Superhuman Sports — a Testing Ground for Augmenting Our Senses

This article reviews recent developments in superhuman sports with regard to extending the human body and augmenting the playing field, and gives an outlook on future research directions.

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As a kid, have you ever dreamed of having superpowers such as X-ray vision, becoming invisible, or being able to fly? Children can be very creative in their ways to enhance their playtime by imagining superpowers. As researchers, we want to tap into this imagination to enhance how sports are experienced. Driven by this idea, a diverse set of researchers from HCI, robotics, and the VR/AR fields have been working on "superhuman sports." The field of superhuman sports focuses on augmented sports that aim to technologically augment, supplement, or even create from scratch novel abilities that can be used for competition [1]. The augmented or designed abilities are expected to level players by removing the burden of physical constraints and athletic requirements.

On the one hand, we see superhuman sports as a method to apply digital technologies to make us experience superhuman senses. On the other hand, we also believe it can be used as a testing ground for augmented human technologies: to explore artificial senses and other technologies that alter our perception in a safe, constrained setting. We can test what works and what does not, as well as spark ethical questions on if and how these technologies might be used by society at large.

Superhuman sports spans a wide field, and like any new discipline, researchers struggle with definitions and scope. Right now the field focuses on using augmented, wearable and virtual reality technologies to enhance the player's senses, to extend somebody's body, augment the sports field and ultimately to create new VR/AR sports. This article introduces some examples of those topics. Yet, the efforts of the academic Superhuman Sports Society are not limited to that.

We are not only creating superhu-

Image by Direnko Kateryna

man sports, but are building a community of designers and enthusiasts. We conclude the article with an overview of our activities so far, emphasizing that for the emerging field of superhuman sports just presenting our work on paper is not good enough. You need to be able to experience and use the technologies. You need to feel and perceive through new, augmented senses.

AUGMENTING OUR SENSES

Many superheroes can perceive things that normal people cannot. Such abilities range from the "spider sense"—a way to detect danger—to X-ray vision and clairvoyance. To give a player a comparable experience, we need to map the "invisible world" we want to represent onto one of the existing senses.

Some very promising methods to achieve this are sensory augmentation, substitution, and supplementation: the change of the properties of one's specific sensory modality (e.g. vision, audio, temperature, taste, pressure, or smell) into stimuli of another sensory modality.

One of the most famous sensory augmentation was presented by Nagel et al. [2]. They gave users the ability to perceive the magnetic North over a belt with a vibration motor. For some participants, significant improvements in navigation were perceived as well as an integration of the magnetic sense into the subcognitive (the realm of unconsciousness), meaning they did not need to spend active attention on understanding the signal anymore.

Applying sensory supplementation to superhuman sports, Chernyshov et al. present a sensory supplementation experience in virtual reality based on the thermal and vibrotactile feedback [3]. The system provides hot and cold sensations around the hand and forearm of the person wearing it. The user is exposed to the virtual reality environment with the goal to deflect projectiles coming its way while relying on thermal sensations to detect them.

A different approach can use haptic—the sense of touch—and other actuators to simulate a particular experience for the user. One example is Virtual Super-Leaping, an immersive virtual experience that provides the feeling of extreme jumping into the air. Sasaki et al. achieve the sense of a "super jump" by combining visual feedback over a virtual reality headset and haptic feedback providing both kinesthesia and airflow using multiple synchronized propeller units [4].

Another example of augmenting vision is SpiderVision, a wearable device that can extend the field of human vision [5]. SpiderVision merges the view from front and back cameras on a VR headset to enable the user to see both (front and back) at the same time, giving him effectively a 360 degree vision.

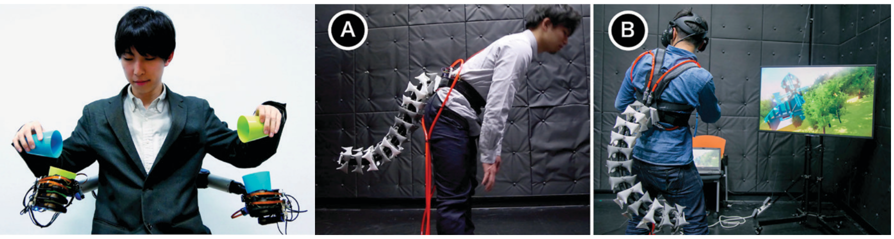
EXTENDING OUR BODY

When top athletes describe their performance, they often mention a state

Figure 1. Concept art for novel *Superhuman Sports* from a design workshop in Japan.

Figure 2. Dubhap: a sensory substitution based superhuman sport using thermal and vibrotactile feedback (on the right) and virtual super-leaping (on the left).

