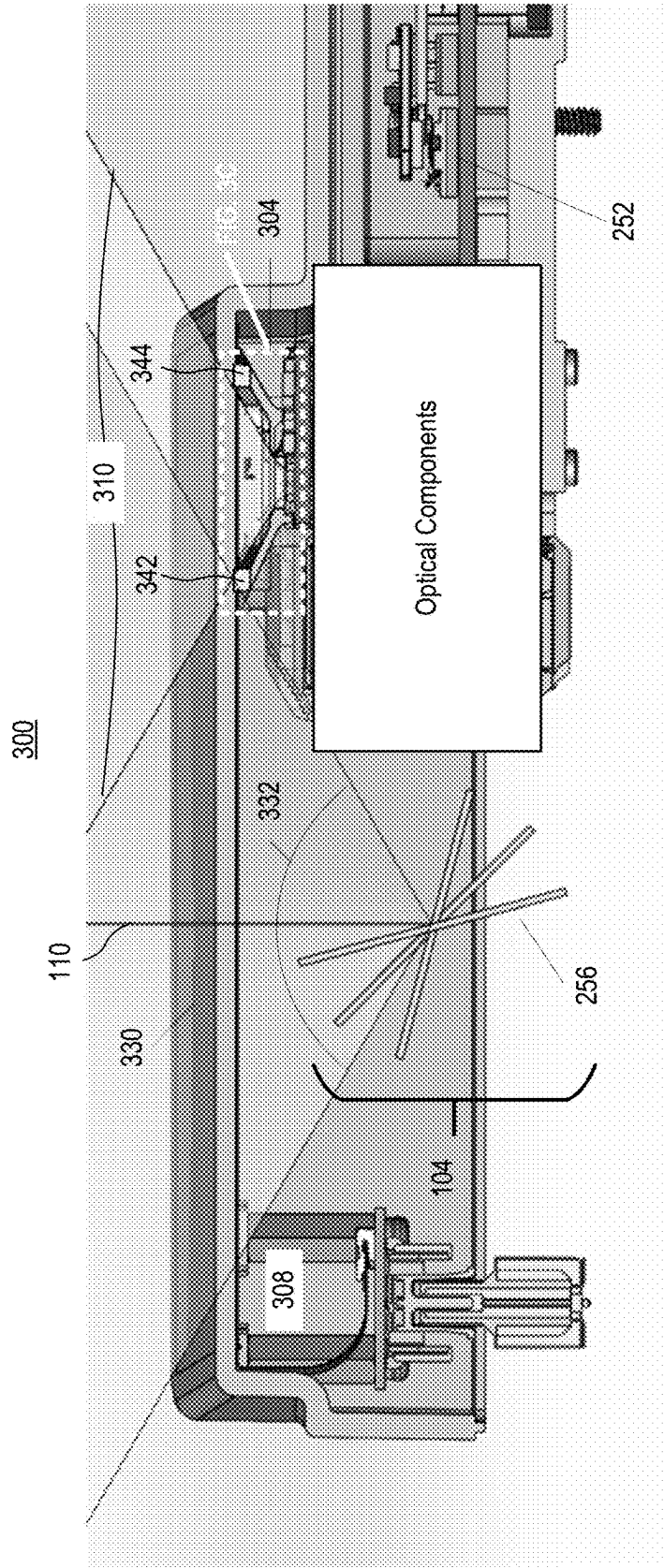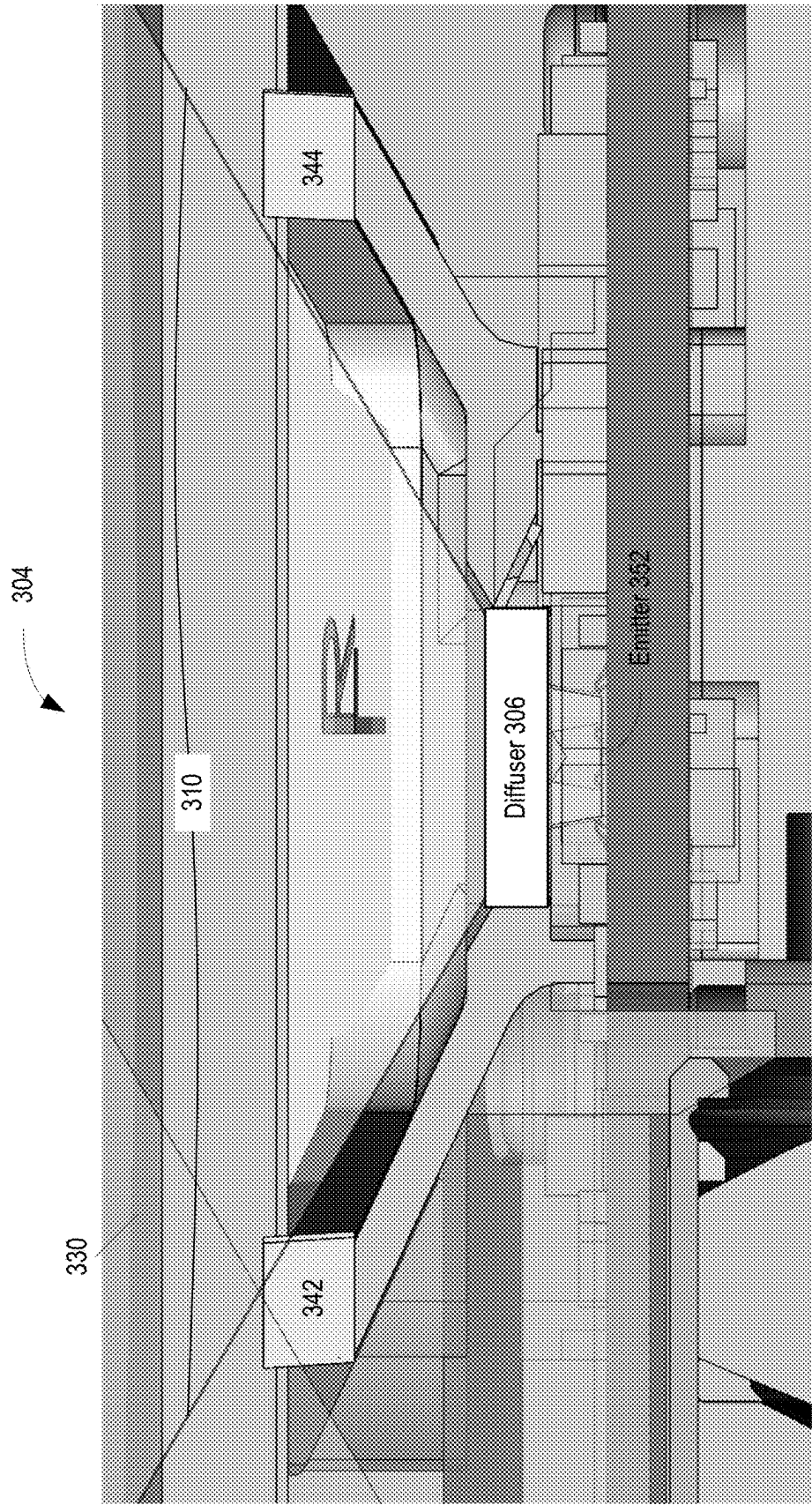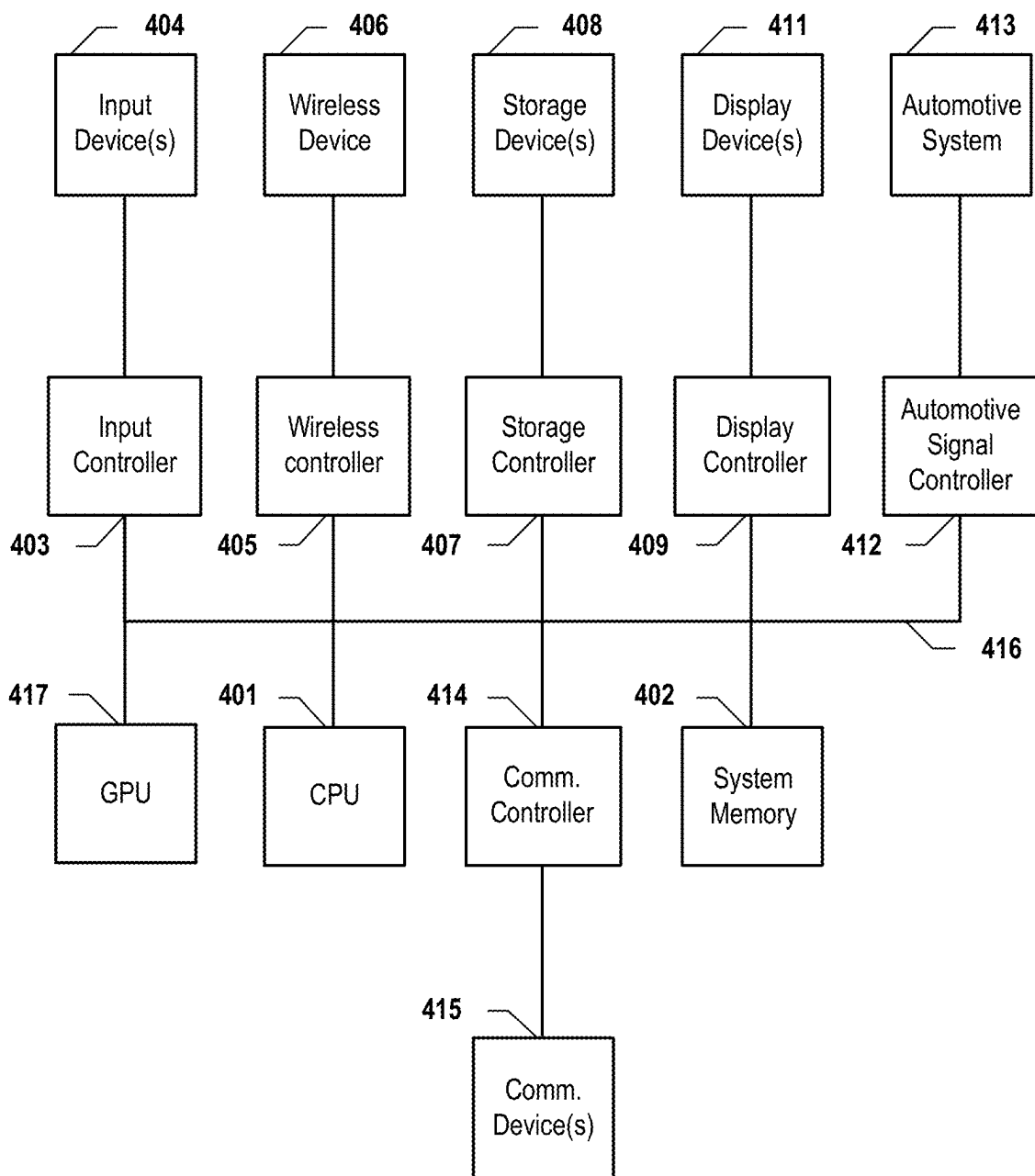