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(57) Embodiments of the present invention provide a shooting range simulator system and method able to monitor the aiming history of a shooter. The method may include determining an aimed-at position of one or more aiming devices on a target screen by selectively illuminating positions on the screen according to a predefined scheme; detecting scattered light from the illuminated

position from one or more viewing angles; and deriving coordinates of the aimed-at position based on the timing of the detection relative to the scanning scheme. The system may include a scanner to selectively illuminate screen elements and a processing center to determine an aimed-at position on the screen. Additional features are described and claimed.



DescriptionFIELD OF THE INVENTION

5 **[0001]** The invention relates to the field of shooting range simulators and, more particularly, to systems and methods of aim detection and hit detection.

BACKGROUND OF THE INVENTION

10 **[0002]** Conventional, physical, shooting ranges allow a person ("shooter") to improve their skills, especially with regards to aiming, with a firearm-type weapon through repeated practice in controlled conditions. A virtual shooting range, with the benefit of computer-simulations and other technological advancements, may have the further advantage of being able to provide sophisticated feedback for training purposes. For example, in some shooting range simulators, it may be possible to discern, not just whether a shooter hit or missed a target, or by how much, but also factors that affect the
15 shooter's aiming accuracy. Examples of such data are grip pressure, weapon orientation, response to weapon kick-back, and aiming history.

[0003] Aiming is a process that lasts for more than an instant of time and typically includes many slight adjustments by the shooter before the trigger is pressed. Additionally, there is typically a discrepancy between an aimed-at location and actual hit position. Therefore, it may be desired to track the aimed-at position during the aiming process, e.g.,
20 continually or shortly before firing. This tracking may be used, for example, to monitor the aiming history of a shooter.

[0004] Existing shooting simulator systems may include a target screen, an aiming device, e.g., a simulated weapon, and a processing center. In some existing systems, the target screen may include an array of photo-sensors, the aiming device may include a light beam emitter, and the processing center may include algorithms or circuits for determining where an aiming device is aimed or whether a particular target is hit, based on the photo-sensors in the target screen
25 detecting the light beam from the aiming device. Such a system may not be able to distinguish between multiple aiming devices aiming at the same position on the target screen.

[0005] In other existing systems, for example, those implemented in the field of video games, a particular target on the target screen may be marked by some property such as a distinctly colored pixel; the aiming device may include a detector for that property with a narrow field of view that is able to detect a target on the screen with a desired resolution;
30 and the processing center may include algorithms or circuits for determining whether the particular target is hit, based on the detector in the aiming device detecting the target property within the narrow field of view. Such a system may not be able to detect where an aiming device is aimed on the target screen unless it is perfectly aimed at the particular target, and thus may not be able to monitor misses or aiming in general, and will give a hit/miss indication only.

[0006] Generally, existing shooting range simulator systems and methods may rely heavily on image-processing, may
35 be costly in resources, and may be inefficient for tracking multiple aiming devices randomly firing at the same target screen.

SUMMARY OF THE INVENTION

40 **[0007]** Some exemplary embodiments of the invention may include a system for simulating a shooting range, including a target screen, one or more aiming devices, e.g., simulated weapons, and a processing center, as described in detail below. Optionally, the system may include a scenario generator to reproduce, for example, a scenario image, e.g., a static or moving image, on the target screen.

[0008] Further, some exemplary embodiments of the invention may include a system and method for determining and tracking an aimed-at position of one or more aiming devices on a target screen. The system may include the target
45 screen, a scanner to produce selective illumination of positions on the target screen according to a predetermined scanning scheme, a directional pickup attached to the aiming device for detection of illuminated elements of the target screen, and a processing center to process aiming and/or hit data, based on the scanning scheme and an input from the directional pickup. The target screen may be, for example, a flat screen, a cylindrical screen, a spherical, screen, a multi-plane screen, or any other configuration suitable for displaying the scenario image and/or video movie. Positions
50 on the target screen may be identified with reference to the time passed from the beginning of a scan cycle.

[0009] According to some exemplary embodiments of the invention, for example, when the optional scenario generator is included, the target screen may display a simulated scenario with, for example, dynamic targets for one or more shooters to aim and "fire" at.

[0010] According to some exemplary embodiments of the invention, the scanner may selectively illuminate the target
55 screen according to a predefined scan sequence and at a predefined scan frequency, such that at any given moment in time one screen element is actively illuminated, as described below. Thus, it may be possible to determine aiming position as a function of time based on synchronization between the scanning scheme and time at which light from an illuminated screen element may be detected by a directional pickup device. The resolution of the scanner may effectively

determine the resolution of the screen elements, i.e., the highest resolution at which positions may be discriminated on the target screen. For example, a screen element may correspond to one or more scanner pixels. Additionally, the scan frequency may determine the highest resolution in time at which an aiming event, e.g., aiming device movements while aiming, stability of aiming at a screen element, hit position, next aiming position after weapon kick-back, etc., may be measured.

[0011] According to one exemplary embodiment of the invention, the target screen may be scanned by a light beam from a scanner, which may be embodied in a separate unit. For example, the scenario generator may be equipped with a laser projector capable of producing a plurality of laser beams, e.g., sequentially or simultaneously, to project a scenario image and/or video movie onto the scenario screen. In addition, the laser projector may be able to produce an additional laser beam, e.g., an invisible laser beam, to be used for a scanning function, as explained in detail below. In another exemplary embodiment, the target screen may include scanning functionality, e.g., in the form of selective activation of screen pixels, as explained below.

[0012] According to some exemplary embodiments of the invention, an illuminated screen element may reflect or emit a pulse of scattered light outwards from the target screen and thus may be viewed from a wide range of viewing angles. It will be appreciated by those skilled in the art that a target and a shooter may be essentially interchangeable for the purpose of monitoring the shooter's aim at the target. That is, if a shooter correctly aims an aiming device at a target in a particular direction and angle, then the target is likewise aimed at the shooter from the opposite direction, i.e., there is reciprocity between target and aiming device.

[0013] According to some exemplary embodiments of the invention, the directional pickup may be telescopic and may have a narrow field of view with a resolution, for example, of one or more screen element. Thus, any number of aiming devices equipped with appropriate directional pickups which are aimed at the illuminated screen element may be able to detect the same light pulse substantially simultaneously, as explained in detail below.

[0014] According to some exemplary embodiments of the invention, the processing center may include scan sequence control logic, a timing component, e.g., one or more clocks, an algorithm or circuit for determining aimed position as a function of time, and components for communicating with other parts of the system, for example, an Ethernet, as is known in the art. The processing center may be able to distinguish between different aiming devices, for example, by assigning to each aiming device a unique shooter identification tag.

[0015] According to some exemplary embodiments of the invention, the shooting range simulator system may include an event signal generator to simulate additional aspects of a shooting range, e.g., "firing" of a simulated weapon. According to some exemplary embodiments of the invention, a trigger depression event signal, for example, may be generated and transmitted to the processing center in response to mechanical actions of a shooter. For example, the shooter may depress a trigger of a simulated weapon to activate a micro-switch and generate an electric signal. Further, the simulated weapon trigger may, for example, be connected to an air compressor, which may be able to physically simulate a kick-back effect.

