VRow-VRow-VRow-Your-Boat: A Toolkit for Integrating Commodity Ergometers in Virtual Reality Experiences

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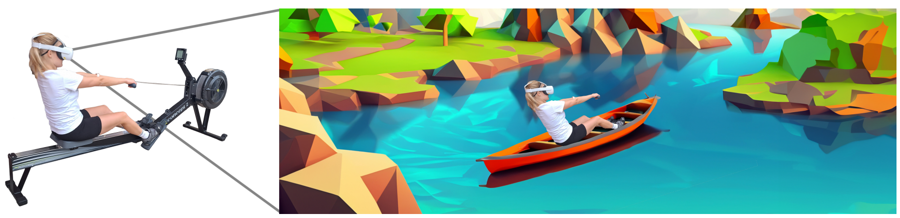

Figure 1: VRow allows for easy integration of ergometers, like the rower in this example, into Virtual Reality applications for synchronous fitness training.

ABSTRACT

Exergames, video games designed to blend entertainment with physical activity, aim to improve users' physical fitness by combining gaming with exercise. However, integrating exercise equipment, such as rowers, bikes, and ski ergometers into Virtual Reality (VR) environments remains challenging. In this poster, we introduce a toolkit that simplifies the integration of ergometers into Unity-based projects. Researchers can access detailed ergometer data for logging and use inside their projects, while our toolkit handles tedious tasks, like connection-handling or parsing. VRow offers valuable support for creating immersive and interactive fitness experiences.

CCS CONCEPTS

• **Human-centered computing** → Virtual reality.

KEYWORDS

Virtual Reality, Exergame, Ergometer, Rower

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1 INTRODUCTION

Engaging in physical activities is vital for a healthy life, as it has proven positive effects on the body [9, 26] and can even improve mental health [6]. While the number of people having a gym membership is growing by more than 3-5% each year just in the US[1], the motivation to actually perform a physical workout is highly variable and might even decrease [4]. To deal with decreasing motivation, research suggests incorporating technology into people's workouts [2]. In particular, exergames have been identified as a driving factor for intrinsic and extrinsic motivation gains due to their gamification aspects [14, 19]. Exergames aim to blend gaming with physical exercise to encourage users' physical fitness [19, 22], for example, in nursing and elderly care contexts [11, 15, 18], rehabilitation treatments [5, 24], and personal workout [3, 7, 10, 21]. In these settings, exergames strengthen muscles, improve balance, enhance mobility, and promote proper ergonomic muscle usage [15].

However, developing such exergames can present challenges, particularly when integrating exercise equipment, like ergometers [7, 12, 20, 23], or other physical devices [1, 8, 13, 17, 19, 25], into Virtual Reality (VR) experiences. Commercial vendors, such as Concept2[2], offer a range of different ergometer machines, including rowers, bikes, and ski ergometers, for physical exercise purposes and are considered the market leader. The key to simplifying the implementation of VR exergames with such ergometer integration lies in creating software that connects these devices with Unity. In this poster, we present VRow Toolkit, a software toolkit to easily integrate Concept2 ergometers, like rowers, ski-ergs, or bikes, into Unity projects. Developers can receive detailed information from the exercise machine to log and use in VR environments.

[1] https://www.ihrsa.org/publications/the-2022-ihrsa-health-club-consumer-report/
[2] https://www.concept2.com/

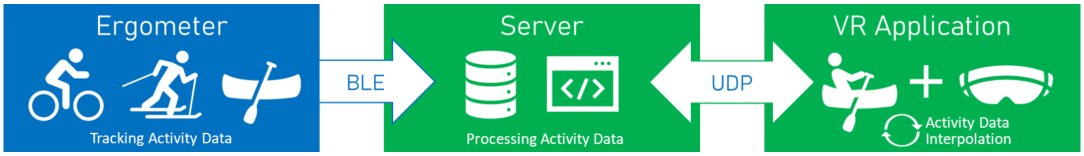

Figure 2: Pipeline for (1) tracking physical activity data from an ergometer which is sent every 100-1000 ms via Bluetooth to (2) our self-developed server application that processes the activity data. Then, (3) a VR application can establish a UDP connection to the server and interpolate the tracked activity data for a synchronous experience.