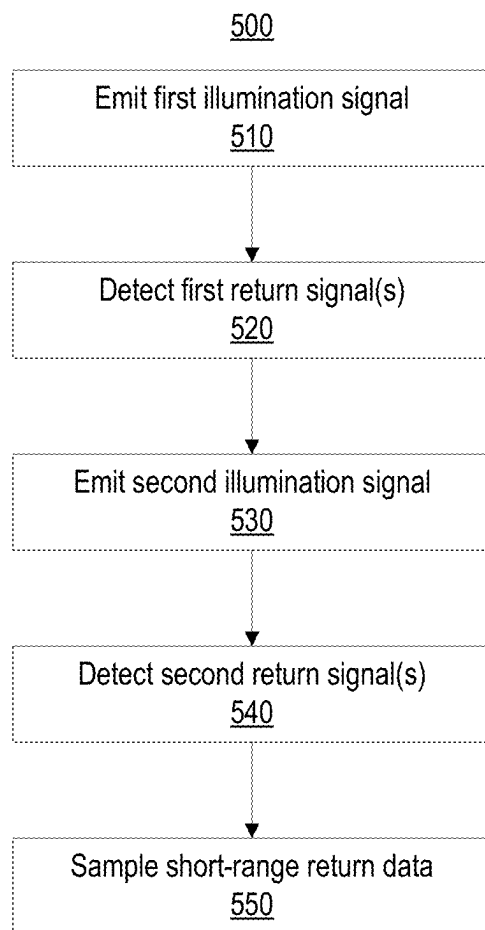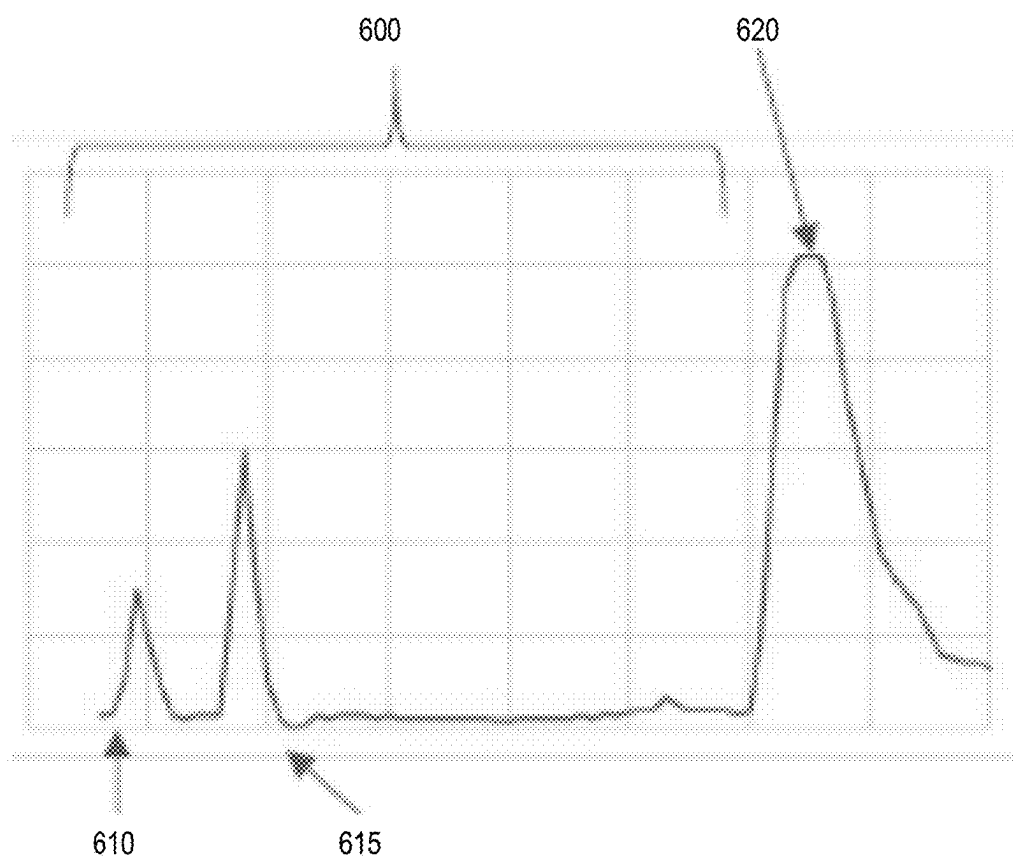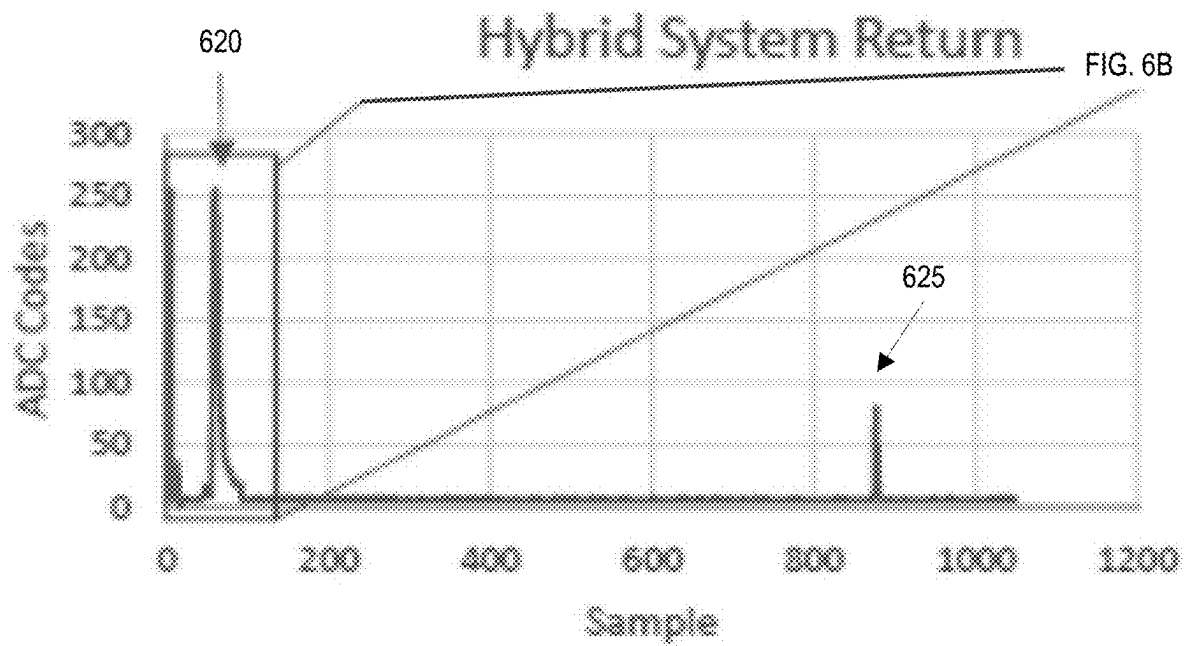
FIG. 8
(PRIOR ART)