[0016] According to some exemplary embodiments of the invention, the processing center may be able to, for example, receive signals from the directional pickup and from the event generator, and derive an aiming device's aimed position at the time of an event. The processing center may optionally be coordinated with the scenario generator to provide appropriate feedback to the user. Additionally or alternatively, the processing center may include a data storage component to record training data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanied drawings in which:

Fig. 1 is a schematic illustration of a shooting range simulation system in accordance with some exemplary embodiments of the invention;

Fig. 2 is a schematic illustration of an aiming and hit processing unit in accordance with some exemplary embodiments of the invention;

Fig. 3 is a schematic illustration of a simulation weapon hub in accordance with some exemplary embodiments of the invention;

Fig. 4 is a schematic illustration of a timing diagram useful for demonstrating a method of determining aiming position in accordance with some exemplary embodiments of the invention;

Fig. 5 is a schematic illustration of an aiming device having a directional pickup in accordance with some exemplary embodiments of the invention;

Fig. 6 is a schematic illustration of a directional pickup engaging a target in accordance with some exemplary embodiments of the invention;

Fig. 7 is a schematic illustration of a scanning system in accordance with some exemplary embodiments of the invention; and

Fig. 8 is a schematic diagram of a method of simulating a shooting range in accordance with some exemplary embodiments of the invention.

[0018] It will be appreciated that for simplicity and clarity of illustration, elements shown in the drawings have not necessarily been drawn accurately or to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity or several physical components included in one functional block or element. Further, where considered appropriate, reference numerals may be repeated among the drawings to indicate corresponding or analogous elements. Moreover, some of the blocks depicted in the drawings may be combined into a single function.

DETAILED DESCRIPTION OF THE INVENTION

[0019] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those of ordinary skill in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, components and circuits may not have been described in detail so as not to obscure the present invention.

[0020] Unless specifically stated otherwise, as apparent from the following discussions, it is appreciated that throughout the specification discussions utilizing terms such as "processing," "computing," "calculating," "determining," or the like, refer to the action and/or processes of a computer or computing system, or similar electronic computing device, that manipulate and/or transform data represented as physical, such as electronic, quantities within the computing system's registers and/or memories into other data similarly represented as physical quantities within the computing system's memories, registers or other such information storage, transmission or display devices. In addition, the term "plurality" may be used throughout the specification to describe two or more components, devices, elements, parameters and the like.

[0021] Reference is made to Fig. 1, which schematically illustrates a shooting range simulator system 100 in accordance with some exemplary embodiments of the invention. System 100 may include a target screen 108, an optional scenario generator system 101, a scanner 110, one or more aiming devices 136 having a directional pickup 120, and a processing center 124, which may include one or more simulation weapon hubs 126, as well as an aiming and hit processing (AHP) center 128.

[0022] Scenario generator system 101 may include a scenario controller 102, a scenario projector 104, and an audio output unit 106. Scenario controller 102 may provide a target scenario, which may include images of targets to be aimed at and, optionally, "fired" at by one or more users ("shooters"). The scenario controller may additionally display feedback to the user according to data received from processing center 124, for example, by indicating that a target has been hit or displaying aiming information superimposed on the target scenario. For example, scenario controller 102 may include an image generator capable of reproducing an image corresponding to the target scenario and/or additional information to be displayed. Additionally or alternatively, scenario controller 102 may alter the target scenario behavior in response to, for example, a hit or a near-hit, according to a programmable scenario script.

[0023] According to some exemplary embodiments of the invention, the target scenario may be projected onto target screen 108 via projector 104. For example, projector 104 may include a video projector, e.g. a Barco projector, as is known in the art, or a laser projector, e.g., a solid-state continuous wave RGB laser, as is known in the art, capable of displaying an image from the image generator onto a passive target screen. Alternatively, target screen 108 may include a direct display device capable of directly displaying the target scenario without a separate projection unit, e.g., an LCD, a CRT display, a plasma display, or a back projection display. Audio effects may also be provided via an audio output device 106, which may include, for example, an amplifier and a speaker.

[0024] According to some exemplary embodiments of the invention, target screen 108 may be, for example, a flat screen, a cylindrical screen, a spherical screen, a multi-plane screen such as walls of a house, or any other suitable screen. Positions on target screen 108 may be identified with reference to a predefined coordinate grid. For example, a screen element 116 is shown in Fig. 1. According to some exemplary embodiments of the invention, a screen element may be a position on a passive target screen, e.g., a reflective and diffusive screen, such as a white screen, or one or more pixels on an illuminating display, e.g., a LCD, a CRT display, a back-illuminated projector, a plasma display, or

any other type of display device.

[0025] According to some exemplary embodiments of the invention, scanner 110, for example, a solid-state continuous wave RGB laser scanner, or any other suitable device known in the art, may be adapted to selectively illuminate positions on the target screen, e.g., sequentially, according to a predefined scanning scheme, which may be controlled by a scan controller 112. For example, a commercially available RGB laser projector such as, for example, a Digistar 3 Laser or a Jenoptik Ltd GmbH Laser Display Technology laser, may be adapted to include an additional laser beam to provide scanning functionality. Thus, according to some exemplary embodiments of the invention, scenario projector 104, scanner 110, and/or scan controller 112 may be implemented as components of the same device within shooting range simulator system 100. In alternative embodiments of the invention, for example, when target screen 108 includes an illuminating display, pixels of target screen 108 may be selectively illuminated according to a predetermined scheme under the control of scan controller 112. The scanning scheme is explained in more detail below with reference to Fig. 4. The operation of scanner 110 in accordance with one exemplary embodiment of the invention is explained in more detail below with reference to Fig. 7.

[0026] According to embodiments of the invention, scanner 110 may generate a scanning light beam 114, which may be diffusely reflected by target screen 108, e.g., from screen element 116. For example, screen element 116 may reflect or emit scattered light to spread outwards in all directions, including that of a return beam 118. Beam 118 may be detected by directional pickup 120 mounted on aiming device 136, as is explained in more detail below with reference to Fig. 5 and Fig. 6. Beams 114 and 118 may be, for example, infra-red beams at a wavelength of 1550 nm, or at any other desired wavelength that may be distinguished from the spectra of the scenario optionally displayed on the target screen, and may be safe for the human eye, e.g., in compliance with FDA regulations.

[0027] According to some exemplary embodiments of the invention, system 100 may include an event signal generator 134 to simulate additional aspects of a shooting range, e.g., "firing" of a simulated weapon. According to some exemplary embodiments of the invention, a trigger depression event signal, for example, may be generated and transmitted to the processing center in response to mechanical actions of a shooter. For example, event signal generator 134 may include an air compressor to supply air pressure in response to depression of the weapon trigger for simulation of a weapon recoil mechanism, e.g., an air valve may release a burst of pressurized air to push an actuator. Additionally, event signal generator 134 may include a micro-switch associated with a trigger of the simulation weapon such that depression of the weapon trigger may activate the micro-switch and generate an electric signal.

[0028] It will be appreciated that the shooting range simulator system 100 may include a plurality of aiming devices 136, e.g., simulated weapons, each equipped with a directional pickup 120 and uniquely identified within processing center 124, e.g., using a shooter identification (ID) tag that may be, for example, assigned to each simulated weapon as it is logged into the shooting range simulator system. The directional pickup may be mounted instead of the weapon's compensator, or muzzle brake, as known in the art, on or in parallel with the longitudinal axis of the weapon barrel, and may roughly match the compensator in weight so that the center of gravity and balance of a weapon may be preserved.

[0029] According to some exemplary embodiments of the invention, processing center 124 may include one or more weapon hubs 126, aiming and hit processor (AHP) 128, scan start interrupt line 130, and may be connected to a communication network 132, e.g., a local area network (LAN) or Ethernet, as known in the art.

