SHOOTING SIMULATION SYSTEM WITH IMMERSIVE DISPLAY

FIELD OF THE INVENTION

The present invention relates to interactive simulation systems, and more particularly, to shooting simulation systems configured to display virtual targets, track firearm orientation, and simulate virtual projectile impacts, with optional immersive stereoscopic display, partial spherical screen, haptic recoil, and spatial audio variants.

BACKGROUND OF THE INVENTION

Shooting sports such as trap, skeet, sporting clays, and hunting require a shooter to engage moving targets with precise lead and aim. Conventional virtual reality systems use head-mounted displays (HMDs), which obscure the user's view of their own firearm and prevent natural firearm handling, such as cheek weld and barrel alignment.

The disclosed invention provides:
1. A core shooting simulation system using a display surface, firearm tracking, and virtual projectile simulation (hit/miss feedback).
2. An immersive display variant using a spherical display surface and stereoscopic rendering, enabling natural depth perception without HMDs.

SUMMARY OF THE INVENTION

The disclosed system includes:
- A display surface showing virtual targets;
- A tracking subsystem determining firearm orientation and position;
- A simulation engine that generates virtual shots, detects collisions with virtual targets, and provides hit/miss output.

An immersive variant uses:
- A spherical display surface capable of stereoscopic projection;
- A synchronization mechanism and shutter-based 3D glasses;
- An extended field of view providing high-fidelity depth perception. Optional features include haptic recoil mechanisms and spatial audio for enhanced realism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the core shooting simulation system showing user position relative to a display surface.

FIG. 2 is a schematic of the tracking subsystem.
FIG. 3 is a sequence diagram of core simulation steps.
FIG. 4 is a perspective view of the immersive stereoscopic variant with spherical display and shutter-based glasses.
FIG. 5 is a block diagram of the immersive system subsystems.
FIG. 6 shows optional components including haptic feedback and multi-user support.
FIG. 7 is a perspective view of the core shooting simulation system showing user position

DETAILED DESCRIPTION OF THE INVENTION

CLAIMS

1. A shooting simulation system, comprising:
a display surface configured to present virtual targets within a simulated environment;
a tracking subsystem configured to determine a position and orientation of a physical firearm or firearm replica operated by a user; and
a simulation engine configured to:
generate a virtual shot in response to a trigger event associated with the firearm or firearm replica,
determine whether the virtual shot intersects one or more virtual targets displayed on the display surface, and
provide output indicative of a hit or miss based on the intersection determination.

2. The system of claim 1, wherein the display surface comprises a spherical or curved surface configured to provide an immersive viewing field.

3. The system of claim 1, wherein the tracking subsystem comprises at least one of: an optical tracking system, an inertial measurement unit (IMU)-based system, or an electromagnetic tracking system.

4. The system of claim 1, further comprising an optional haptic feedback mechanism configured to simulate firearm recoil upon trigger activation, wherein the haptic feedback mechanism comprises any conventional actuator or similar commercially available solution.

5. The system of claim 1, wherein the simulation engine further comprises an analytics module configured to record hit/miss performance and generate training data for the user.

6. The system of claim 1, further comprising a multi-user mode enabling simultaneous participation of a plurality of users in the same simulated environment.

7. The system of claim 1, wherein the display surface comprises a direct-view emissive display.

8. The system of claim 1, wherein the display surface comprises a projection-based display.

11. An immersive display system for shooting simulation, comprising:
a spherical display surface having an interior surface configured to present stereoscopic imagery over a wide field of view;
a simulation engine configured to generate stereoscopic image pairs representing a three-dimensional virtual environment including virtual targets;
a display subsystem coupled to the simulation engine and configured to display the stereoscopic image pairs on the spherical display surface, wherein the display subsystem comprises at least one of: a direct-view emissive display or a projection-based display;
a synchronization mechanism configured to coordinate shutter-based three-dimensional glasses worn by the user with the stereoscopic image pairs, enabling the user to perceive depth within the virtual environment without use of a head-mounted display;
a tracking subsystem configured to determine position and orientation of a physical firearm or firearm replica operated by the user; and
a simulation feedback subsystem configured to simulate projectile trajectories based on the determined position and orientation, detect collisions with virtual targets, and provide output signals indicative of shot results.

12. The system of claim 11, wherein the spherical display surface subtends a field of view of at least 180 degrees in azimuth and 90 degrees in elevation relative to a user position.