LIDAR SYSTEMS FOR NEAR-FIELD AND FAR-FIELD DETECTION, AND RELATED METHODS AND APPARATUS

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. application Ser. No. 17/306,885, filed May 3, 2021, the disclosure of which is incorporated by reference herein.

FIELD OF TECHNOLOGY

[0002] The present disclosure relates generally to light detection and ranging ("LiDAR") technology and, more specifically, to LiDAR systems for detecting objects in both the near and far fields.

BACKGROUND

[0003] Light detection and ranging ("LiDAR") systems measure the attributes of their surrounding environments (e.g., shape of a target, contour of a target, distance to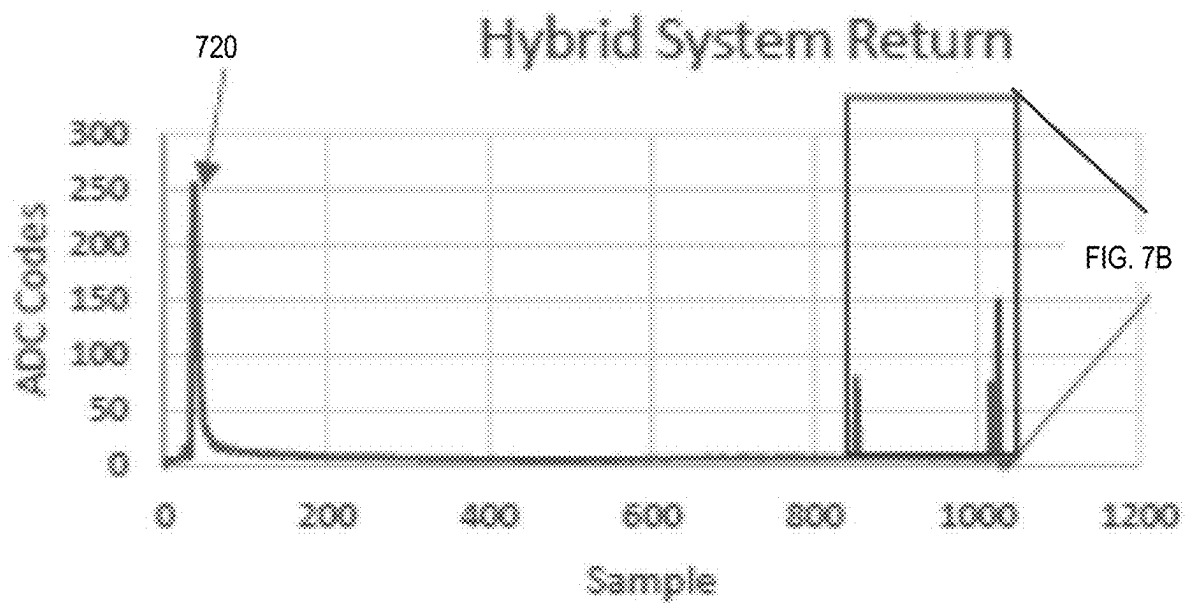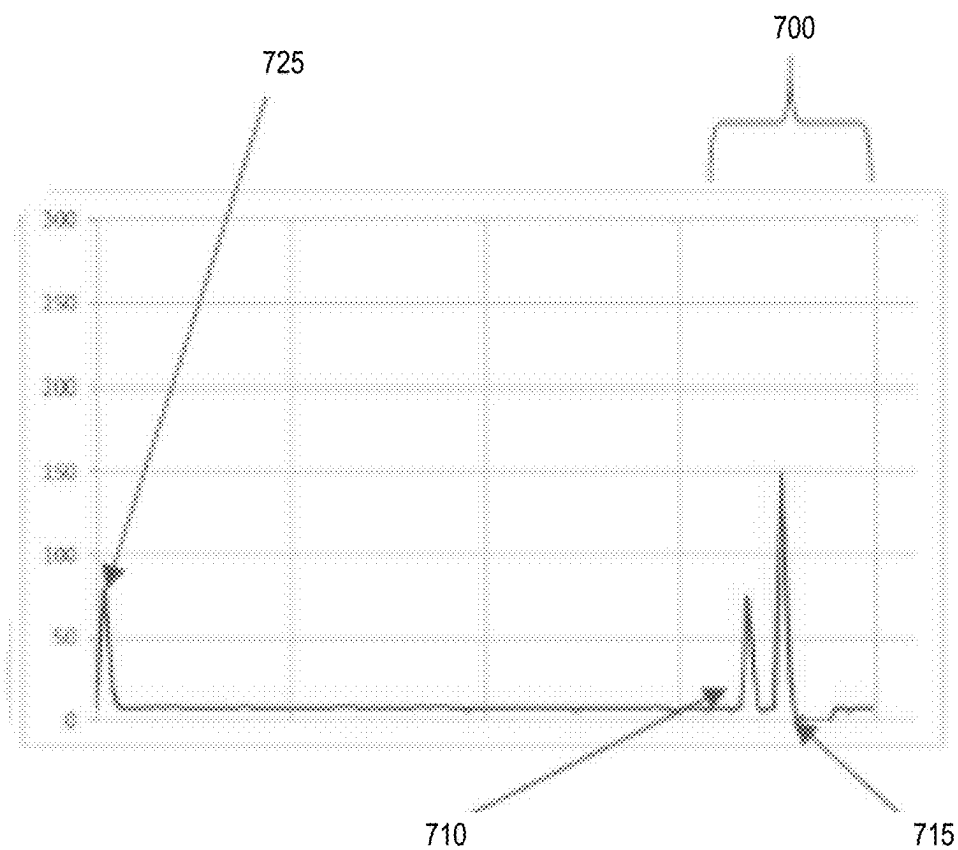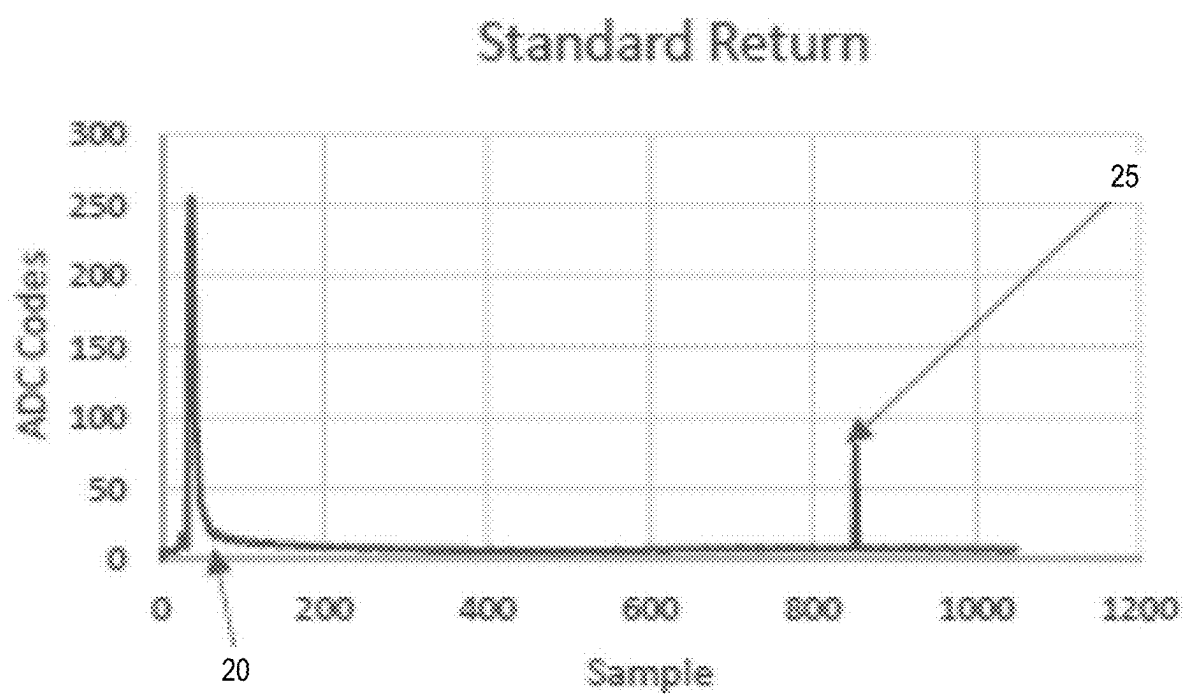 a target, etc.) by illuminating the target with pulsed laser light and measuring the reflected pulses with sensors. Differences in laser return times and wavelengths can then be used to make digital, three-dimensional ("3D") representations of a surrounding environment. LiDAR technology may be used in various applications including autonomous vehicles, advanced driver assistance systems, mapping, security, surveying, robotics, geology and soil science, agriculture, unmanned aerial vehicles, airborne obstacle detection (e.g., obstacle detection systems for aircraft), and so forth. Depending on the application and associated field of view (FOV), multiple channels or laser beams may be used to produce images in a desired resolution. A LiDAR system with greater numbers of channels can generally generate larger numbers of pixels.

[0004] In a conventional multi-channel LiDAR device, optical transmitters are paired with optical receivers to form multiple "channels." In operation, each channel's transmitter emits an optical (e.g., laser) illumination signal into the device's environment and each channel's receiver detects the portion of the return signal that is reflected back to the receiver by the surrounding environment. In this way, each channel provides "point" measurements of the environment, which can be aggregated with the point measurements provided by the other channel(s) to form a "point cloud" of measurements of the environment.

