HeatSense – Thermal Sensory Supplementation for Superhuman Sports

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Abstract

This paper presents a sensory supplementation experience in virtual reality based on the thermal and vibrotactile feedback. We have implemented a physical system that provides hot and cold sensations around the hand and forearm of the person wearing it. After being equipped with the system the user is exposed to the virtual reality environment with the goal to deflect projectiles coming their way while relying on the thermal sensations to detect them. Presented experience makes a case for using thermal sensory supplementation as an interaction modality in virtual reality environments.

Index Terms: Superhuman Sports—Sensory Supplementation—Haptic Feedback—Thermal Feedback—Virtual Reality

1 Introduction

The field of Superhuman Sports (SHS) focuses on augmented sports that aim to technologically augment, suppliment or even create from scratch novel abilities that could be used for competitive sports. The augmented or designed abilities are expected to level the players by removing the burden physical constraints and athletic requirements. By building a competitive sport around the idea of technological human augmentation SHS are challenging the traditional views on sports by making the technology and skill more important than physique, physical strength and agility. According to the definition of the Superhuman Sports by it's original creators, we can conclude that SHS is a sport aimed to explore augmentation and supplimentation of human abilities in a playful way. It should combine competition and physical elements from traditional sports with technology that is seen as means to overcome the physical and sensory limitations of our bodies. [4]

This particular paper focuses on sensory augmentation and supplementation as a way to enable novel sensing modalities allowing new game mechanics to be built upon.

2 Related Work

In this section we present a few examples of superhuman sports focusing on the enabling techology behind them.

2.1 Bubble Jumper

Sport Inspired by Japanese traditional sumo wrestling, that combines jumping stilts with protective air bubbles. Jumping stilts are used to increase players ability to jump and the air-filled bubble increases the physical size of the player while providing protection from impact. [1]

2.2 Muscleblazer

Muscleblazer uses Electromyography as a part of game interaction combining it with a wearable flexible force feedback suit powrerd by pneumatic gel muscles. The game mechanics resembles one of the team first person shooters with infrared emitters and sensors for aiming and shooting. [3]

Figure 1: User trying out the experience

2.3 Dubhap

This sport focuses on providing novel senses and novel ways to perceive and assess the game progress. Players are required to rely on their haptic sensation and proprioseption to "sense" the game field and objects on it and interact with them using gestures. The game does not require vision at all and substitutes it with haptic and thermal sensations on the palm. The game mechanics are akin to voleyball or table tennis. [2]

2.4 D-Ball

D-Ball relies on augmentation of human vision by filtering out most of the colors normally perceived by human eye. Players are required to wear uniforms with special markers that remain visible to other players, however barely have any resemblance to a human player. This allows them to hide from other players by hiding the markers or taking postures that confuse the opponents. The main object used for the game is a ball that also remains visible. The game follows the catch and pass scheme with a player in between trying to abrupt the pass. [6]

2.5 League of Lasers

Venga! Augments the traditionall wall climbing by bringing it into virutal reality. Players are required to climb a climbing wall while wearing a head-mounted display. The climbing rocks in the virtual environment are exactly matched with the real ones, so the experience is seamless. This setup allows more gamification of the climbing experience as well as hiding some of the existing rocks from the players. [8]

As one can see from the examples above, superhuman sports are mostly based on traditional game mechanics but all bring a new angle to them. Which is understandable, since there is a limited number of activities that our bodies can perform and human senses are also limited. It is reasonable to expect that throughout the history of sports almost any possible interaction that could give a rise to a new sport has ben explored. Still, this approach could make even the

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existing sports and game mechanics more entertaining and friendly for wider audiences. Another aplicaion of the Superhuman Sports approach is augmented training for professional athletes, which could give them a new perspective on their performance and allow them to focus on refining certain skills by amplifing and isolating them from the rest of the playing experience. Also it can serve as a good test ground for research on techological human abilities augmentation.

The present work however is aiming to give rise to completley new types of sports by exploring novel senses and interactions that can be based on them.

3 Approach

The task of designing a superhuman sport experience can be approached in several different ways. Such experience can blend different interaction mediums together, push the limits of natural physical abilities of the participants, augment or supplement their natural abilities, or it can be a combination of all the the above. While designing an interactive experience focused around the human abilities associated with regular sport activities is relatively straightforward, it is the sensory augmentation and supplementation approach that provides freedom of exploration and allows for unique interactions to take place.

Sensory supplementation, which could be defined as the use of devices giving supplementary information for the accomplishment of a particular task [5], can serve as a powerful method of conveying information about the environment to the user. People are accustomed to rely mostly on visual and audio cues in their daily life. When information is delivered via haptic sensations, it can be easier distinguished from the audio and visual noise and has a higher chance of being perceived and acted upon. Various forms of haptic feedback have been explored in a research setting, such as vibrotactile, electrotactile and force feedback mechanisms [7].

