

# Recreate immersive scenarios for practicing sports in gyms - User Application

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**Abstract**— This paper presents the development of a mobile application to integrate immersive features into fitness devices to enhance user experience and athletic performance. The proposed architecture ensures compatibility with a wide range of fitness equipment, regardless of brand or model. Central to the system is the playback of authentic route videos, augmented by contextual data such as speed, altitude, and environmental conditions. This allows dynamic equipment control, adjusting parameters like resistance and slope for a more consistent immersive experience. The application acts as a central interface, managing video recordings and data collection, all synchronized through a cloud-based platform that builds a community-driven repository of shared routes. Additionally, the application integrates cloud and edge computing alongside artificial intelligence to provide tailored workout adjustments based on historical performance and real-time metrics. Communication between the application, fitness devices, and wearables relies on SIG BLE standards. Users can create new immersive routes and download shared ones for enhanced training sessions. The paper elaborates on the application's architectural design and technological choices while discussing implementation progress, challenges, and future improvements.

**Keywords**— *workout, sports performance, fitness application, immersive experiences, cloud computing, edge computing, Wearables, Bluetooth Low Energy*

## I. INTRODUCTION

Sports practice is recognized for its profound benefits to physical and mental health, contributing significantly to the quality of life across various age groups. The trend towards indoor physical activity, supported by gyms and home fitness equipment such as treadmills and stationary bikes, has seen increasing adoption. Technological advancements have been instrumental in this shift, providing smartphone connectivity for tracking training progress and enabling personalized workout

routines. However, substantial innovation potential remains, particularly in enhancing real-time interaction between users and training equipment.

Technological fitness innovation facilitates tracking training data and enhances motivation and user experience. Fitness devices connected to mobile applications can create a more immersive and interactive training atmosphere, essential for users seeking to maintain motivation during indoor workouts. Integrating virtual environments, contextualized data, and adaptive resistance mechanisms allows a better simulation of outdoor conditions, which can be a notable change for athletes and regular users alike.

This paper proposes a mobile application to address these challenges by offering a more engaging and personalized training experience. The application aims to elevate athletic performance through custom training plans tailored to the user's profile and history while enhancing interactivity between the user and fitness equipment. By leveraging immersive real-world video scenarios, contextual data integration, and advanced features such as Bluetooth SIG BLE for device communication, the application is the focal point of a comprehensive solution to mitigate the monotony of indoor exercise. Additionally, the proposed system fosters a community-driven repository, encouraging users to share their training experiences and routes, which enhances social engagement and provides users with a richer set of workout options.

The paper is organized as follows: Section 2 presents the related works; Section 3 details the proposed solution from a functional perspective; Section 4 describes the system architecture and underlying technologies; Section 5 discusses the results; and Section 6 concludes the study with future work recommendations.

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## II. TECHNOLOGIES AND TRENDS

### A. State-of-Art

In [1], J. Polechoński et al. evaluate the intensity of physical exercise for wheelchair boxers using the FitXR application in immersive VR. Using heart rate monitors and perceived exertion scales, they found that VR boxing provides moderate-intensity exercise, sufficient for health benefits. While hand-held weights were introduced, they did not significantly impact the intensity of physical activity, though users reported high satisfaction levels with the VR experience. This study highlights VR's ability to reduce pain, improve motor and cognitive functions, and enhance rehabilitation, especially for users with disabilities. This is significant because, like in our work, it demonstrates the power of immersive technology to engage users and optimize physical activity. Their findings reinforce the potential of using immersive environments, which supports our approach of recreating real-world scenarios to enhance athletic performance and user experience across diverse fitness equipment.

In [2], Thuong Hoang et al. systematically reviewed immersive fitness and sports training technologies. The review highlights the development trends, challenges, and future directions for VR, AR, and MR technologies. It emphasizes the need for better industry collaboration, trainer-trainee experience, and social dynamics in sports. This comprehensive overview aligns with our work by underscoring the importance of immersive technology in creating engaging and effective fitness experiences. The findings from this review can be instrumental in refining our approach to integrating real-world scenarios into fitness devices, ensuring our application remains at the forefront of technological advancements and user engagement strategies.

