# Health, Fun, and Engagement: Computing technologies that support physical activity

**More and more interactive systems accompany us when we engage in physical activity. But can technologies actually make sports more fun? Or perhaps we will become better at sports through technology?**

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Physical activity has become part of our everyday lives. In the European Union, the average person exercises regularly with 51 percent of the population engaged in physical activity at least twice a week. For many years, research has been primarily concerned with convincing people to exercise. Many developments in persuasive technology were aimed at providing incentives to exercise. This trend left behind users who were already exercising and not receiving adequate support. Given that so many of us actively exercise, how can technologies help us to enjoy it and integrate sports in our lives?

In this article, we discuss emerging computer technologies that aim to support us in the sweaty setting of physical activity. We conclude with a report on future challenges for developing meaningful technologies for making physical activity more beneficial, fun, social, and meaningful.

## EMERGING TECHNOLOGIES FOR PHYSICAL ACTIVITY

First, we will look at recent trends in the spectrum of mixed realities as well as sports trackers, and show how they affect our experience of physical activity. This article focuses on active participation in physical activity. While technology also offers exciting new opportunities for spectator sports, they are not addressed here.

**Virtual reality.** In 2006, Nintendo surprised everyone with motion controls and mini-games that restricted video game competitions not only to friends who sit on a couch, but with