13. The system of claim 11, wherein the tracking subsystem comprises at least one of: an optical marker-based tracking system, an inertial measurement unit (IMU)-based tracking system, or an electromagnetic tracking system.

14. The system of claim 11, wherein the simulation feedback subsystem further comprises an optional haptic feedback mechanism configured to simulate firearm recoil upon virtual projectile discharge.

15. The system of claim 11, wherein the simulation engine is configured to generate spatial audio corresponding to projectile firing and target impacts and output the spatial audio to a user-worn or environment-mounted audio system.

16. The system of claim 11, further comprising a multi-user mode enabling simultaneous participation of a plurality of users within the same virtual environment.

EMBODIMENT OF THE INVENTION

In one embodiment, the system comprises a high-performance computing workstation configured to execute a real-time 3D simulation engine, such as Unreal Engine, to render a virtual environment containing dynamic virtual targets. The workstation includes a multi-core, multi-threaded central processing unit (CPU), one or more graphics processing units (GPUs), and sufficient memory to render approximately sixteen million pixels at high frame rates without visual artifacts or bottlenecks.

Rendering and Display Pipeline
The simulation engine renders stereoscopic views of the virtual environment using two virtual cameras, separated by an interocular distance corresponding to that of a human user. Each camera produces a distinct image corresponding to one eye of the user. These images are processed by one or more display controllers, such as a NovaStar MCTRL4K controller array or equivalent, which perform scaling, color space conversion, high dynamic range (HDR) mapping, and low-latency buffering.

The output of the display controllers is divided among multiple receiving cards, for example seventy receiving cards in one configuration, each associated with one or more display modules. The receiving cards perform gamma correction and other panel-specific compensation before forwarding data to the integrated circuit (IC) drivers of individual display modules. These drivers generate precise current waveforms to control light emission from red, green, and blue subpixels in each display element, thereby creating a seamless, high-resolution visual field across the display surface.

In one embodiment, the display surface is a spherical or curved surface providing at least 180 degrees of horizontal field of view and at least 90 degrees of vertical field of view relative to the user's position. The display may be constructed from curved light-emitting diode (LED) panels or may use one or more projectors mapped for spherical presentation.

Stereoscopic Synchronization
The display controllers also provide left-eye/right-eye synchronization data to an emitter, which wirelessly transmits synchronization pulses (e.g., infrared pulses) to active shutter 3D glasses worn by the user. These pulses ensure that the correct image for each eye is perceived at the correct time, enabling stereoscopic depth perception without the need for a head-mounted display.

Tracking Subsystem
The position and orientation of the user's firearm or firearm replica is determined by a tracking subsystem that may include optical tracking using passive or active markers, one or more high-resolution tracking cameras, inertial measurement units (IMUs), or electromagnetic tracking sensors. As the user moves the firearm or their head, the simulation engine updates the point of focus and aiming vector in real time.

Interaction and Feedback
When the user pulls the trigger, the simulation engine generates a virtual shot trajectory based on the position and orientation of the firearm and using ballistics appropriate to the simulated ammunition type. The engine performs collision detection to determine whether the virtual shot intersects any virtual targets. If a target is hit, the target is visually and audibly updated to reflect impact; if the shot misses, appropriate feedback is provided.

In one embodiment, an optional haptic mechanism, such as a commercially available actuator integrated into the firearm stock or grip, is activated to provide a physical recoil sensation. Spatial audio is generated by the simulation engine to represent environmental sounds, including target movement, impacts, and ambient background cues, and is delivered via a spatial audio system such as surround speakers or user-worn headphones.

User Interface and Control

The user can initiate a simulation session via a conventional graphical user interface or by issuing voice commands. Voice commands can also be used during active simulation sessions to control simulation parameters, request scoring updates, or change virtual scenarios.

Multi-User and Analytics

In multi-user embodiments, multiple users, each with independently tracked firearms and optional haptic feedback, can participate simultaneously in the same simulated environment. The simulation engine maintains separate tracking streams and collision detection for each user and may update scores and analytics in real time. An analytics module may record hit/miss statistics, reaction times, and training performance metrics for post-session review.

DRAWING SHEETS

FIGURE 1 – Core System Overview

Purpose: Show user interacting with the basic shooting simulation system.