[0005] Advantageously, the measurements collected by any LiDAR channel may be used, inter alia, to determine the distance (i.e., "range") from the device to the surface in the environment that reflected the channel's transmitted optical signal back to the channel's receiver. The range to a surface may be determined based on the time of flight (TOF) of the channel's signal (e.g., the time elapsed from the transmitter's emission of the optical (e.g., illumination) signal to the receiver's reception of the return signal reflected by the surface).

[0006] In some instances, LiDAR measurements may also be used to determine the reflectance of the surface that reflects an optical (e.g., illumination) signal. The reflectance of a surface may be determined based on the intensity on the return signal, which generally depends not only on the reflectance of the surface but also on the range to the surface, the emitted signal's glancing angle with respect to the surface, the power level of the channel's transmitter, the alignment of the channel's transmitter and receiver, and other factors.

SUMMARY

[0007] Disclosed herein are LiDAR systems for near-field and far-field detection, and related methods and apparatus. In a first aspect, a light detection and ranging (LiDAR) method for near-field detection includes generating, by a first transmitter, a first light illumination signal; generating, by a second transmitter, a second light illumination signal; receiving first return signals corresponding to the first light illumination signal; receiving second return signals corresponding to the second light illumination signal; and sampling the first return signals or the second return signals during a short-range sampling period, such that the short-range sampling period avoids a period of dazzle. In some applications, the short-range sampling period occurs before the dazzle signal is received, whereas, in other applications, the short-range sampling period occurs after a last return of the first return signals. Advantageously, each of the first return signal and the second return signal may be received by a common channel signal detector. Optionally, the method may also include diffusing, using a diffuser, at least one of the first light signal and the second light signal.

[0008] In a second aspect, a light detection and ranging (LiDAR) system includes a first transmitter, a second transmitter, and a receiver. In some embodiments, the first transmitter is adapted to generate and emit a first light illumination signal towards a medium-range scan area and/or a long-range scan area, and the receiver is adapted to detect and receive first return signals corresponding to the first light illumination signal; the second transmitter is adapted to generate and emit a second light illumination signal towards at least one object in a short-range scan area within a near field, wherein the receiver is further adapted to receive second return signals corresponding to the second light illumination signal.

[0009] The above and other preferred features, including various novel details of implementation and combination of events, will now be more particularly described with reference to the accompanying figures and pointed out in the claims. It will be understood that the particular systems and methods described herein are shown by way of illustration only and not as limitations. As will be understood by those skilled in the art, the principles and features described herein may be employed in various and numerous embodiments without departing from the scope of any of the present inventions. As can be appreciated from foregoing and following description, each and every feature described herein, and each and every combination of two or more such features, is included within the scope of the present disclosure provided that the features included in such a combination are not mutually inconsistent. In addition, any feature or combination of features may be specifically excluded from any embodiment of any of the present inventions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying figures, which are included as part of the present specification, illustrate the presently preferred embodiments and together with the general description given above and the detailed description of the

preferred embodiments given below serve to explain and teach the principles described herein.

[0011] FIG. 1 shows an illustration of an exemplary LiDAR system, in accordance with some embodiments.

[0012] FIG. 2A shows an illustration of the operation of the LiDAR system of FIG. 1, in accordance with some embodiments.

[0013] FIG. 2B shows an illustration of optical components of a channel of a LiDAR system, in accordance with some embodiments.

[0014] FIG. 3A shows a block diagram of a hybrid LiDAR system, in accordance with some embodiments.

[0015] FIG. 3B shows a cross-sectional view of a portion of a hybrid LiDAR system, in accordance with some embodiments.

[0016] FIG. 3C shows a cross-sectional view of a short-range LiDAR transmitter, in accordance with some embodiments.

[0017] FIG. 4 shows a block diagram of a computing device/information handling system, in accordance with some embodiments.

[0018] FIG. 5 shows a flow chart of a method of avoiding dazzle to detect (e.g., short-range) return signals of objects in a near field, in accordance with some embodiments.

[0019] FIGS. 6A and 6B show illustrative examples of received return signals during a short-range sampling period occurring before dazzle occurs, in accordance with some embodiments.

[0020] FIGS. 7A and 7B show illustrative examples of received return signals during a short-range sampling period occurring after receipt of the last (e.g., long-range) return signals, in accordance with some embodiments.

[0021] FIG. 8 shows the relationship between dazzle and received (e.g., imaging) signals in accordance with the prior art.

[0022] While the present disclosure is subject to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and will herein be described in detail. The present disclosure should not be understood to be limited to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure.

DETAILED DESCRIPTION

[0023] Systems and methods for LiDAR-based near-field and far-field detection are disclosed. It will be appreciated that, for simplicity and clarity of illustration, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the exemplary embodiments described herein. However, it will be understood by those of ordinary skill in the art that the exemplary embodiments described herein may be practiced without these specific details.

Motivation for and Benefits of Some Embodiments

[0024] Problematically, conventional LiDAR devices that are capable of medium- to long-range detection of objects in the far field are not capable of high-quality short-range detection of objects in the near field. Furthermore, during a brief time period occurring shortly after a conventional

LiDAR device transmits the ranging (e.g., illumination) signal, the LiDAR detector may be blinded by "dazzle." Dazzle refers to a phenomenon whereby the channel receiver detects (and is blinded by) portions of the transmitted ranging (e.g., illumination) signal that have not been reflected by objects external to the LiDAR device. In some instances, dazzle may be caused by one or more of: leakage of the transmitted ranging signal within or between channels, partial reflection of the transmitted signals by the window, blockage on the window through which the ranging (e.g., illumination) signals are meant to be transmitted, back reflection of the ranging (e.g., illumination) signals by a lens or other optical device, and the like. Disadvantageously, conventional LiDAR devices are unable to discern return signals reflected back to the channel receivers from short-range objects located in the near field (e.g., objects within a few meters (1-2 meters)) due to the presence of dazzle.

[0025] Referring to FIG. 8, the relationship between the received dazzle 20 and a return signal 25 reflected by an object in the near field is shown. Disadvantageously, the dazzle 20 typically occurs concurrently as shorter-range return signals arrive at the LiDAR detectors, essentially blinding them, preventing the LiDAR detectors from detecting the return signals.

[0026] Accordingly, it would be desirable to provide a (e.g., solid-state) LiDAR system that is structured and arranged to provide short-range detection of objects in the near field and, moreover to provide short-, medium-, and long-range detection data concurrently.

Terminology

[0027] Measurements, sizes, amounts, and the like may be presented herein in a range format. The description in range format is provided merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as 1-20 meters should be considered to have specifically disclosed subranges such as 1 meter, 2 meters, 1-2 meters, less than 2 meters, 10-11 meters, 10-12 meters, 10-13 meters, 10-14 meters, 11-12 meters, 11-13 meters, etc.

[0028] Furthermore, connections between components or systems within the figures are not intended to be limited to direct connections. Rather, data or signals between these components may be modified, re-formatted, or otherwise changed by intermediary components. Also, additional or fewer connections may be used. The terms "coupled," "connected," or "communicatively coupled" shall be understood to include direct connections, indirect connections through one or more intermediary devices, wireless connections, and so forth.

[0029] Reference in the specification to "one embodiment," "preferred embodiment," "an embodiment," "some embodiments," or "embodiments" means that a particular feature, structure, characteristic, or function described in connection with the embodiment is included in at least one embodiment of the invention and may be in more than one embodiment. Also, the appearance of the above-noted phrases in various places in the specification is not necessarily referring to the same embodiment or embodiments.

[0030] The use of certain terms in various places in the specification is for illustration purposes only and should not

be construed as limiting. A service, function, or resource is not limited to a single service, function, or resource; usage of these terms may refer to a grouping of related services, functions, or resources, which may be distributed or aggregated.

[0031] Furthermore, one skilled in the art shall recognize that: (1) certain steps may optionally be performed; (2) steps may not be limited to the specific order set forth herein; (3) certain steps may be performed in different orders; and (4) certain steps may be performed simultaneously or concurrently.

[0032] The term "approximately", the phrase "approximately equal to", and other similar phrases, as used in the specification and the claims (e.g., "X has a value of approximately Y" or "X is approximately equal to Y"), should be understood to mean that one value (X) is within a predetermined range of another value (Y). The predetermined range may be plus or minus 20%, 10%, 5%, 3%, 1%, 0.1%, or less than 0.1%, unless otherwise indicated.

[0033] The indefinite articles "a" and "an," as used in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one." The phrase "and/or," as used in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with "and/or" should be construed in the same fashion, i.e., "one or more" of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to "A and/or B", when used in conjunction with open-ended language such as "comprising" can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements).

[0034] As used in the specification and in the claims, "or" should be understood to have the same meaning as "and/or" as defined above. For example, when separating items in a list, "or" or "and/or" shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as "only one of" or "exactly one of," or, when used in the claims, "consisting of," will refer to the inclusion of exactly one element of a number or list of elements. In general, the term "or" as used shall only be interpreted as indicating exclusive alternatives (i.e. "one or the other but not both") when preceded by terms of exclusivity, such as "either," "one of," "only one of," or "exactly one of." "Consisting essentially of," when used in the claims, shall have its ordinary meaning as used in the field of patent law.

