# Poster: UbiTrain: Leveraging the Physical and Virtual Environment for Ubiquitous Sports Training

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## Abstract
Training for any kind of sports not only requires dedication, but also the correct way of obtaining the necessary information. To maximize training, we delve into the understanding of bridging between spectating and practice by bridging the virtual and physical space. We introduce the concept of ubiquitous sports training in UbiTrain, where the user is able to train anytime, anywhere with the help of mixed reality (MR) and virtual reality (VR). The contribution of this work are the following; 1) it leverages the use of physical and virtual space for sports training, 2) it adapts to any physical space the user is currently in, thus allowing ubiquitous usage, and 3) it combines both practice and observation as an effective learning package.

## Author Keywords
Ubiquitous VR; Virtual Reality; Mixed Reality; Spatial Awareness.

## ACM Classification Keywords
H.5.1 [Information interfaces and presentation (e.g., HCI)]: Multimedia Information Systems

## Introduction
Sports is an activity that can be enjoyed by a wide a variety of audience by a wide variety of form; either a high schooler watching a football match in the living room, or a profes-

**Figure 1:** Scenario of Using UbiTrain in an office; (left) user can at anytime, practice throws that obeys the physical space collision, (center) user can cross through a portal into a VR environment, and (right) user spectating a game and learning player motions, all in a seamless process.

sional basketball player practicing for the next international tournament. Because of this, sports has become a platform of interaction for activities like spectating, learning, merchandising, and so on. Learning in particular, is the main highlight in this work as we focus on maximizing training efficiency in sports. We introduce the concept of ubiquitous training, which is a platform to encourage users or sports athletes to train anytime anywhere, through the use of virtual and mixed reality.

VR, MR and augmented reality (AR) are technologies that are currently blooming and may very well replace the devices that we are currently using. In fact, there has already been a push for making these technologies more ubiquitous as well [4, 5]. This paper continues this push by utilizing this technology to push towards ubiquitous sports training.

We propose UbiTrain for scenarios where players or even professional sports athletes may train physically and virtually anywhere using MR head-mounted displays (HMD). In th MR space, users may continue with daily activities since they can still see the physical world; however, it has been augmented with key elements of a desired sports around them for training on-the-go. At anytime, the user then can transition to the VR world through a virtual portal to fully spectate a selected match. The VR space brings a benefit of total control of the environment, allowing the user to control the playback of each player and to learn their movements while being completely separated from the physical space. In other words, the VR space provides spectating and study on the motion of professional players using time manipulation, whereas the MR space augments the physical space with training elements.

## Related Work

The idea regarding the use of AR, MR or VR for training, skill transfer, and simulation has been explored almost since the introduction of said technology. The main benefit of learning or training in a VR environment is that, it is able to cut down on the cost of physically owning a space or tool for that sport while preserving the interactiveness which is more effective than simply watching a video [1]. For example, VR has been used for flight simulation, medical training, military training and so on [8]. Sports in particular, has

been one of the main focus since it is more mainstream and can appeal to anyone with even the slightest interest in sports, all the way to professional players. In a recent work, it was found that 43% of participants believe that the use of AR/VR technology can improve sports performance [3].

However, an approach than delves into the proper bridge between AR, MR and VR to maximize training effectiveness has rarely been explored. This technology can be used for us to obtain skills where we can apply them in its physical counterpart because it is the closest to the actual motion; however, differences still do exist. The design of UbiTrain is rooted from the idea that, even though VR is able to provide a fully virtualized scenario that may seem ideal for skill transfer, there has been studies that show that the unnaturally perceived environment can instead lead towards an unnatural performance in real life. This is also largely due to limitations in the current VR technology,such as limited field-of-view (FOV), delay, low resolution, and computer generated environments that aren't 100% true to life, which in turn effects the human perception, most notably our distance perception [7].

## Implementation

Based on these related works, our approach can be motivated based on the idea that any physical space can be used for sports training with the proper understanding of transitioning between a fully virtualized environment, and an augmented one.

We use the Unity engine together with the SRWorks SDK to develop UbiTrain. We also collaborated with NTT Media Intelligence Laboratories to obtain motion capture data of professional basketball players to be implemented in our prototype. For a MR and VR experience, we chose to use the HTC Vive Pro VR HMD which includes a stereoscopic front facing camera. However, any MR headset can possibly be used, as long as it includes hand tracking and spatial mapping for our designed interactions.