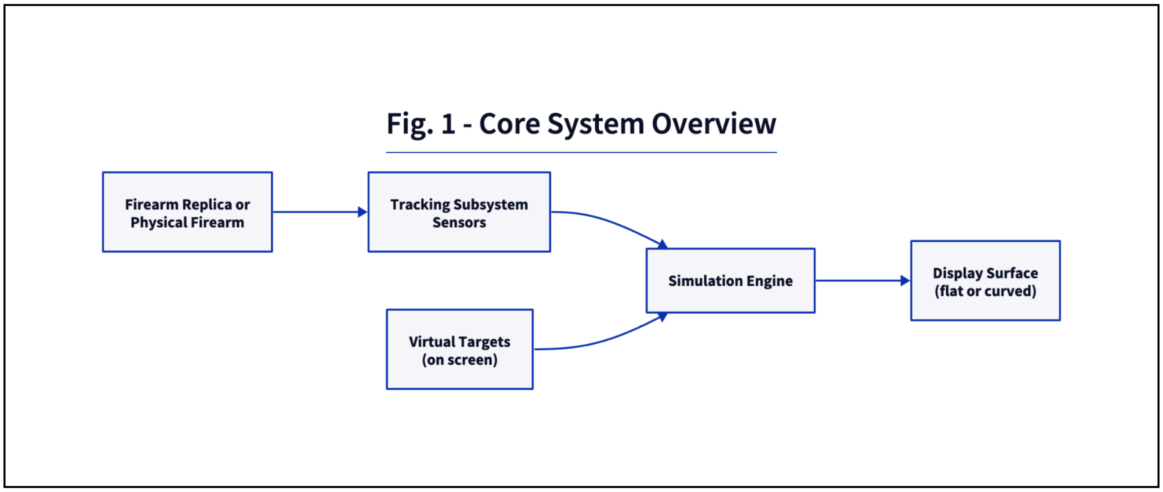


FIGURE 2 – Tracking Subsystem

Purpose: Show options for firearm tracking.

