US010030937B2

(12) **United States Patent**
Northrup et al.

(10) **Patent No.: US 10,030,937 B2**
(45) **Date of Patent: Jul. 24, 2018**

(54) **SYSTEM AND METHOD FOR MARKSMANSHIP TRAINING**

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(73) Assignee: **Shooting Simulator, LLC**, Yantis, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 438 days.

(21) Appl. No.: **14/686,398**

(22) Filed: **Apr. 14, 2015**

(65) **Prior Publication Data**

US 2015/0276349 A1 Oct. 1, 2015

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/149,418, filed on Jan. 7, 2014, now Pat. No. 9,261,332, which (Continued)

(51) **Int. Cl.**
F41G 3/26 (2006.01)
F41A 33/00 (2006.01)
G06F 3/01 (2006.01)

(52) **U.S. Cl.**
CPC ***F41G 3/2633*** (2013.01); ***F41A 33/00*** (2013.01); ***F41G 3/26*** (2013.01); ***F41G 3/2655*** (2013.01); ***G06F 3/011*** (2013.01)

(58) **Field of Classification Search**
CPC ..... F41A 33/00; F41A 33/02; F41A 33/04; F41A 33/06; F41G 3/26; F41G 3/2605; (Continued)

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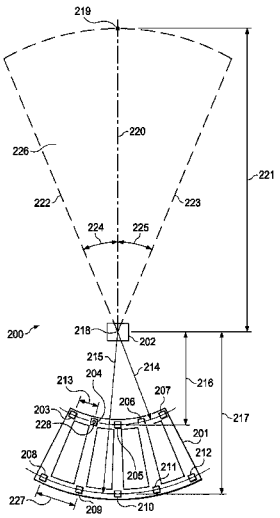
Primary Examiner — Timothy A Musselman
(74) *Attorney, Agent, or Firm* — Schultz & Associates, P.C.

(57) **ABSTRACT**

A system and method for simulating lead of a target includes a network, a simulation administrator and a user device connected to the network, a database connected to the simulation administrator, and a set of position trackers positioned at a simulator site. The user device includes a virtual reality unit and a computer connected to the set of virtual reality unit and to the network. A generated target is simulated. The target and the user are tracked to generate a phantom target and a phantom halo. The phantom target and the phantom halo are displayed on the virtual reality unit at a lead distance and a drop distance from the target as viewed through the virtual reality unit.

32 Claims, 21 Drawing Sheets



Related U.S. Application Data

is a continuation-in-part of application No. 13/890,997, filed on May 9, 2013, now Pat. No. 9,267,762.

(58) **Field of Classification Search**

CPC F41G 3/2611; F41G 3/2616; F41G 3/2622; F41G 3/2627; F41G 3/2633; F41G 3/2638; F41G 3/2644; F41G 3/265; F41G 3/2655; F41G 3/2661; F41G 3/2666; F41G 3/2672; F41G 3/2677; F41G 3/2683; F41G 3/2688; F41G 3/2694

See application file for complete search history.

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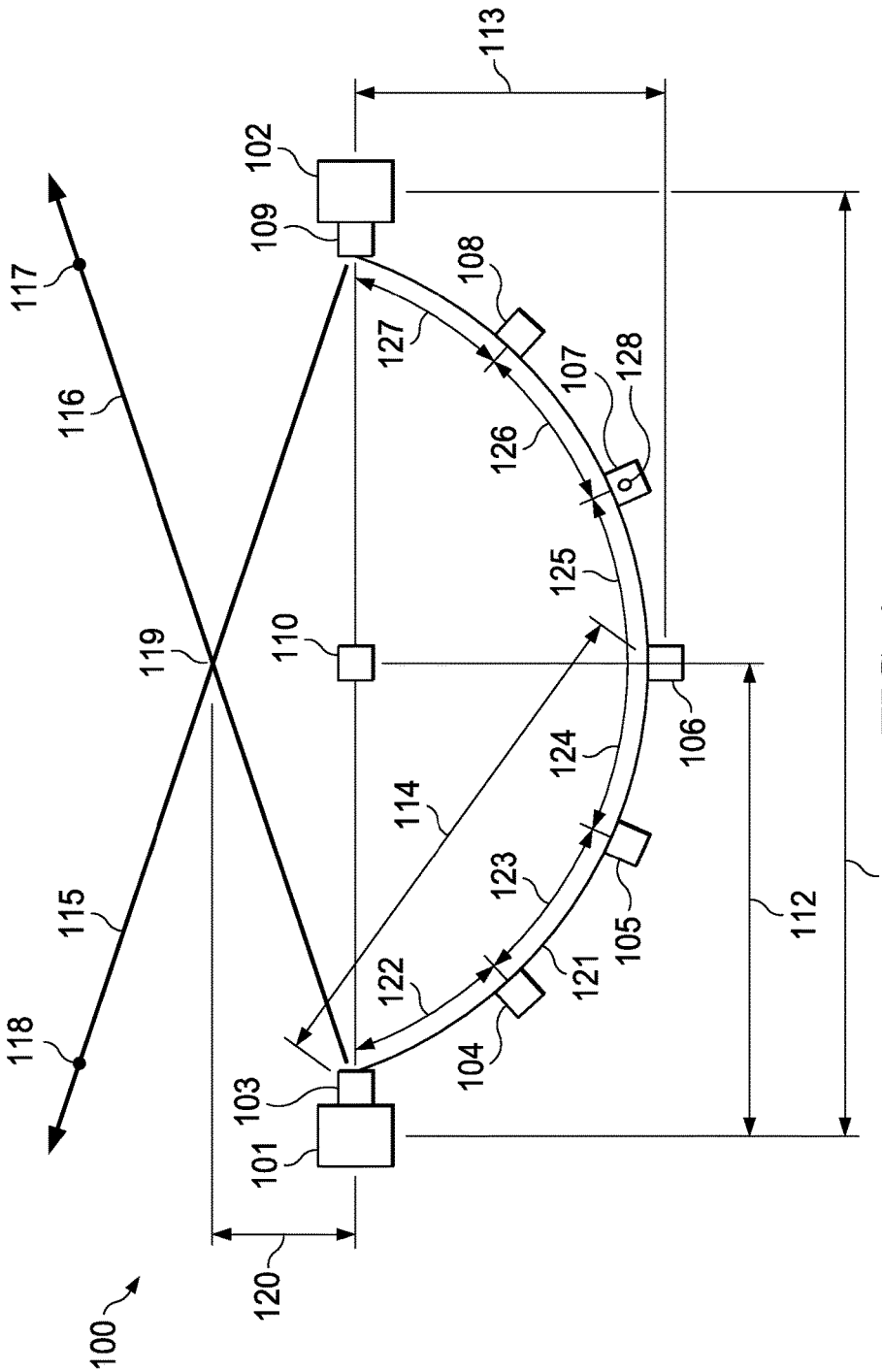
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FIG. 1

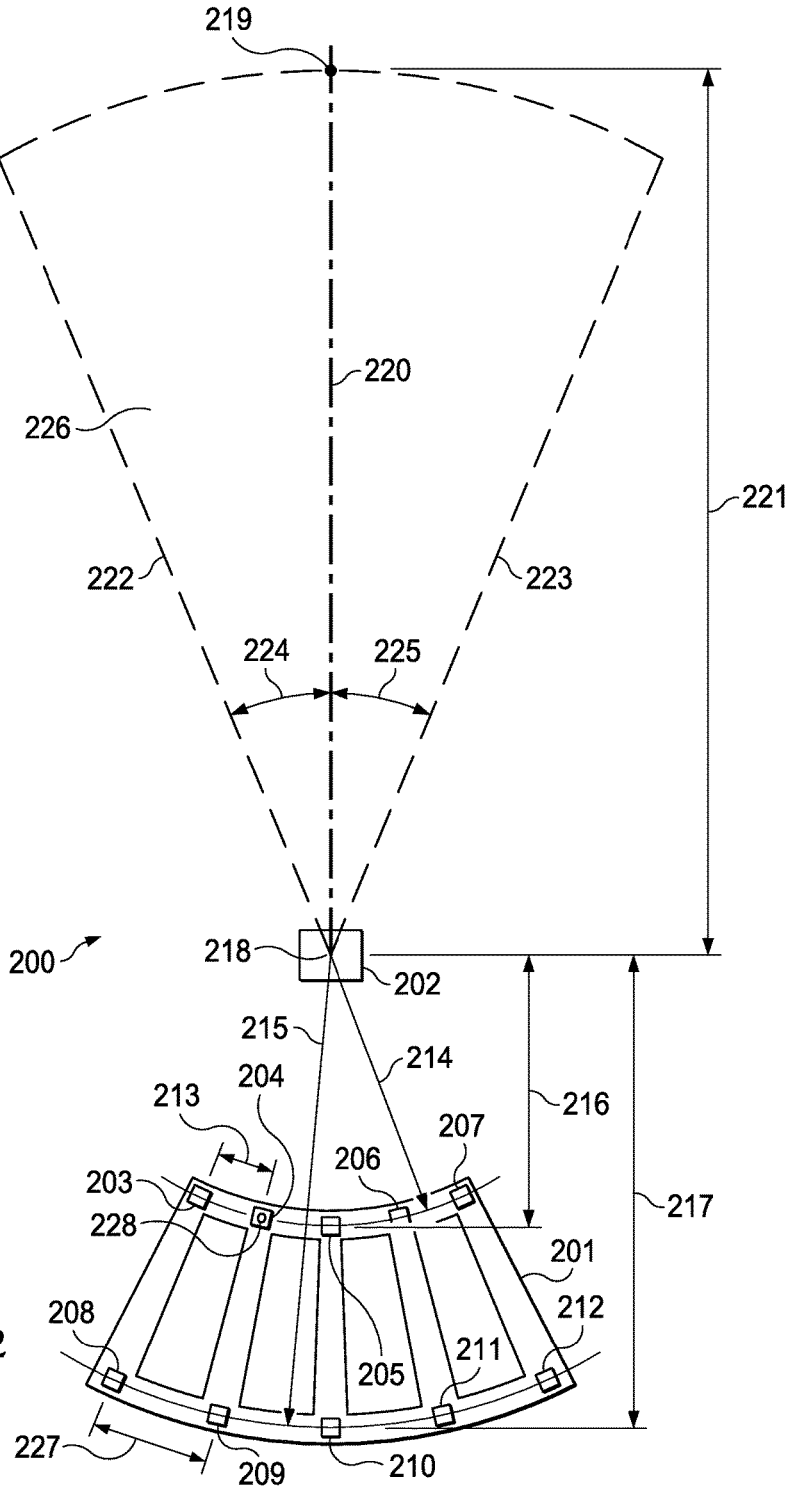
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FIG. 2