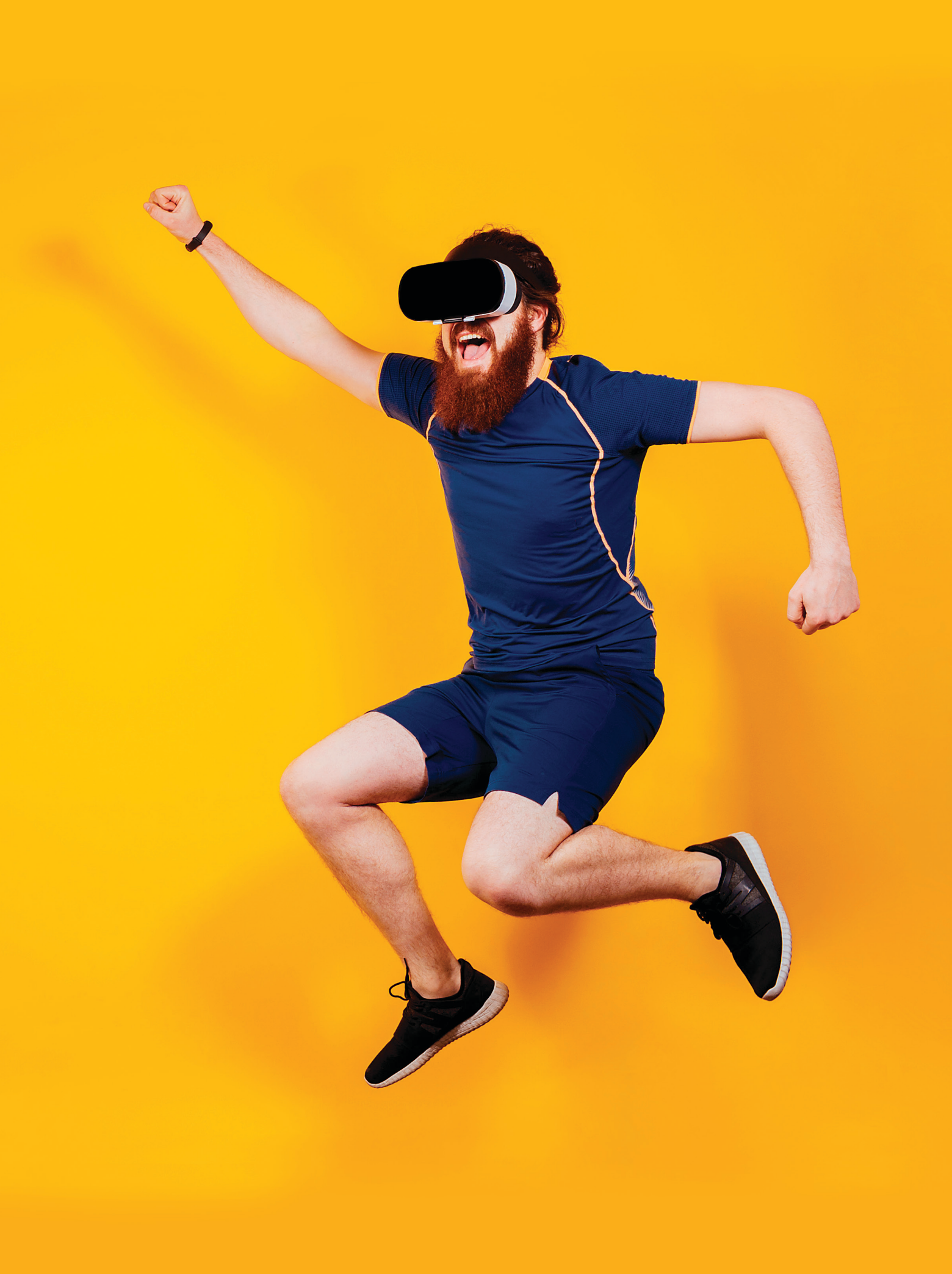


**Figure 1. Exercising in a VR headset can not only be dangerous, but it also has negative social effects.**

its simplistic controls and motivating presentation. Nintendo managed to even get elderly people to pick up a controller (in the form of a Wiimote and Nunchuk) and play some rounds of bowling, golf, or tennis. Wii Sports was not only a financial success, but also showed how simple games with easy (natural and intuitive) controls could get all kinds of people interested and motivated.

The latest virtual reality (VR) technologies offer high immersion and can quickly capture, fascinate and motivate people. The possibility to freely roam around and explore new environments presented with high visual and auditory quality ensures high engagement. Adopting the simplicity and flexibility of existing motion controllers, intuitive input is supported. The transfer of real-life motions and inputs into the virtual environment allows the user to feel more present. Consequently, VR offers a spectrum of possibilities for physical activity, allowing us to exercise in a new environment every day.

Commercial systems that use VR for sports have become widely available. Zwift is a platform that enables cyclists on stationary bikes to participate in races modeled after locations around the world. Meanwhile researchers have proposed skiing with a VR headset on, providing input through a device that detects speed and turns on the slope.

For those of us who are bored with the ordinary park loop, VR will soon offer attractive alternatives. Yet, for now, VR devices are hardly welcome in places where people practice sport (see Figure 1).

**Augmented reality.** Recent technology advances and developments allow rendering high fidelity auditory and visual augmented reality (AR) in mobile environments. Speakers or headphones typically present auditory AR while visual AR is displayed through mobile or stationary projection for reasonable multi-user scenarios. Recently, a multitude of different head-up displays and AR glasses were developed. Many of these are target industry use cases. Yet, AR technology has not fully unfolded its potential in everyday life nor does it support us during exercise.

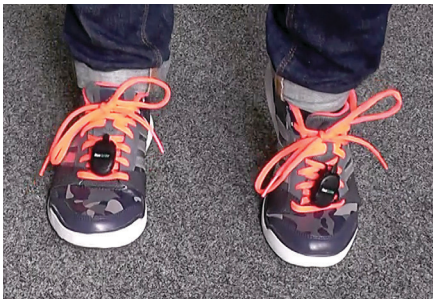
Many available AR systems supporting athletes are currently focused on only providing real-time information about the current workout such as speed, distance, or heart rate. More advanced collaborative systems show a map, track, or location of peers. Often, this information is displayed on a HUD (head-up display) integrated inside ski or bike goggles. Advanced AR systems offer more flexibility and can enhance the environment with virtual real-time information and feedback. An augmented climbing wall allows interactive bouldering training sessions to improve the diversity of movements and challenges [1].

An important design consideration for AR for physical activity is the fact that athletes must pay attention to their surroundings while exercising outside. In contrast, looking on one's smartphone could lead to injuries due to tripping. Hence, auditory AR applications—like "Zombies, Run!"—that integrate gamification elements can safely enhance the fun and run experience. Yet, even slow-paced AR games like "Pokémon Go" have been reported to motivate individuals to go outside and roam around.

For the future, we can expect multiple new AR scenarios that intensify our workouts and go beyond wearable sensors and displays that provide real-time data. We imagine virtual fitness coaches exercising with us and providing feedback to prevent overstrain. The next generation will seamlessly incorporate gamification elements like challenges and badges known from social networks to keep athletes motivated. This implies that our interactions with data about our activity will be constant and go beyond simply reviewing results after an activity is completed. Further, training with virtual representations of remote peers will be an exciting new way to exercise and can be expected to be available soon. How-

**Figure 2. While augmented reality (AR) has great potential for enhancing physical activity, current AR devices are hardly ready to be worn while practicing sports.**

**Figure 3. RunScribe is a pair of sensors that attach to the runner's feet in order to gather detailed gait data.**



ever, to achieve seamless AR for physical activity, a new wave of AR devices must first be developed (see Figure 2).

