[0001] DRONE SHOOTING SIMULATION SYSTEM WITH VIRTUAL PROJECTILES

[0002] FIELD OF THE INVENTION

[0003] The present invention relates to interactive shooting simulation systems, and more particularly, to systems in which users fire virtual projectiles from a physical firearm or replica at actual moving drone targets, with position tracking of both the drones and the firearm mapped to a common world space. Optional features include immersive visualization, haptic recoil, spatial audio, and analytics capabilities.

[0004] BACKGROUND OF THE INVENTION

[0005] Shooting sports such as skeet, trap, and sporting clays traditionally involve targeting fast-moving clay pigeons or similar airborne targets. Modern simulation systems often replace real targets with virtual representations displayed on screens or head-mounted displays. While such systems offer valuable training, they fail to reproduce the challenge and realism of engaging physical moving targets in real space. In particular, existing virtual reality (VR) systems require head-mounted displays that obscure a user's natural view of their firearm and surroundings. There exists a need for a system that allows users to engage actual drone targets while firing virtual projectiles, providing a safe, realistic, and highly immersive shooting experience without the limitations of VR headsets.

[0006] SUMMARY OF THE INVENTION

[0007] The disclosed system enables a user to engage real, physical drone targets using virtual projectiles simulated within a shared world space. The system tracks both the user's firearm and the position of one or more drones, maps these positions into a common coordinate system, and simulates the flight and interaction of virtual projectiles with drone targets. When a virtual projectile intersects the modeled volume of a drone, a hit is registered, and feedback is provided to the user. Optional features include haptic recoil simulation, spatial audio representing target motion and impacts, immersive visual overlays, and training analytics. The same core architecture supports variants including multi-user sessions and drone swarms.

[0008] BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a side view of a user engaging drone targets with virtual projectiles.
FIG. 2 is a schematic of the firearm and drone tracking subsystems.
FIG. 3 is a sequence diagram of core simulation steps including virtual projectile generation and collision detection with drones.

FIG. 4 is a block diagram of the simulation engine and feedback subsystems.
FIG. 5 shows optional features including haptic feedback, spatial audio, and multi-user support.
FIG. 6 illustrates a swarm drone training scenario.
FIG. 7 shows the mapping of firearm and drone positions into a common world-space coordinate system.
FIG. 8 shows a sequence diagram of an embodiment of the system.

[0010] DETAILED DESCRIPTION OF THE INVENTION

[0011] Referring to FIG. 1, the system includes a tracked firearm or firearm replica (100) and one or more autonomous drones (102) serving as moving targets. A tracking subsystem (104) determines the position and orientation of both the firearm and each drone in real time, mapping them into a shared world space. A simulation engine (106) generates virtual projectiles in response to trigger events and computes their trajectory using modeled ballistics.

As shown in FIG. 2, the tracking subsystem may include optical or radio-frequency trackers on the firearm and drones, inertial sensors, or external multi-camera arrays. Position data is fused (108) to produce high-fidelity, low-latency motion estimates.

Referring to FIG. 3, when the user pulls the trigger (110), the simulation engine generates a virtual projectile (112) and performs collision detection (114) to determine if it intersects any drone’s modeled volume. A hit or miss determination (116) is made, and corresponding feedback (118), including audio and scoring updates, is provided.

FIG. 4 illustrates the overall architecture, including the simulation engine (120), feedback subsystem (122) providing haptic and audio cues, and optional visual overlays (124) for enhanced situational awareness. The drone control system (126) ensures safe operation and can orchestrate complex flight patterns.

FIG. 5 shows optional features such as haptic recoil actuators (130) in the firearm, spatial audio (132) to represent drone flight paths, and a multi-user support module (134) enabling competitive or cooperative engagements. Analytics (136) can record reaction times, hit percentages, and other performance data.

FIG. 6 illustrates a swarm drone training scenario, where multiple drones (140) operate autonomously in coordinated flight paths, increasing difficulty and providing diverse training experiences.