Figure 3. Examples for body extensions. On the left, MetaArms, where two additional robotic arms controlled by the legs [6] On the right a prosthetic tail with applications for balancing (A) and force-feedback in virtual reality [7].



of flow, of being in the zone, as well as "becoming one with their equipment." The player uses the equipment as a natural extension of the body. Can we create the same feeling for digital and robotic extensions to our body? Can we create wearable computing systems that "feel" integrated with our body? Here again, superhuman sports provide a great testing ground.

Early research examples towards this direction include MetaArms, a backpack with two robotic arms that can be controlled by leg movements (see Figure 3) [6]. So far, it can only be used while sitting, as the legs movements are directly mapped to the robotic limbs—for instance moving the foot up leads to an upward movement in the artificial limb. Interestingly, a lot of users describe that after some time (3–5 minutes) it feels as if they are using a third and fourth arm (instead of using the legs).

Another experimental robotic extension is Nabeshima et al.'s prosthetic tail [7]. Potential applications include better balancing support (see Figure 3a) or simulating momentum changes in virtual reality (see Figure 3b).

We plan to use those and similar extensions for sports applications. The research question driving us is: Can we create digital, wearable technologies that feel like an extension of our body? If we can create superhuman sports competitions where player use those body schema extensions effectively, maybe in the future people will be able to use these artificial limbs in real life.

AUGMENTING THE PLAYING FIELD

Augmentations in the playing field aim to make sports more interesting and enjoyable to play. It can lead to completely new sports. An example is HADO, in which two teams of three players compete against each other with the goal of hitting players of the other team with energy balls [8]. Players can create a barrier to block incoming energy balls. To play HADO, players only need a head-mounted AR display and a gesture tracking wristband. This allows them to move around almost like in traditional sports, without being re-

Figure 4. Player's view through the Microsoft Hololens in STAR.

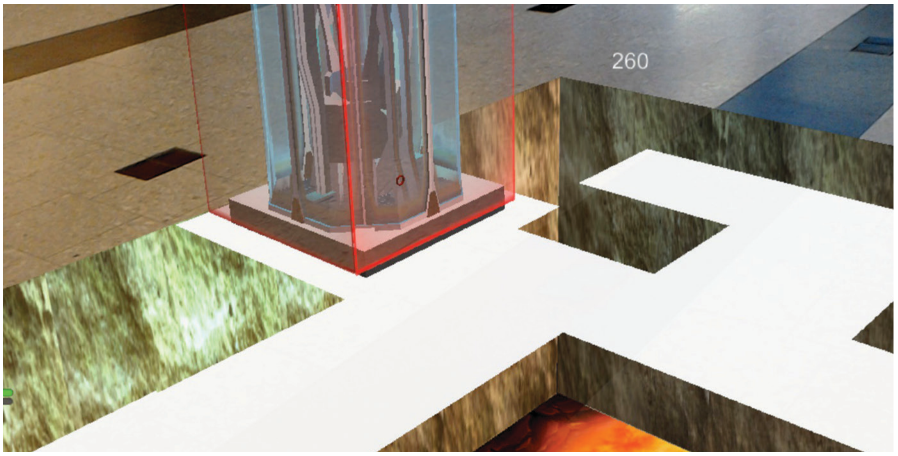


Figure 5. Player's view through the Microsoft Hololens in League of Lasers.

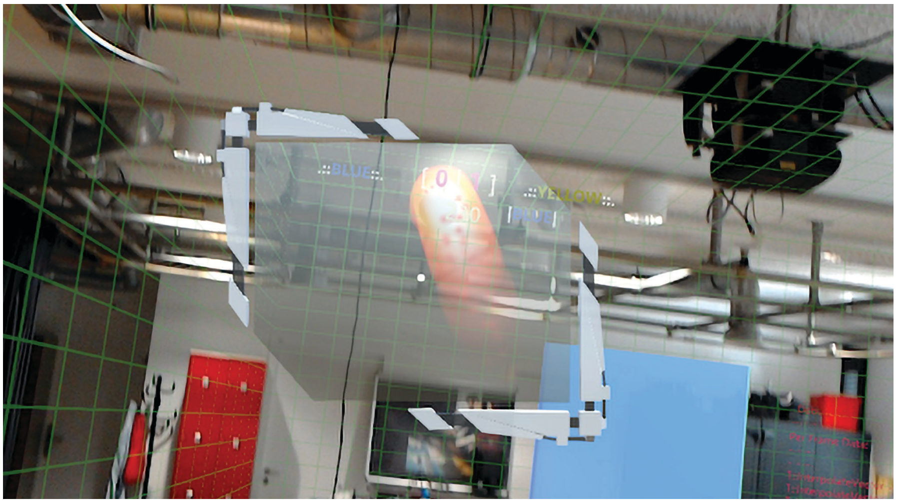


Figure 6. A setup of D-Ball. Only the red lines, ball, and markup are visible to the players.