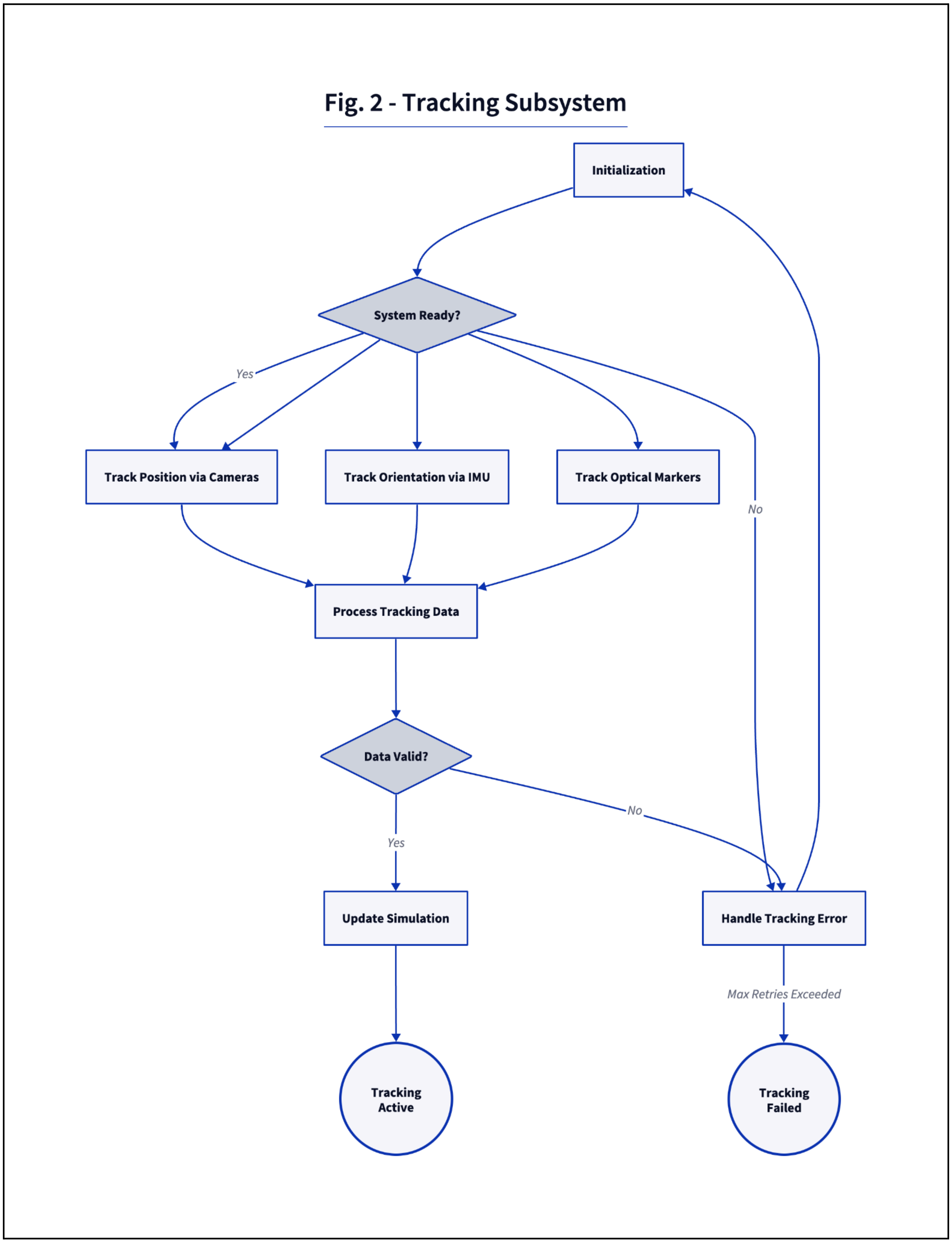


FIGURE 3 – Core Simulation Sequence Diagram

Purpose: Functional flow of hit/miss logic and other mechanisms in core loop.