When the user first puts on the HMD, he/she will be greeted with a video-see through display, allowing him/her to continue with any current activity. However, the user can, at anytime, use a motion controller to instantiate a baskeball to throw into a virtual basketball hoop that can be placed by the user anywhere in the physical space. Due to spatial mapping, the ball's physics obeys that of the physical world, which bounces and collides with physical objects. This allows instant training for the user, while still being able to multi task with the awareness of the physical space around them.

However, we provide an option for the user to switch to a completely VR environment through a virtual portal. When the user steps into the portal, he/she is greeted with an actual rendition of basketball players playing in a virtual basketball field. In a virtual space, we leverage its benefit by providing the user with a myriad of tools for full control, such as the option to control time. The user may pause, rewind, or fast forward a play to allow them to not only casually spectate, but perform analysis on the player's movement and motion in the field. The user is also still able to practice basketball at the same time, now in a virtualized foodball field instead that obeys the physics of the VR environment. This transition between MR and VR is the key method to provide users with a ubiquitous training tool; the VR environment for observing, spectating, and analysis, and the MR environment for grounded real-world training that also allows multi-tasking.

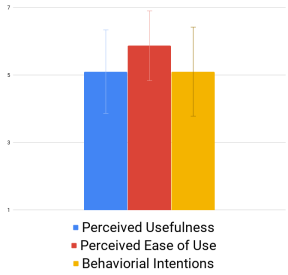


**Figure 2:** Result for the User Study

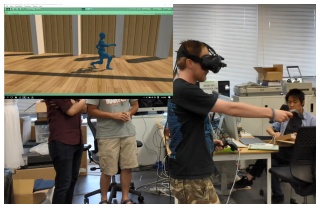

**Figure 3:** UbiTrain being used for Karate training

## User Study

For this work, we wish to understand the user's feedback regarding the effectiveness of the proposed training tools. With reference to [6], we conducted a preliminary qualitative study to understand the perceived usefulness, ease of use, and behavioral intentions of UbiTrain using a 7-point Likert Scale [2]. We recruited 5 participants (3 male and 2 female) within their 20s (mean:25.6, std:1.949) to experience an early version of UbiTrain.

From our results, we found that users rated an average of 5.1 for perceived usefulness, 5.87 for perceived ease of use, and 5.1 for behavioral intentions, as shown in Figure 3. This shows us that in general, the participants felt that UbiTrain is overall relatively useful and they are willing to use the system for practice or training, and a higher score for the ease of use in transitioning between MR and VR as well as the time controls. Their main feedback to improve the system is to improve the physics of the basketball and the haptics of the sensation, but they praised the use of both MR and VR for the concept of training or practicing anytime, anywhere.

For the proposed second study, we will move on to obtain quantitative data by directly comparing the effects of training in VR, MR, and by simply watching a video. To do this, each participant needs to be involved in a game of basketball where the hesitation time is calculated, which is the time between two successful moving trajectories [6]. The lesser the hesitation time, the more effective the training method. With this, we can understand the differences in training in MR against VR, as well as its overall improvements over watching a video.

## Limitations and Future Works

One of the key limitations with UbiTrain is the assumption that everyone has a VR HMD readily available for use. Even though this is a possible future, we are still far from it as many issues need to be tackled first, such as cost and social acceptance. Furthermore, current HMD solutions also still suffer from technological limitations; in the MR world, it is essentially a video see-through solution, but the stereoscopic cameras on the Vive Pro only has VGA resolution, making the real world look much blurrier that how our actual eyes perceive them. We also tried the ZED Mini and Hololens, but were instead presented with a limited FOV which makes transitioning to the VR world less effective.

The concept of ubiquitous sports training is relatively new and requires further refinement, but we believe it carries potential obtaining, transferring, and improving skill and knowledge. We use sports in this case, but we understand that no sports are equal and some could benefit more in VR as opposed to MR, such as for racing or skiing where the change in environment is crucial for the perceiving the sense of speed. Yet, other sports like karate training may benefit from this tool, as shown in Figure We plan to further expand and improve the concept of UbiTrain so that it can be used for a wider variety of training purposes, as well as several more seamless solutions to transition between the MR space and VR space.

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