In [3], Małgorzata Dębska et al. assess the enjoyment and intensity of physical activity in immersive virtual reality (IVR) using innovative training devices like the Omni treadmill and Icaros Pro flight simulator. The study finds that both devices provide essential levels of enjoyment and sufficient exercise intensity to meet health recommendations, with the Omni treadmill offering higher intensity. Participants also found these activities enjoyable and helpful in meeting their physical activity needs. This aligns with our work on integrating immersive features into fitness devices, as both studies highlight the potential of VR to enhance physical activity and user experience. The findings from this study can be instrumental in refining our approach to ensure that our application not only recreates real-world environments but also maintains the necessary intensity and engagement to meet health benefits, enhancing user satisfaction and adherence to fitness routines.

In [4], Maged N. Kamel Boulos and Stephen P. Yang review mobile physical activity (PA) planning and tracking applications, highlighting their potential to improve health outcomes through advanced smartphone features like GPS, Bluetooth, and motion sensing. They discuss various application categories, including GPS trackers, workout planners, and exergames, emphasizing the need for accurate tracking, social interaction, and personalized feedback. The authors suggest that the ideal application should support individual and public health by providing precise PA advice and community-level indicators.

This aligns with our work on integrating immersive features into fitness devices, as both studies emphasize the potential of technology to enhance physical activity and user experience. The insights from this review can be instrumental in refining our application to ensure it offers precise tracking, social engagement, and personalized feedback, thereby enhancing user satisfaction and adherence to fitness routines.

In [5], Jacek Polechoński et al. assess the attractiveness and intensity of physical activity in immersive virtual reality (IVR) for obese children using an omnidirectional treadmill. The study finds that active video games (AVGs) in IVR are more enjoyable than conventional video games and can provide high-intensity exercise that is beneficial for health. The research highlights those games that require players to follow a set route to increase exercise intensity compared to those allowing movement in a limited space. This aligns with our work on integrating immersive features into fitness devices, as both studies emphasize the potential of VR to enhance physical activity and user experience. The findings from this study can be instrumental in refining our approach to ensure that our application not only recreates real-world environments but also maintains the necessary intensity and engagement to meet health benefits, enhancing user satisfaction and adherence to fitness routines.

In [6], Hélder Pereira and Paulo Matos propose an architectural solution to integrate immersive features into fitness devices, enhancing user experience and athletic performance. The architecture is designed to be open and compatible with various fitness equipment across varied brands and models. Their approach recreates real-world environments through video playback of actual routes, enriched with contextual data such as speed and altitude variations. This data facilitates the dynamic control of compatible fitness equipment by adjusting parameters like resistance, slope, and inertia to synchronize with the video, creating an authentic and immersive experience. This work is foundational for implementing this application.

In [7], Alireza Farrokhi et al. provides a comprehensive survey on the application of the Internet of Things (IoT) and Artificial Intelligence (AI) in intelligent fitness. The study categorizes IoT-based smart fitness into three principal areas: fitness trackers (wearable and non-wearable sensors), movement analysis, and fitness applications. It highlights how data collected from these devices can enhance training performance through AI-based algorithms. The paper also discusses the role of Social-IoT, which facilitates data sharing and user experience enhancement across different devices and locations. This aligns with our work on integrating immersive features into fitness devices, as both studies emphasize the potential of technology to enhance physical activity and user experience. The insights from this survey can be instrumental in refining our application to ensure it leverages IoT and AI for precise tracking, personalized feedback, and social engagement, thereby enhancing user satisfaction and adherence to fitness routines.

### B. This Sector Innovations

In recent years, the fitness sector has witnessed significant developments, with a notable increase in immersive

technologies that enhance the user's experience. One of the platforms that stands out in this context is Rouvy [7], which combines indoor cycling with real-route videos, allowing users to ride on authentic paths around the world.