FIG. 7 provides an alternate perspective view showing the mapping of firearm position (150) and drone positions (152) into the common world coordinate system, ensuring accurate collision detection and hit registration without physical ammunition.

FIG. 8 shows a sequence diagram of an embodiment of the system for an indoor venue using several optional aspects of the system such as pass-through AR, spatial audio, and a projected environment.

[0012] CLAIMS

[0013] 1. A shooting simulation system for engaging drone targets, comprising:

a tracking subsystem configured to determine a position and orientation of a physical firearm or firearm replica operated by a user;

a tracking subsystem configured to determine positions of one or more drones acting as physical moving targets;

a simulation engine configured to:

generate a virtual projectile in response to a trigger event associated with the firearm or firearm replica,

model a trajectory of the virtual projectile in a shared world coordinate system based on the determined firearm position and orientation,

determine whether the virtual projectile intersects a modeled volume of any of the tracked drones, and

provide output indicative of a hit or miss based on the intersection determination.

2. The system of claim 1, wherein the tracking subsystem comprises at least one of: an optical marker-based tracking system, a radio-frequency tracking system, an inertial measurement unit (IMU)-based tracking system, or an external camera array.

3. The system of claim 1, further comprising a haptic feedback mechanism configured to simulate firearm recoil upon trigger activation.

4. The system of claim 1, wherein the simulation engine further comprises a spatial audio module configured to represent drone motion and projectile impacts.

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 engaging one or more drones.

7. The system of claim 1, wherein the one or more drones are operated autonomously according to predefined or adaptive flight paths.

8. The system of claim 1, wherein the system includes safety controls to ensure drone flight paths avoid collisions with users or infrastructure.

[0014] EMBODIMENT OF THE INVENTION

[0015] In one embodiment, the system includes a passthrough AR display pipeline that replaces tracked drones with virtual bird models. The system, illustrated FIG. 8, comprises several key components: User[160] wearing AR Glasses[162], Drone[164] equipped with visual odometry/SLAM and IMU sensors, Tracking System[166] that processes drone pose data, Rendering Engine[168] that generates 3D virtual models, Spatial Mapping[170] that builds world reference frames, Coordinate System[172] that synchronizes drone and user head poses, Virtual Bird Model[174] that replaces the drone with animated bird geometry, and Spatial Audio[176] that provides spatialized sound feedback.

The tracking subsystem uses visual odometry/SLAM and IMU sensors on the Drone[164] to provide real-time position and orientation data to the Tracking System[166]. The AR Glasses[162] provide head position and orientation data to the Spatial Mapping[170] component, which builds a world reference frame. The Coordinate System[172] performs calibration steps to synchronize the drone and user coordinate spaces.

The Rendering Engine[168] predicts drone pose 30ms ahead and generates 3D bird models with orientation offsets and animated wing cycles. The Spatial Mapping[170] provides fully opaque replacement for the Virtual Bird Model[174], ensuring proper occlusion handling. The rendering pipeline applies textures, shading, and motion blur before compositing the final display to the AR Glasses[162].

The Spatial Audio[176] system provides spatialized bird sounds that mask drone propeller noise, creating an immersive experience where the User[160] sees and hears a bird flying naturally instead of a drone. The entire pipeline maintains less than 50ms end-to-end latency using Kalman filter prediction to ensure smooth real-time performance.

[0016] DRAWING SHEETS

FIGURE 1 - Simplified Side View of User and System

FIG. 1 is a side view of a user engaging drone targets with virtual projectiles.