[0030] According to some exemplary embodiments of the invention, directional pickup 120 may transmit a signal 122 to weapon hub 126 in response to detecting return beam 118 of the scattered light from screen element 116. Additionally, event generator 134 may transmit an event signal 138 to weapon hub 126 in response to an event; for example, depression of a trigger of simulated weapon 136 may activate a micro-switch, which may close a circuit to generate a trigger depression signal. Additionally, scan start interrupt line 130 may transmit a signal from scan controller 112 to weapon hub 126 at the beginning of a new cycle of the scan sequence. According to some exemplary embodiments of the invention, scan start interrupt line 130 may be, for example a TTL level logic line or an RS-422 differential line, and may have a known propagation delay, which may be taken into account for the purpose of calculating the actual time elapsed from the beginning of a scan cycle to the detection of light by directional pickup 120.

[0031] According to some exemplary embodiments of the invention, weapon hub 126 may derive the aimed-at position of each aiming device 136 in synchronization with event signals 138 such as, for example, trigger depression signals. Weapon hub 126 may transmit data packets of, for example, <shooter ID, screen element coordinates, event tag>, and/or any other desired information, to AHP 128, e.g., via communication network 132. According to some exemplary embodiments of the invention, AHP 128 may store feedback data for training purposes and/or to further coordinate with scenario controller 102, as described below. According to some exemplary embodiments of the invention, scan controller 112 may be implemented by hardware and/or software within AHP 128.

[0032] Reference is now made to Fig. 2, which schematically illustrates an AHP 200 according to some exemplary embodiments of the invention. Although the invention is not limited in this respect, AHP 200 may be implemented by shooting range simulator system 100, for example, as AHP 128 (Fig. 1).

[0033] According to some exemplary embodiments of the invention, AHP 200 may include a scan controller 206 (112) to control the scanning sequence and generate scan start interrupt signals 201; a central processing unit (CPU) storage

memory interface 208, e.g., a commercially available computer with suitable memory and communication interface, or a dedicated stand-alone device designed to perform the functions of the invention; a memory 210, which may include a volatile memory, e.g., SRAM or DRAM, as is known in the art, or a non-volatile memory, e.g., Flash memory, EEPROM, or hard disk, as is known in the art; and a communication network interface 212, e.g., Ethernet, USB, or RS-232, as is known in the art. AHP 200 may be implemented as, for example, an integrated embedded controller or as a discrete assembly of processing unit, memory, and communication interface. Data may be communicated to and from weapon hub(s) 216 via a communication line 204, such as, for example Ethernet, USB, or RS-232. Additionally, according to some exemplary embodiments of the invention, data may be communicated to and from the scenario controller (not shown in Fig. 2) via a bus 214, and the scenario controller may modify the scenario in response to the communicated data, as described below.

[0034] For example, AHP 200 may receive data packets from hub(s) 216, e.g., the aiming history of a shooter. Additionally, AHP 200 may, for example, receive data packets from scenario controller (not shown in Fig. 2) via a bus 214, e.g., a position of a particular target within the simulated scenario. AHP 200 may, for example, determine whether the particular target is hit and, if the target is missed, the relative position of the aim to the target, and may transmit such hit/miss data back to the scenario controller via bus 214. According to some exemplary embodiments of the invention, the scenario controller may, for example, alter the target scenario behavior in response to, for example, a hit or a near-hit, or superimpose the scenario image and/or audio with data relating to a hit target or a shooter's aiming position. Aiming history data may be displayed on the target screen or on a separate display. Additionally or alternatively, AHP 200 may store the data at CPU storage memory 208.

[0035] Reference is now made to Fig. 3, which schematically illustrates a simulation weapon hub 300 according to some exemplary embodiments of the invention. Although the invention is not limited in this respect, simulation weapon hub 300 may be implemented by shooting range simulator system 100, for example, as one or more of simulation weapon hubs 126 (Fig. 1).

[0036] According to some exemplary embodiments of the invention, simulation weapon hub 300 may receive signals such as, for example, scan start interrupt signal 301, light detection signals 302, and trigger depression event signals 304. Weapon hub 300 may include multiple connection nodes 306, each of which may be associated with a unique ID tag that may be assigned to an aiming device 307 which may be attached to the hub. ID tags may be assigned according to, for example, physical points of connection or network addresses. In order to derive the aiming history of each aiming device, the hub may include one or more timers 308, e.g. clocks, an aiming position decoding unit 310, a CPU 312, and a memory 314. According to some exemplary embodiments of the invention, timers 308 may provide timing data of received signals to aiming position decoding unit 310, which may derive the aimed-at position of an aiming device, as described in detail below with reference to Fig. 4. Additionally, the hub may include communication network interface 316 for communication with other parts of the system and a weapon sensors interface for receiving other input from the simulated weapons. Hub 300 may be implemented by, for example, an integrated embedded controller or by a discrete assembly including a processing unit (e.g., CPU, microcontroller or DSP), a volatile memory (e.g., SRAM or DRAM), a non-volatile memory (e.g., FLASH, EEPROM or hard disk), a communication interface (e.g., Ethernet, USB or RS-232), and a weapon sensors interface (e.g., A/D, TTL, RS-422, optocouplers, dry contacts and/or the like).

[0037] Reference is now made to Fig. 4, which schematically illustrates a timing diagram useful for demonstrating a method for determining aiming position according to some exemplary embodiments of the invention. Although the invention is not limited in this respect, timing scheme 400 may be implemented by hardware and/or software within aiming position decoding unit 310 (Fig. 3).

[0038] For the purpose of understanding the operation of some embodiments of the invention, the following parameters of the scanning scheme may be defined:

N	number of screen elements in the target screen
{p1, p2, ... , pN}	sequence in which screen elements are illuminated
1/m	length of time (in seconds) for which each screen element is illuminated
K	frequency (in Hz) of the scan, $K = m/N$
T	length of a scan cycle (in seconds), $T = 1/K$
T _i	time interval during which i-th scan occurs
P _j	time slot during which j-th screen element is illuminated

[0039] The target screen may be subdivided into N screen elements, each of which may be illuminated for 1/m seconds according to a scan sequence {p1, p2, ..., pN}. Since the scanning scheme is known, it may be possible to determine by means of a mathematical transformation the positional (x,y) coordinates corresponding to each screen element p1 through pN. The scan sequence may repeat at a frequency of K cycles per second (Hz), where $K = m/N$. The scan frequency K may determine a time interval T, where $T = 1/K$ seconds. For example, if a screen element is illuminated 100 times per second, a corresponding event scale would have a resolution of 10 milliseconds.

[0040] According to some exemplary embodiments of the invention, the scan sequence may be initialized simultaneously with timer 401. Every T seconds there may be a synchronization point 402 for the timer, representing the beginning of a new scan cycle. Each T-long time interval 404 may be subdivided into time slots 406, each lasting 1/m seconds. When an event signal 408, e.g., a light detection signal or a trigger depression signal, is received, it may necessarily fall within a unique time slot P_j and time interval T_i . For example, if an event interrupt occurs at time $t = x$ seconds, then $i = (x \bmod T)$ and $j = (x \bmod 1/m)$. Thus, T may represent the highest resolution in time at which events can be measured. For example, if the scan cycle frequency is 80 Hz, the resolution in time would be 12.5 milliseconds.

[0041] Reference is now made to Fig. 5, which illustrates an aiming device equipped with a directional pickup 500 in accordance with some exemplary embodiments of the invention.