2 IMPLEMENTATION

VRow Toolkit consists of three parts, see Figure 2: (1) the ergometer, (2) a server application responsible for connecting with the ergometer and distributing the parsed data, and (3) Unity scripts to receive and replay the data.

- **(1) Ergometer:** As proof-of-concept, we support the widely available Concept2 ergometers, such as their row-, ski- or bike-erg, featuring the performance monitor (PM5) version with BLE connectivity. However, we also intend to support other vendors and connection interfaces later in our toolkit. It is worth mentioning, that Bluetooth seems to be the most relevant interfaces to vendors, as they enable connectivity to the endusers's smart phone.
- **(2) Server:** To communicate with the ergometer, we first have to establish a server that receives the live activity data via Bluetooth LE (BLE) in intervals of 100-1000 ms. The server is a self-developed connector between the ergometer and the respective VR application. To further simplify the setup effort, the server application scans specifically only for available compatible and supported ergometers and guides the user through the setup. After establishing the connection, the server automatically processes the activity data stream. In terms of the rower, the server can handle and parse the distance, duration, stroke-rate, drag-factor, speed, rest-time, pace, stroke-recovery-time, stroke-distance, peak-driveforce, average driveforce, and many other factors[3]. The processed activity data is then made available for other applications to connect via a UDP socket.
- **(3) VR Application:** We provide a plug-and-play Unity package containing C# scripts, responsible for receiving the preprocessed activity data from the server. Further, the package provides features to automatically update the game state, for example, by moving a linked object to a user's rowing speed. While the data is processed and transmitted synchronously in real-time, the update rate of the ergometer is limited to 100-1000 ms, depending on the ergometer's settings. Therefore, the processed activity data has to be interpolated between two updates for a smoother player experience, which is handled in the background by our VRow Toolkit.

While we mainly focused on integrating VR applications, VRow Toolkit is ready for every other Unity-based application, such as desktop or mobile applications. To use VRow Toolkit, developers start the provided server application and connect to the ergometer guided by the application. In the Unity-project, use the provided script to receive the data from the server. Here, you can hook up any gameplay functionality, like moving the player, based on the received the data. Also, since our server's main processing is abstracted, other applications can receive the activity data via custom UDP connections. We contribute the full source code, instructions, and samples of VRow Toolkit in a public repository for the community at *https://github.com/Dominik-Schoen/VRow*.

[3]https://www.concept2.co.uk/files/pdf/us/monitors/PM5_BluetoothSmartInterfaceDefinition.pdf

3 FUTURE APPLICATIONS

Fusing traditional ergometers with Virtual Reality environments opens up future physical health-related applications. Further exploration of gamification aspects and social interaction in VR with highly dynamic environments can boost user motivation during workouts. Thus, investigating novel ways to make VR-supported exercise more enjoyable and immersive should increase the workout quality, ultimately resulting in more efficient training output. As a consequence for a better social experience, we plan to add multiplayer support by allowing multiple ergometers to connect to the server, which then allows for out-of-the-box multiplayer capabilities in order to easily create shared experiences.

Furthermore, our toolkit is a first step to exploring adaptive VR systems that adjust to a user's biomechanics and posture to enhance workout techniques and training ergonomics. For example, such a system can potentially assist users in developing more conscious and subconscious ergonomic behaviors (cf. [16]), ultimately promoting healthier training practices.

4 SUMMARY

In this contribution, we introduced the VRow Toolkit that is designed to seamlessly incorporate commodity ergometers into Unity-based projects. This facilitates the simplified integration of ergometer-based VR experiences, including row-, ski-, or bike-ergs, along with the efficient logging of associated activity data. With the current version, VRow supports Concept2 ergometers, but can be updated to support other vendors as well. With the aid of VRow, developers can shift their focus towards creating immersive health-related experiences without the requiring cumbersome setup procedures. We further published the complete source code and instructions as open-source in a repository for the community at *https://github.com/Dominik-Schoen/VRow*.

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