Fig. 1 - Simplified Side View of User and System

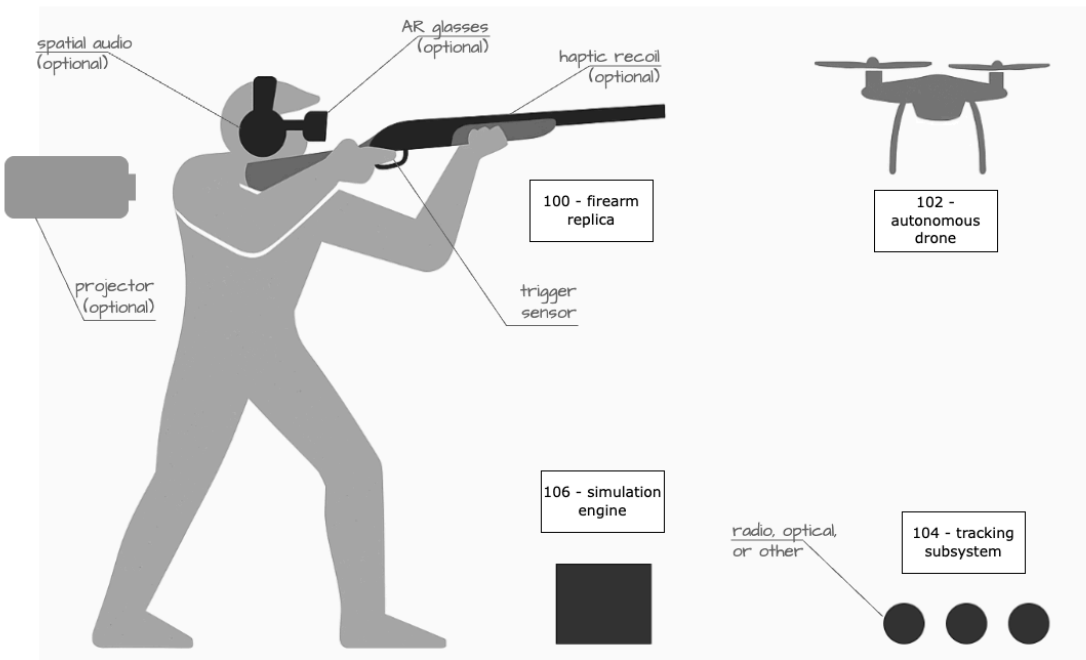

FIGURE 2 - Tracking Subsystems

FIG. 2 is a schematic of the firearm and drone tracking subsystems.