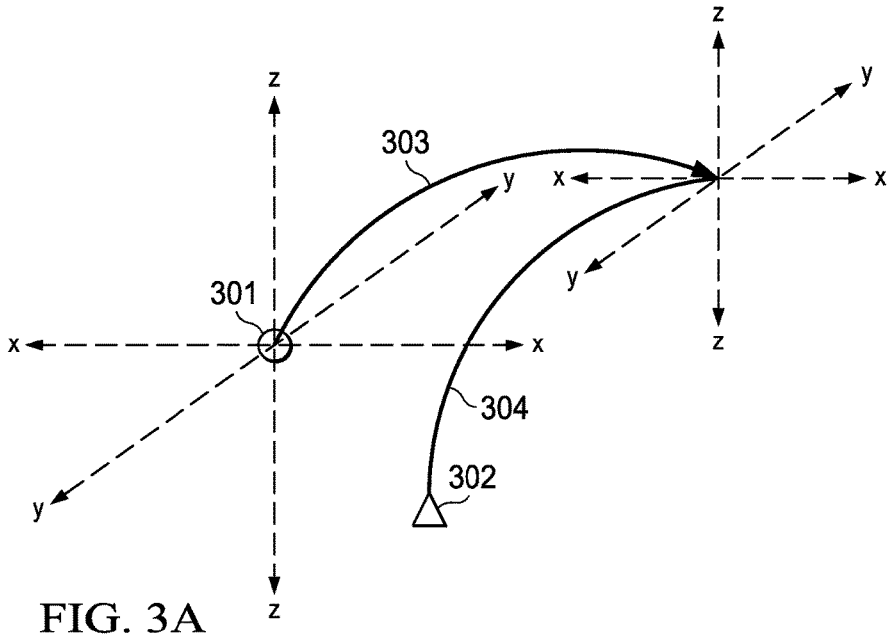


FIG. 3A

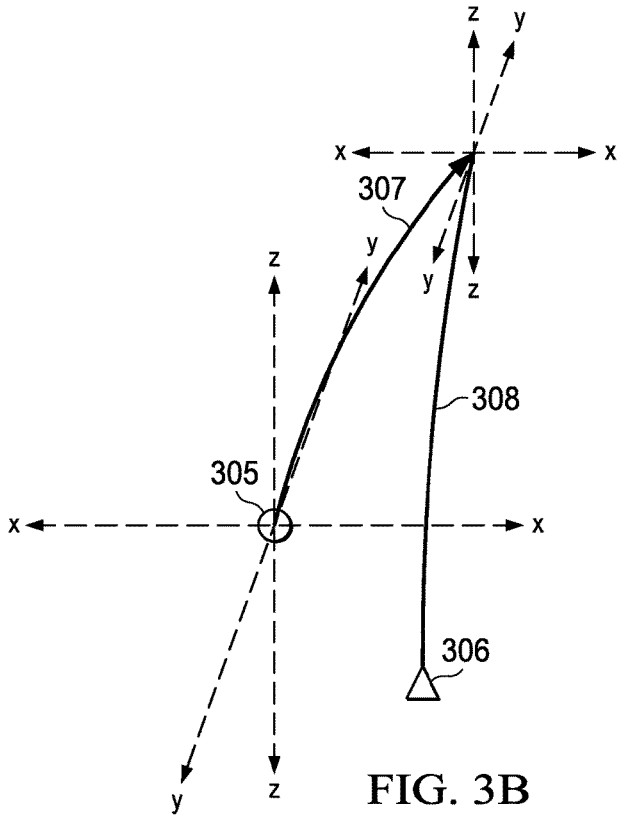


FIG. 3B

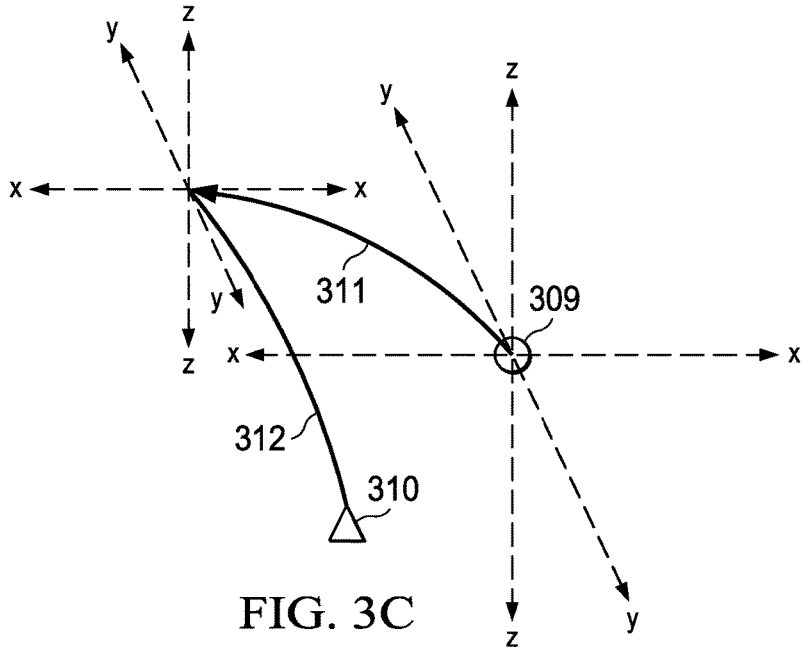


FIG. 3C

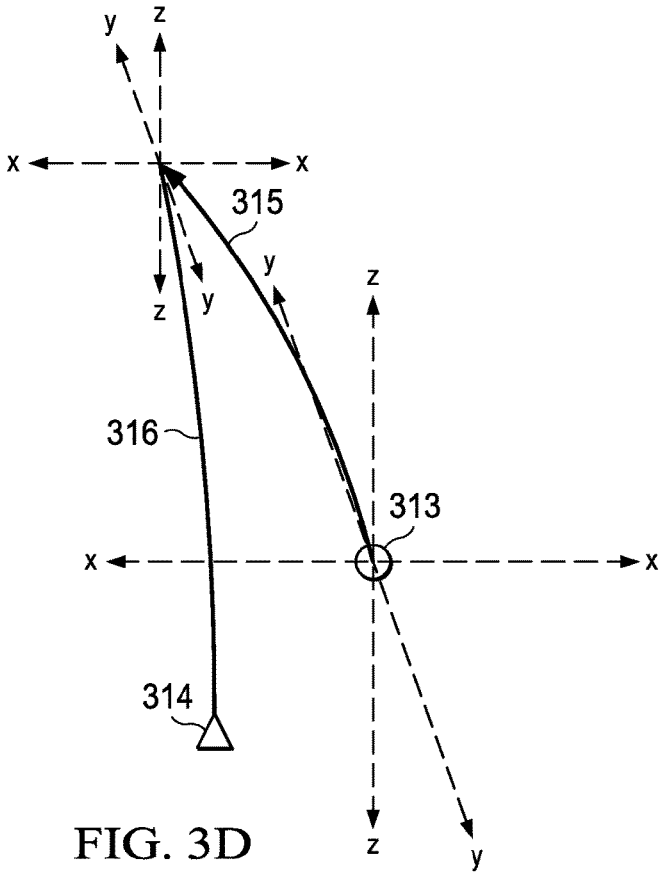


FIG. 3D

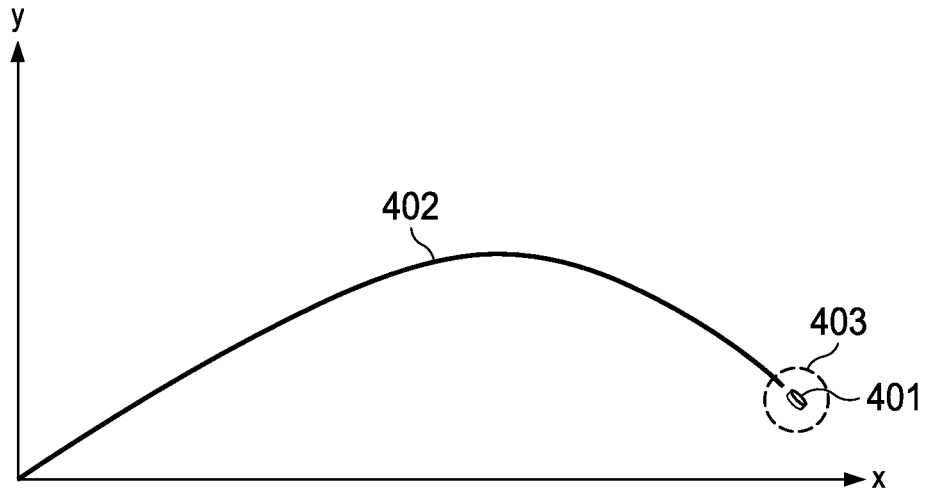


FIG. 4A

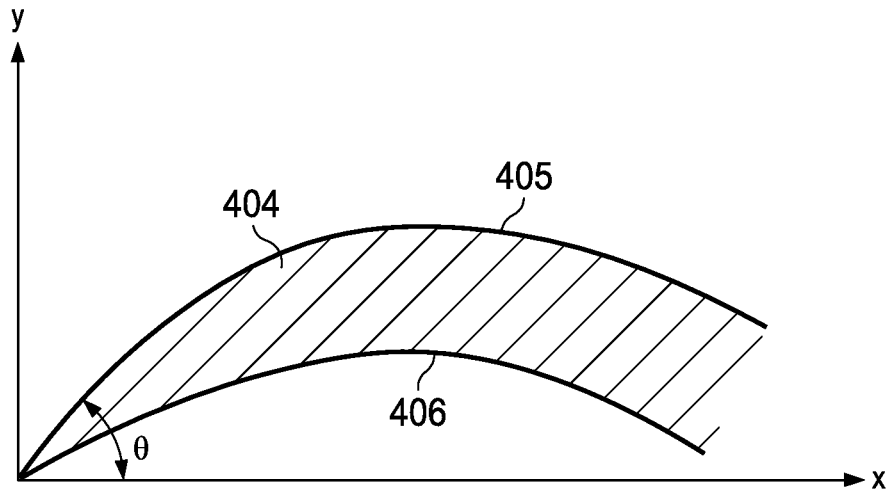


FIG. 4B

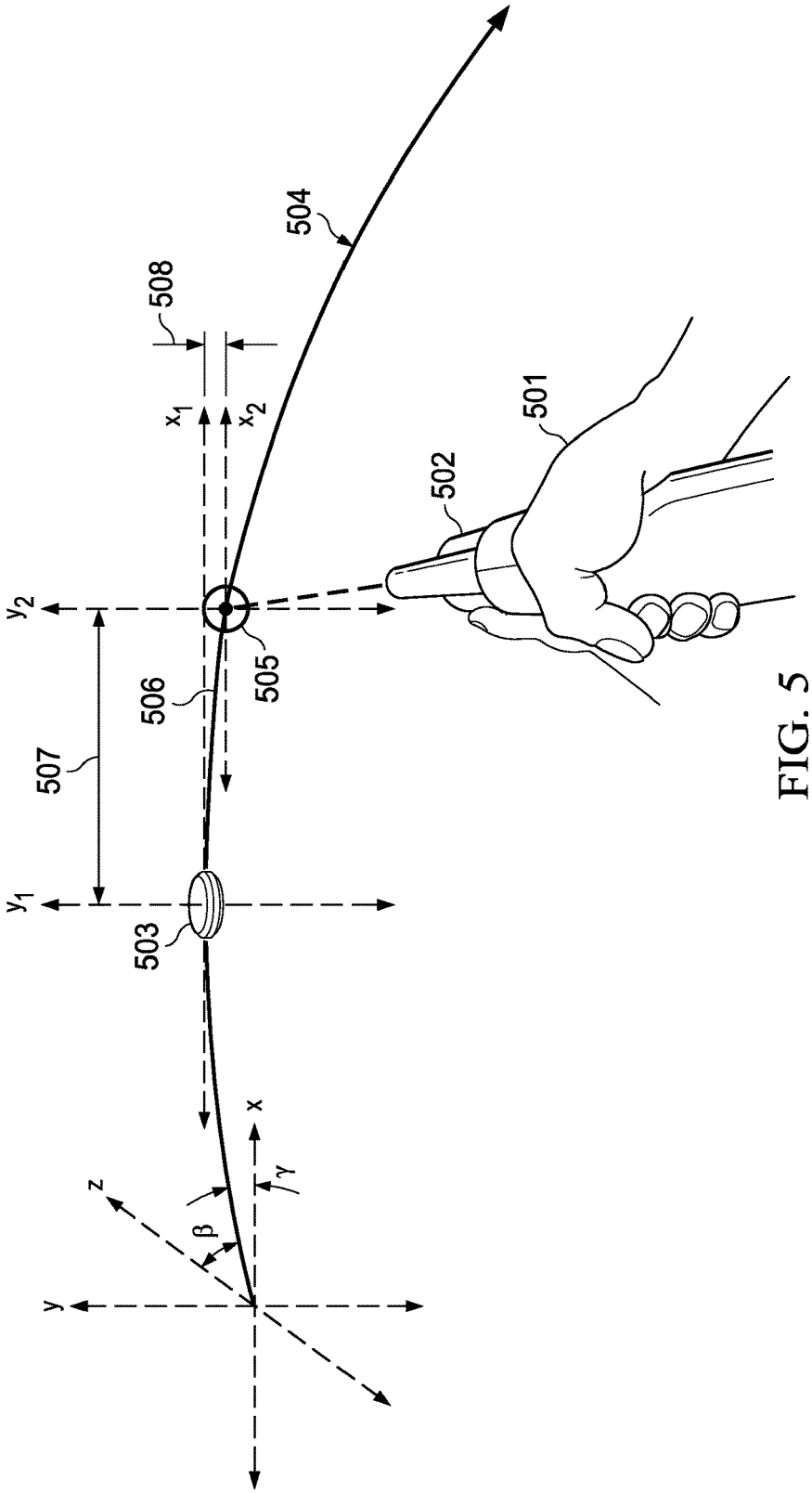
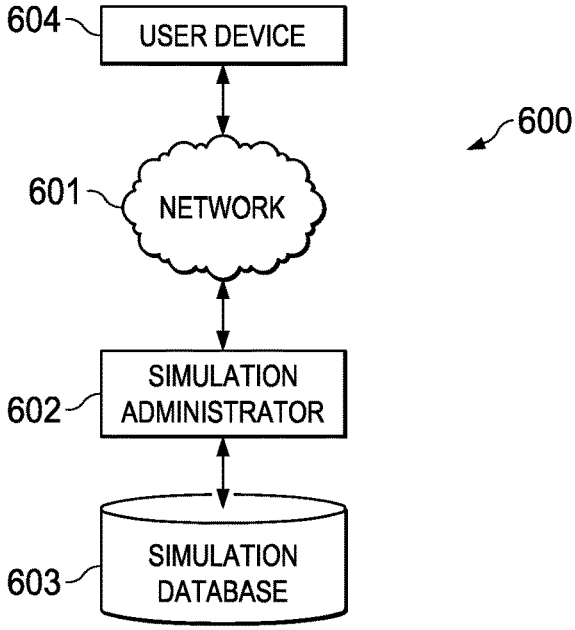


FIG. 5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USER DEVICE
600
601
NETWORK
602
SIMULATION ADMINISTRATOR
603
SIMULATION DATABASE

FIG. 6

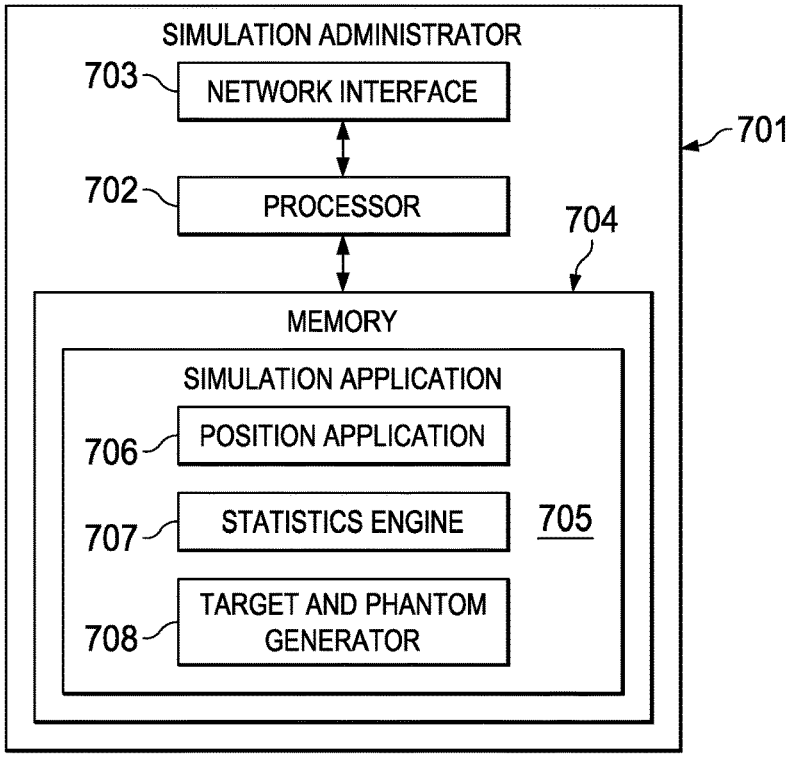
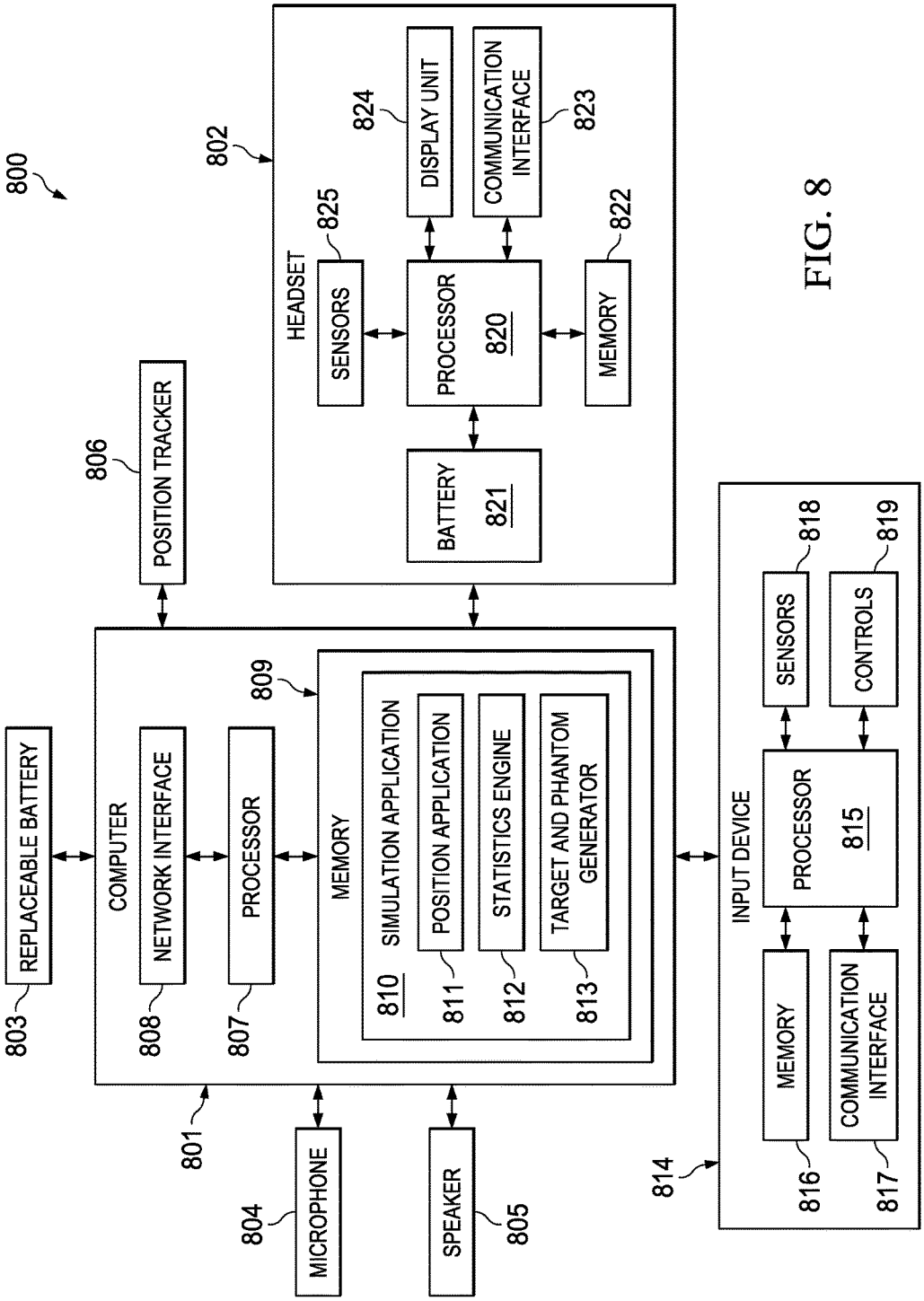

SIMULATION ADMINISTRATOR
703
NETWORK INTERFACE
701
702
PROCESSOR
704
MEMORY
SIMULATION APPLICATION
706
POSITION APPLICATION
707
STATISTICS ENGINE
705
708
TARGET AND PHANTOM GENERATOR

FIG. 7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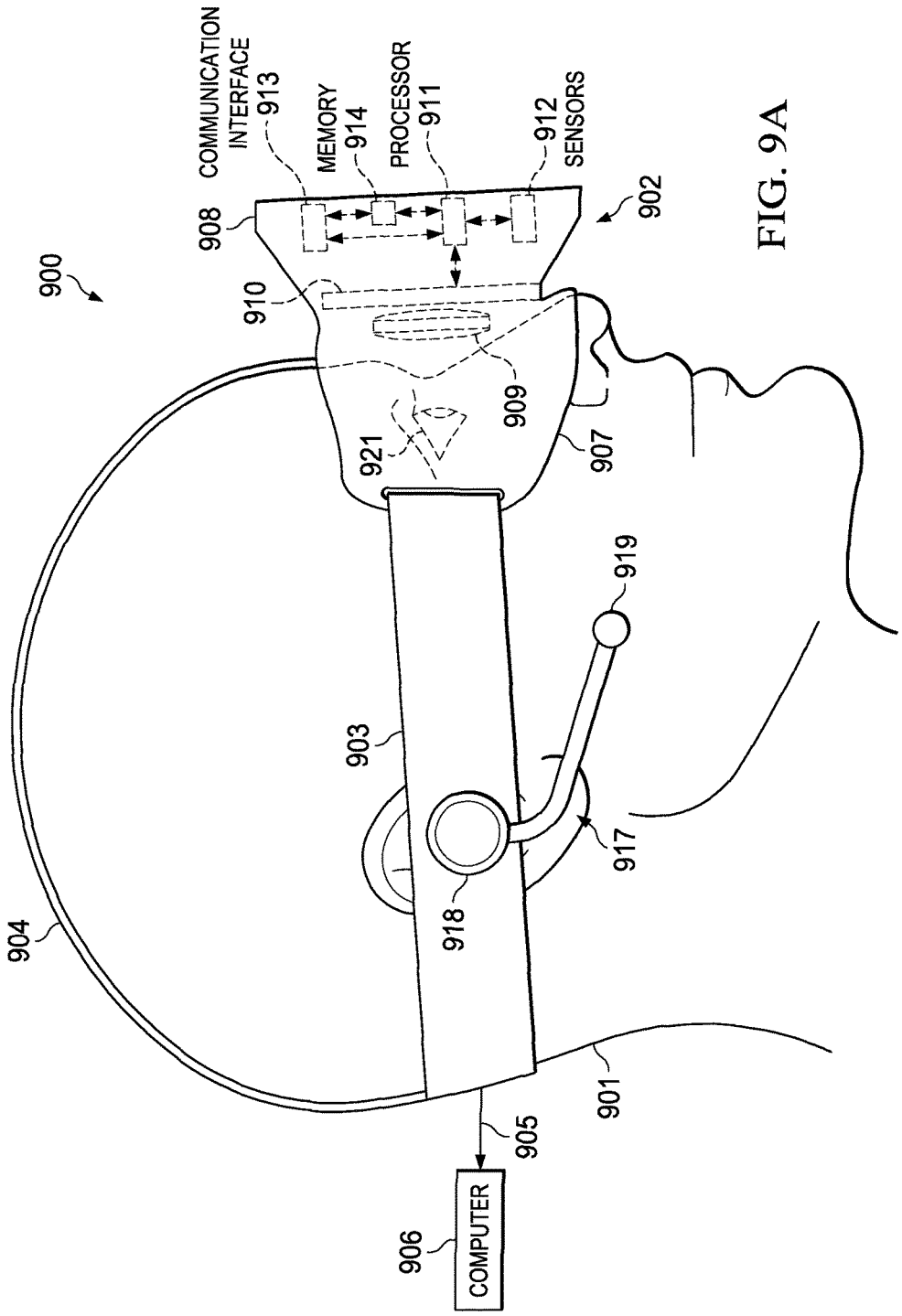
802
HEADSET
824
DISPLAY UNIT
823
COMMUNICATION INTERFACE
825
SENSORS
PROCESSOR 820
822
MEMORY
BATTERY 821
806
POSITION TRACKER
809
MEMORY
SIMULATION APPLICATION 810
POSITION APPLICATION 811
STATISTICS ENGINE 812
TARGET AND PHANTOM GENERATOR 813
803
REPLACEABLE BATTERY
COMPUTER
808
NETWORK INTERFACE
807
PROCESSOR
801
804
MICROPHONE
805
SPEAKER
814
INPUT DEVICE
818
SENSORS
819
CONTROLS
PROCESSOR 815
816
MEMORY
817
COMMUNICATION INTERFACE