Rouvy offers an interactive experience where cyclists can choose from various video-recorded routes, which are adjusted to simulate the actual terrain conditions. This immersion type makes workouts more engaging and helps athletes maintain motivation while providing accurate performance metrics.

Another notable brand is Peloton [8], which has revolutionized indoor training with its connected bikes and live classes. Peloton combines technology and community, allowing users to participate in real-time interactive courses led by instructors while competing against other community members. However, unlike these solutions that focus primarily on bikes, our concept proposes a more comprehensive approach, integrating various sports modalities and immersive technologies that transform the training experience in indoor environments.

These innovations on the Rouvy and Peloton platforms reflect a growing trend where digital technologies transform people's exercise, promoting a more engaging and adaptive approach to physical training.

### III. ARCHITECTURE AND IMPLEMENTATION PROPOSAL

This chapter outlines the proposed architecture for an immersive training solution, emphasizing how different components collaborate to enhance user engagement and athletic performance. We will delve into the architectural framework, detailing the design considerations and technical aspects that underpin the system.

#### A. Proposed Architecture

This section provides a comprehensive overview of the proposed architecture, focusing on the key elements and the interactions that contribute to an engaging training experience. It will detail how various components work in unison, including the integration of real-world data and user feedback, to create a seamless and motivating environment for athletes.

Figure 1 serves as a visual representation of the proposed architecture, illustrating the interactions and the components:

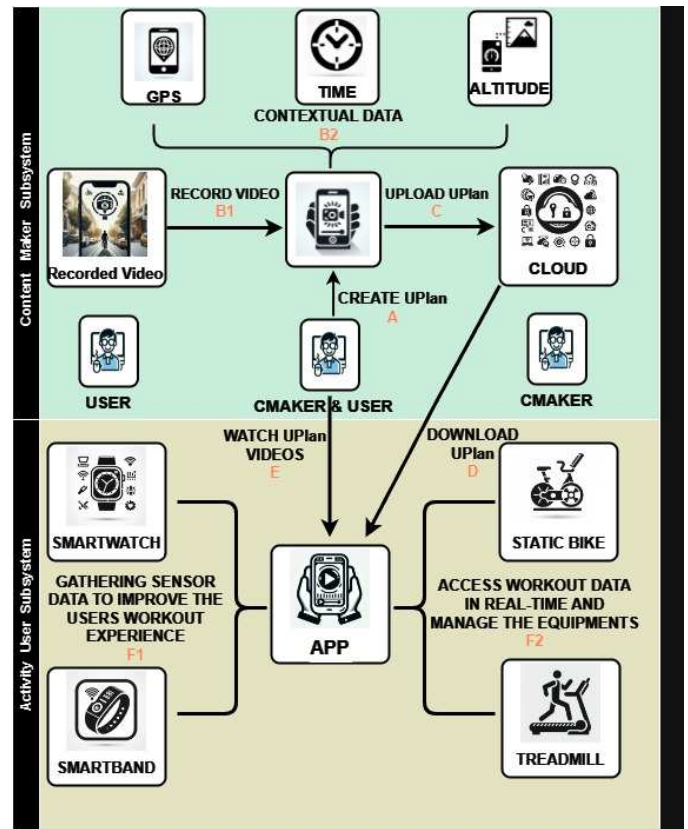


Fig. 1 - Functional diagram with the subsystems Creator and Player

The architecture is divided into two primary subsystems: the Content Maker Subsystem and the Activity User Subsystem, designed to streamline the user experience and enhance workout effectiveness.

The Content Maker Subsystem captures immersive workout videos enriched with contextual data, such as GPS, altitude, and time. The process begins with the user creating a personalized user workout plan (UPlan) (A). The UPlan will combine the recorded video (B1) and the contextual data (B2). Once the recording is complete, UPlan is uploaded to a cloud-based platform (C) for sharing with the community.