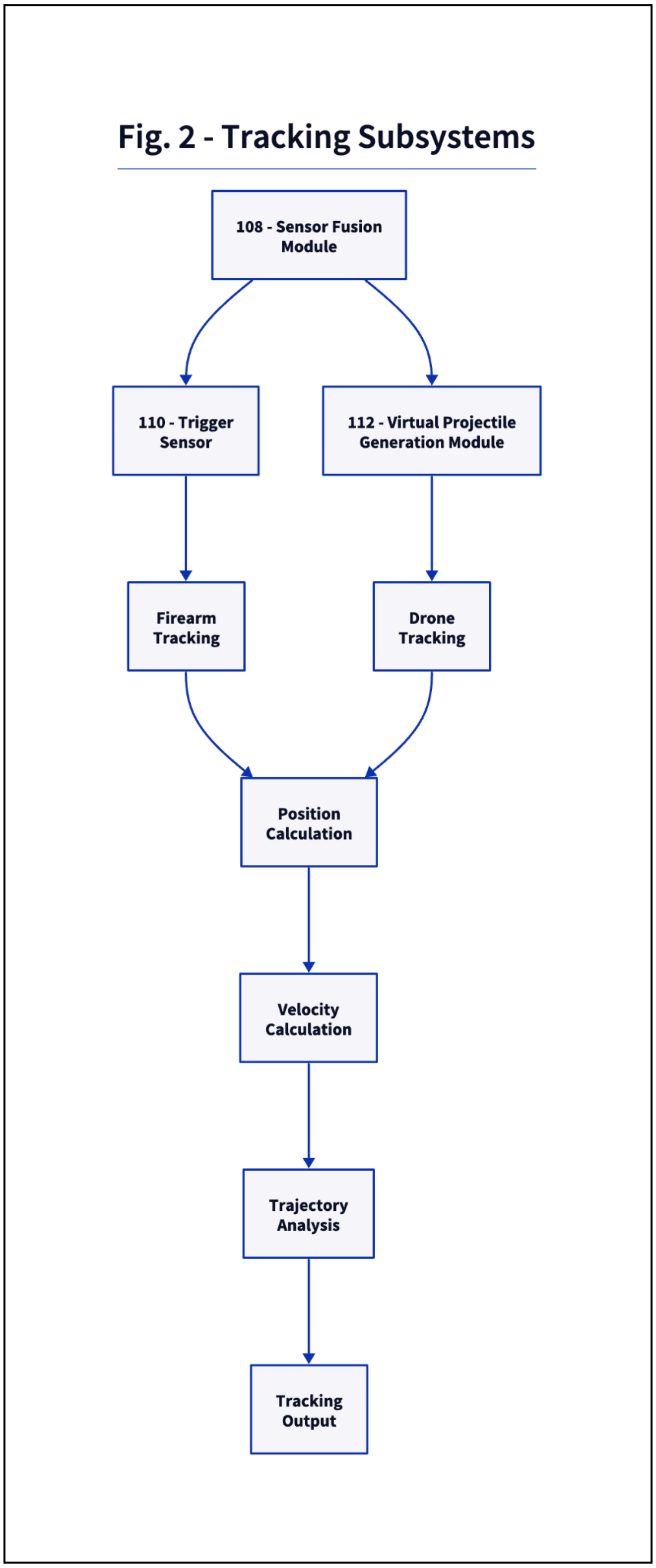

FIGURE 3 - Core Simulation Sequence Diagram

FIG. 3 is a sequence diagram of core simulation steps including virtual projectile generation and collision detection with drones.