FIG. 8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COMMUNICATION INTERFACE 913
MEMORY 914
PROCESSOR 911
912 SENSORS
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905
906
COMPUTER

FIG. 9A

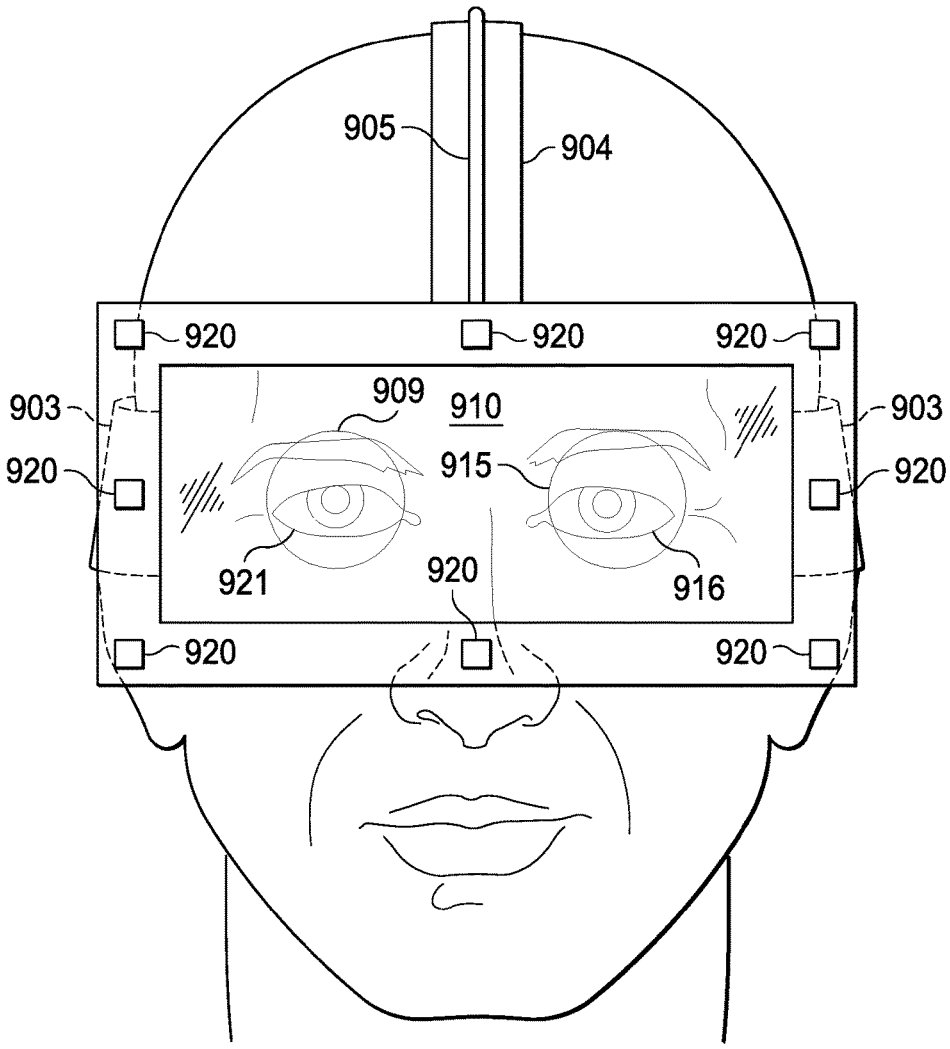
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FIG. 9B

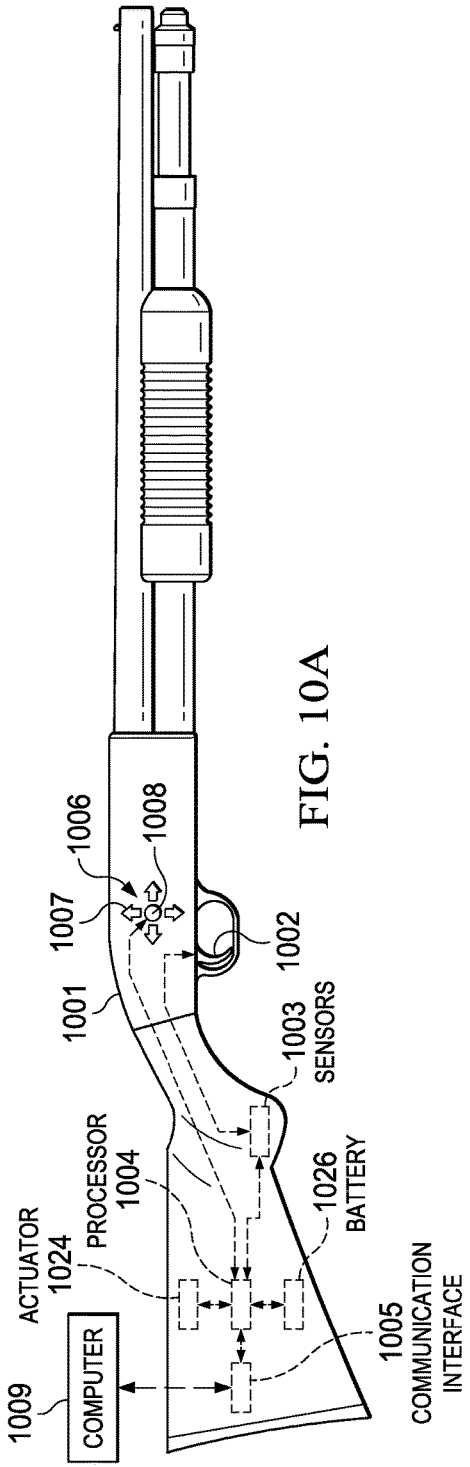


FIG. 10A

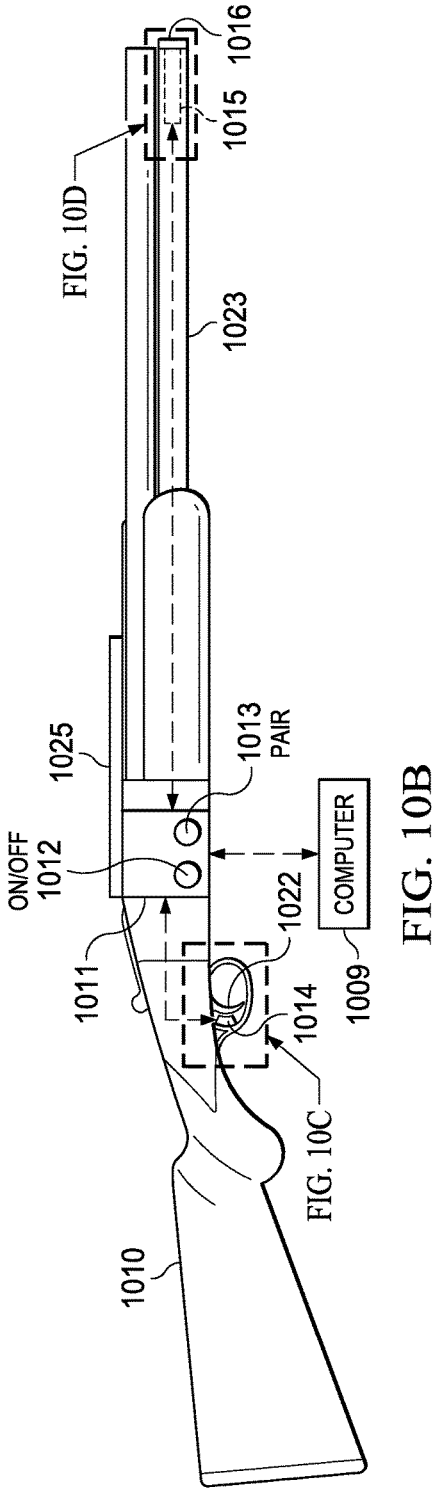


FIG. 10B

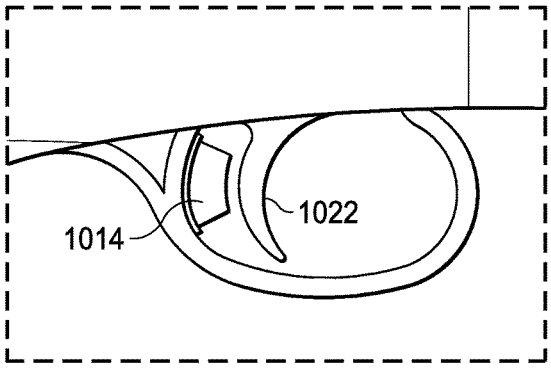


FIG. 10C

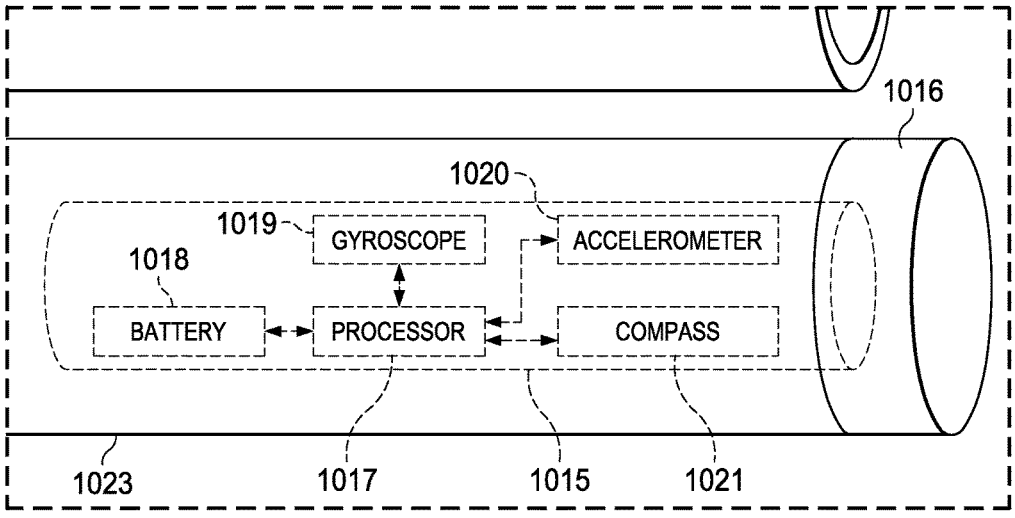
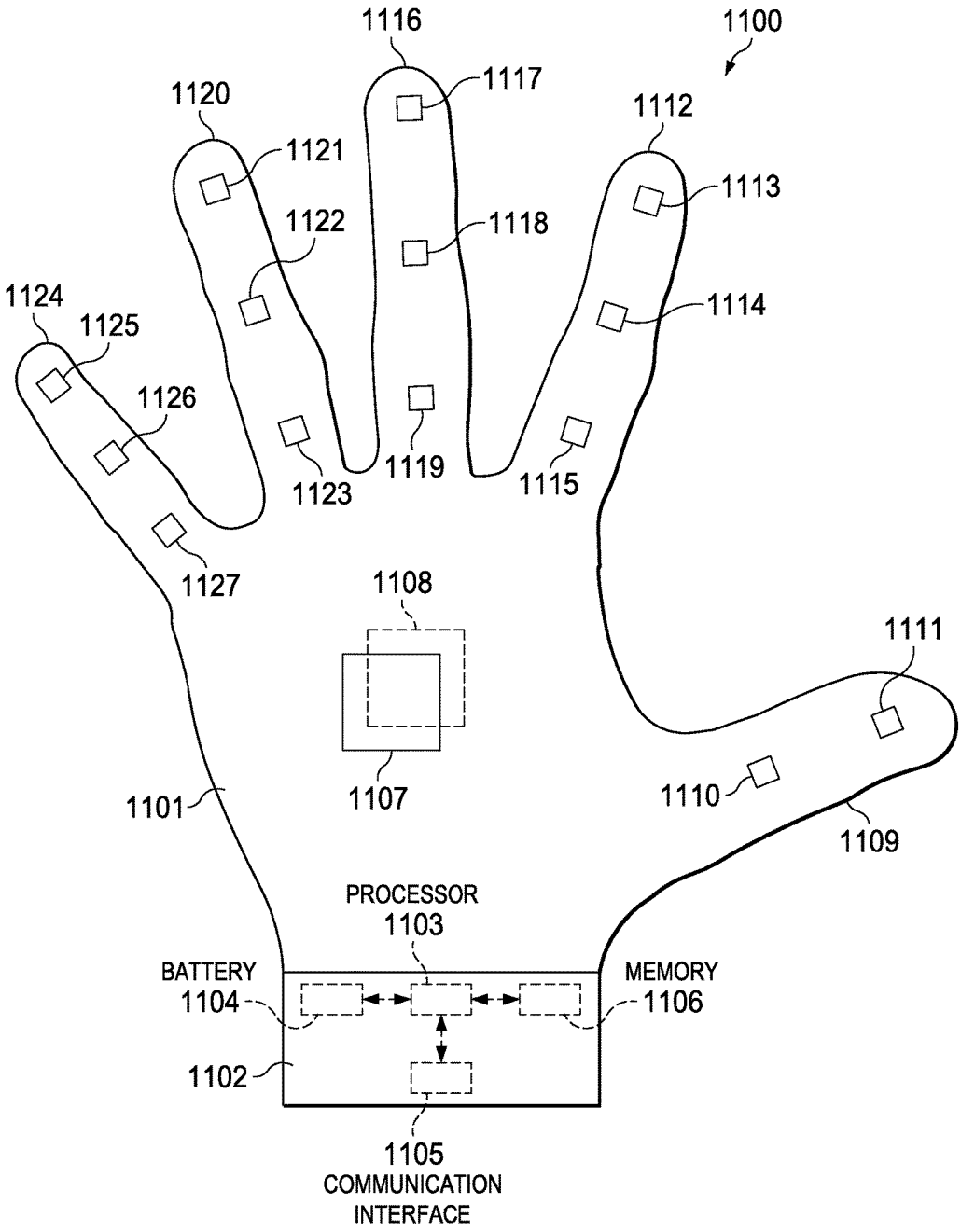


FIG. 10D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1108
1111
1107
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PROCESSOR
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BATTERY
1104
MEMORY
1106
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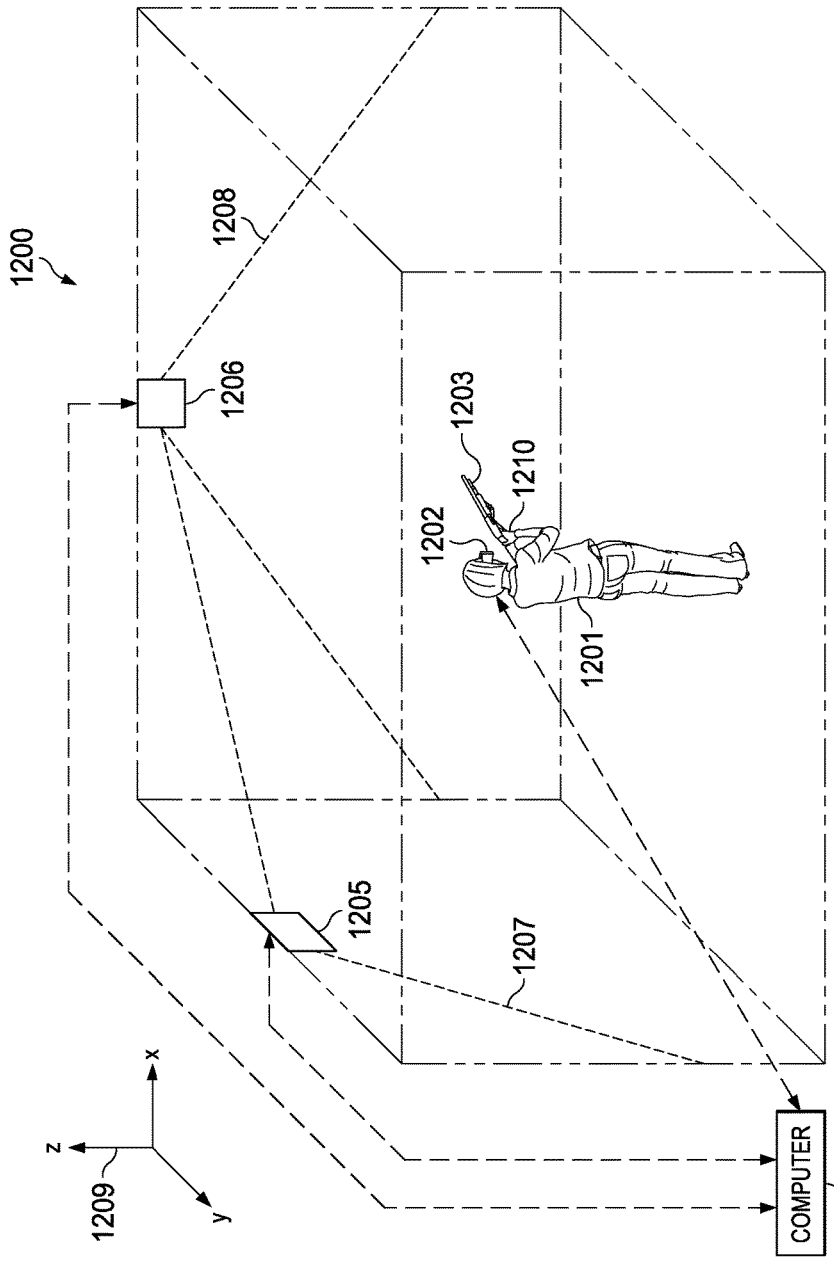
1105
COMMUNICATION
INTERFACE

