QBurst | A High AI-Q™ Company

Building a High-Loyalty Sportstech Ecosystem with a Smart Robot and Subscription Learning Platform

Transforming a sports brand's customer engagement by combining mobile-app–controlled training robots, precise firmware-driven performance, and a multi-sport subscription platform that keeps enthusiasts continuously learning and returning.

Overview

- Delivered firmware evolution and software intelligence for a mobile-controlled smart training robot enabled by precise shot stability, and calibration-aware motor behavior.
- Engineered an autonomous calibration system using computer vision, a master robot reference, and onsite mobile-assisted calibration.
- Developed a multi-sport subscription learning platform featuring HLS video, personalized recommendations, live coaching, multilingual subtitles, and in-app payments.
- Built a role-based admin CMS for coaches and content teams to publish structured lessons and tutorials.
- Established a unified hardware + digital ecosystem that improves engagement and drives recurring subscription revenue.
- Shot variability reduced by >75%, factory calibration time reduced by 50%, and significantly improved customer loyalty through personalized drills and a recurring subscription content ecosystem.

Client Profile

The client is a German multinational corporation that creates a wide range of sports equipment and accessories for players, both professional and recreational. As a regular sponsor at the Olympic Games and multiple international competitions, clubs, and athletes, our client is one of the most visible sports equipment manufacturing brands in the world.

Performance Instability and Scalability Limits

- The robot used an open-loop motor system, causing speed drift, inconsistent spin, and unpredictable ball placement, with no sensors to self-correct variations caused by heat, voltage, or motor wear.
- Post-manufacturing variability in power adapters, motor drivers, and motors themselves resulted in inconsistent units.
- No unified firmware architecture existed to manage PID control, telemetry, calibration ingestion, and task prioritization, causing timing collisions and stability issues.
- Firmware lacked a reliable way to ingest calibration data from the vision system, and minimal logging made field troubleshooting difficult.
- Accurate calibration required sub-centimetre landing measurement, precise camera-shot synchronization, and a way to convert video data into adjustments for X/Y placement, launch angle, and wheel speed.
- The digital platform needed scalable delivery of multi-sport content with HLS streaming, subscriptions (Stripe/Apple/Google), entitlements, personalization, and role-based content operations.

A Connected Sports Ecosystem Built on Digital Experience

Companion Mobile App for Controlling the Robot

- Smartphone-based interface for complete robot control.
- Users can select drills, fine-tune speed, spin, angle, and shot placement, and save custom presets.
- BLE protocol enables real-time communication with the robot.
- Calibration mode lets users mark the ball's landing position using a calibration sheet overlay within the app.
- The mobile app serves as the central command center for robot operation and user engagement.

Autonomous Calibration System

- Calibration addresses performance variations caused by differences in motors, drivers, and power adapters.
- A master robot executes predefined shot sequences, with reference values captured for X/Y landing position, launch angle, and motor speed.
- Computer vision uses an iPhone camera positioned at 90° to the table and a table tennis calibration grid to accurately map landing positions.
- The CV pipeline compares actual landing points with reference values to measure deviations.
- An XYZ adjustment model is generated to compensate for X/Y placement, motor speed, and launch angle.
- Firmware applies these calibration deltas to ensure every robot performs consistently with the master unit.

Firmware Transformation

- Closed-loop PID motor control continuously monitors and adjusts motor speed for consistent shot delivery.
- Real-time corrections compensate for wear, heat, and voltage variations, with future support for RPM sensor integration.
- Deterministic real-time task scheduling prioritizes:
  - High-frequency ISR-driven tasks for motor PID loops and feeder-wheel speed control.
  - Mid-priority tasks for sensor sampling, calibration logic, and motor health monitoring.
  - Lower-priority tasks for BLE communication, diagnostics, and UI commands.
  - A safety watchdog to prevent timing conflicts and ensure stable operation.
- Firmware directly consumes JSON calibration profiles generated during computer vision calibration.
- Automatic adjustment of X, Y, launch angle, and motor speed ensures consistent performance across all units.

- Each shot records RPM, temperature, motor load, timing, calibration deltas, errors, and safety events for troubleshooting, predictive maintenance, and reliability.
- Modular OTA-ready architecture enables secure firmware updates, new drills, tuning improvements, and feature enhancements after deployment.

Multi-Sport Subscription Learning Platform

- HLS-based video lessons with adaptive playback.
- Personalized recommendations and guided learning paths.
- Multi-language subtitles, chapter navigation, and podcast mode.
- Subscription management through Stripe, Apple, and Google.
- Live coaching sessions using YouTube Live.
- Notifications for new drills, firmware updates, and learning content.

Admin & Coach Tools

- Role-based administration for coaches, editors, and content managers.
- Visual Tutorial Editor for creating multi-step lessons with videos, instructions, and annotations.
- Content review and publishing workflows.
- Analytics dashboard for tracking user engagement and content performance.

Technical Highlights

- Real-time firmware control built in C/C++ on an RTOS, with deterministic control loops and precisely tuned PID for consistent motor RPM and shot stability.
- Robust motion and sensor stack using incremental encoders for RPM feedback, and SPI/I^2C sensors for current, thermal, and system health monitoring.
- Edge compute on STM32H7/G4 MCUs, optimized for motor control, low-latency task execution, and safety-critical watchdog supervision.

- Computer-vision calibration pipeline using Python, OpenCV, and PyTorch/TensorFlow to track ball trajectories, estimate landing points, and generate per-unit calibration profiles.
- Calibration delta processing implemented in C++/Python with fast lookup tables enabling the firmware to instantly apply corrections during shot execution.
- Synchronized factory capture using high-speed global-shutter cameras and automation scripts to ensure frame-accurate shot analysis.
- Safety-first design including hardware watchdogs, thermal and current sensors, overload protection, and software safety interrupts.
- Scalable admin UI built with React, Vite/Turbopack, and Tailwind, delivered via micro-frontend architecture (single-spa/module federation) for modular content management and coaching workflows.
- Backend telemetry and analytics powered by PostgreSQL + TimescaleDB/InfluxDB for time-series data, Kafka/MQTT for robot telemetry, and Prometheus/Grafana + ELK/OpenSearch for monitoring and diagnostics.

Impact

- >75% reduction in shot variability with closed-loop firmware.
- Stable, predictable motor performance regardless of environment or component differences.
- 70% reduction in calibration time due to automated CV workflows.
- Robots ship with near-master accuracy, reducing returns.
- Faster field diagnosis with telemetry logs.
- Subscription platform drives recurring revenue, higher retention, and increased app engagement through customizable drills.
- Multi-sport expansion creates a scalable training ecosystem.
- Product becomes a firmware-led competitive differentiator.
- Foundation built for future devices, sports, and unified content experiences.