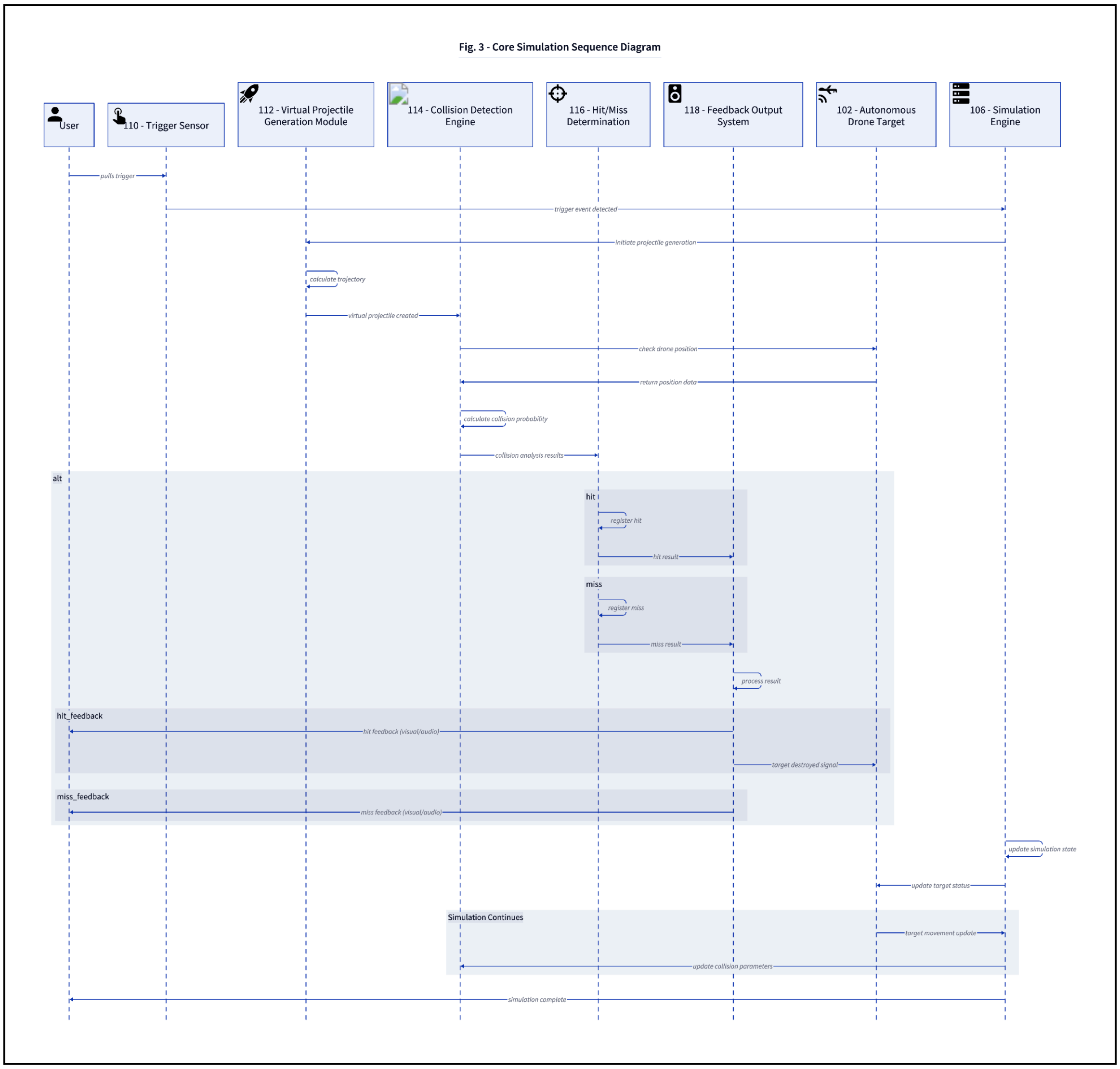

FIGURE 4 - Simulation Engine and Feedback Subsystems

FIG. 4 is a block diagram of the simulation engine and feedback subsystems.

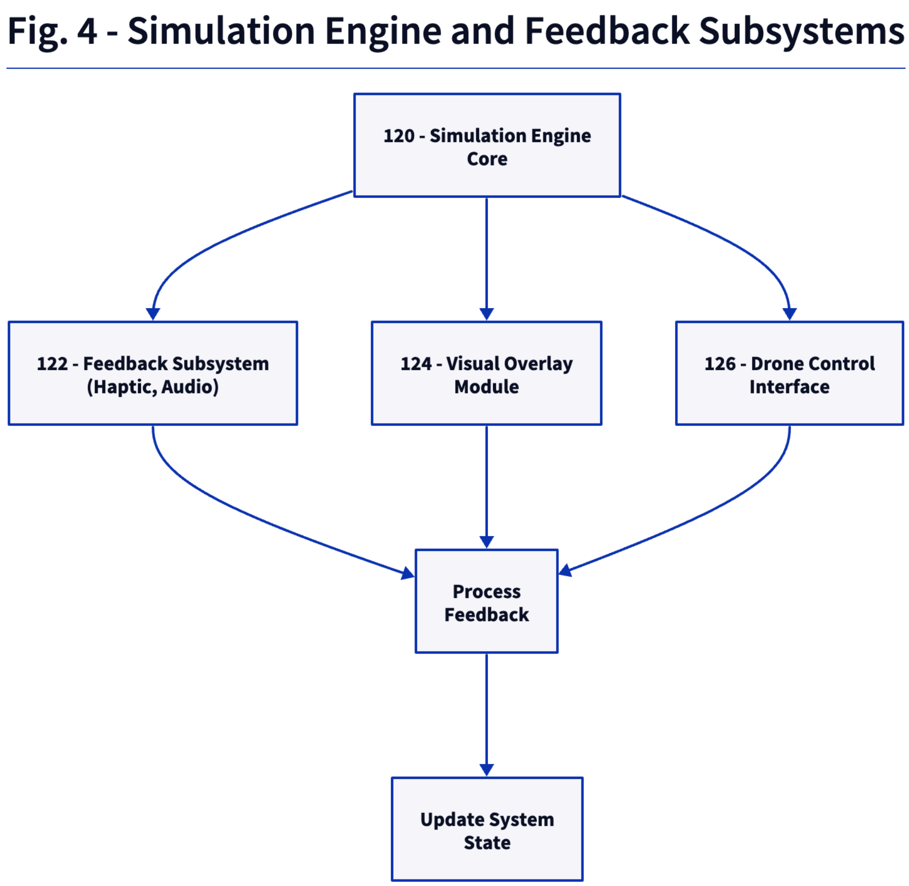

FIGURE 5 - Optional Features

FIG. 5 shows optional features including haptic feedback, spatial audio, and multi-user support.