Figure 7. Two teams playing Augmented Dodgeball. The large screen in the back shows the current score and roles of the players.

Figure 8. A setup of Venga. The screen shows the environment in which the player is moving.

stricted down by the equipment. Superhuman Training in Augmented Reality (STAR) is another example of playing field augmentation using the Microsoft Hololens [9]. STAR is a survival game where one or two players have to navigate a virtual maze while avoiding enemies. Those enemies can be killed by shooting at them with light beams, which adds a superhuman impression to the game. The game is won by destroying the enemy's energy core (see Figure 4). Similarly, League of Lasers uses Microsoft Hololens to augment the playing field [10, 11]. It requires players to move around the field in order to deflect a virtual laser pulse using a virtual deflector displayed in front of each player (see Figure 5). The goal is to deflect the laser in such a way that it is directed into the opponent's goal. Each match is time-based and at the end, the player with the highest score wins.

Compared to the aforementioned examples, technology can also be used to create a diminished reality experience. In D-Ball, two teams of two players compete with each other [12]. Each player wears a head-mounted AR display, which only shows the playing ball, the playfield lines, and the markers attached to the other players (see Figure 6). Everything else in the display is pitch black. With such diminished reality, teams try to pass the playing ball from one side of the playing field to the other.

Augmented Dodgeball is an adaptation of the classic game dodgeball [13]. Augmented Dodgeball uses a physical ball that is augmented with RFID technology. Players can energize the ball and determine the impact of a hit. For each player different values are kept track of such as life points, attack points, and defense points. Each player can choose between different roles: attacker, defender, or balanced and hybrid role. All roles have the same amount of life points but different attack and defense statistics. The current status of the game is displayed to the audience (see Figure 7). Like Augmented Dodgeball, "the design of VRabl was inspired by dodgeball [14]. VRabl is a competitive superhuman sport in which two players compete against one another by throwing virtual balls at the opponent's targets—virtual rabbits. Both players can defend their rabbits and use virtual carrots to attract the opponent's rabbits.

As final example, an augmented playing field could also be used to train for and become better in a traditional sport. Venga combines a real climbing wall with virtual reality [15]. Climbers in Venga try to climb along a given route on the real-world climbing wall while wearing a head-mounted VR display (see Figure 8). Since the players only see what is happening in the virtual world, they experience a sensation of height while still being at ground level. With that, Venga tries to create a safe environment and prepare climbers for the sensation of height they will experience when climbing in the real-world.

All of these examples augment the playing field to create superhuman sports. Some of them—such as HADO, STAR, or League of Lasers—use augmentation to create new sports and enrich the playing experience. D-Ball pursues a different direction. Though inspired by dodgeball, it uses augmentation to confine the experience and let players focus on the essential sports elements. Augmented Dodgeball and VRabl both start from the traditional dodgeball game, but enrich it to make it attractive to a different group of players, i.e. those that are interested in technology-enhanced sports. Finally, Venga uses mixed reality to enable climb training in a safe environment. Despite the differences, all of the discussed playing field augmentations aim to motivate players to be physically active during gameplay.

Augmented or designed abilities are expected to level players by removing the burden of physical constraints and athletic requirements.

OUTLOOK

This article gave a brief overview on the emerging field of superhuman sports and its current focus on enriching a player or its team's experience by augmenting the senses or the playing field. While promising, the discussed superhuman sports are still largely neglecting the audience's experience. Spectators are often challenged to understand and follow what is happening on the playing field. Future work on superhuman sports should thus also address the audience's experience. How could the activities on the playing field be visualized so that the audience is engaged in watching the sports? Could the audience be actively integrated in the sports? Physical activities of the audience could, for instance, provide power-ups to the supported team and thereby influence the play. Also, such support could not only be limited to physically present spectators but also spectators that follow from a remote location.

A major part of the discussed superhuman sports were demonstrated during the first Superhuman Sports Design Challenge (SHS'18). If you want to contribute to the field, write us an e-mail or just participate in some of the events. We are in the process of organizing the Superhuman Sports workshop at IEEE VR 2019 in Osaka, and there will be another Superhuman Sports Design Challenge by the end of this year (most likely in Germany or somewhere else in Europe). We are also working toward an event to compete in some superhuman sports before or after the 2020 Olympic Games in Tokyo. Stay tuned and check http://shs.fit/ for updates.

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