In the Activity User Subsystem, users select UPlan videos (E), which initiate the download of the workout plans (D) to the application. The application then uses data from training devices, such as static bikes or treadmills (F2), and wearable devices, such as smartwatches and smartbands (F1), to personalize and adjust the UPlan in real time. Users can access real-time workout data to monitor and adjust the intensity based on their fitness goals. This subdivision into two subsystems ensures a clear separation of content creation and user activity, allowing for modular development, scalability, and enhanced user engagement through a seamless data flow.

#### B. Technologies

The development of the application requires integrating several key technologies, each playing a fundamental role in

delivering a personalized, immersive, and connected workout experience. Bluetooth Low Energy (BLE) is a central technology that enables real-time communication between the application and fitness devices, such as treadmills and stationary bikes. Using the Fitness Machine Service (FTMS) protocol [9], the application monitors and dynamically adjusts workout parameters like speed, resistance, and slope, ensuring precise and effective interaction with the equipment. This integration is essential for synchronizing exercises with workout data and providing instant feedback to the user.

Google Firebase [10] is critical in data storage and management. This technology facilitates uploading and synchronizing user-created workout plans, allowing access to data across different devices at any time. Additionally, Firebase enables efficient data sharing among users, fostering an interactive community and a global database of workout plans.

The Google Health Connect API [11] facilitates the integration of data from wearable devices, such as smartwatches and fitness bands, into the application ecosystem. Through this API, the application collects biometric data, including heart rate and calories burned, enabling further personalization and workout adjustments based on detailed performance metrics.

Edge computing will ensure critical operations, such as real-time analysis of workout data, are performed locally on the user's device, minimizing reliance on cloud processing. This approach aims to reduce latency and provide immediate feedback, essential for maintaining a smooth and responsive workout experience.

Lastly, machine learning will be introduced to personalize workout plans. Machine learning algorithms will analyze the user's workout history, automatically adjusting parameters to match their capabilities and goals. This continuous adaptation aims to provide an optimized, data-driven experience tailored to each user's needs.

In summary, combining these technologies ensures that the application will provide a modern, interactive, highly personalized workout experience centered on the user's needs and supported by a robust and adaptable technological framework.

### C. User Interface and Design

The application's user interface design is critical, focusing on delivering a seamless, engaging experience that integrates real-time interaction, personalized feedback, and workout sharing through cloud technologies. The following figures highlight the key layers of the interface, emphasizing how users can navigate between distinctive features to manage their training, track progress, and interact with shared workout plans.

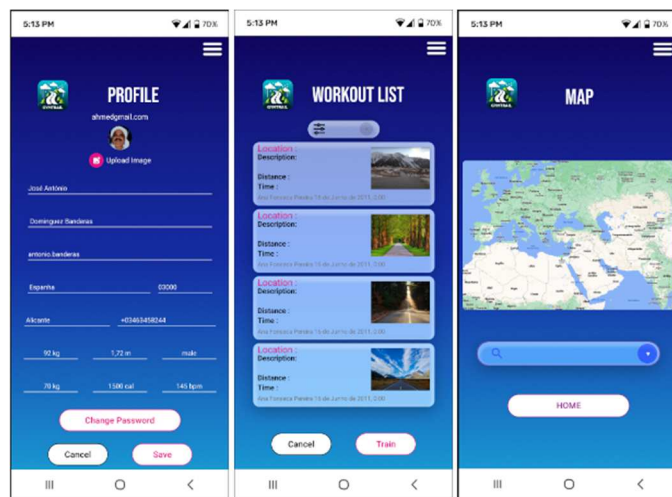


Figure 2 - Profile, Workout List, and Map Screens

The **Profile** screen (left) lets users input their data, including weight, height, and specific workout goals (such as burning calories or heart rate targets). These parameters form the foundation for a personalized training experience, enabling the application to offer tailored suggestions based on user objectives. Future edge computing or AI integration will allow dynamic, real-time adjustments to workout intensity, ensuring that users maintain their target heart rate (bpm) throughout each session.