FIG. 11


1200
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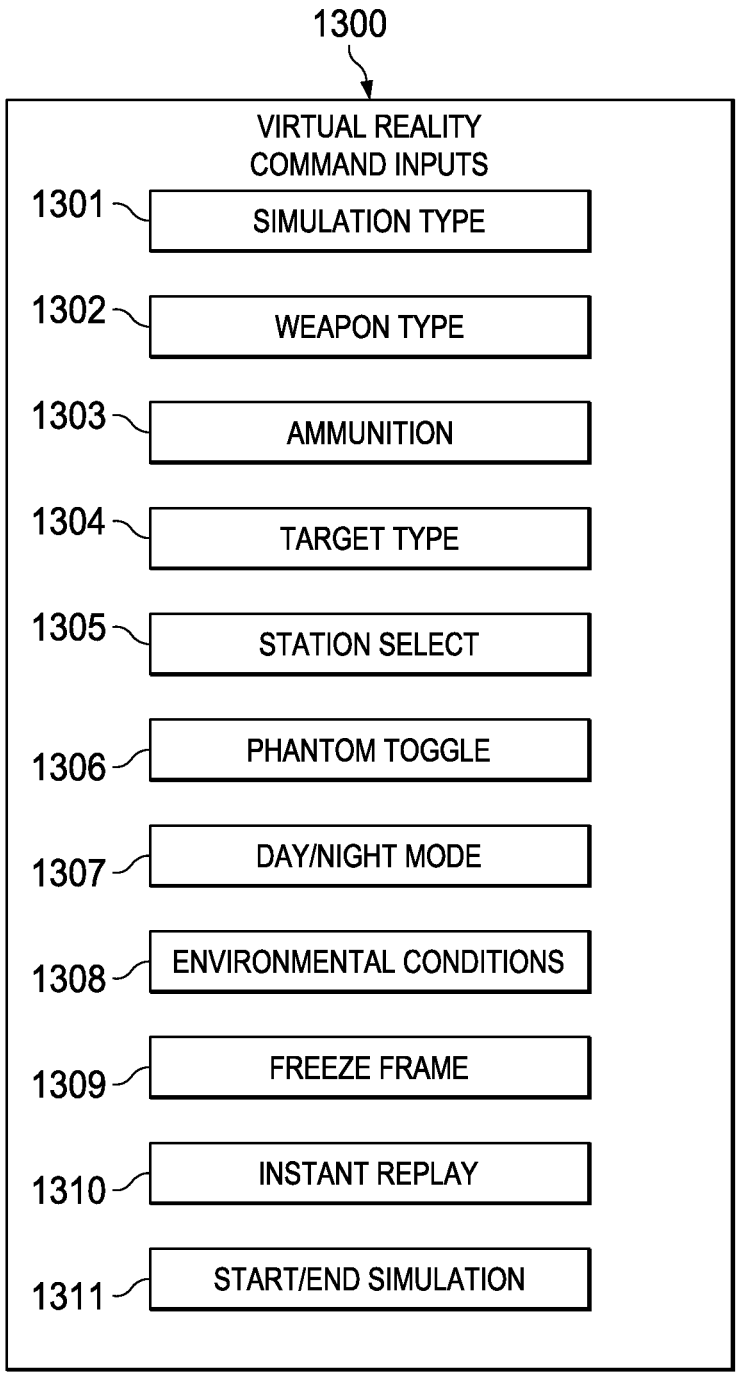
z
y
1209
COMPUTER
1204

FIG. 12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AMMUNITION
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TARGET TYPE
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STATION SELECT
1306
PHANTOM TOGGLE
1307
DAY/NIGHT MODE
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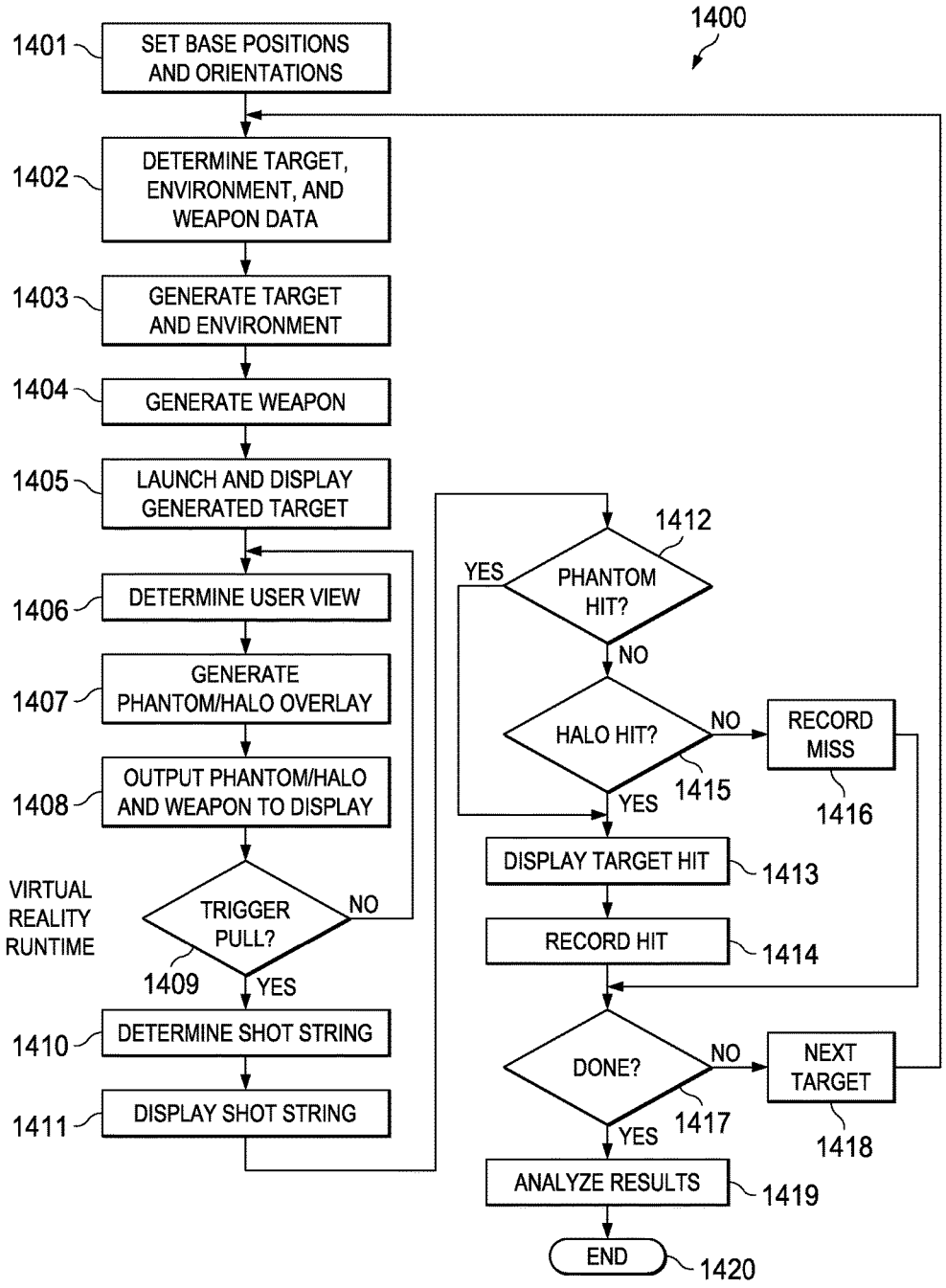
ENVIRONMENTAL CONDITIONS
1309
FREEZE FRAME
1310
INSTANT REPLAY
1311
START/END SIMULATION

FIG. 13


1400
1401
SET BASE POSITIONS AND ORIENTATIONS
1402
DETERMINE TARGET, ENVIRONMENT, AND WEAPON DATA
1403
GENERATE TARGET AND ENVIRONMENT
1404
GENERATE WEAPON
1405
LAUNCH AND DISPLAY GENERATED TARGET
1406
DETERMINE USER VIEW
1407
GENERATE PHANTOM/HALO OVERLAY
1408
OUTPUT PHANTOM/HALO AND WEAPON TO DISPLAY
VIRTUAL REALITY RUNTIME
TRIGGER PULL?
NO
1409
YES
1410
DETERMINE SHOT STRING
1411
DISPLAY SHOT STRING
1412
YES
PHANTOM HIT?
NO
HALO HIT?
NO
RECORD MISS
1415
1416
YES
DISPLAY TARGET HIT
1413
RECORD HIT
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DONE?
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NEXT TARGET
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YES
ANALYZE RESULTS
1419
END
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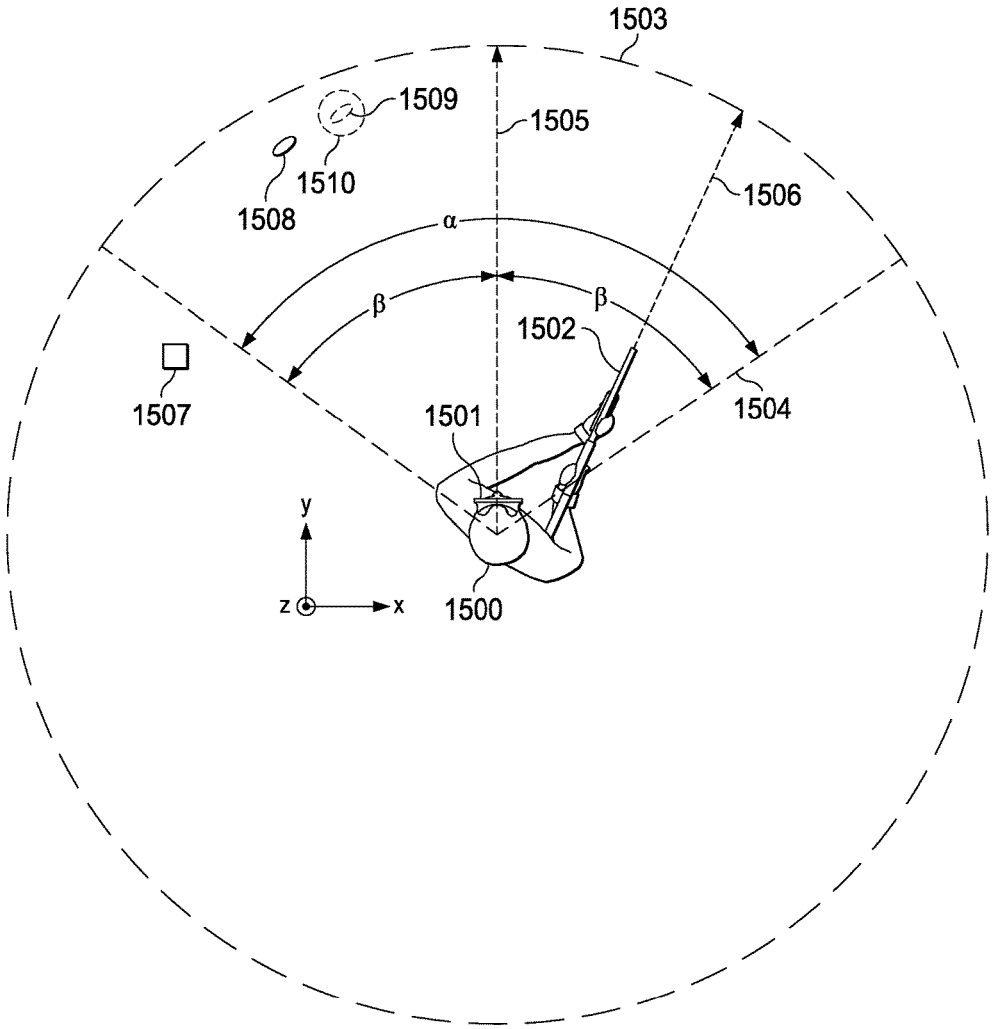
FIG. 14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1507
1501
1504
y
z
x
1500

FIG. 15A

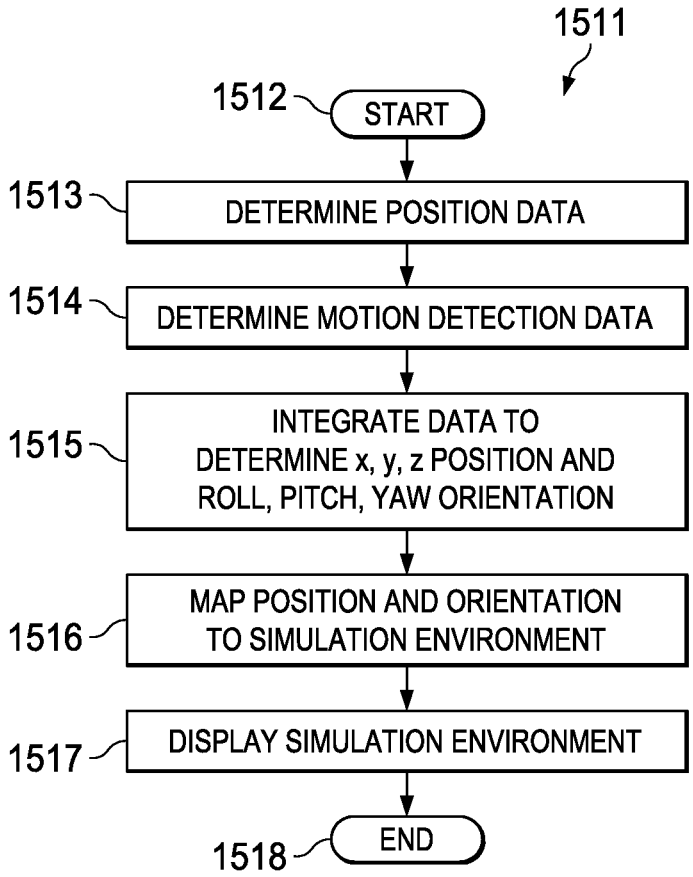
1511
1512
START
1513
DETERMINE POSITION DATA
1514
DETERMINE MOTION DETECTION DATA
1515
INTEGRATE DATA TO DETERMINE x, y, z POSITION AND ROLL, PITCH, YAW ORIENTATION
1516
MAP POSITION AND ORIENTATION TO SIMULATION ENVIRONMENT
1517
DISPLAY SIMULATION ENVIRONMENT
1518
END