Fig. 3 - Core Simulation Sequence Diagram

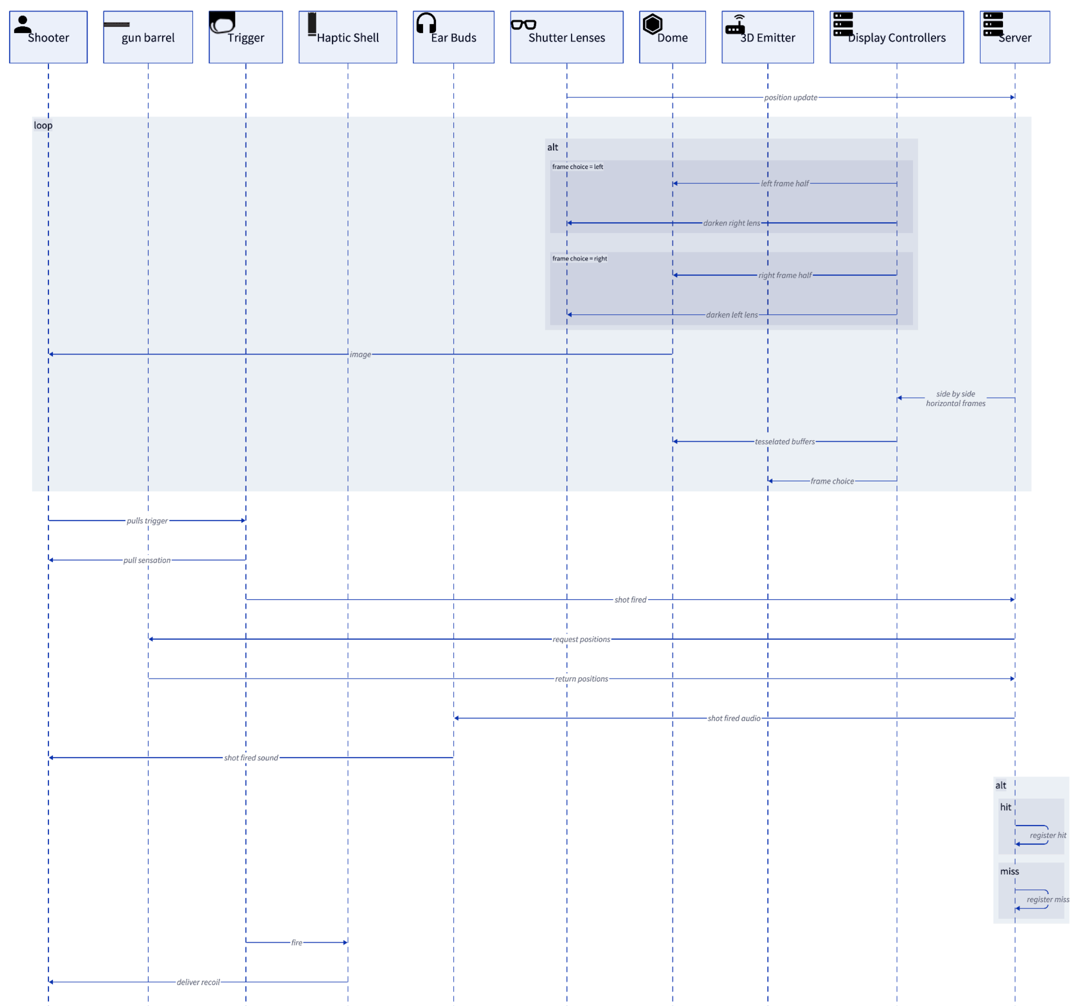


FIGURE 4 – Immersive Stereoscopic Variant

Purpose: Highlight immersive spherical setup and glasses.

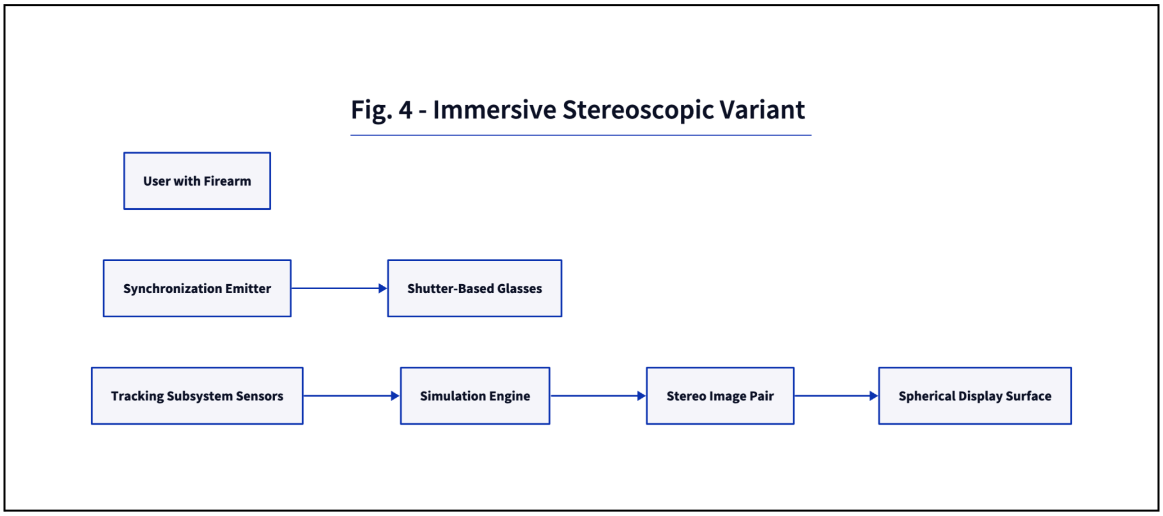


FIGURE 5 – Immersive System Block Diagram

Purpose: Show subsystems and data flow.