[0035] As used in the specification and in the claims, the phrase "at least one," in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifi-

cally identified within the list of elements to which the phrase "at least one" refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements).

[0036] The use of "including," "comprising," "having," "containing," "involving," and variations thereof, is meant to encompass the items listed thereafter and additional items.

[0037] Use of ordinal terms such as "first," "second," "third," etc., in the claims to modify a claim element does not by itself connote any priority, precedence, or order of one claim element over another or the temporal order in which acts of a method are performed. Ordinal terms are used merely as labels to distinguish one claim element having a certain name from another element having a same name (but for use of the ordinal term), to distinguish the claim elements.

Exemplary LiDAR Systems

[0038] A light detection and ranging ("LiDAR") system may be used to measure the shape and contour of the environment surrounding the system. LiDAR systems may be applied to numerous applications including autonomous navigation and aerial mapping of surfaces. In general, a LiDAR system emits (e.g., illumination) light (e.g., laser) pulses that are subsequently reflected by objects within the environment in which the system operates. The time each pulse travels from being emitted to being received (i.e., time-of-flight) may be measured to determine the distance between the LiDAR system and the object that reflects the pulse. The science of LiDAR systems is based on the physics of light and optics.

[0039] In a LiDAR system, (e.g., illumination) light may be emitted from a rapidly firing laser. Laser (e.g., illumination) light travels through a medium and reflects off points of surfaces in the environment (e.g., surfaces of buildings, tree branches, vehicles, etc.). The reflected light energy returns to a LiDAR detector where it may be recorded and used to map the environment.

[0040] FIG. 1 depicts the operation of the medium- and long-range portion of an exemplary LiDAR system 100, according to some embodiments. In the example of FIG. 1, the LiDAR system 100 includes a LiDAR device 102, which may include a transmitter 104 that is configured to generate and transmit an emitted (e.g., illumination) light signal 110, a receiver 106 that is configured to detect a return light signal 114, and a control & data acquisition module 108. The transmitter 104 may include a light source (e.g., laser), electrical components operable to activate ("drive") and deactivate the light source in response to electrical control signals, and optical components adapted to shape and redirect the light emitted by the light source. The receiver 106 may include an optical detector (e.g., photodiode) and optical components adapted to shape return light signals 114

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and direct those signals to the detector. In some implementations, one or more of optical components (e.g., lenses, mirrors, etc.) may be shared by the transmitter and the receiver. The LiDAR device **102** may be referred to as a LIDAR transceiver or "channel." In operation, the emitted (e.g., illumination) light signal **110** propagates through a medium and reflects off an object(s) **112**, whereby a return light signal **114** propagates through the medium and is received by receiver **106**.

[0041] The control & data acquisition module **108** may be adapted to control the light emission by the transmitter **104** and may record data derived from the return light signal **114** detected by the receiver **106**. In some embodiments, the control & data acquisition module **108** is further adapted to control the power level at which the transmitter **104** operates when emitting (e.g., illumination) light. For example, the transmitter **104** may be configured to operate at a plurality of different power levels, and the control & data acquisition module **108** may select the power level at which the transmitter **104** operates at any given time. Any suitable technique may be used to control the power level at which the transmitter **104** operates. In some variations, the control & data acquisition module **108** may be adapted to determine (e.g., measure) particular characteristics of the return light signal **114** detected by the receiver **106**. For example, the control & data acquisition module **108** may be configured to measure the intensity of the return light signal **114** using any suitable technique.

[0042] A LIDAR transceiver **102** may include one or more optical lenses and/or mirrors (not shown) to transmit and shape the emitted (e.g., illumination) light signal **110** and/or to redirect and shape the return light signal **114**. For example, the transmitter **104** may emit a laser beam having a plurality of pulses in a particular sequence. Design elements of the receiver **106** may include its horizontal field of view (hereinafter, "FOV") and its vertical FOV. One skilled in the art will recognize that the FOV parameters effectively define the visibility region relating to the specific LiDAR transceiver **102**. More generally, the horizontal and vertical FOVs of a LiDAR system **100** may be defined by a single LiDAR device (e.g., sensor) or may relate to a plurality of configurable sensors (which may be exclusively LiDAR sensors or may have different types of sensors). The FOV may be considered a scanning area for a LiDAR system **100**. A scanning mirror may be utilized to obtain a scanned FOV.

[0043] In some implementations, the LiDAR system **100** may also include or may be electronically coupled to a data analysis & interpretation module **109**, which may be adapted to receive output (e.g., via connection **116**) from the control & data acquisition module **108** and, moreover, to perform data analysis functions on, for example, return signal data. The connection **116** may be implemented using a wireless or non-contact communication technique.

[0044] FIG. **2A** illustrates the operation of the medium- and long-range portion(s) of a LiDAR system **202**, in accordance with some embodiments. In the example of FIG. **2A**, two return light signals **203** and **205** are shown, corresponding to medium-range and long-range return signals. Laser beams generally tend to diverge as they travel through a medium. Due to the laser's beam divergence, a single (e.g., illumination) laser emission may hit multiple objects at different ranges from the LiDAR system **202**, producing multiple return signals **203**, **205**. The LiDAR system **202** may analyze multiple return signals **203**, **205** and report one

of the return signals (e.g., the strongest return signal, the last return signal, etc.) **203**, **205** or more than one (e.g., all) of the return signals **203**, **205**. In the illustrative example shown in FIG. **2A**, LiDAR system **202** emits a (e.g., illumination) laser in the direction of medium-range wall **204** and long-range wall **208**. As illustrated, the majority of the emitted (e.g., illumination) beam hits the medium-range wall **204** at area **206** resulting in a (e.g., medium-range) return signal **203**, and another portion of the emitted (e.g., illumination) beam hits the long-range wall **208** at area **210** resulting in a (e.g., long-range) return signal **205**. Return (e.g., medium-range) signal **203** may have a shorter TOF and a stronger received signal strength compared with return (e.g., long-range) signal **205**. In both single- and multiple-return LiDAR systems **202**, it is important that each return signal **203**, **205** is accurately associated with the transmitted (e.g., illumination) light signal so that an accurate TOF may be calculated.

[0045] Some embodiments of a LiDAR system may capture distance data in a (e.g., single plane) two-dimensional (2D) point cloud manner. These LiDAR systems may be used in industrial applications, or for surveying, mapping, autonomous navigation, and other uses. Some embodiments of these systems rely on the use of a single laser emitter/detector pair combined with a moving mirror to effect scanning across at least one plane. This mirror may reflect the emitted (e.g., illumination) light from the transmitter (e.g., laser diode), and/or may reflect the return light to the detector. Use of a movable (e.g., oscillating) mirror in this manner may enable the LiDAR system to achieve 90-180-360 degrees of azimuth (horizontal) view while simplifying both the system design and manufacturability. Many applications require more data than just a single (e.g., 2D) plane. The 2D point cloud, however, may be expanded to form a 3D point cloud, in which multiple 2D point clouds are used, each pointing at a different elevation (i.e., vertical) angle. Design elements of the receiver of the LiDAR system **202** may include the horizontal FOV and the vertical FOV.

[0046] FIG. **2B** depicts a set of optical components **250** of a channel **102** of a LiDAR system **100** according to some embodiments. In the example of FIG. **2B**, the LiDAR channel **102** uses a single emitter **252**/detector **262** pair combined with a fixed mirror **254** and a movable mirror **256** to effectively scan across a plane. Distance measurements obtained by such a system may be effectively two-dimensional (e.g., planar), and the captured distance points may be rendered as a 2D (e.g., single plane) point cloud. In some embodiments, but without limitation, the movable mirror **256** may oscillate at very fast speeds (e.g., thousands of cycles per minute).

[0047] The emitted laser signal **251** may be directed to a fixed mirror **254**, which may reflect the emitted laser signal **251** to the movable mirror **256**. As movable mirror **256** moves (e.g., oscillates), the emitted laser signal **251** may reflect off an object **258** in its propagation path. The reflected return signal **253** may be coupled to the detector **262** via the movable mirror **256** and the fixed mirror **254**. Design elements of the LiDAR system **250** include the horizontal FOV and the vertical FOV, which define a scanning area.

Hybrid LiDAR System

[0048] Referring to FIG. **3A**, a block diagram of an illustrative (e.g., hybrid) LiDAR system **300** that is structured and arranged to provide long-, medium-, and short-

range detection in accordance with some embodiments is shown. Although the hybrid LiDAR system **300** will be described as part of a system that is capable of detecting and processing short-range return signals as well as medium- and long-range return signals, those skilled in the art can appreciate that a stand-alone system may be designed to detect and process only short-range return signals. In some implementations, the short-range components are capable of detecting objects in the range of about 10 to about 20 meters from the LiDAR system **300**; although application of a diffuser **306** to the short-range illumination signals may limit the detection range to about 1 or 2 meters (or less).