FIG. 15B

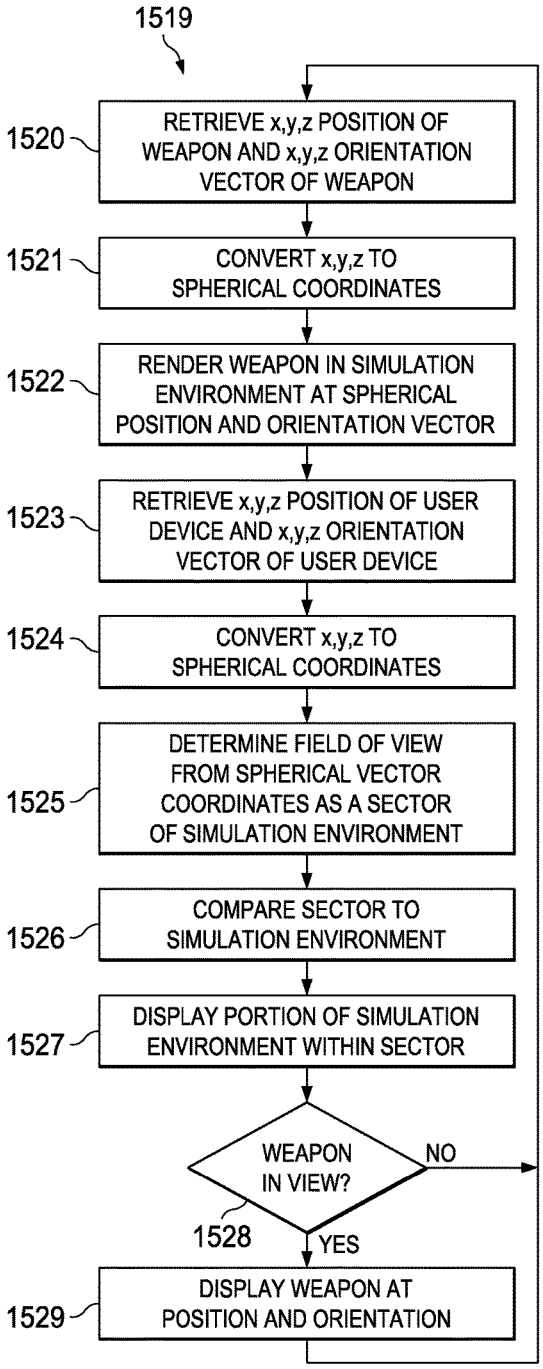

FIG. 15C

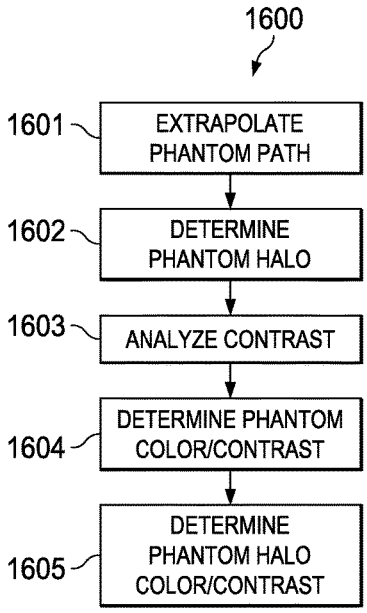

FIG. 16A

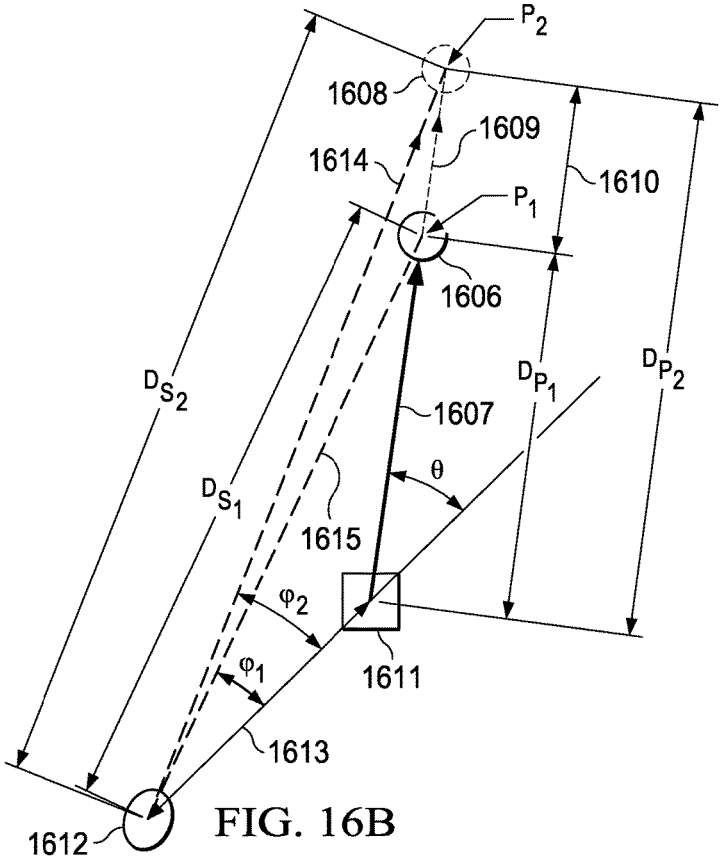

FIG. 16B

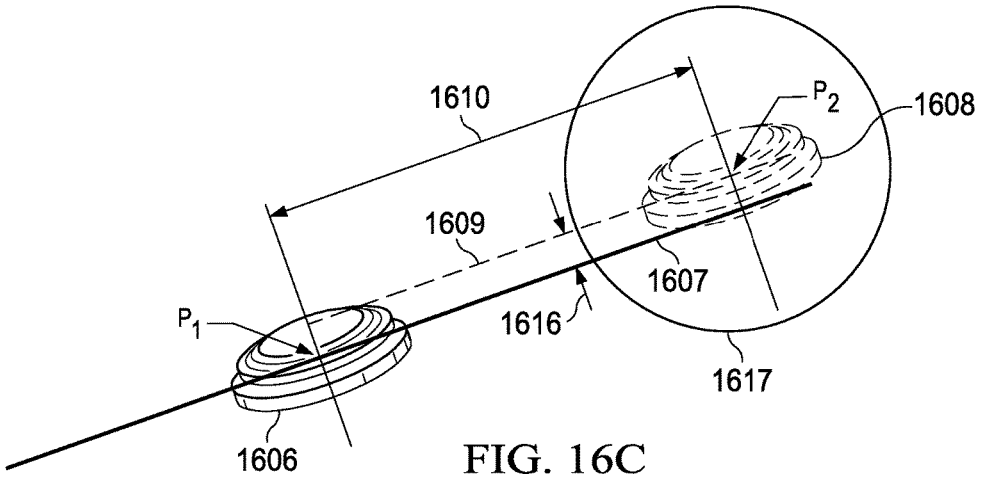

FIG. 16C

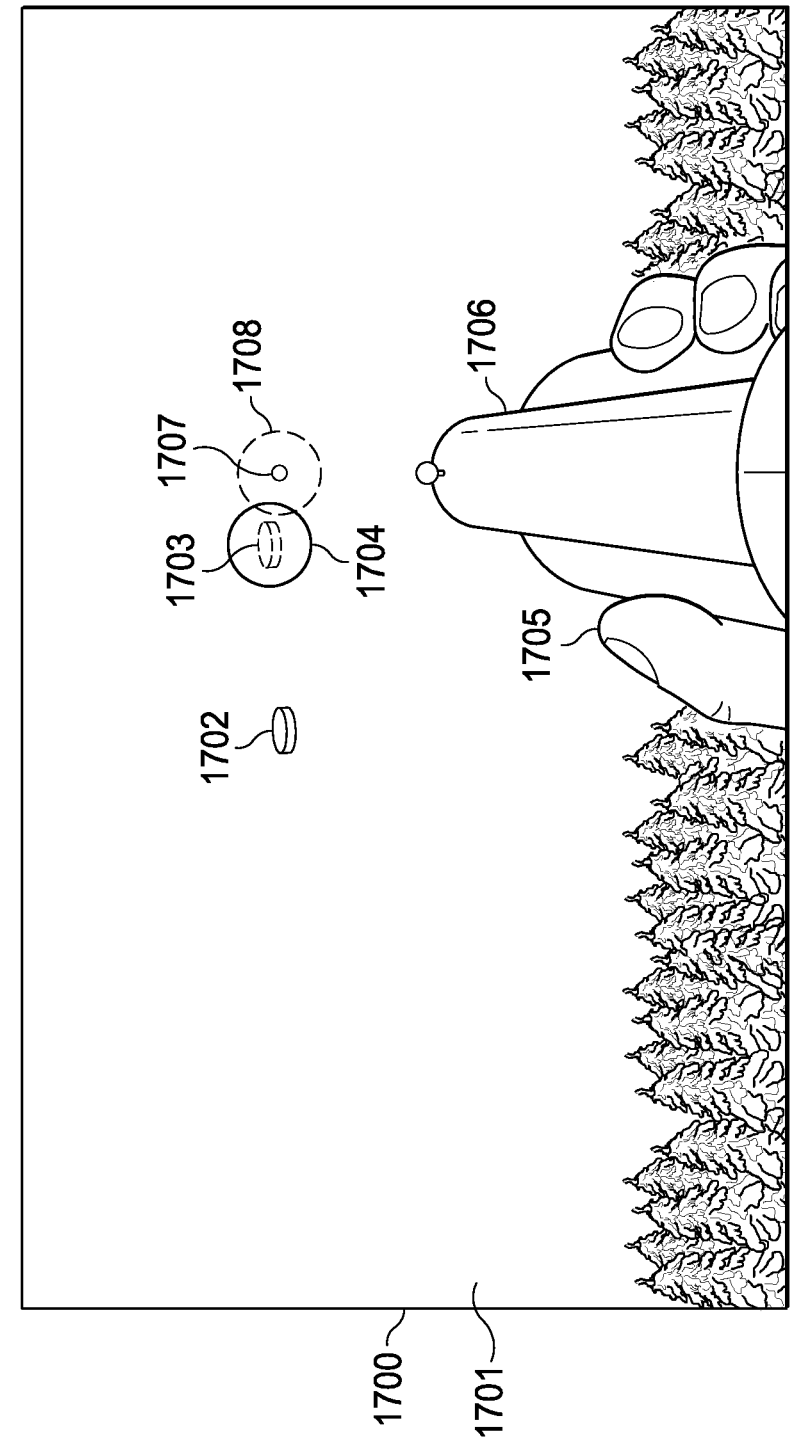

FIG. 17

SYSTEM AND METHOD FOR MARKSMANSHIP TRAINING

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation in part of U.S. application Ser. No. 14/149,418 filed Jan. 7, 2014, which is a continuation in part of U.S. application Ser. No. 13/890,997 filed May 9, 2013. Each of the patent applications identified above is incorporated herein by reference in its entirety to provide continuity of disclosure.

FIELD OF THE INVENTION

The present invention relates to devices for teaching marksmen how to properly lead a moving target with a weapon. More particularly, the invention relates to optical projection systems to monitor and simulate trap, skeet, and sporting clay shooting.

BACKGROUND OF THE INVENTION

Marksmen typically train and hone their shooting skills by engaging in skeet, trap or sporting clay shooting at a shooting range. The objective for a marksman is to successfully hit a moving target by tracking at various distances and angles and anticipating the delay time between the shot and the impact. In order to hit the moving target, the marksman must aim the weapon ahead of and above the moving target by a distance sufficient to allow a projectile fired from the weapon sufficient time to reach the moving target. The process of aiming the weapon ahead of the moving target is known in the art as "leading the target". "Lead" is defined as the distance between the moving target and the aiming point. The correct lead distance is critical to successfully hit the moving target. Further, the correct lead distance is increasingly important as the distance of the marksman to the moving target increases, the speed of the moving target increases, and the direction of movement becomes more oblique.

FIG. **1** depicts the general dimensions of a skeet shooting range. Skeet shooting range **100** has high house **101** and low house **102** separated by distance **111**. Distance **111** is about 120 feet. Station **103** is adjacent high house **101**. Station **109** is adjacent low house **102**. Station **110** is equidistant from high house **101** and low house **102** at distance **112**. Distance **112** is about 60 feet. Station **106** is equidistant from high house **101** and low house **102** and generally perpendicular to distance **111** at distance **113**. Distance **113** is 45 feet. Station **106** is distance **114** from station **103**. Distance **114** is about 75 feet. Stations **104** and **105** are positioned along arc **121** between stations **103** and **106** at equal arc lengths. Each of arc lengths **122**, **123**, and **124** is about 27 feet. Stations **107** and **108** are positioned along arc **121** between stations **106** and **109** at equal arc lengths. Each of arc lengths **125**, **126**, and **127** is 26 feet, 8⅜ inches.

Target flight path **116** extends from high house **101** to marker **117**. Marker **117** is positioned about 130 feet from high house **101** along target flight path **115**. Target flight path **115** extends from low house **102** to marker **118**. Marker **118** is about 130 feet from low house **102** along target flight path **116**. Target flight paths **115** and **116** intersect at target crossing point **119**. Target crossing point **119** is positioned distance **120** from station **110** and is 15 feet above the ground. Distance **120** is 18 feet. Clay targets are launched from high house **101** and low house **102** along target flight paths **115** and **116**, respectively. Marksman **128** positioned at any of stations **103**, **104**, **105**, **106**, **107**, **108**, **109**, and **110** attempts to shoot and break the launched clay targets.

FIG. **2** depicts the general dimensions of a trap shooting range. Trap shooting range **200** comprises firing lanes **201** and trap house **202**. Stations **203**, **204**, **205**, **206**, and **207** are positioned along radius **214** from center **218** of trap house **202**. Radius **214** is distance **216** from center **218**. Distance **216** is 48 feet. Each of stations **203**, **204**, **205**, **206**, and **207** is positioned at radius **214** at equal arc lengths. Arc length **213** is 9 feet. Stations **208**, **209**, **210**, **211**, and **212** are positioned along radius **215** from center **218**. Radius **215** is distance **217** from center **218**. Distance **217** is 81 feet. Each of stations **208**, **209**, **210**, **211**, and **212** is positioned at radius **215** at equal arc lengths. Arc length **227** is 12 feet. Field **226** has length **221** from center **218** along center line **220** of trap house **202** to point **219**. Length **221** is 150 feet. Boundary line **222** extends 150 feet from center **218** at angle **224** from center line **220**. Boundary line **223** extends 150 feet from center **218** at angle **225** from center line **220**. Angles **224** and **225** are each 22° from center line **220**. Trap house **202** launches clay targets at various trajectories within field **226**. Marksman **228** positioned at any of stations **203**, **204**, **205**, **206**, **207**, **208**, **209**, **210**, **211**, and **212** attempts to shoot and break the launched clay targets.

FIGS. **3**A, **3**B, **3**C, and **3**D depict examples of target paths and associated projectile paths illustrating the wide range of lead distances and distances required of the marksman. The term "projectile," as used in this application, means any projectile fired from a weapon but more typically a shotgun round comprised of pellets of various sizes. For example, FIG. **3**A shows a left to right trajectory **303** of target **301** and left to right intercept trajectory **304** for projectile **302**. In this example, the intercept path is oblique, requiring the lead to be a greater distance along the positive X axis. FIG. **3**B shows a left to right trajectory **307** of target **305** and intercept trajectory **308** for projectile **306**. In this example, the intercept path is acute, requiring the lead to be a lesser distance in the positive X direction. FIG. **3**C shows a right to left trajectory **311** of target **309** and intercepting trajectory **312** for projectile **310**. In this example, the intercept path is oblique and requires a greater lead in the negative X direction. FIG. **3**D shows a proximal to distal and right to left trajectory **315** of target **313** and intercept trajectory **316** for projectile **314**. In this example, the intercept path is acute and requires a lesser lead in the negative X direction.

FIGS. **4**A and **4**B depict a range of paths of a clay target and an associated intercept projectile. The most typical projectile used in skeet and trap shooting is a shotgun round, such as a 12 gauge round or a 20 gauge round. When fired, the pellets of the round spread out into a "shot string" having a generally circular cross-section. The cross-section increases as the flight time of the pellets increases. Referring to FIG. **4**A, clay target **401** moves along path **402**. Shot string **403** intercepts target **401**. Path **402** is an ideal path, in that no variables are considered that may alter path **402** of clay target **401** once clay target **401** is launched.

Referring to FIG. **4**B, path range **404** depicts a range of potential flight paths for a clay target after being released on a shooting range. The flight path of the clay target is affected by several variables. Variables include mass, wind, drag, lift force, altitude, humidity, and temperature, resulting in a range of probable flight paths, path range **404**. Path range **404** has upper limit **405** and lower limit **406**. Path range **404** from launch angle θ is extrapolated using:

$$x = x_o + v_{xo}t + \frac{1}{2}a_x t^2 + C_x \quad \text{Eq. 1}$$

$$y = y_o + v_{yo}t + \frac{1}{2}a_y t^2 + C_y \quad \text{Eq. 2}$$

where x is the clay position along the x-axis, x_o is the initial position of the clay target along the x-axis, v_{xo} is the initial velocity along the x-axis, a_x is the acceleration along the x-axis, t is time, and C_x is the drag and lift variable along the x-axis, y is the clay position along the y-axis, y_o is the initial position of the clay target along the y-axis, v_{yo} is the initial velocity along the y-axis, a_y, is the acceleration along the y-axis, t is time, and C_y is the drag and lift variable along the x-axis. Upper limit **405** is a maximum distance along the x-axis with C_x at a maximum and a maximum along the y-axis with C_y at a maximum. Lower limit **406** is a minimum distance along the x-axis with C_x at a minimum and a minimum along the y-axis with C_y at a minimum. Drag and lift are given by:

$$F_{drag} = \frac{1}{2}\rho v^2 C_D A \quad \text{Eq. 3}$$

where F_{drag} is the drag force, ρ is the density of the air, v is v_o, A is the cross-sectional area, and C_D is the drag coefficient;

$$F_{lift} = \frac{1}{2}\rho v^2 C_L A \quad \text{Eq. 4}$$

where F_{lift} is the lift force, ρ is the density of the air, v is v_0, A is the planform area, and C_L is the lift coefficient.

Referring to FIG. **5**, an example of lead from the perspective of the marksman is described. Marksman **501** aims weapon **502** at clay target **503** moving along path **504** left to right. In order to hit target **503**, marksman **501** must anticipate the time delay for a projectile fired from weapon **502** to intercept clay target **503** by aiming weapon **502** ahead of clay target **503** at aim point **505**. Aim point **505** is lead distance **506** ahead of clay target **503** along path **504**. Marksman **501** must anticipate and adjust aim point **505** according to a best guess at the anticipated path of the target.

Clay target **503** has initial trajectory angles γ and β, positional coordinates x_1, y_1 and a velocity v_1. Aim point **505** has coordinates x_2, y_2. Lead distance **506** has x-component **507** and y-component **508**. X-component **507** and y-component **508** are calculated by:

$$\Delta x = x_2 - x_1 \quad \text{Eq. 5}$$

$$\Delta y = y_2 - y_1 \quad \text{Eq. 6}$$

where Δx is x component **507** and Δy is y component **508**. As γ increases, Δy must increase. As γ increases, Δx must increase. As β increases, Δy must increase.

The prior art has attempted to address the problems of teaching proper lead distance with limited success. For example, U.S. Pat. No. 3,748,751 to Breglia et al. discloses a laser, automatic fire weapon simulator. The simulator includes a display screen, a projector for projecting a motion picture on the display screen. A housing attaches to the barrel of the weapon. A camera with a narrow band-pass filter positioned to view the display screen detects and records the laser light and the target shown on the display screen. However, the simulator requires the marksman to aim at an invisible object, thereby making the learning process of leading a target difficult and time-consuming.

U.S. Pat. No. 3,940,204 to Yokoi discloses a clay shooting simulation system. The system includes a screen, a first projector providing a visible mark on the screen, a second projector providing an infrared mark on the screen, a mirror adapted to reflect the visible mark and the infrared mark to the screen, and a mechanical apparatus for moving the mirror in three dimensions to move the two marks on the screen such that the infrared mark leads the visible mark to simulate a lead-sighting point in actual clay shooting. A light receiver receives the reflected infrared light. However, the system in Yokoi requires a complex mechanical device to project and move the target on the screen, which leads to frequent failure and increased maintenance.