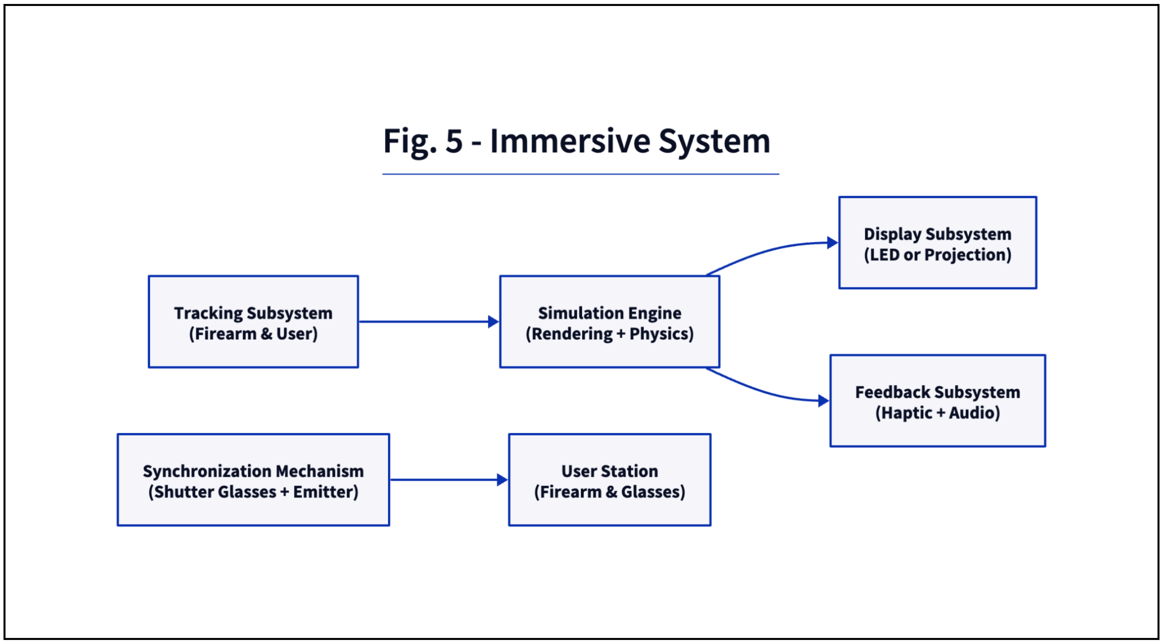


FIGURE 6 – Optional Features

Purpose: Show add-ons (dependent claims).

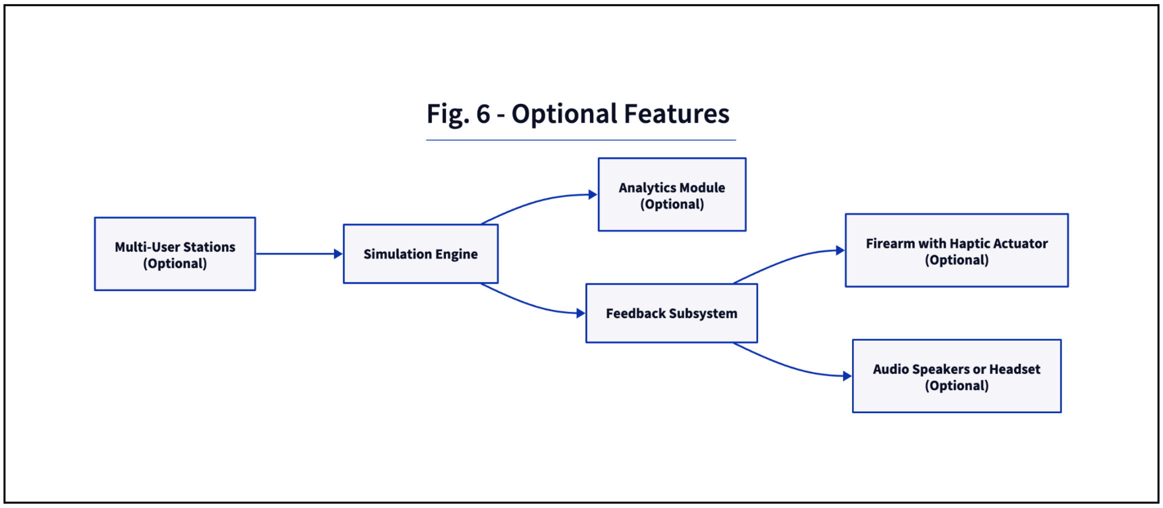
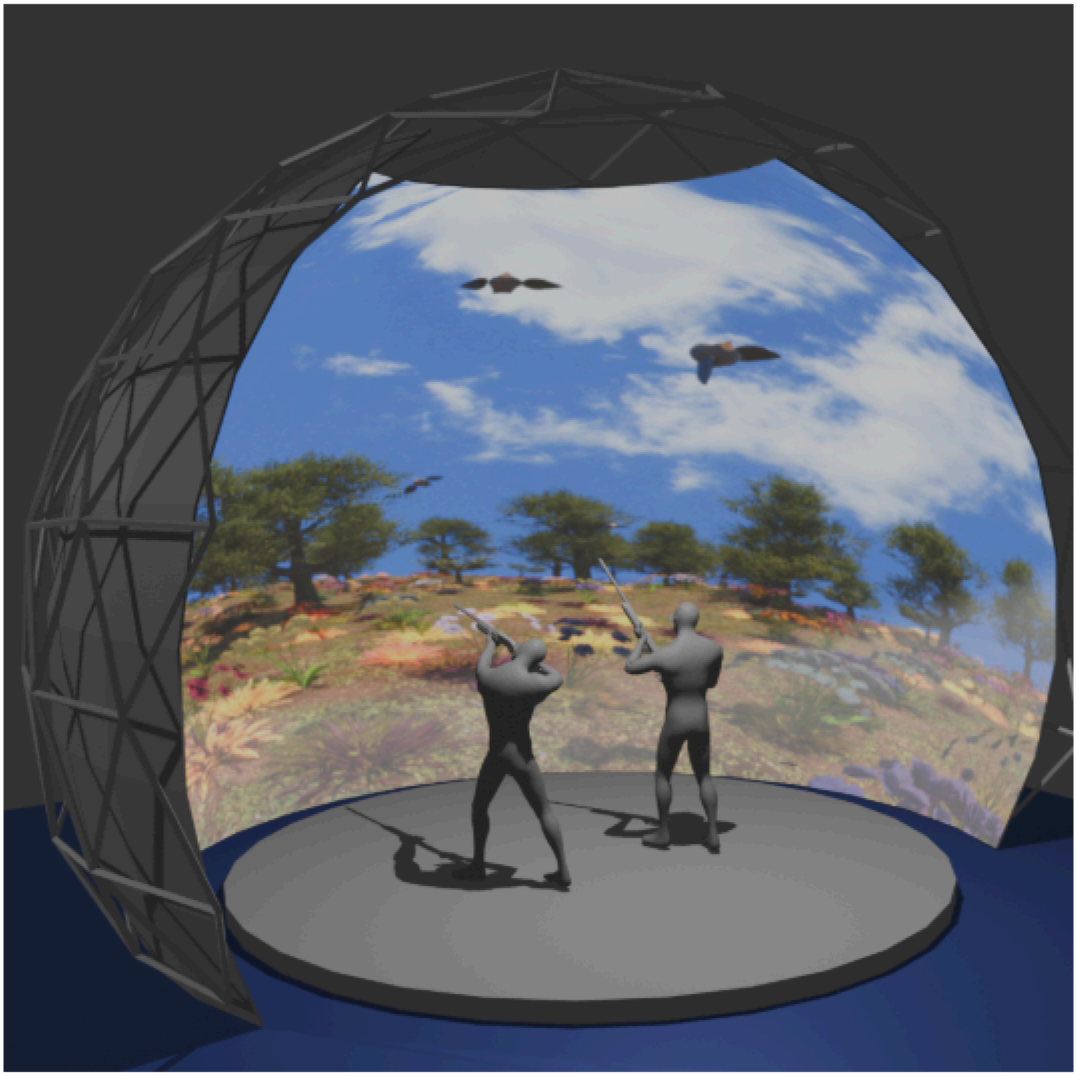