**Wearables.** Fitness trackers and smartwatches have quickly become the most popular wearables and are a common sight on our wrists. These devices evolved from simple step counters to physiological monitors, measuring floors climbed, miles biked, pulse, and even stress. While fitness tracker providers compete in new measures, screen sizes, and form factors, we are still unsure if trackers actually benefit our health or enhance the experience of physical activity.

Recent long-term studies have failed to show a positive effect of wearing a fitness tracker on one's body mass index. While computing research has made crucial progress in processing wearable sensor data and detecting everyday activity, we still do not know how to leverage this knowledge to support users in their everyday endeavors. How can fitness tracker data be used to trigger reflection or help maintain a better work-life balance? Helping users understand fitness tracker data remains a challenge for interaction design and visualization.

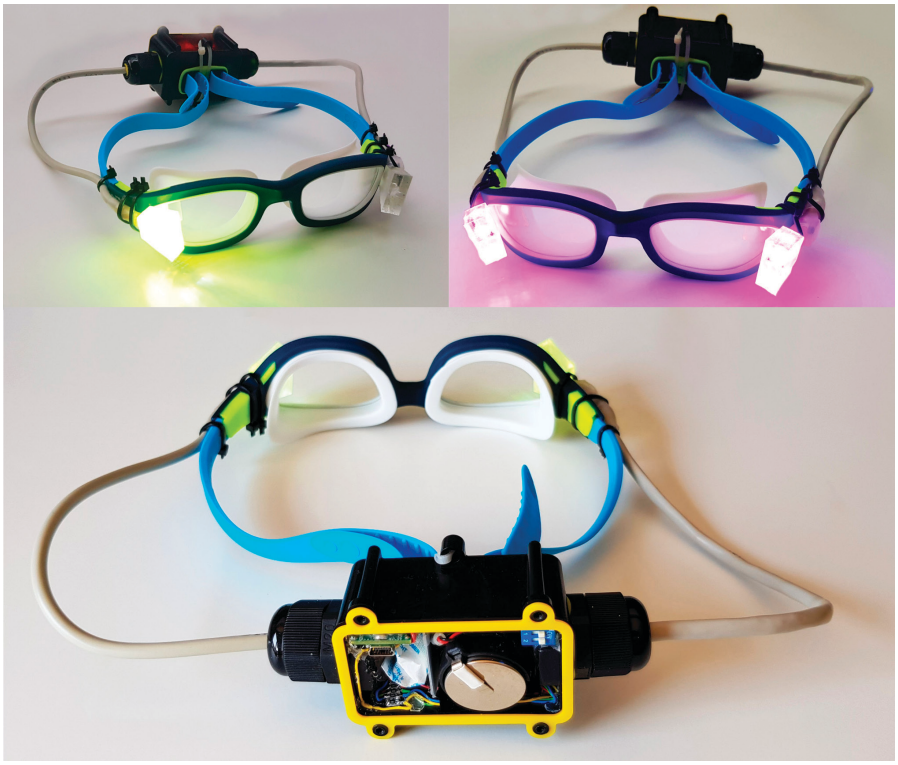
While we are now used to people wearing smartwatches in the street, other wearables are less common. A wave of new products and research prototypes indicates that we will soon see wearable devices for sports in many forms. Running sensors offer an interesting example. Devices like RunScribe (see Figure 3) or Stryd offer very accurate accelerometer data that can be gathered during a run. After their activity, runners can view the recording of their run in a mobile application or a dedicated online dashboard.

As wearable sensors will enable us to gather more and more data about or bodies when engaging in physical activity, we will need to learn how to interpret and act upon that data. It remains a challenge to build systems that do not overwhelm amateur users with physiological data and provide useful insight.

## IMPROVING COMPUTING'S PERSONAL BEST

New computing technologies provide vast opportunities to enhance physical activity. But, do we know what it takes to build new technologies that really enhance our exercise routines? Next, we review some challenges ahead of computing that we need to address to build better sports technologies.

**Figure 4. Clairbuoyance is a prototype wearable device that aid swimmers to swim in a given direction. Developing prototypes that can withstand the external conditions related to sport, such as moisture or wind, is a key challenge in building better systems that support physical activity.**



**Entering the virtual world, for real.** Currently supported interactions in VR range from simply looking around to complex tasks that involve walking around a room, manipulation by using both hands, and even talking to other people. The user's actions can be visualized via a whole body avatar or only parts of it such as hovering hands and heads.