[0049] In some variations, the hybrid LiDAR system **300** is a solid-state system that is structured and arranged to include a far-field transmitter **104** (e.g., "first," "primary," or "far-field" transmitter), a transmitter **304** (e.g., "second," "supplemental," "flash," or "near-field" transmitter), a receiver **106**, a control & data acquisition module **108**, and a data analysis & interpretation module **109**. Collectively, the far-field transmitter **104**, receiver **106**, and control & data acquisition module **108** may be configured to operate as a far-field LiDAR device (e.g., channel), capable of providing data from medium- and long-range scan areas as previously described. In some implementations, the far-field transmitter **104** is configured to emit laser (e.g., illumination) light signals **110** towards a medium- and long-range scan area and to receive return signals **114** therefrom. In some embodiments, the light source of the far-field transmitter **104** may be a light-emitting diode (LED), an edge-emitting diode laser, a line laser having an edge emitter and a (e.g., fiber) filter, or any other light source suitable for transmitting illumination signals to the far field. In some embodiments, after being shaped by the optical components of the far-field transmitter **104**, the emitted light signal **110** may be tightly focused (e.g., with divergence of less than 15 degrees, less than 10 degrees, less than 5 degrees, less than 2 degrees, or less than 1 degree), and may have a range of tens to hundreds of meters.

[0050] Collectively, the near-field transmitter **304**, receiver **106**, and control & data acquisition module **108** may be configured to operate as a near-field LiDAR device (e.g., channel), capable of providing data from short-range scan areas. In some applications, the near-field transmitter **304** is structured and arranged to generate and emit a (e.g., supplemental) laser (e.g., illumination) signal **310** that is capable of illuminating objects **312** in a short-range scan area located within the near field, such that the (e.g., short-range) return signals **314** may be received and detected by the receiver **106**.

[0051] In some applications, the near-field transmitter **304** may be adapted to emit a short-range light (e.g., illumination) beam **310** to illuminate objects in the near field. The short-range beam (sometimes referred to herein as a "flash beam") may be significantly more diffuse and more divergent than the long-range light beam **110**, such that the short-range beam's energy density decreases rapidly with distance and effective range is low (e.g., a few meters). In some embodiments, the near-field transmitter **304** includes one or more laser emitters each capable of emitting a (e.g., short-range) laser beam. In some variations, each of the emitters of the transmitter **304** may be a vertical-cavity surface-emitting lasers (VCSELs), a line laser having an edge emitter and a (e.g., fiber) filter, etc. In some embodiments, the short-range transmitter **304** may also include one

or more diffusers adapted to shape the beams generated by the short-range transmitter **304** such that they fill the horizontal and vertical FOV of the LiDAR device **300**.

[0052] Referring to FIG. 3B, a cross-sectional view of a portion of one possible implementation of a hybrid LiDAR system **300** is shown. In the example of FIG. 3B, the far-field transmitter **104** includes an emitter **252**, one or more optical components (e.g., lenses), and a movable mirror **256**. The movable mirror **256** may be configured to scan the long-range beam **110** generated by the emitter **252** over the horizontal FOV **332** (e.g., 120 degrees). In some embodiments, the LiDAR system **300** may include an array of far-field transmitters **104** (e.g., 8, 16, 32, 64, or 128 far-field transmitters), each of which may horizontally scan a different portion of the system's vertical FOV (e.g., 32 degrees).

[0053] In the example of FIG. 3B, the far-field transmitter **104** is positioned below the near-field transmitter **304**. In this example, the receiver **106** is not shown, but shares at least a portion of the optical path of the transmitter **104**. Because the far-field emitter **252** is positioned relatively close to the receiver **106** and to one or more optical components (which may reflect portions of an illumination beam emitted by the far-field emitter **252**), the dazzle produced by the far-field emitter **252** at the receiver **106** can be very strong. In contrast, any dazzle produced by the near-field transmitter **304** at the receiver **106** is much weaker, for at least two reasons. First, the receiver **106** and near-field transmitter **304** are located in separate, physically partitioned compartments, with baffles (**342**, **344**) configured to limit optical communication between the compartments. This physical partitioning and optical shielding limit the amount of dazzle that might otherwise be produced by the emission of the line beam **310** from the short-range transmitter **304**. Second, even if a small amount of light emitted by the short-range transmitter **304** reflects off the viewing window **330** of the LiDAR system **300** and is directed to the receiver **106**, any dazzle produced by such internally reflected signals is relatively weak because such internally reflected signals are not directly incident on the receiver **106**.

[0054] FIG. 3C shows a cross-sectional view of a near-field LiDAR transmitter **304**, in accordance with some embodiments. As discussed above, the near-field transmitter **304** may include an emitter **352** and a diffuser **306**. The emitter **352** may be, for example, a VCSEL. The VCSEL may emit a line beam perpendicular to the substrate of the chip in which the VCSEL is formed. In some embodiments, the beam emitted by the VCSEL is substantially symmetric and exhibits substantial divergence (e.g., 20 degrees by 20 degrees). In some embodiments, the VCSEL may emit a pulsed beam, with a pulse repetition frequency of approximately 200 kHz. Other pulse repetition frequencies (e.g., frequencies between 50 kHz and 500 kHz) are possible. In some embodiments, the emitted line beam is shaped by a diffuser **306**. The diffuser **306** may be any suitable diffractive beam-shaping optical component. In some embodiments, the diffuser spreads the line beam **310** in the vertical and horizontal directions. In some embodiments, the divergence of the diffused line beam **310** may match the FOV of the LiDAR device **300** (e.g., 120 degrees by 32 degrees).

[0055] In some embodiments, the LiDAR system **100** includes one second transmitter **304**. In some embodiments, the LiDAR system **100** includes one second transmitter **304** per array of first transmitters **104** (or array of first emitters) configured to scan different vertical regions of the system's

FOV (e.g., array of 4, 8, 16, 32, or 64 transmitters or emitters). In some embodiments, the LiDAR system **100** includes one second transmitter **304** per first transmitter **104** (or emitter).

[0056] In some embodiments, the LiDAR system **100** activates a single receiver **106** to receive return signals in the short-range listening period after the transmitter **304** emits a laser signal **310**. In such embodiments, the LiDAR system **100** may be able to detect the presence of an object within the near field, but may not be able to determine the precise location of the object (e.g., the vertical and horizontal coordinates of the object) within the FOV. In some embodiments, the LiDAR system **100** activates two or more receivers **106** (e.g., an array of 4, 8, 16, 32, or 64 receivers) to receive return signals in the short-range listening period after the transmitter **304** emits a laser signal **310**. In such embodiments, the LiDAR system **100** may be able to detect the presence of an object within the near field, and able to determine at least the vertical coordinate(s) of the object within the FOV. In some embodiments, the LiDAR system **100** may activate the second transmitter once each time the system finishes scanning the entire FOV, once each time a first transmitter (or first emitter) finishes scanning a scan line (e.g., horizontal scan line) within the FOV, or once each time a first transmitter (or first emitter) scans a pixel within the FOV. Any of the foregoing configurations may be suitable for various applications of LiDAR system **100** (e.g., autonomous vehicle navigation).

[0057] Referring again to FIG. 3B, one of ordinary skill in the art will appreciate that the illustrated configuration of the near-field transmitter **304** may not provide full coverage of the LiDAR system's FOV at a range of 2 meters or less, because the near-field transmitter **304** is not positioned centrally with respect to the system's FOV. In some embodiments, the LiDAR system **300** may include a second near-field transmitter **304**, which may be positioned proximate to location **308**. Together, the illustrated near-field transmitter **304** and a second near-field transmitter positioned proximate to location **308** may provide full coverage of the system's FOV. In some embodiments, the two near-field transmitters may transmit pulses synchronously (e.g., with the two transmitters transmitting their pulses simultaneously or in an alternating sequence).

[0058] Advantageously, the timing of the firing of the transmitter **304** of the near-field LiDAR device with respect to the firing of the transmitter **104** of the far-field LiDAR device is selected, inter alia, to avoid dazzle interference. More particularly, the near-field transmitter **304** may be adapted to generate and emit a flash (e.g., illumination) signal **310** a predetermined amount of time before or after the generation and emission of light (e.g., illumination) signals **110** by the far-field transmitter **104**.

[0059] Preferably, the flash signal **310** is emitted separately and distinctly from the (e.g., laser) light (e.g., illumination) signals **110** emitted by the transmitter **104** of the (e.g. primary) LiDAR device **102**. Such emission may occur, for example, at the end of or at the beginning of every laser position (LPOS). Those of ordinary skill in the art can appreciate that the receiver **106** and control & data acquisition module **108** integrated into the LiDAR device **102**, as well as the data analysis & interpretation module **109**, may also be used to control the firing of the flash signals **310** by the (e.g., supplemental) transmitter **304** of the (e.g., secondary) flash LiDAR device **302** and to receive and process the

return flash signals **314**. Optionally, in some embodiments, the (e.g., secondary) flash LiDAR device **302** may be structured and arranged to include a separate receiver (not shown), control & data acquisition module (not shown), and/or data analysis & interpretation module (not shown).