[0042] According to some exemplary embodiments of the invention, an illuminated screen element 502 of a target screen, e.g., screen 108 of Fig. 1, may reflect or emit scattered light 504 in all directions, including that of beam 506. Directional pickup 500 may be aimed at screen element 502 and may therefore detect beam 506, as explained in further detail below with reference to Fig. 6. According to some exemplary embodiments of the invention, a signal responsive to the detected light may be transmitted along a wire 508 to a timing and communication unit 510, which may record the time of receiving the signal, e.g., based on a clock signal, and transmit the recorded time of light detection to a processing unit, e.g., in weapon hub 300 (Fig. 3) or AHP 200 (Fig. 2), capable of synchronizing the light detection time relative to the beginning of a scan cycle, thereby to monitor aiming by the aiming device, as discussed above. Reference is now made to Fig. 6, which schematically illustrates a directional pickup 600 in accordance with some exemplary embodiments of the invention. Although the invention is not limited in this respect, pickup 600 may be mounted on aiming device 136 (Fig. 1), for example, as illustrated by pickup 500 (Fig. 5).

[0043] According to some exemplary embodiments of the invention, a light beam 602 may hit a target screen 603 and may be diffusely reflected from the screen, e.g., at the position of a screen element 604. Scattered light 606 may spread outwards in all directions. Directional pickup 600 may view a narrow field of view 610 via an aperture 612, such that only beams from screen element 604 may be detected, as explained below.

[0044] It will be appreciated that the energy level collected by the directional pickup from screen elements adjacent to element 604, e.g., screen element 616 as illustrated, may be significantly lower than the energy level collected from the aimed-at element 604. The total energy E collected by the directional pickup from element 604 may be calculated according to the formula $E = I * R * \cos(a) * A$, where I is the energy of the laser beam, R is the diffuse reflection coefficient, a is an angle 614, and A is solid angle 610, representing the narrow field of view. Thus, a threshold energy level may be defined to facilitate detection of an illuminated screen element 604 within the tolerance of the pick-up optics and sensor system.

[0045] According to some exemplary embodiments of the system, directional pickup 600 may include a collimating lens 618, which may be fitted into aperture 612 to focus collected light onto a mirror 620, which may in turn reflect the collected light onto a photo-sensor 622. The sensor may then generate an electric signal responsive to the light collected, and the signal may be carried by a wire 624 to a simulation weapon hub (not shown in Fig. 6), as explained above.

[0046] Reference is now made to Fig. 7, which schematically illustrates a target scanning system 700 in accordance with some exemplary embodiments of the invention. Although the invention is not limited in this respect, scan system 700 may be implemented by shooting range simulator system 100 (Fig. 1) and may, for example, perform the functionality of scanner 110 (Fig. 1). In addition, in accordance with some exemplary embodiments of the invention, scan system 700 may include a laser projector with a plurality of beams such as, e.g., a solid-state continuous wave RGB laser, which may be adapted to provide the functionality of scanner 110 (Fig. 1) along with the functionality of scenario projector 104 (Fig. 1), as explained below. Although the invention is not limited in this respect, a special-purpose or commercially available laser such as, e.g., a Digistar 3 Laser or a Jenoptik Ltd GmbH Laser Display Technology laser, may be adapted to provide an additional beam for scanning, e.g., an invisible beam or a beam of a distinct wavelength or frequency which may be distinguished from the spectra of the projection beams.

[0047] According to some exemplary embodiments of the invention, scanning system 700 may include a light beam source 702, e.g., a laser diode, a collimating lens 704, a pulse formation component 706, e.g., an acusto-optics modulator (AOM), as is known in the art, a rotating polygon mirror 708, and an output lens 710. It will be appreciated that an AOM may be used to modulate a light beam 703 to form a pulse with a high peak intensity.

[0048] According to some exemplary embodiments of the invention, light beam source 702 may emit a light beam 703. Collimating lens 704 may focus beam 703 onto pulse formation component 706, which may generate a scan line 707 on a facet 709 of polygonal mirror 708. According to some exemplary embodiments of the invention, mirror facet

709 may reflect a beam 711, which may be focused by lens 710 onto target screen 712, thus illuminating a screen element. According to some exemplary embodiments of the invention, polygonal mirror 708 may rotate at a predetermined speed, which may determine the scan frequency. It may be appreciated by those skilled in the art that, as mirror 708 rotates, scan line 707 may move from facet 709 to a next facet of the mirror, and beam 711 may correspondingly illuminate a next screen element.

[0049] Reference is now made to Fig. 8, which schematically illustrates a method for simulating a shooting range in accordance with some exemplary embodiments of the invention.

[0050] According to some exemplary embodiments of the invention, a simulation may be initialized, as indicated at block 800, and may provide targets for users to aim and "fire" at on a target screen, as described above with reference to Fig. 1. In addition, a scan sequence may begin, as indicated at block 804, and a synchronization timer may be activated, as indicated at block 806, to selectively illuminate positions on a target screen according to a predetermined scheme and at a predetermined frequency, as described above with reference to Fig. 4 and Fig. 1. As a user aiming device enters the simulation, it may be assigned a unique shooter ID tag, as indicated at block 802. According to some exemplary embodiments of the invention, aiming devices equipped with directional pickups may detect light from illuminated screen elements, as indicated at block 808 and described above with reference to Fig. 6. Additionally, as indicated at block 810, event signals may be generated, as described above with reference to Fig. 1.

[0051] According to some exemplary embodiments of the invention, data, e.g., shooter ID and light detection signal, representing that a particular aiming device is aimed at an illuminated screen element, may be received, as indicated at block 812 and described above with reference to Fig. 5. As indicated at block 816, it may be possible to derive the aimed-at position of an aiming device based on the light detection signal, scanning scheme, and timing information, as described above with reference to Fig. 4. Similarly, data, e.g., a shooter ID and an event signal, may be received, as indicated at block 814, and may be combined with timing data to record the event time, as indicated at block 818 and described above with reference to Fig. 1.

[0052] According to some exemplary embodiments of the invention, aiming data, event time data, and scenario data 822 may be compared, as indicated at block 820 and described above with reference to Fig. 1. As indicated by block 824, feedback to the user, e.g., aiming history or hit/miss information, may be displayed, e.g. on the target screen, as described above with reference to Fig. 2. Additionally or alternatively, aiming history of a shooter using an aiming device within the shooting range simulator system may be compiled for the purpose of later review and future training, as indicated at block 826 and described above with reference to Fig. 2.

[0053] Embodiments of the present invention may be implemented by software, by hardware, or by any combination of software and/or hardware as may be suitable for specific applications or in accordance with specific design requirements. Embodiments of the present invention may include modules, units and sub-units, which may be separate of each other or combined together, in whole or in part, and may be implemented using specific, multipurpose or general processors, or devices as are known in the art. Some embodiments of the present invention may include buffers, registers, storage units and/or memory units, for temporary or long-term storage of data and/or in order to facilitate the operation of a specific embodiment.

[0054] While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents may occur to those of ordinary skill in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the scope of the invention.

[0055] Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

[0056] Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0057] Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

Claims

1. A method of determining an aimed-at position of one or more aiming devices on a target screen, comprising:

selectively illuminating positions on a target screen according to a predefined scanning scheme;
detecting from one or more viewing angles, within a narrow field of view, scattered light from an illuminated position on said target screen; and
deriving coordinates of an aimed-at position on said target screen based on the timing, in reference to said

scanning scheme, of a detection signal responsive to detection of light from one or more of said viewing angles.

2. The method of claim 1, comprising compiling a history of said aimed-at positions.

5 3. The method of claim 2, comprising displaying one or more values representing a history of said aimed-at positions.

4. The method of any of claims 1-3, comprising reproducing a desired scenario on said target screen, said scenario including one or more virtual targets.