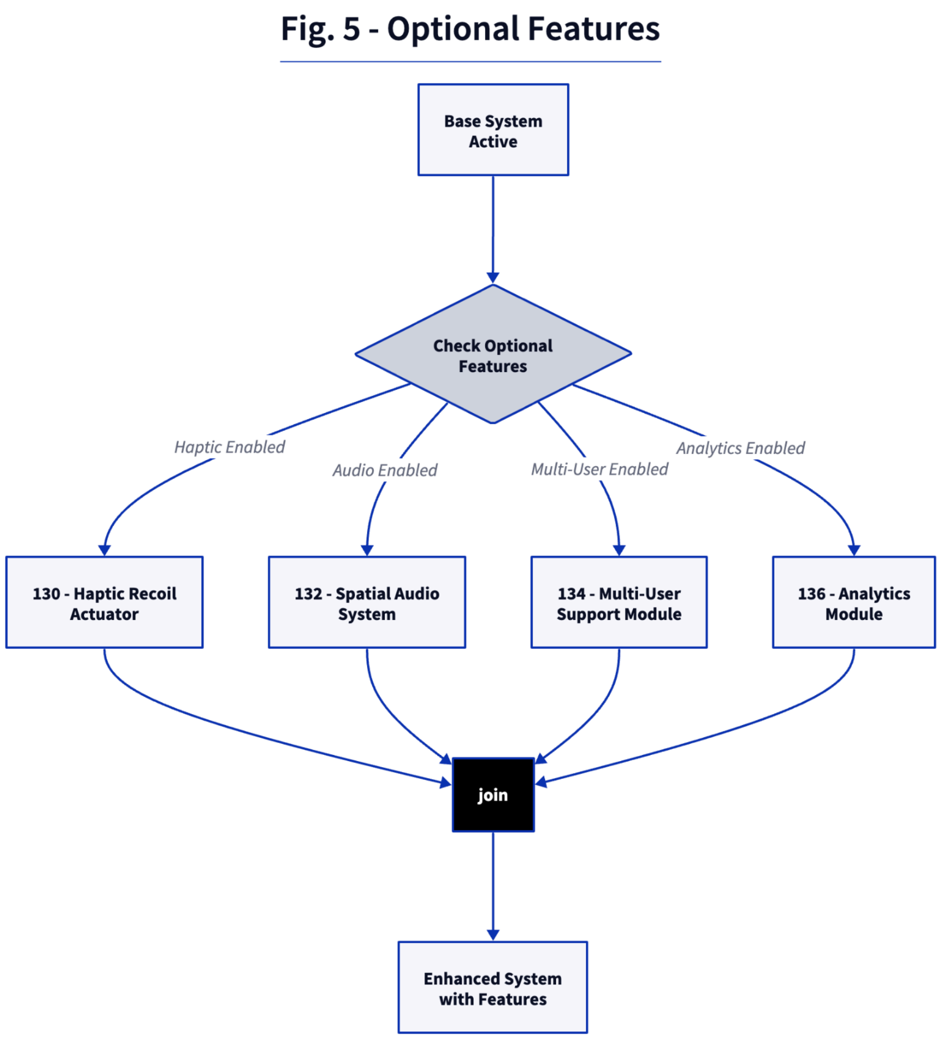

FIGURE 6 - Swarm Drone Scenario

FIG. 6 illustrates a swarm drone training scenario.