[0060] In embodiments, aspects of the techniques described herein (e.g., timing the emission of the transmitted signal and the flash signal, processing received return signals, and so forth) may be directed to or implemented on information handling systems/computing systems. For purposes of this disclosure, a computing system may include any instrumentality or aggregate of instrumentalities operable to compute, calculate, determine, classify, process, transmit, receive, retrieve, originate, route, switch, store, display, communicate, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, a computing system may be a personal computer (e.g., laptop), tablet computer, phablet, personal digital assistant (PDA), smart phone, smart watch, smart package, server (e.g., blade server or rack server), a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price.

[0061] The computing system may include random access memory (RAM), one or more processing resources such as a central processing unit (CPU) or hardware or software control logic, ROM, and/or other types of memory. Additional components of the computing system may include one or more disk drives, one or more network ports for communicating with external devices as well as various input and output (I/O) devices, such as a keyboard, a mouse, a touchscreen, and/or a video display. The computing system may also include one or more buses operable to transmit communications between the various hardware components.

[0062] FIG. 4 depicts a simplified block diagram of a computing device/information handling system (or computing system) according to embodiments of the present disclosure. It will be understood that the functionalities shown for system **400** may operate to support various embodiments of an information handling system—although it shall be understood that an information handling system may be differently configured and include different components.

[0063] As illustrated in FIG. 4, system **400** includes one or more central processing units (CPU) **401** that provide(s) computing resources and control(s) the computer. CPU **401** may be implemented with a microprocessor or the like, and may also include one or more graphics processing units (GPU) **417** and/or a floating point coprocessor for mathematical computations. System **400** may also include a system memory **402**, which may be in the form of random-access memory (RAM), read-only memory (ROM), or both.

[0064] A number of controllers and peripheral devices may also be provided. For example, an input controller **403** represents an interface to various input device(s) **404**, such as a keyboard, mouse, or stylus. There may also be a scanner controller **405**, which communicates with a scanner **406**. System **400** may also include a storage controller **407** for interfacing with one or more storage devices **408** each of which includes a storage medium such as magnetic tape or disk, or an optical medium that might be used to record programs of instructions for operating systems, utilities, and applications, which may include embodiments of programs that implement various aspects of the techniques described herein. Storage device(s) **408** may also be used to store

processed data or data to be processed in accordance with some embodiments. System **400** may also include a display controller **409** for providing an interface to a display device **411**, which may be a cathode ray tube (CRT), a thin film transistor (TFT) display, or other type of display. The computing system **400** may also include an automotive signal controller **412** for communicating with an automotive system **413**. A communications controller **414** may interface with one or more communication devices **415**, which enables system **400** to connect to remote devices through any of a variety of networks including the Internet, a cloud resource (e.g., an Ethernet cloud, an Fiber Channel over Ethernet (FCOE)/Data Center Bridging (DCB) cloud, etc.), a local area network (LAN), a wide area network (WAN), a storage area network (SAN), or through any suitable electromagnetic carrier signals including infrared signals.

[0065] In the illustrated system, all major system components may connect to a bus **416**, which may represent more than one physical bus. However, various system components may or may not be in physical proximity to one another. For example, input data and/or output data may be remotely transmitted from one physical location to another. In addition, programs that implement various aspects of some embodiments may be accessed from a remote location (e.g., a server) over a network. Such data and/or programs may be conveyed through any of a variety of machine-readable medium including, but are not limited to: magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROMs and holographic devices; magneto-optical media; and hardware devices that are specially configured to store or to store and execute program code, such as application specific integrated circuits (ASICs), programmable logic devices (PLDs), flash memory devices, and ROM and RAM devices. Some embodiments may be encoded upon one or more non-transitory, computer-readable media with instructions for one or more processors or processing units to cause steps to be performed. It shall be noted that the one or more non-transitory, computer-readable media shall include volatile and non-volatile memory. It shall also be noted that alternative implementations are possible, including a hardware implementation or a software/hardware implementation. Hardware-implemented functions may be realized using ASIC(s), programmable arrays, digital signal processing circuitry, or the like. Accordingly, the "means" terms in any claims are intended to cover both software and hardware implementations. Similarly, the term "computer-readable medium or media" as used herein includes software and/or hardware having a program of instructions embodied thereon, or a combination thereof. With these implementation alternatives in mind, it is to be understood that the figures and accompanying description provide the functional information one skilled in the art would require to write program code (i.e., software) and/or to fabricate circuits (i.e., hardware) to perform the processing required.

[0066] It shall be noted that some embodiments may further relate to computer products with a non-transitory, tangible computer-readable medium that has computer code thereon for performing various computer-implemented operations. The medium and computer code may be those specially designed and constructed for the purposes of the techniques described herein, or they may be of the kind known or available to those having skill in the relevant arts. Examples of tangible, computer-readable media include, but

are not limited to: magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROMs and holographic devices; magneto-optical media; and hardware devices that are specially configured to store or to store and execute program code, such as application specific integrated circuits (ASICs), programmable logic devices (PLDs), flash memory devices, and ROM and RAM devices. Examples of computer code include machine code, such as produced by a compiler, and files containing higher level code that is executed by a computer using an interpreter. Some embodiments may be implemented in whole or in part as machine-executable instructions that may be in program modules that are executed by a processing device. Examples of program modules include libraries, programs, routines, objects, components, and data structures. In distributed computing environments, program modules may be physically located in settings that are local, remote, or both.

[0067] One skilled in the art will recognize no computing system or programming language is critical to the practice of the techniques described herein. One skilled in the art will also recognize that a number of the elements described above may be physically and/or functionally separated into sub-modules or combined together.

Method of Performing Short-Range Detection

[0068] Having described a hybrid LiDAR system **300** for compensating for dazzle in order to, inter alia, detect objects in the near field (e.g., within 1 or 2 meters of the system **300**, i.e., within a short-range scan area that is spatially distant from the medium- and long-range scan areas), using a near-field transmitter **304** to match the FOV of the long-range channels, a method of detecting objects in a short-range scan area within the near field and mitigating the effects of dazzle will now be described. Two variations of methods of mitigating the effects of dazzle and detecting objects in a short-range scan area within the near field will now be described. The first technique involves one or more near-field transmitters **304** transmitting flash line (e.g., illumination) beam(s) **310** towards objects **312** in a short-range scan area within the near field prior to the time period corresponding to a laser position (LPOS) of the far-field transmitter **104**, while the second technique involves a near-field transmitter(s) **304** transmitting flash line beam(s) **310** towards objects **312** in a short-range scan area within the near field at the end of the LPOS of the far-field transmitter **104**. In both instances, the timing of the firing of the flash line (e.g., illumination) beam(s) **310** is controlled so that the short-range returns resulting from the flash line (e.g., illumination) beam(s) **310** are not affected by dazzle created by far-field transmitters **104**.

[0069] Referring to FIG. **5** and FIGS. **6A** and **6B**, according to the first technique, initially, the (e.g., medium- and long-range) transmitters **104** and supplemental (i.e., short-range) transmitters **304** are in an OFF state and the (e.g., long-range) channel detectors **106** in the LiDAR device **102** are focused on the near field. As previously mentioned, the detectors **106** may be integrated into each of the (e.g., primary) LiDAR device **102** and the flash (e.g., secondary) LiDAR device **302**; however, to reduce space and cost, for the purpose of this description, it will be assumed that the medium- and long-range channel detectors **106** are integrated exclusively into the (e.g., primary) LiDAR device **102**.

[0070] In a first embodiment of a method **500** for mitigating the effects of dazzle, at time to, the supplemental (i.e., short-range) transmitters **304** generate and emit (e.g., short-range) flash (e.g., illumination) signals **310** (act **510**) towards objects **312** in a short-range scan area within the near field (e.g., between about 1 meter and 20 meters, or, more preferably, less than about 2 meters). The emitted flash signal **310** illuminates the object(s) **312** in short-range scan area within the near field and is reflected back towards the system **300** as a return flash signal **314** that, at time t_1, is received and detected (**610, 615**) by the channel detectors **106** (act **520**) integrated into the (e.g., primary) LiDAR device **102**. Subsequently, the primary (e.g., long-range) transmitters **104** generate and emit a laser light (e.g., illumination) signal **110** (act **530**). The latter laser light (e.g., illumination) signal **110** causes, at time t_2, the detectors **106** integrated into the (e.g., primary) LiDAR device **102** to receive and detect a signal corresponding to dazzle **620**. Subsequently, second return signals **114** from objects **112** in the medium- or long-range fields are received and detected **625** by the long-range channel detectors **106** (act **540**). Advantageously, the return flash signals **314** are received and detected (**610, 615**) before the primary (e.g., long-range) transmitters **104** produce dazzle **620** that would otherwise blind the (e.g., long-range) channel detectors **106** while flash return signals **314** were reflected by (e.g., short-range) near-field objects **312**. As a result, short-range, flash return data may be received, detected, and processed within a short-range sampling period **600** extending approximately from a time just after the flash signal **310** is emitted to a time just before the incidence of dazzle **620** (or just before the emission of the long-range signal **110**) (act **550**).