10 5. The method of claim 4, comprising comparing said aimed-at position with the position of one or more of said virtual targets to determine a parameter indicative of the aiming accuracy of said aimed-at position.

6. The method of claim 5, comprising displaying a value related to the degree of accuracy of said aimed-at position relative to one or more said virtual targets.

15 7. The method of claim 6, wherein displaying comprises graphically displaying said aiming accuracy value on said target screen.

8. The method of any of claims 1-7, comprising receiving an event signal generated in response to an event related to said aiming device.

9. The method of claim 8, wherein said event signal comprises a trigger depression signal generated in response to depression of a trigger of said aiming device.

25 10. The method of claim 9, comprising comparing said aimed-at position at the time of said trigger depression event to the position of one or more of said virtual targets to determine shooting accuracy of said aiming device relative to said one or more of said virtual targets.

30 11. The method of claim 10, comprising displaying a value related to the degree of said shooting accuracy.

12. The method of claim 11, wherein displaying comprises graphically displaying said shooting accuracy value on said target screen.

35 13. The method of any of claims 1-12, wherein selectively illuminating comprises scanning said target screen with an invisible light beam.

14. The method of any of claims 1-13 wherein selectively illuminating comprises scanning said target screen with a laser beam.

40 15. A shooting range simulator system comprising:

a target screen having a plurality of screen elements;

a scanner to selectively illuminate said screen elements according to a predefined scanning scheme;

45 one or more aiming devices having directional pickups with a narrow field of view to detect light scattered from said illuminated screen elements; and

a processing center to determine an aimed-at position on said target screen based on the timing of signals received from said aiming devices in reference to said scanning scheme.

50 16. The system of claim 15, wherein said aiming device is able to produce a trigger depression event signal in response to depression of a trigger of said aiming device.

17. The system of claim 16, wherein said processing center is able to detect shooting accuracy of said aiming device based on the timing of said trigger depression event in reference to said scanning scheme.

55 18. The system of claim 15, wherein said scanner comprises an external scanning device, able to produce a light beam to selectively illuminate a screen element of said target screen.

19. The system of any of claims 15-18, comprising a scenario generator to reproduce on said screen a scenario including

one or more virtual targets.

20. The system of claim 19, wherein said scenario generator comprises a laser projector able to produce a plurality of laser beams to reproduce a scenario on said screen.

5 **21.** The system of claim 20, wherein said laser projector is able to produce a light beam to selectively illuminate a screen element of said target screen.

10 **22.** The system of claim 21, wherein said light beam is an invisible laser beam.

23. The system of claim 21, wherein said light beam is a visible laser beam of a wavelength that is distinguishable from the spectra of said scenario.

15 **24.** The system of any of claims 15-23, wherein said target screen comprises an illuminating display, and where said scanner is able to selectively cause illumination of pixels of said illuminating display.

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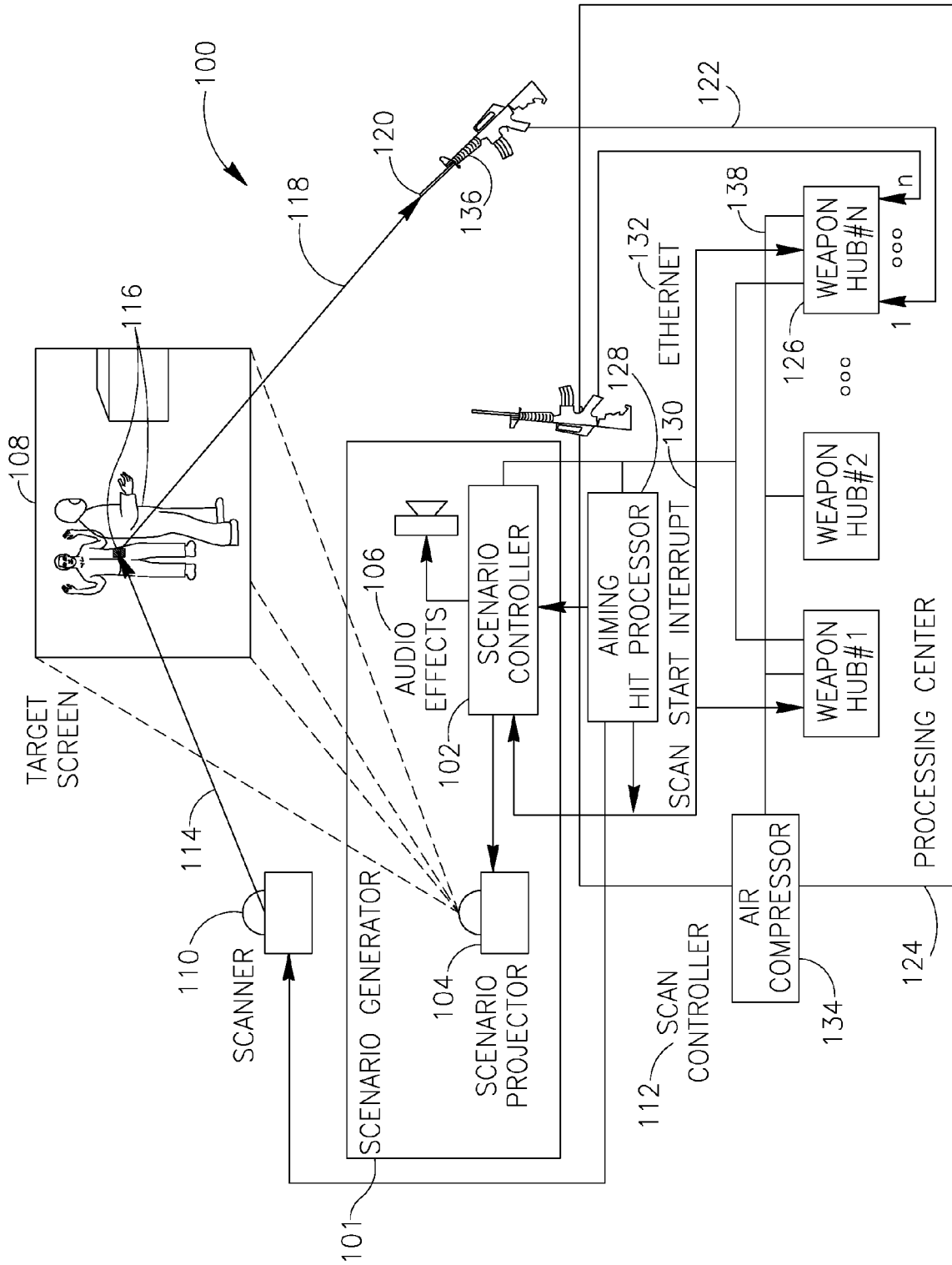