U.S. Pat. No. 3,945,133 to Mohon et al. discloses a weapons training simulator utilizing polarized light. The simulator includes a screen and a projector projecting a two-layer film. The two-layer film is formed of a normal film and a polarized film. The normal film shows a background scene with a target with non-polarized light. The polarized film shows a leading target with polarized light. The polarized film is layered on top of the normal non-polarized film. A polarized light sensor is mounted on the barrel of a gun. However, the weapons training simulator requires two cameras and two types of film to produce the two-layered film making the simulator expensive and time-consuming to build and operate.

U.S. Pat. No. 5,194,006 to Zaenglein, Jr. discloses a shooting simulator. The simulator includes a screen, a projector for displaying a moving target image on the screen, and a weapon connected to the projector. When a marksman pulls the trigger a beam of infrared light is emitted from the weapon. A delay is introduced between the time the trigger is pulled and the beam is emitted. An infrared light sensor detects the beam of infrared light. However, the training device in Zaenglein, Jr. requires the marksman to aim at an invisible object, thereby making the learning process of leading a target difficult and time-consuming.

U.S. Patent Publication No. 2010/0201620 to Sargent discloses a firearm training system for moving targets. The system includes a firearm, two cameras mounted on the firearm, a processor, and a display. The two cameras capture a set of stereo images of the moving target along the moving target's path when the trigger is pulled. However, the system requires the marksman to aim at an invisible object, thereby making the learning process of leading a target difficult and time-consuming. Further, the system requires two cameras mounted on the firearm making the firearm heavy and difficult to manipulate leading to inaccurate aiming and firing by the marksman when firing live ammunition without the mounted cameras.

The prior art fails to disclose or suggest a system and method for simulating a lead for a moving target using generated images of targets projected at the same scale as viewed in the field and a phantom target positioned ahead of the targets having a variable contrast. The prior art further fails to disclose or suggest a system and method for simulating lead in a virtual reality system. Therefore, there is a need in the art for a shooting simulator that recreates moving targets at the same visual scale as seen in the field with a phantom target to teach proper lead of a moving target in a virtual reality platform.

SUMMARY

A system and method for simulating lead of a target includes a network, a simulation administrator connected to

the network, a database connected to the simulation administrator, and a user device connected to the network. The user device includes a set of virtual reality unit, and a computer connected to the virtual reality unit and to the network. A set of position trackers are connected to the computer.

In a preferred embodiment, a target is simulated. In one embodiment, a simulated weapon is provided. In another embodiment, a set of sensors is attached to a real weapon. In another embodiment, a set of gloves having a set of sensors is worn by a user. The system generates a simulated target and displays the simulated target upon launch of the generated target. The computer tracks the position of the generated target and the position of the virtual reality unit and the weapon to generate a phantom target and a phantom halo. The generated phantom target and the generated phantom halo are displayed on the virtual reality unit at a lead distance and a drop distance from the live target as viewed through the virtual reality unit. The computer determines a hit or a miss of the generated target using the weapon, the phantom target, and the phantom halo. In one embodiment, the disclosed system and method is implemented in a two-dimensional video game.

The present disclosure provides a system which embodies significantly more than an abstract idea including technical advancements in the field of data processing and a transformation of data which is directly related to real world objects and situations. The disclosed embodiments create and transform imagery in hardware, for example, a weapon peripheral and a sensor attachment to a real weapon.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosed embodiments will be described with reference to the accompanying drawings.

FIG. **1** is a plan view of a skeet shooting range.

FIG. **2** is a plan view of a trap shooting range.

FIG. **3**A is a target path and an associated projectile path.

FIG. **3**B is a target path and an associated projectile path.

FIG. **3**C is a target path and an associated projectile path.

FIG. **3**D is a target path and an associated projectile path.

FIG. **4**A is an ideal path of a moving target.

FIG. **4**B is a range of probable flight paths of a target.

FIG. **5** is a perspective view of a marksman aiming at a moving target.

FIG. **6** is a schematic of a simulator system of a preferred embodiment.

FIG. **7** is a schematic of a simulation administrator of a preferred embodiment.

FIG. **8** is a schematic of a user device of a simulator system of a preferred embodiment.

FIG. **9**A is a side view of a user device of a virtual reality simulator system of a preferred embodiment.

FIG. **9**B is a front view of a user device of a virtual reality simulator system of a preferred embodiment.

FIG. **10**A is a side view of a simulated weapon for a virtual reality system of a preferred embodiment.

FIG. **10**B is a side view of a real weapon with a set of sensors attachment for a virtual reality system of a preferred embodiment.

FIG. **10**C is a detail view of a trigger sensor of a preferred embodiment.

FIG. **10**D is a detail view of a set of muzzle sensors of a preferred embodiment.

FIG. **11** is a top view of a glove controller for a virtual reality system of a preferred embodiment.

FIG. **12** is a schematic view of a virtual reality simulation environment of a preferred embodiment.

FIG. **13** is a command input menu for a virtual reality simulator system of a preferred embodiment.

FIG. **14** is a flow chart of a method for runtime process of a virtual reality simulation system of a preferred embodiment.

FIG. **15**A is top view of a user and a simulation environment of a preferred embodiment.

FIG. **15**B is a flow chart of a method for determining a view for a user device with respect to a position and an orientation of the user device and the weapon.

FIG. **15**C is a flow chart of a method for mapping the position and orientation of the user device and the weapon to the simulation environment for determining a display field of view a preferred embodiment.

FIG. **16**A is a flowchart of a method for determining a phantom and halo of a preferred embodiment.

FIG. **16**B is a plan view of a target and a phantom of a preferred embodiment.

FIG. **16**C is an isometric view of a target and a phantom of a preferred embodiment.

FIG. **17** is a user point of view of a virtual reality simulation system of a preferred embodiment.

DETAILED DESCRIPTION

It will be appreciated by those skilled in the art that aspects of the present disclosure may be illustrated and described herein in any of a number of patentable classes or context including any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof. Therefore, aspects of the present disclosure may be implemented entirely in hardware, entirely in software (including firmware, resident software, micro-code, etc.) or combining software and hardware implementation that may all generally be referred to herein as a "circuit," "module," "component," or "system." Further, aspects of the present disclosure may take the form of a computer program product embodied in one or more computer readable media having computer readable program code embodied thereon.

Any combination of one or more computer readable media may be utilized. The computer readable media may be a computer readable signal medium or a computer readable storage medium. For example, a computer readable storage medium may be, but not limited to, an electronic, magnetic, optical, electromagnetic, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the computer readable storage medium would include, but are not limited to: a portable computer diskette, a hard disk, a random access memory ("RAM"), a read-only memory ("ROM"), an erasable programmable read-only memory ("EPROM" or Flash memory), an appropriate optical fiber with a repeater, a portable compact disc read-only memory ("CD-ROM"), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. Thus, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. The propagated data signal may take any of a variety of forms, including, but not limited to, electromagnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage

medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device. Program code embodied on a computer readable signal medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, or any suitable combination thereof.

Computer program code for carrying out operations for aspects of the present disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Scala, Smalltalk, Eiffel, JADE, Emerald, C++, C#, VB.NET, Python or the like, conventional procedural programming languages, such as the "C" programming language, Visual Basic, Fortran 2003, Perl, COBOL 2002, PHP, ABAP, dynamic programming languages such as Python, Ruby and Groovy, or other programming languages.

Aspects of the present disclosure are described with reference to flowchart illustrations and/or block diagrams of methods, systems and computer program products according to embodiments of the disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable instruction execution apparatus, create a mechanism for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer readable medium that when executed can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions when stored in the computer readable medium produce an article of manufacture including instructions which when executed, cause a computer to implement the function/act specified in the flowchart and/or block diagram block or blocks. The computer program instructions may also be loaded onto a computer, other programmable instruction execution apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatuses or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

Referring to FIG. **6**, system **600** includes network **601**, simulation administrator **602** connected to network **601**, and user device **604** connected to network **601**. System administrator **602** is further connected to simulation database **603** for storage of relevant data. For example, data includes a set of target data, a set of weapon data, and a set of environment data.

In one embodiment, network **601** is a local area network. In another embodiment, network **601** is a wide area network, such as the internet. In other embodiments, network **601** includes a combination of wide area networks and local area networks, includes cellular networks.

In a preferred embodiment, user device **604** communicates with simulation administrator **602** to access database **603** to generate and project a simulation that includes a target, a phantom, and a phantom halo adjacent to the target as will be further described below.

In another embodiment, simulation administrator **602** generates a simulation that includes a target, a phantom, a phantom halo adjacent to the target, and a weapon image as will be further described below and sends the simulation to user device for projection.

Referring to FIG. **7**, simulation administrator **701** includes processor **702**, network interface **703** connected to processor **702**, and memory **704** connected to processor **702**. Simulation application **705** is stored in memory **704** and executed by processor **702**. Simulation application **705** includes position application **706**, statistics engine **707**, and target and phantom generator **708**.

In a preferred embodiment, simulation administrator **701** is a PowerEdge C6100 server and includes a PowerEdge C410x PCIe Expansion Chassis available from Dell Inc. Other suitable servers, server arrangements, and computing devices known in the art may be employed.

In one embodiment, position application **706** communicates with a position tracker connected to the user device to detect the position of the user device for simulation application **705**. Statistics engine **707** communicates with a database to retrieve relevant data and generate renderings according desired simulation criteria, such as desired weapons, environments, and target types for simulation application **705**. Target and phantom generator **708** calculates and generates a target along a target path, a phantom target, and a phantom halo for the desired target along a phantom path for simulation application, as will be further described below.

Referring to FIG. **8**, user device **800** includes computer **801** connected to headset **802**. Computer **801** is further connected to replaceable battery **803**, microphone **804**, speaker **805**, and position tracker **806**.

Computer **801** includes processor **807**, memory **809** connected to processor **807**, and network interface **808** connected to processor **807**. Simulation application **810** is stored in memory **809** and executed by processor **807**. Simulation application **810** includes position application **811**, statistics engine **812**, and target and phantom generator **813**. In a preferred embodiment, position application **811** communicates with position tracker **806** to detect the position of headset **802** for simulation application **810**. Statistics engine **812** communicates with a database to retrieve relevant data and generate renderings according desired simulation criteria, such as desired weapons, environments, and target types for simulation application **810**. Target and phantom generator **813** calculates and generates a target along a target path, a phantom target, and a phantom halo for the desired target along a phantom path for simulation application **810**, as will be further described below.

Input device **814** is connected to computer **801**. Input device **814** includes processor **815**, memory **816** connected to processor **815**, communication interface **817** connected to processor **815**, a set of sensors **818** connected to processor **816**, and a set of controls **819** connected to processor **815**.

In one embodiment, input device **814** is a simulated weapon, such as a shot gun, a rifle, or a handgun. In another embodiment, input device **814** is a set of sensors connected to a disabled real weapon, such as a shot gun, a rifle, or a handgun, to detect movement and actions of the real weapon. In another embodiment, input device **814** is a glove having a set of sensors worn by a user to detect positions and movements of a hand of a user.

Headset **802** includes processor **820**, battery **821** connected to processor **820**, memory **822** connected to proces-

sor **820**, communication interface **823** connected to processor **820**, display unit **824** connected to processor **820**, and a set of sensors **825** connected to processor **820**.

Referring to FIGS. **9**A and **9**B, a preferred implementation of user device **800** is described as user device **900**. User **901** wears virtual reality unit **902** having straps **903** and **904**. Virtual reality unit **902** is connected to computer **906** via connection **905**. Computer **906** is preferably a portable computing device, such as a laptop or tablet computer, worn by user **901**. In other embodiments, computer **906** is a desktop computer or a server, not worn by the user. Any suitable computing device known in the art may be employed. Connection **905** provides a data and power connection from computer **906** to virtual reality unit **902**.

Virtual reality unit **902** includes skirt **907** attached to straps **903** and **904** and display portion **908** attached to skirt **907**. Skirt **907** covers eyes **921** and **916** of user **901**. Display portion **908** includes processor **911**, display unit **910** connected to processor **911**, a set of sensors **912** connected to processor **911**, communication interface **913** connected to processor **911**, and memory **914** connected to processor **911**. Lens **909** is positioned adjacent to display unit **910** and eye **921** of user **901**. Lens **915** is positioned adjacent to display unit **910** and eye **916** of user **901**. Virtual reality unit **902** provides a stereoscopic three-dimensional view of images to user **901**.

User **901** wears communication device **917**. Communication device **917** includes earpiece speaker **918** and microphone **919**. Communication device **917** is preferably connected to computer **906** via a wireless connection such as a Bluetooth connection. In other embodiments, other wireless or wired connections are employed. Communication device **917** enables voice activation and voice control of a simulation application stored in the computer **906** by user **901**.

In one embodiment, virtual reality unit **902** is the Oculus Rift headset available from Oculus VR, LLC. In another embodiment, virtual reality unit **902** is the HTC Vive headset available from HTC Corporation. In this embodiment, a set of laser position sensors **920** is attached to an external surface virtual reality unit **902** to provide position data of virtual reality unit **902**. Any suitable virtual reality unit known in the art may be employed.

In a preferred embodiment, a simulation environment that includes a target is generated by computer **906**. Computer **906** further generates a phantom target and a phantom halo in front of the generated target based on a generated target flight path. The simulation environment including the generated target, the phantom target, and the phantom halo are transmitted from computer **906** to virtual reality unit **902** for viewing adjacent eyes **921** and **916** of user **901**, as will be further described below. The user aims a weapon at the phantom target to attempt to shoot the generated target.

Referring FIG. **10**A in one embodiment, simulated weapon **1001** includes trigger **1002** connected to set of sensors **1003**, which is connected to processor **1004**. Communication interface **1005** is connected to processor **1004** and to computer **1009**. Simulated weapon **1001** further includes a set of controls **1006** attached to an external surface of weapon **1001** and connected to processor **1004**. Set of controls **1006** includes directional pad **1007** and selection button **1008**. Battery **1026** is connected to processor **1004**. Actuator **1024** is connected to processor **1004** to provide haptic feedback.

In a preferred embodiment, simulated weapon **1001** is a shotgun. It will be appreciated by those skilled in the art that any type of weapon may be employed.

In one embodiment, simulated weapon **1001** is a Delta Six first person shooter controller available from Avenger Advantage, LLC. Other suitable simulated weapons known in the art may be employed.

In a preferred embodiment, set of sensors **1003** includes a position sensor for trigger **1002** and a set of motion sensors to detect an orientation of weapon **1001**.

In a preferred embodiment, the position sensor is a Hall Effect sensor. In this embodiment, a magnet is attached to trigger **1002**. Any type of Hall Effect sensor or any other suitable sensor type known in the art may be employed.

In a preferred embodiment, the set of motion sensors is a 9-axis motion tracking system-in-package package sensor, model no. MP11-9150 available from InverSense®, Inc. In this embodiment, the 9-axis sensor combines a 3-axis gyroscope, a 3-axis accelerometer, an on-board digital motion processor, and a 3-axis digital compass. In other embodiments, other suitable sensors and/or suitable combinations of sensors may be employed.

Referring to FIGS. **10**B, **10**C, and **10**D in another embodiment, weapon **1010** includes simulation attachment **1011** removably attached to its stock. Simulation attachment **1011** includes on-off switch **1012** and pair button **1013** to communicate with computer **1009** via Bluetooth connection. Any suitable wireless connection may be employed. Trigger sensor **1014** is removably attached to trigger **1022** and in communication with simulation attachment **1011**. A set of muzzle sensors **1015** is attached to a removable plug **1016** which is removable inserted into barrel **1023** of weapon **1010**. Set of muzzle sensors **1015** include a processor **1017**, battery **1018** connected to processor **1017**, gyroscope **1019** connected to processor, accelerometer **1020** connected to processor **1017**, and compass **1021** connected to processor **1017**.

In one embodiment, set of muzzle sensors **1015** and removable plug **1016** are positioned partially protruding outside of barrel **1023** of weapon **1010**.

In one embodiment, weapon **1010** includes rail **1025** attached to its stock in any position. In this embodiment, set of muzzle sensors **1015** is mounted to rail **1025**.

In one embodiment, weapon **1010** fires blanks to provide kickback to a user.

It will be appreciated by those skilled in the art that any weapon may be employed as weapon **1010**, including any rifle or handgun. It will be further appreciated by those skilled in the art that rail **1025** is optionally mounted to any type of weapon. Set of muzzle sensors **1025** may be mounted in any position on weapon **1010**. Any type of mounting means known in the art may be employed.

Referring to FIG. **11**, tracking glove **1100** includes hand portion **1101** and wrist portion **1102**. Wrist portion **1102** includes processor **1103**, battery **1104** connected to processor **1103**, communication interface **1105**, and memory **1106** connected to processor **1103**. Hand portion **1101** includes thumb portion **1109** and finger portions **1112**, **1116**, **1120**, and **1124**. Hand portion **1101** further includes backhand sensor **1107** and palm sensor **1108**, each of which is connected to processor **1103**. Thumb portion **1109** has sensors **1110** and **1111**, each of which is connected to processor **1103**. Finger portion **1112** has sensors **1113**, **1114**, and **1115**, each of which is connected to processor **1103**. Finger portion **1116** has sensors **1117**, **1118**, and **1119**, each of which is connected to processor **1103**. Finger portion **1120** has sensors **1121**, **1122**, and **1123**, each of which is connected to processor **1103**. Finger portion **1124** has sensors **1125**, **1126**, and **1127**, each of which is connected to processor **1103**.