[0071] Referring to FIG. **5** and FIGS. **7A** and **7B**, according to the second technique (e.g., a second embodiment of the method **500** for mitigating the effects of dazzle), the primary (i.e., medium- and long-range) transmitter **104** generates and emits a light (e.g. illumination) signal **110** (act **510**) towards objects **112** in the medium- and long-range environment. The emitted light (e.g., illumination) signal **110** illuminates objects **112** in the medium- and long-range environment and is reflected back towards the system **300** as return signals **114** that are received and detected **725** by the long-range channel detectors **106** (act **520**). After the last return signal **114** is received **725** by the long-range channel detectors **106**, the supplemental (e.g., short-range) transmitter **304** generates and emits a (e.g., short-range) flash light (e.g., illumination) signal **310** (act **530**) towards a short-range scan area within the near field. Subsequently, return flash signals **314** from objects **312** in the short-range scan area within the near fields are received and detected (**710, 715**) by the long-range channel detectors **106** (act **540**). Advantageously, the return flash signals **314** are received and detected (**710, 715**) after the last return signal **114** produced by the primary (e.g., medium- and long-range) transmitter **104** are received **725** (see act **520**), as well as after any dazzle **720** produced by back-reflecting resulting from the firing of the primary (e.g., medium- and long-range) transmitter **104**. Advantageously, the return flash signals **314** are received and detected (**710, 715**) after any dazzle that would otherwise blind the long-range channel detectors **106**. As a result, (e.g., short-range) flash return data may be received, detect, and processed within a short-range sampling period **700** extending approximately from the end of the listening period for the medium- and long-range

returns (e.g., a period beginning when the primary transmitter **104** emits the signal **110** and having a duration approximately equal to the round-trip travel time for a signal to reach an object at the edge of the LiDAR system's long-range and for the reflected return signal **114** to travel back from that object to the LiDAR system) to the end of the listening period for the short-range returns (e.g., a period beginning when the secondary transmitter **304** emits the signal **310** and having a duration approximately equal to the round-trip travel time for a signal to reach an object at the edge of the LiDAR system's short-range and for the reflected return signal **314** to travel back from that object to the LiDAR system).

[0072] It will be appreciated to those skilled in the art that the preceding examples and embodiments are exemplary and not limiting to the scope of the present disclosure. It is intended that all permutations, enhancements, equivalents, combinations, and improvements thereto that are apparent to those skilled in the art upon a reading of the specification and a study of the drawings are included within the true spirit and scope of the present disclosure. It shall also be noted that elements of any claims may be arranged differently including having multiple dependencies, configurations, and combinations.

What is claimed is:

1. A solid-state light detection and ranging (Lidar) system for near-field and far-field detection, the system comprising:

an array of first emitters and one or more first optical components configured to generate and emit tightly focused pulses of illuminating light at a first degree of divergence into different vertical regions of a far-field scan area, external to the Lidar system, to generate distance measurements within the far-field scan area;

at least one second emitter and one or more second optical components configured to generate and emit pulses of illuminating light at a second degree of divergence into a near-field scan area, external to the Lidar system, to generate distance measurements within the near-field scan area, wherein the second degree of divergence is more divergent than the first degree of divergence and the near-field scan area is spatially distinct from the far-field scan area and is between the Lidar system and the far-field scan area;

emitter control circuitry configured to implement a long-range sampling period in which the array of first emitters are fired to emit illuminating light into the far field, and a short-range sampling period in which the at least one second emitter is fired to emit illuminating light into the near field, wherein timing for firing the at least one second emitter in the short-range sampling period is selected to mitigate effects of dazzle generated by the array of first emitters; and

a receiver comprising an optical detector configured to detect reflections of light generated by the array of first emitters and by the at least one second emitter.

2. The solid-state Lidar system of claim **1** wherein the emitter control circuitry is configured to implement the short-range sampling period prior to the long-range sampling period such that the short-range sampling period extends from when the at least one second emitter is fired to a time just before the array of first emitters is fired.

3. The solid-state Lidar system of claim **1** wherein the emitter control circuitry is configured to implement the short-range sampling period after the long-range sampling

period such that the short-range sampling period extends from an end of a first listening period for reflections of light generated by the array of first light emitters to an end of a second listening period for reflections of light generated by the at least one second emitter.

4. The solid-state Lidar system of claim 3 wherein the first listening period begins when the array of first emitters is fired and has a duration approximately equal to a round-trip travel time for first light generated by the array of first emitters to reach an object at an edge of a far-field detection range of the Lidar system and for reflections of the first light to travel back from the object to the Lidar system.

5. The solid-state Lidar system of claim 4 wherein the second listening period begins when the at least one second emitter is fired and has a duration approximately equal to a round-trip time for second light generated by the at least one second emitter to reach an object at an edge of the Lidar system's near-field detection range and for reflections of the second light to travel back from the object to the Lidar system.

6. The solid-state Lidar system of claim 1 further comprising a movable mirror configured to oscillate at very fast speeds and aligned to receive the illuminating light generated by the array of first emitters and reflect the illuminating light into different horizontal locations within the far-field scan area, and wherein the emitter control circuitry is configured to horizontally scan a field of view of the Lidar system by firing the array of first emitters as the movable mirror oscillates.

7. The solid-state Lidar system of claim 1 wherein the first degree of divergence is less than 10 degrees and the at least one second emitter generates a flash beam.

8. The solid-state Lidar system of claim 1 wherein the at least one second emitter and the one or more second optical components are configured to generate a flash beam that fills a horizontal and vertical field of view of the Lidar system.

9. The solid-state Lidar system of claim 8 further comprising a movable mirror configured to oscillate at thousands of cycles per minute and aligned to receive the illuminating light generated by the array of first emitters and reflect the illuminating light into different horizontal locations within the far-field scan area, and wherein the emitter control circuitry is configured to scan a field of view of the Lidar system by firing the array of first emitters as the movable mirror oscillates.

10. The solid-state Lidar system of claim 8 wherein the one or more second optical components comprise a diffuser that spreads the pulses of illuminating light emitted by the at least one second emitter in horizontal and vertical directions.

11. The solid-state Lidar system of claim 10 wherein the diffuser spreads the pulses of illuminating light emitted by the at least one second emitter in the horizontal and vertical directions to match a field of view of the Lidar system.

12. The solid-state Lidar system of claim 1 further comprising data acquisition circuitry coupled to the receiver and configured to record data derived from the reflections of light detected by the receiver.

13. The solid-state Lidar system of claim 12 further comprising a data analysis module coupled to wirelessly receive output data from the data acquisition circuitry and configured to perform data analysis functions on the output data.

14. A light detection and ranging system for near-field and far-field detection, the system comprising:

an array of first emitters configured to generate and emit tightly focused pulses of illuminating light at a first degree of divergence into different vertical regions of a far-field scan area external to the light detection and ranging system to generate distance measurements within the far-field scan area;

at least one second emitter and an optical diffuser configured to generate and emit one or more pulses of a flash beam of illuminating light at a second degree of divergence, which is more divergent than the first degree of divergence, into a near-field scan area external to the light detection and ranging system to generate distance measurements within the near-field scan area, wherein the flash beam of illuminating light fills a horizontal and vertical field of view of the light detection and ranging system;

a receiver comprising an optical detector configured to detect reflections of light generated by the array of first emitters and by the at least one second emitter; and

control circuitry configured to implement a long-range sampling period in which the array of first emitters are fired to emit illuminating light into the far field and reflections from the illuminating light emitted by the array of first emitters travels back to the light detection and ranging system, and a short-range sampling period, separate and distinct in time from the long-range sampling period, in which the at least one second emitter is fired to emit illuminating light into the near field and reflections from the illuminating light emitted by the at least one second emitter travel back to the light detection and ranging system.

15. The light detection and ranging system of claim 14 further comprising a movable mirror configured to oscillate at very fast speeds and aligned to receive the illuminating light generated by the array of first emitters and reflect the illuminating light into different horizontal locations within the far-field scan area, and wherein the control circuitry is configured to horizontally scan a far-range field of view of the light detection and ranging system by firing the array of first emitters as the movable mirror oscillates.

16. The light detection and ranging system of claim 15 wherein the one or more pulse of a flash beam of illuminating light are directed into the near-field scan area without being reflected off the movable mirror.

17. The light detection and ranging system of claim 14 further comprising a baffle configured to reduce transmission of light from the at least one second emitter to the receiver along an optical path internal to the light detection and ranging system.

18. The light detection and ranging system of claim 14 wherein the near-field scan area is spatially distinct from the far-field scan area and is between the light detection and ranging system and the far-field scan area.

19. The light detection and ranging system of claim 14 wherein timing for firing the at least one second emitter in the short-range sampling period is selected to mitigate effects of dazzle generated by the array of first emitters.

20. The light detection and ranging system of claim 14 further comprising:

data acquisition circuitry configured to record data derived from the reflections of light detected by the receiver; and

a data analysis module coupled to wirelessly receive data from the data acquisition circuitry and configured to perform data analysis functions on the received data.

*   *   *   *   *