FIG. 1

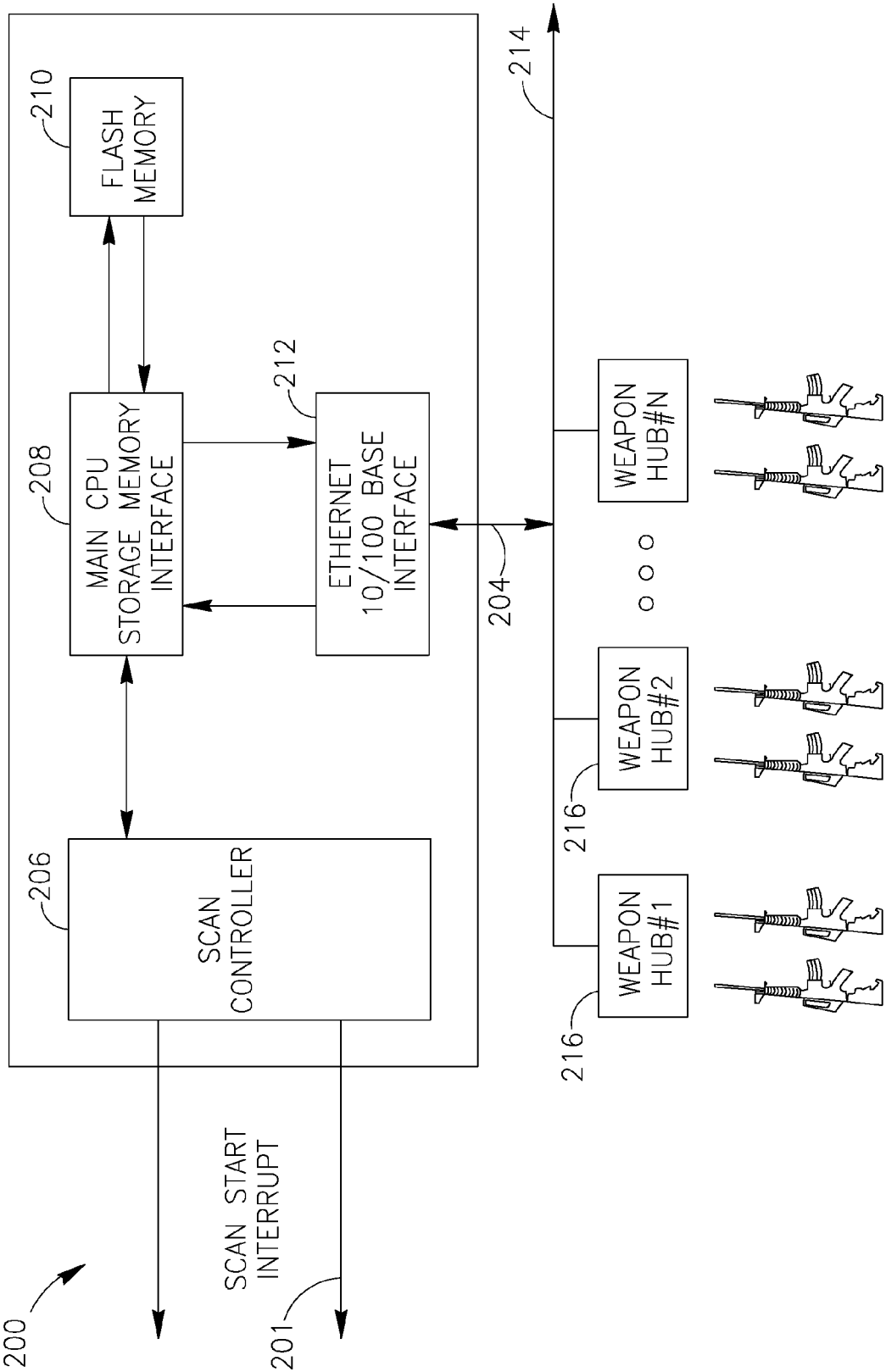


FIG.2

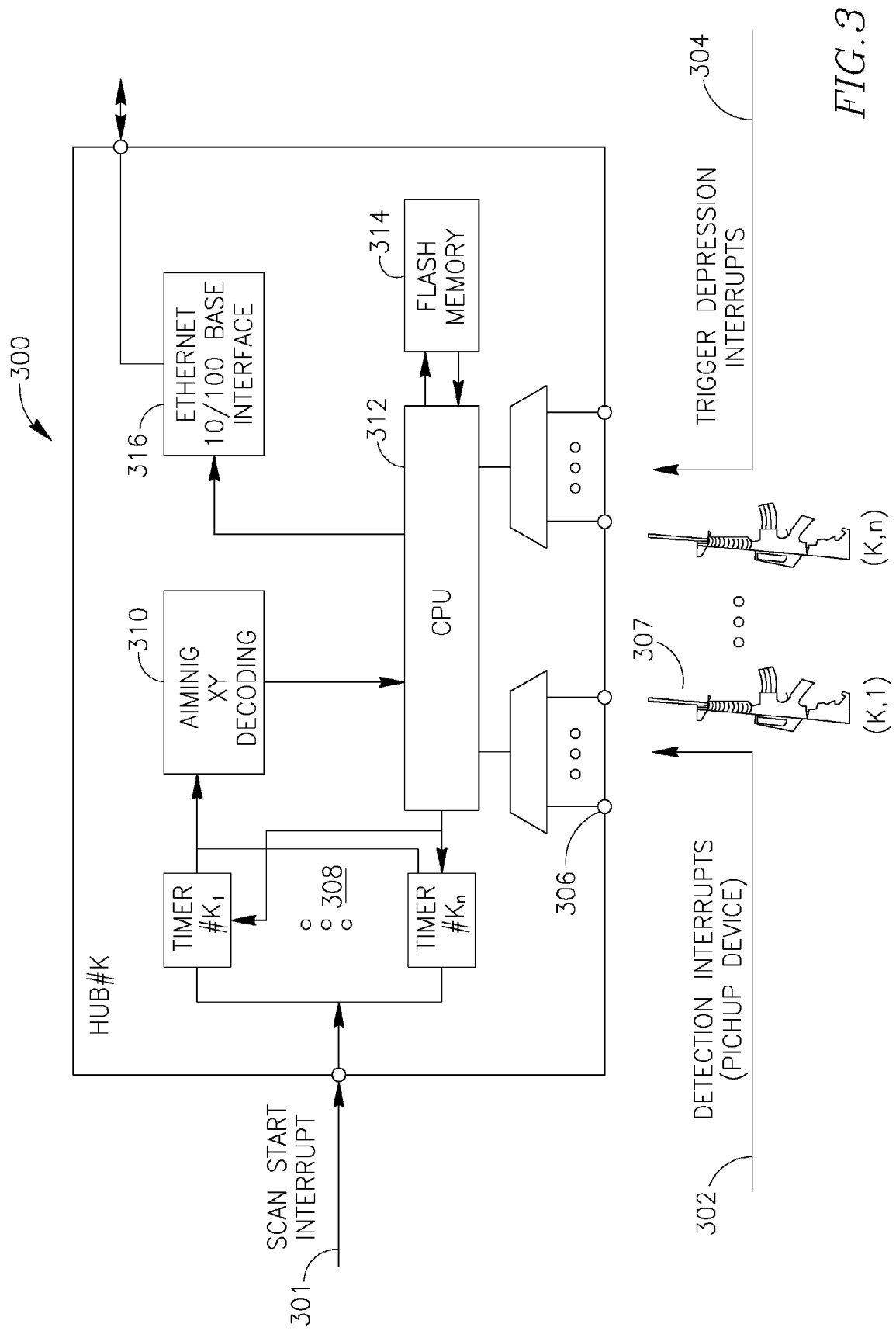


FIG.3