The **Workout List** (center) screen provides a catalog of available workout options, each accompanied by location, description, and essential data such as distance and duration. This screen serves as a gateway to exercise selection, simplifying the process of choosing workouts based on personal preferences and geographic location. Cloud-sharing capabilities allow users to upload and share workout plans, fostering a collaborative environment where users can exchange routines and provide feedback on various exercises.

The **Map** screen (right) is designed to provide a geographical overview of available workout locations. Users can quickly identify and select workout points based on their surroundings by utilizing location-based services. This feature is crucial for outdoor exercises, such as trail runs or cycling routes, where users can choose specific workouts tied to a geographic area. This real-time map-based workout identification is complemented by the cloud-sharing system, which allows users to upload and share workout videos and plans associated with specific areas, creating a global repository of location-based workouts.

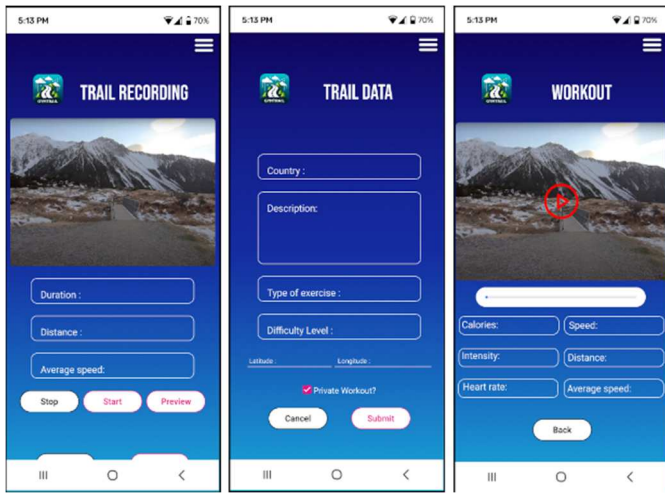


Figure 3- Trail Recording, Trail Data, and Workout Screens

The **Trail Recording** screen (left) facilitates the real-time recording of workout data, including duration, distance, and average speed. Users can quickly initiate a workout recording, preview their route, and monitor progress during the activity. Recording and analyzing data locally on the device (through edge computing) reduces latency. It makes critical metrics available instantaneously, providing users with real-time performance feedback.

The **Trail Data** screen (center) is essential for users to document and categorize workout details. Parameters such as exercise type, difficulty level, and geographic location are captured, ensuring that each workout is well-defined and easily identifiable. This feature assists users in organizing their training routines and plays a crucial role in video identification. By associating workout data with video recordings, the application simplifies the process of cataloging and retrieving workout sessions for future reference. Cloud storage integration allows users to upload and share these categorized videos with the broader community, enabling them to receive feedback and suggestions for improvement.

The **Workout Play** screen (right) offers users a real-time dashboard to track key performance metrics such as burning calories, heart rate, speed, and distance during their workout. This screen is designed to deliver instantaneous feedback, ensuring that users remain engaged and motivated. The application aims to leverage machine learning algorithms to dynamically adjust workout parameters based on real-time data in future iterations, enabling a more tailored and responsive training experience.

The horizontal layout (Figure 4) is designed for an optimal viewing experience, especially on larger devices like tablets or smartphones in landscape mode. The central video window provides a real-world trail or path view, creating an engaging environment for users to simulate outdoor workouts. The overlaid play button allows easy interaction, letting the user start, pause, or continue their workout session.

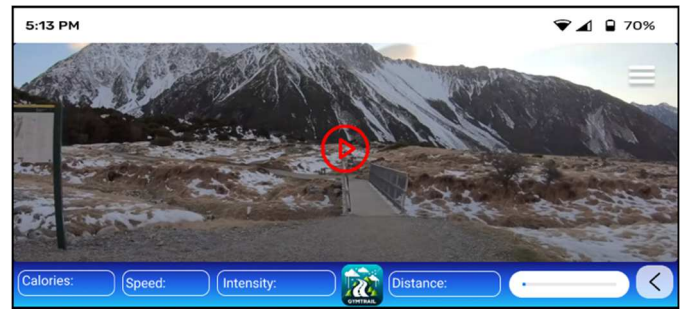


Figure 4- Video Playback Screen

Below the video, key workout metrics are displayed to provide real-time feedback and support users in maintaining their workout goals. These metrics include:

- **Calories:** Displays the estimated number of calories burned during the session.
- **Speed:** Shows the current workout speed, synchronizing with the treadmill, static bike, or other equipment.
- **Intensity:** Reflects the effort level and is customizable based on the type of exercise equipment. For example, it could represent slope for treadmills or tension for static bikes, adjusting dynamically to offer a personalized workout experience.
- **Distance:** Tracks the total distance covered during the session, offering an essential gauge for endurance training.

In the bottom right corner, the **arrow button** provides access to additional commands that are less frequently used during a workout but are essential for fine-tuning the experience, such as adjusting video playback settings or accessing detailed performance metrics.

This screen is a critical component of the application's immersive experience, simulating real-life workout environments while giving users instant feedback on their performance. It ties into the **edge computing** architecture discussed earlier, as real-time data such as heart rate, speed, and workout intensity could influence the video playback speed or difficulty, making the session more interactive and tailored to individual performance.

#### IV. RESULTS AND DISCUSSION

The development of the application successfully integrated key technologies such as Bluetooth Low Energy (BLE) and the Fitness Machine Service (FTMS) protocol. This enabled real-time communication with fitness equipment and dynamic adjustments to workout parameters like speed and resistance. The library `react-native-ble-plx` [12] was utilized to scan, connect to devices, and handle FTMS features, enabling compatibility with various fitness devices. However, usability tests revealed challenges as performance varied across devices.

Older hardware showed sensor data inconsistencies, highlighting the need for optimization across device types.

Due to equipment availability, testing was limited to devices like the Mi Smart Scale 2 and smartbands. The app performed well with these, but more extensive testing with advanced devices like treadmills and stationary bikes is needed. Devices with advanced sensors yielded more accurate data, while others exhibited noise and inconsistencies, further indicating the need for optimization.

The video playback feature was well-received, but image stabilization and orientation issues were encountered for videos recorded vertically or horizontally. Map-based navigation worked well, enabling users to find and share workout trails by geographic region. However, data accuracy challenges arose when distinguishing similar trails, which can be addressed by adding richer metadata, such as difficulty and terrain, in future updates.

Edge Computing was evaluated on select devices, reducing cloud dependency and improving real-time feedback. Machine Learning also showed potential for personalized workout recommendations, though further integration is needed. The horizontal video playback interface was clean, but some users found it less intuitive for controlling specific workout commands. The app differentiates between parameters like slope (for treadmills) and resistance (for stationary bikes), though more explicit guidance on these features would improve usability.

## V. CONCLUSION

The development of the GymTrail application represents a significant advancement in creating personalized and immersive workout experiences. The integration of Bluetooth Low Energy (BLE) with the Fitness Machine Service (FTMS) protocol enables real-time communication with fitness devices, allowing dynamic adjustments to workout parameters. Google Firebase facilitates data synchronization across platforms, enhancing accessibility and fostering the growth of a community-driven fitness ecosystem. The map-based navigation feature allows users to share and discover trails by location, adding a geographic dimension to workout personalization.

Despite these advancements, challenges remain, particularly in ensuring consistent performance across different devices. Variations in sensor quality and data acquisition accuracy on older hardware highlight the need for further optimization. Issues with image stabilization and discrepancies in the orientation of horizontally and vertically recorded videos also point to areas for refinement. Early-stage integration of Edge Computing has shown promise in reducing latency by locally processing workout data, enabling smoother feedback. Similarly, initial tests of Machine Learning algorithms suggest the potential for highly adaptive and personalized workout recommendations, though further development is needed.

In summary, GymTrail already provides a solid and scalable platform for connected fitness, but addressing challenges related to device compatibility, video playback, and data reliability will be crucial. These improvements will enhance the overall user experience and position GymTrail as a leading tool in shaping the future of connected fitness technology.

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