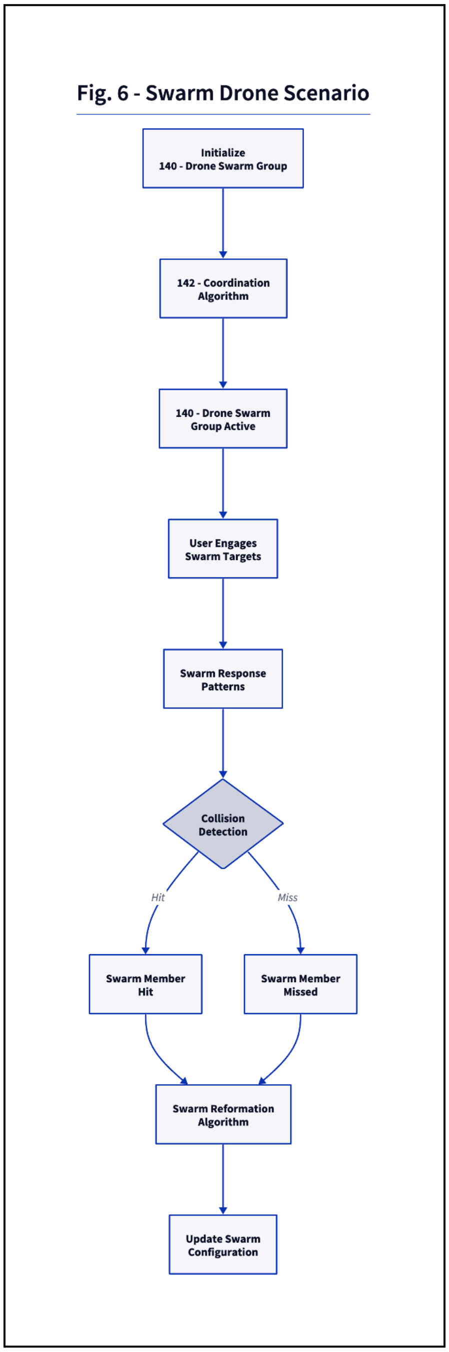

FIGURE 7 - World Space Mapping View

FIG. 7 shows the mapping of firearm and drone positions into a common world-space coordinate system.

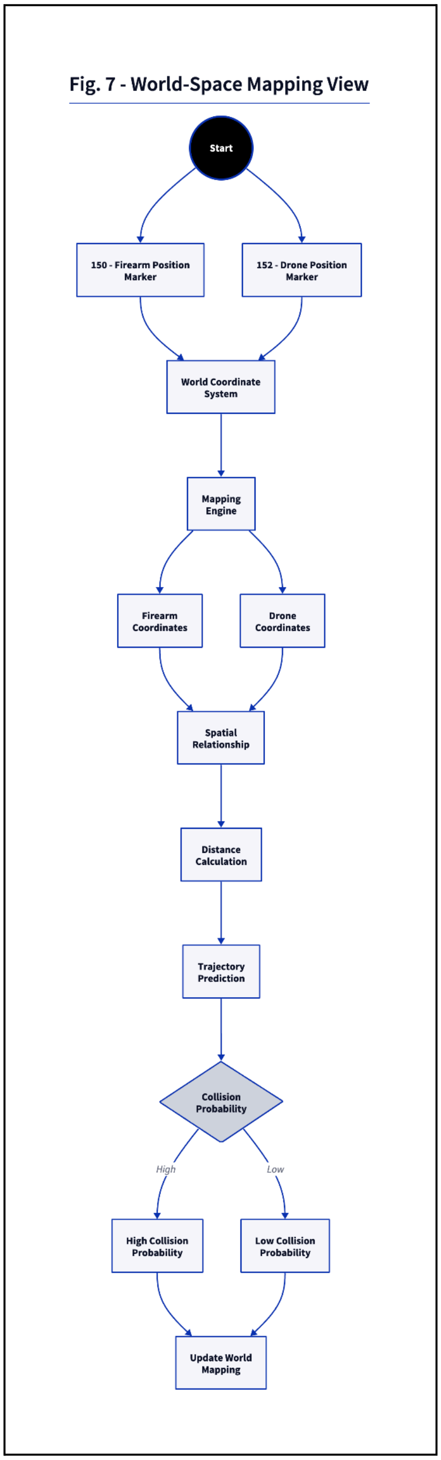

FIGURE 8 - AR Display Pipeline Sequence Diagram

FIG. 8 shows a sequence diagram of an embodiment of the system.