In a preferred embodiment, hand portion **1101** is a polyester, nylon, silicone, and neoprene mixture fabric. In this embodiment, each of sensors **1110**, **1111**, **1113**, **1114**, **1115**, **1117**, **1118**, **1119**, **1121**, **1122**, **1123**, **1125**, **1126**, and **1127** and each of backhand sensor **1107** and palm sensor **1108** sewn into the hand portion. Other suitable fabrics known in the art may be employed.

In a preferred embodiment, wrist portion **1102** includes a hook and loop strap to secure tracking glove **1100**. Other securing means known in the art may be employed.

In a preferred embodiment, each of backhand sensor **1107** and palm sensor **1108** is a an iNEMO inertial module model no. LSM9DS1 available from ST Microelectronics. Other suitable sensors known in the art may be employed.

In a preferred embodiment, each of sensors **1110**, **1111**, **1113**, **1114**, **1115**, **1117**, **1118**, **1119**, **1121**, **1122**, **1123**, **1125**, **1126**, and **1127** is an iNEMO inertial module model no. LSM9DS1 available from ST Microelectronics. Other suitable sensors known in the art may be employed.

Referring to FIG. **12**, in simulation environment **1200** user **1201** wears user device **1202** connected to computer **1204** and holds weapon **1203**. Each of position trackers **1205** and **1206** is connected to computer **1204**. Position tracker **1205** has field of view **1207**. Position tracker **1206** has field of view **1208**. User **1201** is positioned in fields of view **1207** and **1208**.

In one embodiment, weapon **1203** is a simulated weapon. In another embodiment, weapon **1203** is a real weapon with a simulation attachment. In another embodiment, weapon **1203** is a real weapon and user **1201** wears a set of tracking gloves **1210**. In other embodiments, user **1201** wears the set of tracking gloves **1210** and uses the simulated weapon or the real weapon with the simulation attachment.

In a preferred embodiment, each of position trackers **1205** and **1206** is a near infrared CMOS sensor having a refresh rate of 60 Hz. Other suitable position trackers known in the art may be employed.

In a preferred embodiment, position trackers **1205** and **1206** capture the vertical and horizontal positions of user device **1202**, weapon **1203** and/or set of gloves **1210**. For example, position tracker **1205** captures the positions and movement of user device **1202** and weapon **1203**, and/or set of gloves **1210** in the y-z plane of coordinate system **1209** and position tracker **1206** captures the positions and movement of user device **1202** and weapon **1203** and/or set of gloves **1210** in the x-z plane of coordinate system **1209**. Further, a horizontal angle and an inclination angle of the weapon are tracked by analyzing image data from position trackers **1205** and **1206**. Since the horizontal angle and the inclination angle are sufficient to describe the aim point of the weapon, the aim point of the weapon is tracked in time.

In a preferred embodiment, computer **1204** generates the set of target data includes a target launch position, a target launch angle, and a target launch velocity of the generated target. Computer **1204** retrieves a set of weapon data based on a desired weapon, including a weapon type e.g., a shotgun, a rifle, or a handgun, a set of weapon dimensions, a weapon caliber or gauge, a shot type including a load, a caliber, a pellet size, and shot mass, a barrel length, a choke type, and a muzzle velocity. Other weapon data may be employed. Computer **1204** further retrieves a set of environmental data that includes temperature, amount of daylight, amount of clouds, altitude, wind velocity, wind direction, precipitation type, precipitation amount, humidity, and barometric pressure for desired environmental conditions. Other types of environmental data may be employed.

Position trackers **1205** and **1206** capture a set of position image data of user device **1202**, weapon **1203** and/or set of gloves **1210** and the set of images is sent to computer **1204**. Sensors in user device **1202**, weapon **1203** and/or set of gloves **1210** detect a set of orientation data and sends the set of orientation data to computer **1204**. Computer **1204** then calculates a generated target flight path for the generated target based on the set of target data, the set of environment data, and the position and orientation of the user device **1202**. The position and orientation of the user device **1202**, the weapon **1203** and/or set of gloves **1210** are determined from the set of position image data and the set of orientation data. Computer **1204** generates a phantom target and a phantom halo based on the generated target flight path and transmits the phantom target and the phantom halo to user device **1202** for viewing by user **1201**. User **1201** aims weapon **1203** at the phantom target and the phantom halo to attempt to hit the generated target. Computer **1204** detects a trigger pull on weapon **1203** by a trigger sensor and/or a finger sensor and determines a hit or a miss of the generated target based on the timing of the trigger pull, the set of weapon data, the position and orientation of user device **1202**, weapon **1203**, and/or set of gloves **1210**, the phantom target, and the phantom halo.

Referring to FIG. **13**, command menu **1300** includes simulation type **1301**, weapon type **1302**, ammunition **1303**, target type **1304**, station select **1305**, phantom toggle **1306**, day/night mode **1307**, environmental conditions **1308**, freeze frame **1309**, instant replay **1310**, and start/end simulation **1311**. Simulation type **1301** enables a user to select different types of simulations. For example, the simulation type includes skeet shooting, trap shooting, sporting clays, and hunting. Weapon type **1302** enables the user to choose from different weapon types and sizes such as a shot gun, a rifle, and a handgun, and different calibers or gauges of the weapons type. The user further enters a weapon sensor location, for example, in the muzzle or on a rail, and whether the user is right or left handed. Ammunition **1303** enables the user to select different types of ammunition for the selected weapon type. Target type **1304** enables the user to select different types of targets for the simulation, including a target size, a target color, and a target shape. Station select **1305** enables the user to choose different stations to shoot from, for example, in a trap shooting range, a skeet shooting range, or a sporting clays course. The user further selects a number of shot sequences for the station select. In a preferred embodiment, the number of shot sequences in the set of shot sequences is determined by the type of shooting range used and the number of target flight path variations to be generated. For example, the representative number of shot sequences for a skeet shooting range is at least eight, one shot sequence per station. More than one shot per station may be utilized.

Phantom toggle **1306** allows a user to select whether to display a phantom target and a phantom halo during the simulation. The user further selects a phantom color, a phantom brightness level, and a phantom transparency level. Day/night mode **1307** enables the user to switch the environment between daytime and nighttime. Environmental conditions **1308** enables the user to select different simulation environmental conditions including temperature, amount of daylight, amount of clouds, altitude, wind velocity, wind direction, precipitation type, precipitation amount, humidity, and barometric pressure. Other types of environmental data may be employed. Freeze frame **1309** allows the user to "pause" the simulation. Instant replay **1310** enables the user replay the last shot sequence including the shot

attempt by the user. Start/end simulation **1311** enables the user to start or end the simulation. In one embodiment, selection of **1301**, **1302**, **1303**, **1304**, **1305**, **1306**, **1307**, **1308**, **1309**, **1310**, and **1311** is accomplished via voice controls. In another embodiment, selection of **1301**, **1302**, **1303**, **1304**, **1305**, **1306**, **1307**, **1308**, **1309**, **1310**, and **1311** is accomplished via a set of controls on a simulated weapon as previously described.

Referring to FIG. **14**, runtime method **1400** for a target simulation will be described. At step **1401**, a baseline position and orientation of the user device and a baseline position and orientation of the weapon are set. In this step, the computer retrieves a set of position image data from a set of position trackers, a set of orientation data from a set of sensors in the user device, the weapon and/or a set of gloves and saves the current position and orientation of the user device and the weapon into memory. Based on the simulation choice, the virtual position of the launcher relative to the position and orientation of the user device is also set. If the user device is oriented toward the virtual location of the launcher, a virtual image of the launcher will be displayed. At step **1402**, a set of target flight data, a set of environment data, and a set of weapon data are determined from a set of environment sensors and a database.

In a preferred embodiment, the set of weapon data is downloaded and saved into the database based on the type of weapon that is in use. In a preferred embodiment, the set of weapon data includes a weapon type e.g., a shotgun, a rifle, or a handgun, a weapon caliber or gauge, a shot type including a load, a caliber, a pellet size, and shot mass, a barrel length, a choke type, and a muzzle velocity. Other weapon data may be employed.

In a preferred embodiment, the set of environment data is retrieved from the database and includes a wind velocity, an air temperature, an altitude, a relative air humidity, and an outdoor illuminance. Other types of environmental data may be employed.

In a preferred embodiment, the set of target flight data is retrieved from the database based on the type of target in use. In a preferred embodiment, the set of target flight data includes a launch angle of the target, an initial velocity of the target, a mass of the target, a target flight time, a drag force, a lift force, a shape of the target, a color of the target, and a target brightness level.

At step **1403**, the target and environment are generated from the set of target flight data and the set of environmental data. At step **1404**, a virtual weapon image is generated and saved in memory. In this step, images and the set of weapon data of the selected weapon for the simulation is retrieved from the database. At step **1405**, the target is launched and the target and environment are displayed in the user device. In a preferred embodiment, a marksman will initiate the launch with a voice command such as "pull".

At step **1406**, a view of the user device with respect to a virtual target launched is determined, as will be further described below.

At step **1407**, a phantom target and a phantom halo are generated based on a target path and the position and orientation of the user, as will be further described below. The target path is determined from the target position the target velocity using Eqs. 1-4. At step **1408**, the generated phantom target and the generated phantom halo are sent to the user device and displayed, if the user device is oriented toward the target path. The generated weapon is displayed if the user device is oriented toward the position of the virtual weapon. At step **1409**, whether the trigger on the weapon has been pulled is determined from a set of weapon sensors and/or a set of glove sensors. If not, then method **1400** returns to step **1406**. If the trigger has been pulled, then method **1400** proceeds to step **1410**.

At step **1410**, a shot string is determined. In this step, a set of position trackers capture a set of weapon position images. In this step, a set of weapon position data is received from a set of weapon sensors. The shot string is calculated by:

$$A_{shot\ string}=\pi R_{string}^{2} \quad \text{Eq. 7}$$

$$R_{string}=R_{initial}+v_{spread}t \quad \text{Eq. 8}$$

where $A_{shot\ string}$ is the area of the shot string, R_{string} is the radius of the shot string, $R_{initial}$ is the radius of the shot as it leaves the weapon, v_{spread} is the rate at which the shot spreads, and t is the time it takes for the shot to travel from the weapon to the target. An aim point of the weapon is determined from the set of weapon position images and the set of weapon position data. A shot string position is determined from the position of the weapon at the time of firing and the area of the shot string.

At step **1411**, if the user device is oriented along the muzzle of the weapon, the shot string is displayed on the user device at the shot string position. Separately, a gunshot sound is played. At step **1412**, whether the phantom target has been "hit" is determined. The simulation system determines the position of the shot string, as previously described. The simulation system compares the position of the shot string to the position of the phantom target.

If the position of the shot string overlaps the position of the phantom target, then the phantom target is "hit". If the position of the shot string does not overlap the phantom target, then the phantom target is "missed".

If the phantom target is hit and the user device is oriented toward the hit location, then method **1400** displays an animation of the target being destroyed on the user device at the appropriate coordinates and plays a sound of the target being destroyed at step **1413**. At step **1414**, the simulation system records a "hit" in the database.

If a "miss" is determined at step **1412**, then method **1400** proceeds to step **1415**. At step **1415**, whether the phantom halo is hit is determined. In this step, whether the shot string overlaps an area of the phantom halo by a percentage greater than or equal to a predetermined percentage is determined. For example, the predetermined percentage is 50%. Whether the shot string overlaps at least 50% of the area of the phantom halo is determined. Any predetermined percentage may be employed.

If the position of the shot string overlaps the phantom halo by a percentage greater than or equal to the predetermined percentage, then a "hit" is determined and method **1400** proceeds to step **1413**.

If at step **1415**, the shot string does not overlap the area of the phantom halo by a percentage greater than or equal to the predetermined percentage, then a "miss" is determined and the simulation system records a "miss" in the database at step **1416**.

At step **1417**, whether an end command has been received to complete the simulation is determined. If not received, then method **1400** advances to the next target at step **1418**.

If an end command has been received and the simulation is complete, then a trend of shot attempts is analyzed at step **1419** by retrieving a number of "hits" in the set of shot sequences and a number of "misses" in the set of shot sequences from the database. In this step, a shot improvement is determined by evaluating the number of hits in the set of shot sequences and the number of misses in the set of shot sequences. Method **1400** ends at step **1420**.

Referring to FIG. **15**A, user **1500** wears user device **1501** and holds weapon **1502** in simulation environment **1503**. Simulation environment **1503** is a virtual sphere spanning 360° in all directions surrounding user **1500**. User device **1501** has field of view **1504**. Field of view **1504** is a cone that has angular range α and spans an arcuate portion (in two dimensions) or a sectorial portion (in three dimensions) of simulation environment **1503**. User device orientation vector **1505** bisects field of view **1504** and angular range α into equal angles β. Weapon **1502** has weapon orientation vector **1506**. Each of user device orientation vector **1505** and weapon orientation vector **1506** is independent of each other. The positions of user device **1501**, weapon **1502**, user device orientation vector **1505**, and weapon orientation vector have Cartesian x,y,z coordinates. Simulation environment **1503** has spherical coordinates. Simulation environment **1503** includes virtual target launcher **1507**, virtual target **1508**, phantom target **1509** and phantom halo **1510**. As can be seen, weapon **1502**, virtual target **1508**, phantom target **1509**, and phantom halo **1510** are in field of view **1504** of user device **1501**. Virtual target launcher **1507** is not in field of view **1504** of user device **1501**. Weapon **1502**, virtual target **1508**, phantom target **1509** and phantom halo **1510** will be displayed in user device **1501** and virtual launcher **1507** will not be displayed in user device **1501**.

In a preferred embodiment, angular range α is approximately 110° and each of equal angles β is approximately 55°. Other angular ranges may be employed.

Referring to FIG. **15**B, step **1406** will be further described as method **1511** for determining a view for a user device with respect to a position and an orientation of the user device and the weapon. Method **1511** begins at step **1512**. At step **1513**, a set of current position image data is retrieved from a set of position trackers and a set of current position and orientation data is retrieved from the user device and the weapon and/or set of gloves. At step **1514**, a set of motion detection data is received from a set of sensors in the user device to determine movement of the user device and from the weapon and/or set of gloves to determine movement of the weapon. At step **1515**, the set of motion detection data and the position of the user device and the weapon and/or set of gloves are combined to determine an x, y, z position of the user device and the weapon and a roll, pitch, and yaw or detection of the user device and the weapon. The current x, y, z orientation vectors for the user device and the weapon are calculated from the difference between the baseline position and orientation and the current position and orientation of the user device and the weapon. The set of motion detection data received is the roll, pitch, and yaw orientation movement of the head of the user and the weapon. At step **1516**, the current positions and orientation vectors of the user device and the weapon are mapped to the simulation environment. In a preferred embodiment, the current positions and orientation vectors are a 1:1 ratio to the positions and orientation vectors in the simulation environment. For example, for every inch and/or degree that the user device and/or the weapon moves and/or rotates, the view of the user and/or the simulated weapon moves one inch and/or rotates one degree in the simulated environment. Other ratios may be employed. The mapping determines the display view, as will be further described below. At step **1517**, the simulation environment that would be visible the user based on the orientation of the user device and the weapon is displayed. Method **1500** ends at step **1518**.

Referring to FIG. **15**C, step **1516** will be further described as method **1519** for mapping the position and orientation of the user device and the weapon to the simulation environment for determining a display field of view. At step **1520**, the x, y, z positions of the weapon and the weapon orientation vector are retrieved. At step **1521**, the x, y, z positions of the weapon and the weapon orientation vector are converted to spherical coordinates (r, θ, φ) using:

$$r = \sqrt{x^2 + y^2 + z^2} \quad \text{Eq. 9}$$

$$\theta = \arccos\left(\frac{x}{\sqrt{x^2 + y^2 + z^2}}\right) \quad \text{Eq. 10}$$

$$\varphi = \arctan\left(\frac{y}{x}\right) \quad \text{Eq. 11}$$

At step **1522**, the weapon is rendered in the simulation environment at the spherical position and orientation vector. At step **1523**, the x, y, z positions of the user device and the user device orientation vector are retrieved. At step **1524**, the x, y, z positions of the user device and the user device orientation vector are converted to spherical coordinates (r, θ, φ) using Eqs. 9, 10, and 11. At step **1525**, the display field of view is determined from the spherical orientation vector coordinates. In this step, equal angles β are measured from the user device orientation vector to define the display field of view as a sector of the simulation environment in spherical coordinates. At step **1526**, the field of view sector is compared to the simulation environment to determine a portion of the simulation environment within the field of view sector. At step **1527**, the portion of the simulation environment within the field of view sector is displayed on the user device as the display field of view. At step **1528**, the spherical position and orientation vector of the weapon is compared to the field of view sector to determine whether the weapon is in the display field of view. If the weapon is not in the display field of view, then method **1519** returns to step **1520**. If the weapon is in the display field of view, then the weapon is displayed on the user device at the spherical position and orientation. Method **1519** then returns to step **1520**.

Referring to FIG. **16**A, step **1407** will be further described as method **1600** for generating a phantom target and a phantom halo. At step **1601**, a phantom path is extrapolated. Referring to FIGS. **16**B and **16**C, target **1606** is launched from launch point **1611** and moves along target path **1607** at position P_1. Phantom target **1608** moves along phantom path **1609** ahead of target **1606** at position P_2. Position P_2 is lead distance **1610** and drop distance **1616** from position P_1. Phantom path **1609** varies as target **1606** and target path **1607** varies, thereby varying lead distance **1610**. Marksman **1612** is positioned at distance **1613** from launch point **1611**. Marksman **1612** aims at phantom target **1608** and shoots along shot path **1614** to intercept target **1606**. Target path **1607** is extrapolated over time using the set of target flight data. Target path **1607** is calculated using Eqs. 1-4.