FIGURE 7 – Perspective View of Core Shooting Simulation

Purpose: Show a perspective view of the core shooting simulation system with user position



Referring now to FIG. 1, the core shooting simulation system includes a display surface (100) configured to present virtual targets,
a tracking subsystem (102) for detecting position and orientation of a physical or replica firearm (104),
and a simulation engine (106) that calculates projectile trajectories, detects collisions, and provides hit or miss outputs.
The user (108) interacts naturally with the firearm while observing virtual targets on the display surface.

As shown in FIG. 2, the tracking subsystem may include optical markers (202) or inertial measurement units (204) on the firearm,

with tracking cameras (206) capturing position and orientation data. This information is transmitted over a data link (208)
to the simulation engine (210).

Referring now to FIG. 3, when the trigger is pulled (300), the simulation engine generates a virtual projectile trajectory (302)
and performs collision detection (304) with displayed targets. A hit or miss determination (306) is made and corresponding feedback (308),
including visual and scoring updates, is provided.

FIG. 4 illustrates an immersive stereoscopic variant of the system. A spherical display surface (400) presents stereoscopic imagery (402),
viewed through shutter-based glasses (404). A synchronization emitter (408) coordinates frame timing with the glasses to deliver
depth perception without a head-mounted display, while the user (406) interacts with a tracked firearm in the same manner as the core system.
Tracking sensors (412) provide continuous positional data to the simulation engine (410).

As shown in FIG. 5, the immersive system includes a simulation engine (500), a display subsystem (502) that may be an LED dome or projection system,
a synchronization mechanism (504) for stereoscopic viewing, a tracking subsystem (506), a feedback subsystem (508) that may include haptic devices and audio,
and a user station (510).

FIG. 6 shows optional features including a firearm with an integrated haptic actuator (600), spatial audio components (602),
an analytics module (604), and multi-user stations (606). These enhance training realism and data collection but are not required for core operation.

FIG. 7 provides an alternate perspective view of the core shooting simulation system, illustrating the relationship between the user position,
the tracked firearm, and the display surface.