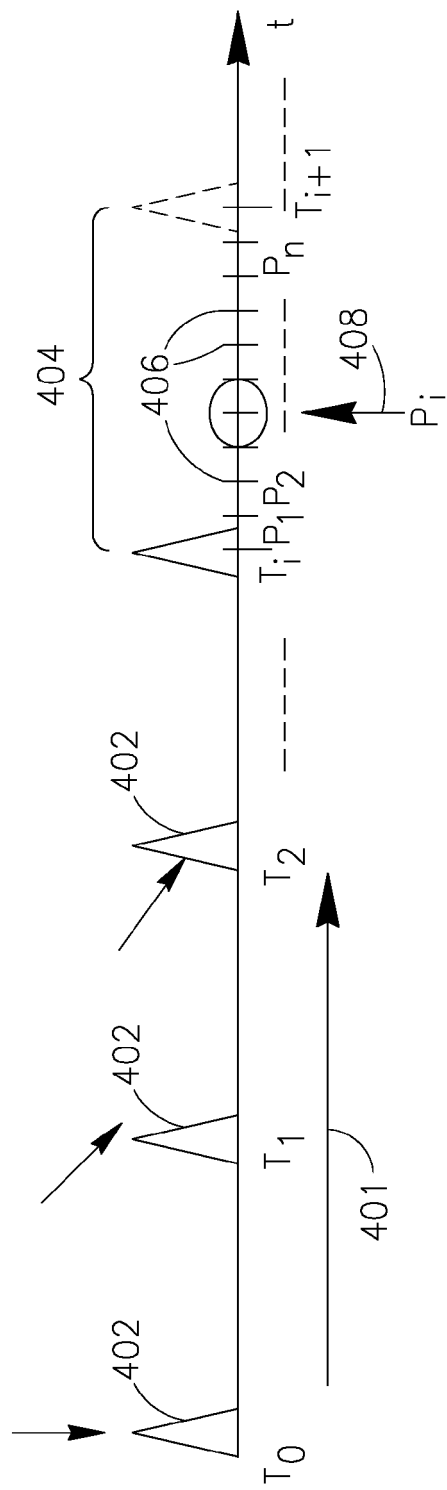


FIG. 4

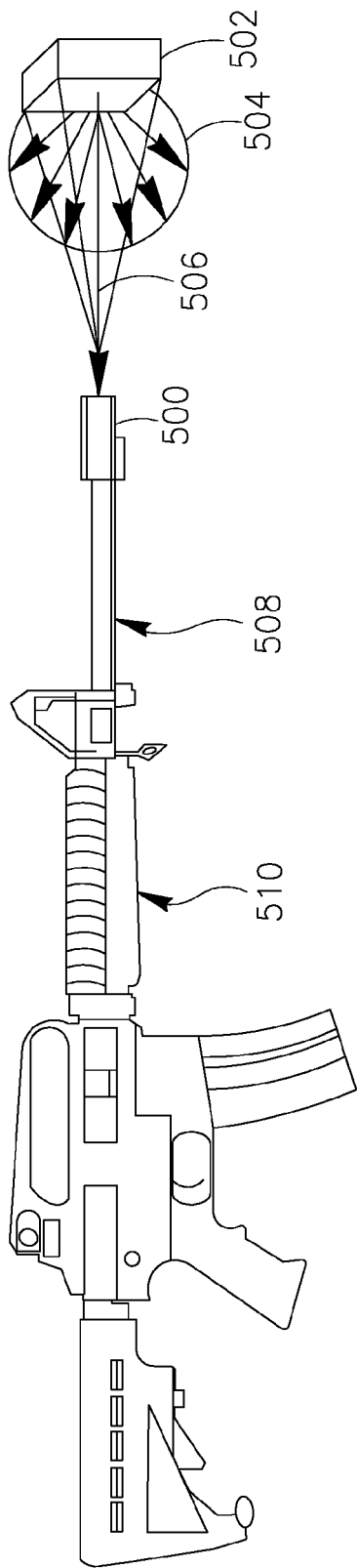
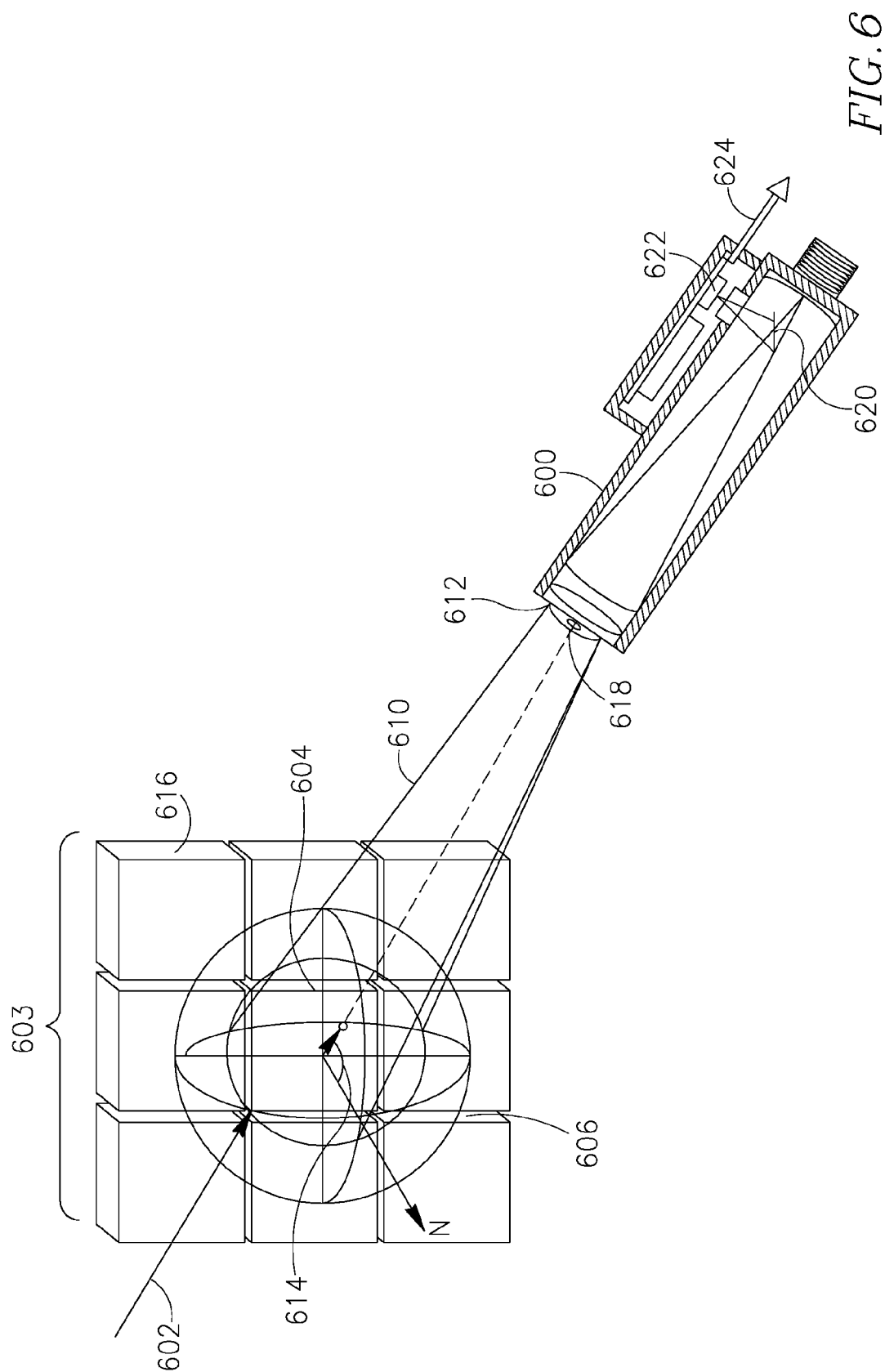