Referring to FIG. **16**B, lead distance **1610** is calculated using target path **1607**, the relative marksman location, and the set of weapon data.

$$D_{P_2} \approx \frac{D_{S_2}\tan\varphi_2}{\cos\theta\tan\varphi_2 - \sin\theta} \quad \text{Eq. 12}$$

$$D_{P_1} \approx \frac{D_{S_1}\tan\varphi_1}{\cos\theta\tan\varphi_1 - \sin\theta} \quad \text{Eq. 13}$$

where D_{P_2} is the distance of phantom target **1608** at position P_2 from launch point **1611**, D_{S_2} is the distance from marksman **1612** to phantom target **1608** along shot path **1614**, φ_2 is the angle between shot path **1614** and distance **1613**, θ is the launch angle between target path **1607** and distance **1613**, D_{P_1} is the distance of target **1606** at position P_1 from launch point **1611**, D_{S_1} is the distance from marksman **1612** to target **1606** along shot path **1615**, φ_1 is the angle between shot path **1615** and distance **1613**, θ is the launch angle between target path **1607** and distance **1613**. Lead distance **1610** is:

$$D_{Lead} \approx D_{P_2} - D_{P_1} \quad \text{Eq. 14}$$

$$D_{Lead} \approx \frac{A\Delta D_S \tan C\Delta\varphi}{\cos B\theta \tan C\Delta\varphi - \sin B\theta} \quad \text{Eq. 15}$$

where D_{Lead} is lead distance **1610**, ΔD_S is the difference between the distances of shot paths **1614** and **1615**, $\Delta\varphi$ is the difference between angles φ_2 and φ_1, θ is the launch angle between target path **1607** and distance **1613**. A is a variable multiplier for shot size, gauge, and shot mass, B is a variable multiplier for θ including vibration of a target thrower and a misaligned target in the target thrower, and C is a variable multiplier for drag, lift, and wind.

For example, the approximate times it takes for a 7½ shot size shell with an initial muzzle velocity of approximately 1,225 feet per second to travel various distances is shown in Table 1.

TABLE 1

Time and Distances of a 7½ Shot

Distance from barrel	Time (seconds)
30 feet	0.027
60 feet	0.060
90 feet	0.097
120 feet	0.139
150 feet	0.186
180 feet	0.238

Various lead distances between target **1606** and phantom target **1608** for target **1606** having an initial velocity of approximately 30 mph is shown in Table 2.

TABLE 2

Lead Distances with a 7½ Shot on a Full Crossing Shot

Distance from Barrel	Lead Distance
60 feet	2.64 feet
90 feet	4.62 feet
120 feet	5.56 feet

Referring to FIG. **16**C, phantom path **1609** is offset from target path **1607** by drop distance **1616** to simulate and compensate for the average exterior ballistics drop of a shot.

The "drop of a shot" is the effect of gravity on the shot during the distance traveled by the shot. The shot trajectory has a near parabolic shape. Due to the near parabolic shape of the shot trajectory, the line of sight or horizontal sighting plane will cross the shot trajectory at two points called the near zero and far zero in the case where the shot has a trajectory with an initial angle inclined upward with respect to the sighting device horizontal plane, thereby causing a portion of the shot trajectory to appear to "rise" above the horizontal sighting plane. The distance at which the weapon is zeroed, and the vertical distance between the sighting device axis and barrel bore axis, determine the amount of the "rise" in both the X and Y axes, i.e., how far above the horizontal sighting plane the rise goes, and over what distance it lasts.

Drop distance **1616** is calculated by:

$$D_{Drop} \approx v_t \tau \ln\left[\cosh\left(\frac{t_{impact}}{\tau}\right)\right] \quad \text{Eq. 16}$$

where D_{Drop} is drop distance **1616**, t_{impact} is the time required for a shot string fired by marksman **1612** to impact target **1608**. T_{impact} is determined by a set of lookup tables having various impact times at predetermined distances for various shot strings.

$$v_t = \sqrt{\frac{2mg}{C\rho A}}, \text{ and} \quad \text{Eq. 17}$$

$$\tau = \frac{v_t}{g} \quad \text{Eq. 18}$$

where v_t is the terminal velocity of target **1606**, m is the mass of target **1606**, g is the vertical acceleration due to gravity, C is the drag coefficient for target **1606**, ρ is the density of the air, A is the planform area of target **1606**, and τ is the characteristic time.

Referring to FIGS. **16**A and **16**C, at step **1602**, phantom halo **1617** is determined. Phantom halo **1617** is a simulation of a shot string at a distance of the phantom target from the position of the marksman. In a preferred embodiment, an area of phantom halo **1617** is determined from the set of weapon data and calculated by:

$$A_{shot\ string} = \pi R_{string}^2 \quad \text{Eq. 19}$$

$$R_{string} = \gamma R_{initial} + v_{spread} t \quad \text{Eq. 20}$$

$$A_{phantom\ halo} = A_{shot\ string} \quad \text{Eq. 21}$$

where $A_{shot\ string}$ is the area of the shot string, R_{string} is the radius of the shot string, $R_{initial}$ is the radius of the shot as it leaves the weapon, γ is a variable multiplier for any choke applied to the weapon as determined from the set of weapon data, v_{spread} is the rate at which the shot spreads, and t is the time it takes for the shot to travel from the weapon to the target. $A_{phantom\ halo}$ is the area of phantom halo **1617**.

In one embodiment, the area of phantom halo **1617** varies as the amount of choke applied to the weapon varies.

Returning to FIG. **16**A, at step **1603**, a relative contrast value between the target and a background surrounding the target is analyzed by calculating the difference between a grayscale brightness of the target and an average brightness of the background surrounding the target and the difference between an average color of the target and a color of the background surrounding the target based on a desired day/night setting and a set of desired environmental conditions.

At step **1604**, a color and a contrast level of a phantom target is determined. In a preferred embodiment, the phantom target includes a set of pixels set at a predetermined contrast level. The predetermined contrast level is determined by the difference of the color between the phantom target and the target and the difference of the brightness

between the phantom target and the target. In this embodiment, the predetermined contrast level is a range from a fully opaque image to a fully transparent image with respect to the image of the target and the image of the background.

In a preferred embodiment, the set of pixels is set at a predetermined color. For example, blaze orange has a pixel equivalent setting of R 232, G 110, B0.

At step **1605**, a color and contrast level of the phantom halo is determined. In a preferred embodiment, the phantom halo includes a set of pixels set at a predetermined contrast level. The predetermined contrast level is determined by the difference of the color between the phantom halo and the target and the difference of the brightness between the phantom halo and the target. In this embodiment, the predetermined contrast level is a range from a fully opaque image to a fully transparent image with respect to the image of the target and the image of the background.

In a preferred embodiment, the set of pixels is set at a predetermined color. For example, black has a pixel equivalent setting of R 0, G 0, B 0. Any color may be employed.

Referring to FIG. **17**, a view of a simulation from the perspective of a marksman wearing a user device is shown. Through display **1700**, background environment **1701** and target **1702** are viewed. Phantom target **1703** is projected at a lead distance and at a drop distance from target **1702**. Phantom halo **1704** is projected surrounding phantom target **1703**. Marksman **1705** aims weapon **1706** at phantom target **1703**.

In a preferred embodiment, shot center **1707** appears on display **1700** when marksman **1705** pulls a trigger of weapon **1706**. Shot string **1708** surrounds shot center **1707**. In a preferred embodiment, shot string **1708** is a simulation of a shot pellet spread fired from weapon **1706**.

It will be appreciated by those skilled in the art that the described embodiments disclose significantly more than an abstract idea including technical advancements in the field of data processing and a transformation of data which is directly related to real world objects and situations in that the disclosed embodiments enable a computer to operate more efficiently. For example, the disclosed embodiments transform positions, orientations, and movements of a user device and a weapon into a graphical representations of the user and the weapon in a simulation environment.

It will be appreciated by those skilled in the art that modifications can be made to the embodiments disclosed and remain within the inventive concept. Therefore, this invention is not limited to the specific embodiments disclosed, but is intended to cover changes within the scope and spirit of the claims.

The invention claimed is:

1. A method for training a marksman comprising:

receiving a set of target data and a set of environment data;

generating a simulation environment from the set of environment data;

generating a target along a target path from the set of target data in the simulation environment;

extrapolating a phantom path from the target path;

calculating a lead distance from the target path;

calculating a drop distance from the target path;

calculating a phantom position along the phantom path at the lead distance and at the drop distance, in the simulation environment;

generating a phantom image at the phantom position;

determining a headset position and a headset orientation;

determining a weapon position and a weapon orientation;

generating a user view of the simulation environment based on the headset position and the headset orientation;

displaying the user view;

receiving a trigger pull signal;

determining a shot string position from the trigger pull signal, the weapon position, and the weapon orientation;

determining a phantom hit condition based on the shot string position and the phantom position; and,

generating a hit signal if the phantom hit condition is true.

2. The method of claim **1**, wherein the step of generating a phantom image further comprises the step of generating the phantom image at a set of predetermined contrast levels.

3. The method of claim **1** further comprising:

calculating a halo position along the phantom path, at the lead distance and at the drop distance, in the simulation environment;

generating a halo image at the halo position;

determining a halo hit condition based on the shot string position and the halo position; and,

generating the hit signal if the halo hit condition is true.

4. The method of claim **3**, further comprising the step of setting a base headset position, a base weapon position, a base headset orientation, and a base weapon orientation.

5. The method of claim **4**, further comprising the steps of:

receiving a set of hand position data;

determining the weapon position from the set of hand position data and the base weapon position;

determining the weapon orientation from the set of hand position data and the base weapon orientation; and,

generating the trigger pull signal from the set of hand position data.

6. The method of claim **3**, further comprising the steps of:

receiving a set of headset position data;

receiving a set of weapon position data;

determining the headset position from the set of headset position data and the base headset position; and,

determining the weapon position from the set of weapon position data and the base weapon position.

7. The method of claim **6**, wherein the step of displaying a user view further comprises the steps of:

receiving a set of headset motion data;

receiving a set of weapon motion data;

calculating a headset orientation vector from the headset position and the set of headset motion data;

calculating a weapon orientation vector from the weapon position and the set of weapon motion data; and,

mapping the headset position, the headset orientation vector, the weapon position, and the weapon orientation vector to the simulation environment.

8. The method of claim **7**, wherein the step of mapping further comprises the steps of:

converting the weapon position and the weapon orientation vector to a first set of coordinates;

rendering the virtual weapon in the simulation environment at the first set of coordinates;

converting the headset position and the headset orientation vector to a second set of coordinates;

defining a field of view of the simulation environment based on the second set of coordinates;

displaying the field of view as the user view;

comparing the first set of coordinates to the field of view; and,

displaying the virtual weapon at the first set of coordinates in the field of view if the first set of coordinates is in the field of view.

9. The method of claim 3, further comprising the steps of:
receiving a set of voice commands; and,
changing at least one of the group selected from the simulation environment, the target, the phantom image, the halo image and the virtual weapon, based on the set of voice commands.

10. The method of claim 3, wherein the step of determining the phantom hit condition further comprises the steps of:
comparing the shot string position to the phantom position; and,
generating the hit signal if the shot string position overlaps the phantom position.

11. The method of claim 3, further comprising the step of receiving a set of weapon data, and wherein the step of determining the halo hit condition further comprises the steps of:
determining a diameter for the halo image from the set of weapon data;
determining a halo position from the diameter and the phantom path;
comparing the shot string position to the halo position;
determining a halo overlap percentage between the halo position and the shot string position; and,
generating the hit signal if the halo overlap percentage is at least a predetermined percentage.

12. The method of claim 11, further comprising the step of generating a virtual weapon from the set of weapon data in the simulation environment.

13. The method of claim 3, wherein the step of generating a halo image further comprises the step of generating the halo image at a set of predetermined contrast levels.

14. A system for marksmanship training comprising:
a computer;
a headset connected to the computer;
a set of weapon sensors connected to the computer;
the computer programmed to:
receive a set of target data, a set of environment data, a selected simulation, and a set of weapon data;
generate a simulation environment from the set of environment data and the selected simulation;
generate a virtual weapon from the set of weapon data in the simulation environment;
generate a target along a target path from the set of target data in the simulation environment;
extrapolate a phantom path from the target path;
calculate a lead distance from the target path;
calculate a drop distance from the target path;
generate a halo and a phantom along the phantom path, at the lead distance, at the drop distance, in the simulation environment;
determine a headset position and a headset orientation;
determine a weapon position and a weapon orientation;
determine a user view of the simulation environment based on the headset position and the headset orientation;
send the user view to the headset;
receive a trigger pull signal from the set of weapon sensors;
determine a shot string position from the trigger pull signal, the set of weapon data, the weapon position, and the weapon orientation;
determine whether a hit is on the target based on the shot string position, the phantom, and the halo; and,
generate a hit signal if the hit is on the target.

15. The system of claim 14, wherein the computer is further programmed to set a base headset position, a base weapon position, a base headset orientation, and a base weapon orientation.

16. The system of claim 15, further comprising a set of hand sensors connected to the computer, and wherein the computer is further programmed to:
receive a set of hand position data from the set of hand sensors;
determine the weapon position from the set of hand position data and the base weapon position;
determine the weapon orientation from the set of hand position data and the base weapon orientation; and,
generate the trigger pull signal from the set of hand position data.

17. The system of claim 15, further comprising a set of position trackers connected to the computer, and wherein the computer is further programmed to:
receive a set of headset position data from the set of position trackers;
receive a set of weapon position data from the set of position trackers;
determine the headset position from the set of headset position data and the base headset position; and,
determine the weapon position from the set of weapon position data and the base weapon position.

18. The system of claim 17, wherein the headset further comprises a set of headset sensors, and wherein the computer is further programmed to:
receive a set of headset motion data from the set of headset sensors;
receive a set of weapon motion data from the set of weapon sensors;
calculate a headset orientation vector from the headset position and the set of headset motion data;
calculate a weapon orientation vector from the weapon position and the set of weapon motion data; and,
map the headset position, the headset orientation vector, the weapon position, and the weapon orientation vector to the simulation environment.

19. The system of claim 18, wherein the computer is further programmed to:
convert the weapon position and the weapon orientation vector to a first set of coordinates;
render the virtual weapon in the simulation environment at the first set of coordinates;
convert the headset position and the headset orientation vector to a second set of coordinates;
define a field of view of the simulation environment based on the second set of coordinates;
send the field of view as the user view to the headset;
compare the first set of coordinates to the field of view; and,
display the virtual weapon at the first set of coordinates in the field of view if the first set of coordinates is in the field of view.

20. The system of claim 14, further comprising a weapon removably attached to the set of weapon sensors.

21. The system of claim 14, further comprising a simulated weapon attached to the set of weapon sensors.

22. The system of claim 14, wherein the headset is a virtual reality headset.

23. The system of claim 14, further comprising a communication device connected to the computer, and wherein the computer is further programmed to:

receive a set of voice commands; and,

change at least one of the group selected from the simulation environment, the target, the phantom, the halo, and the virtual weapon, based on the set of voice commands.

24. The system of claim 14, wherein the computer is further programmed to:

determine a phantom position from the phantom path;

compare the shot string position to the phantom position; and,

generate the hit signal if the shot string position overlaps the phantom path.

25. The system of claim 14, wherein the computer is further programmed to:

determine a diameter for the halo from the set of weapon data;

determine a halo position from the diameter and the phantom path;

compare the shot string position to the halo position;

determine a halo overlap percentage between the halo position and the shot string position; and,

generate the hit signal if the halo overlap percentage is at least a predetermined percentage.

26. A system for teaching lead comprising:

a network;

a simulation administrator connected to the network;

a database connected to the simulation administrator;

a computer connected to the network;

a set of weapon sensors connected to the computer;

a set of position trackers connected to the computer;

a virtual reality unit connected to the computer and configured to be wearable by a user;

a marksmanship simulation, generated by the computer, further comprising a virtual target, a phantom target at a lead distance and a drop distance from the virtual target, and a halo surrounding the phantom;

a user view of the marksmanship simulation, generated by the computer, displayed in the virtual reality unit;

wherein the computer includes a memory and processor that are configured to perform the steps of:

receiving a set of target data and a set of environment data;

generating a simulation environment in the marksmanship simulation from the set of environment data;

generating the virtual target along a target path from the set of target data in the simulation environment;

extrapolating a phantom path from the target path;

calculating the lead distance from the target path;

calculating the drop distance from the target path;

calculating a phantom position of the phantom target along the phantom path at the lead distance and at the drop distance, in the simulation environment;

generating a phantom image of the phantom target at the phantom position;

determining a headset position of the virtual reality unit and a headset orientation of the virtual reality unit;

determining a weapon position and a weapon orientation;

generating the user view of the simulation environment based on the headset position and the headset orientation;

displaying the user view;

receiving a trigger pull signal;

determining a shot string position from the trigger pull signal, the weapon position, and the weapon orientation;

determining a phantom hit condition based on the shot string position and the phantom position; and,

generating a hit signal if the phantom hit condition is true.

27. The system of claim 26, wherein the virtual reality unit further comprises a set of sensors, connected to the computer, for generating motion information of the virtual reality unit that is tracked by the computer.

28. The system of claim 27, further comprising a set of position signals generated by the set of position trackers, and wherein the user view is defined based on the motion information and the set of position signals.

29. The system of claim 28, further comprising:

a set of weapon signals generated by the set of weapon sensors;

a virtual weapon generated by the computer from the set of weapon signals in the marksmanship simulation at the weapon position.

30. The system of claim 29, wherein the virtual weapon is displayed in the user view when the weapon position is within the user view.

31. The system of claim 26, further comprising a real weapon removably attached to the set of weapon sensors.

32. The system of claim 31, wherein the real weapon further comprises a rail, and wherein the set of weapon sensors is removably attached to the rail.

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