Consumer VR sets often come with room-scale tracking that not only allows detecting the rotation of the user's head, but tracks the head position in a space of up to 10x10 meters. Included in these sets are two handheld controllers that are used to track the user's hands. While these only allow the tracking of three body parts, they enable the approximation and therefore the visualization of the body. Even if the visual representation does not align perfectly with the physical body part, it still tricks users into accepting it as their body, according to the proprioception of one's body parts. While these technical features are often enough to offer engaging and entertaining experiences, they also limit the amount of physical activity in which one can engage in VR.

One direction that may help to overcome these limitations and build VR systems for sports is the development of novel hardware for VR platforms. Additional trackers can be placed onto body parts such as feet, to accurately detect and visualize the users feed. The trackers can be placed on objects, and therefore allow the integration of movable furniture or objects that can be used as tools or sports implements. There are various additional hardware accessories that can be added to the setup. Some of them may even be integrated into newer revisions of headsets, such as an eye tracker. Another addon is Leap Motion, an optical sensor that brings virtual representations of one's hands into the virtual world and allows interaction without hand-

held controllers, gloves, or trackers that are attached to the hands.

A quick look at crowdfunding web pages and developer websites reveal that developers are hard at work inventing solutions to another issue that is crucial for physical activity in VR. Many solution providers are currently working on solving the problem of locomotion VR.

If we are interested in building meaningful sports experiences in VR, removing the restriction of the tracking space and empowering the user with the ability to walk beyond the tracking limits will be necessary. Hardware such as walking platforms, (omnidirectional) treadmills, or controllers that are attached to the user's shoes are the "physical/mechanical" alternatives to approaches such as teleportation, redirected walking, or tailoring the virtual world to real-world limitations. In our recent work, we focused on providing a reliable and believable experience of walking in VR [2]. A satisfiable illusion was very difficult to achieve even for simple movements. Providing reliable solutions for the complex motions involved in physical activity will be a challenge in the future.

VR systems of the future may be able to simulate an environment for physical activity accurately. When it comes to sports that involve equipment such as bats, rackets, or sticks, the weight and feel of the controllers have to be adjusted to have the same properties as their real-world counterparts. Depending on the sport and the level of realism you want to emulate additional hardware is necessary. Systems like Zwift (zwift.com) integrate sports equipment, such as bikes or a treadmill, to give the illusion of cycling or running in a beautiful landscape and competitive scenarios, instead of exercising in your cellar. Such systems make use of the advantages of treadmills and stationary bicycles, which are easy to track while introducing no alteration to the original activity. Even though these systems still use screen-based solutions, the increased demand for such products indicates that end-users are likely to appreciate full VR sports environments. This can happen as soon as the technology can offer an acceptable level of realism and support the same range of movement

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required in the non-virtual version of the sport. Yet, there are currently no approaches to represent most sports at a high level of realism without additional hardware or modifications

**Embracing amateur communities.** Everyday training is not a lonely task, despite the set of single user-oriented features that current sport technologies provide. First, many amateur athletes are members of training groups and part of an active community. However, those groups receive little technical support. Community members often use, adopt, and adapt generic tools, like forums or Facebook groups, to coordinate activities. In past research, we studied a high-intensity exercise group that resorted to developing their own exercise support technologies [3]. As lead users begin to innovate, we can see great potential in improving the user experience of sports communities. Many sports are innately social, and we need to understand how to make sports technologies more social. This way, the VR cycling app can become part of a social experience and not a way to do away with fellow bike lovers.

**Engaging with sweaty users.** What makes understanding technology for sports challenging is the fact that we need to study the systems we build. Where sweat, water, snot, and sports drink come into play, and wobbly prototypes may not make it. Further, researchers studying systems for sport always need to make sure the performance of those practicing sports stays unaffected. This is especially true when one is testing technologies for amateur races. Wasting months of training because of relying on a failed prototype is not a possibility for the prospective user.

Despite these challenges, researchers need to bravely experiment with sport technologies to ensure sport is still fun in the future. Initial concepts sometimes require crude means. In our work, we used a waterproof electrical junction box to test navigation technology for swimmers. We still needed to let our users "ruin" three prototypes [4] (see Figure 4). Yet, as these studies can yield new ways to make physical activity more meaningful, flooding some electronics is a fair price to pay.

## THE FINISH LINE

The future is bright. Our society wants to be physically active, and computing is there to help. Designing systems for sports produces a number of exciting challenges, in technical developments and interaction design. Yet, we have to proceed with caution. Researchers and developers should be aware of the limitations and temptations of sports technologies. Working with amateurs and conducting brave user studies will help us ensure sports technologies stay fun and social.


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