FIG. 5



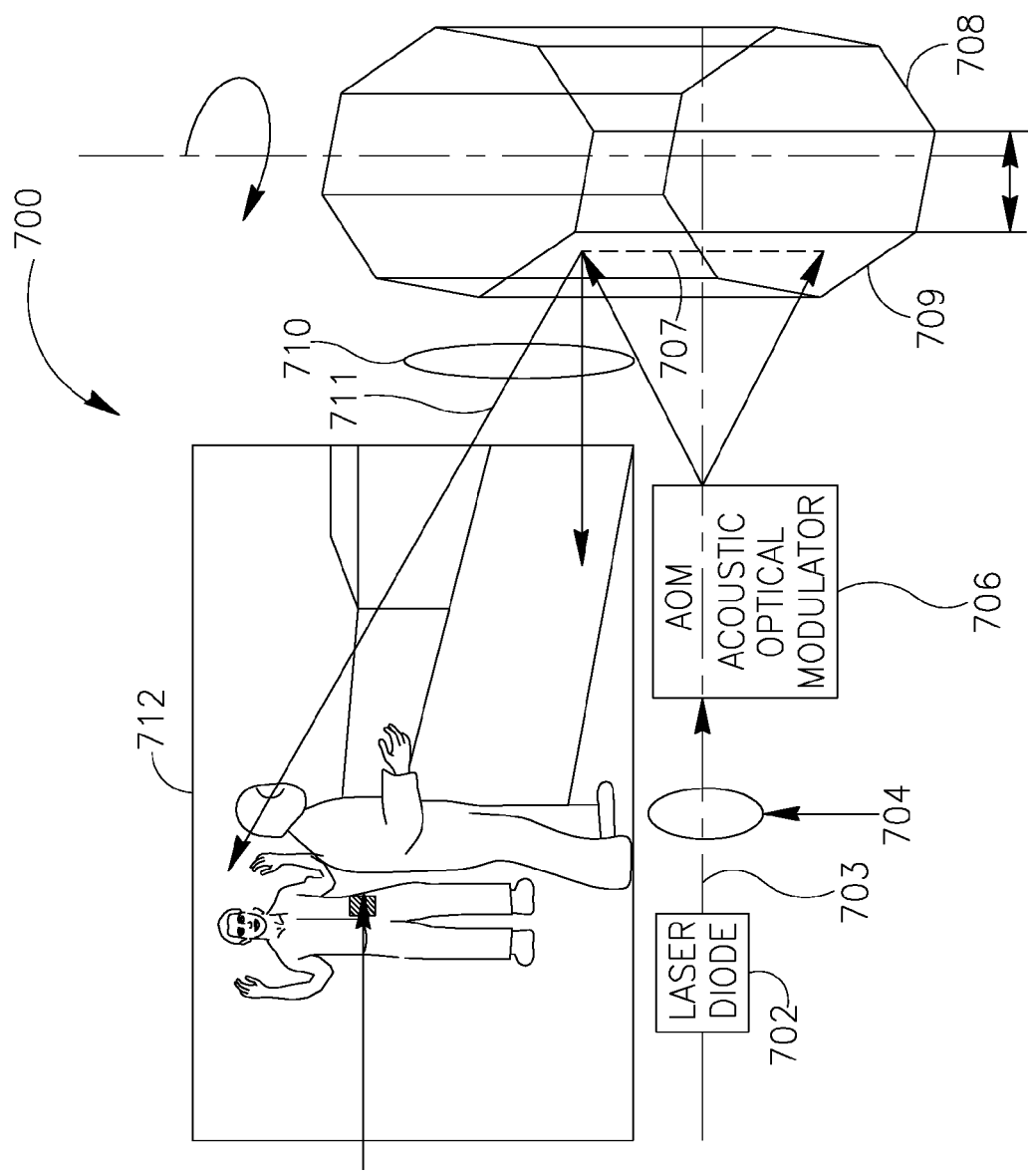


FIG. 7

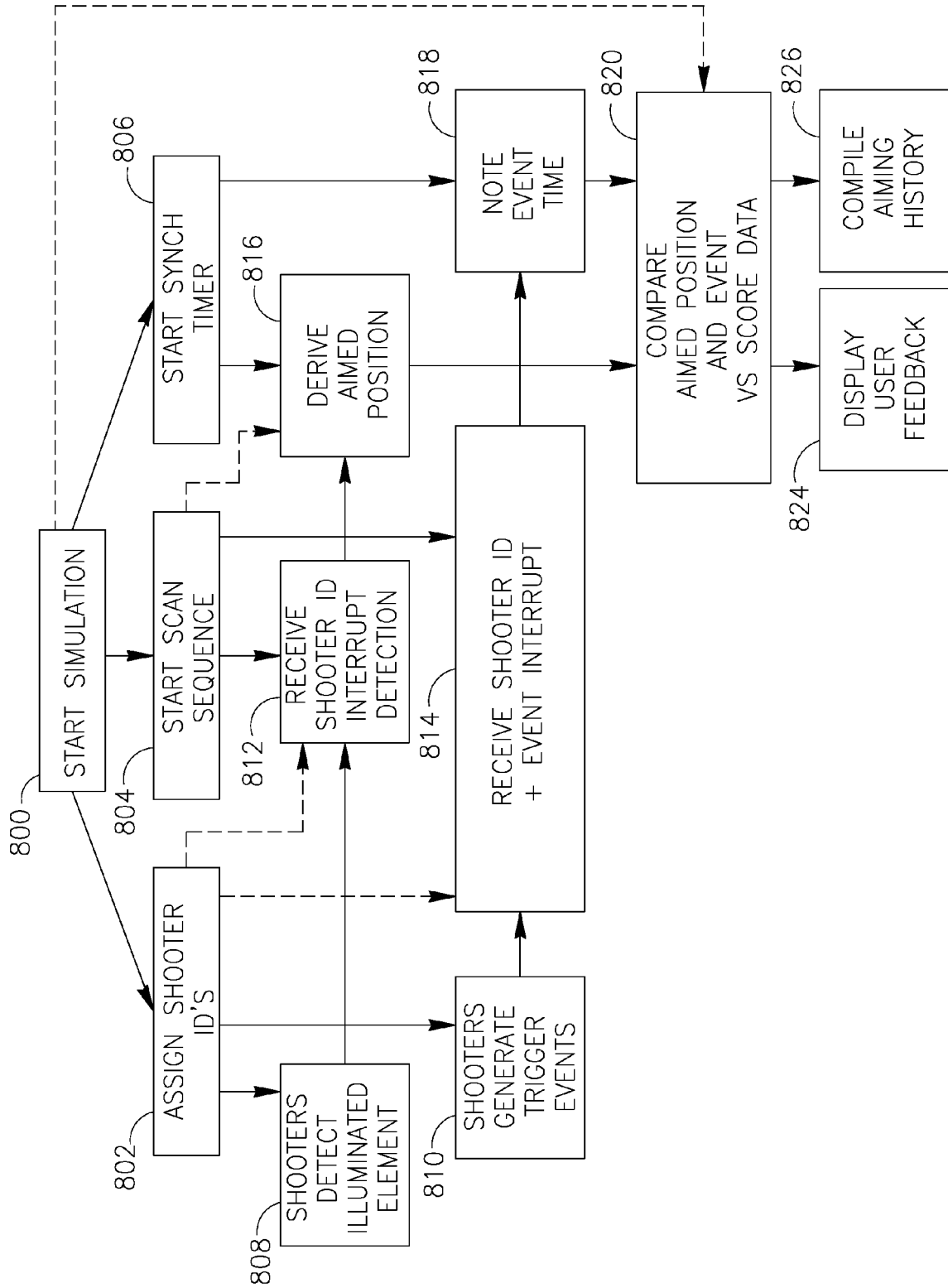


FIG. 8