Vibrotactile feedback is also commonly used in mass-market products as an auxilary feedback mechanic, be it the vibration of the game controller as a reaction to a game event, or a light buzz of the smartphone that adds another dimention to the graphical user interface. Thermal feedback, however, is not as commonly encountered, but still a well estblished field. The human capability to perceive the intensity of thermal sensations, either hot or cold, may suggest that it could potentially be utilized for effective sensory augmentation and supplementation. Hot and cold sensations can evoke a unique emmotional response from the users and can enhance overall immersion in the expereince. In this ‘work we mostly focus on these two modalities, as they are relatively straightforward, easy to comprehand for novice users and are easy to implement.

In order to support the claim that thermal and haptic sensations can be used for sensory substitution in games we have designed a playful experience that uses these modalities in Virtual Reality.

4 Experience Design

The core idea of the experience is to make the players rely on the novel sensory ability as much as possible. In order to achieve that goal, another sensory component has to be diminished to make the interaction more compelling. In our experience we partially take away the visual component and supplement it with thermal and vibrotactile feedback. Although the visuals are a heavy part of any virtual reality experience, a special type of interactible object can be introduced to enable this modality while not affecting the core of the virtual reality experience. This object will not be visible by default, but it will react to user’s actions and could be perceived only through the haptic channel. Projectiles in our experience implement exactly this type of behaviour (Fig.5).

The player cannot see the projectiles, but can sense them when their hand is pointed towards the projectile (Fig. 2). In order to find the projectile players have to carefully sweep the surroundings with

Figure 2: User trying out the experience

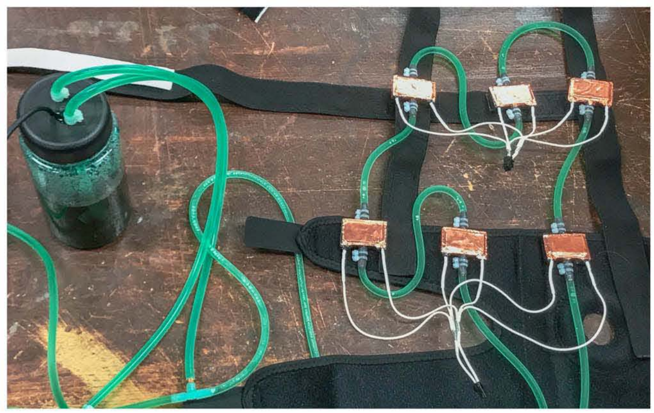

Figure 3: Thermal feedback system with water cooling

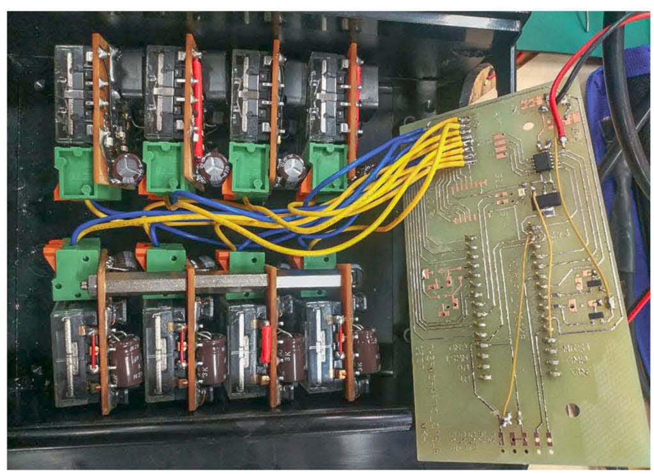

Figure 4: Hardware setup

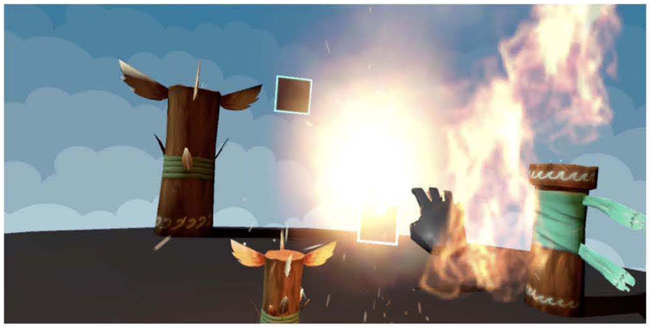

Figure 5: Virtual Environment

their hands trying to locate it (Fig.1). The sensing of the projectile is purely haptic and is implemented using a glove with vibrotactile actuators. Players can feel the thermal sensation when they point the hand towards the interactive projectile object. The intensity of the sensation increases as the object gets closer, while the type of the sensation depends on the type of the object being perceived.

Two major types of projectiles exist in the environment. One of them gives the player a chilling cold sensation on their hand when discovered, while another conveys the feeling of heat and warms their body up. When scanning the environment for the projectiles the player will experience a wide range of thermal sensations on their skin. The player's primary goal is to sense the direction from which the projectile will come towards him or her, and then to successfully deflect it. Only one hand of the player is equipped with the thermal feedback system as it is used for sensing. Deflection mechanic utilizes a conventional input method and is implemented with a standard game controller which the player holds in another hand.

In the early stages of prototyping, hand tracking was implemented with the LeapMotion device mounted on the virtual reality headset. It was quickly discovered after the first user testing sessions that this posed a severe limitation on the experience as a whole, as sensing the projectiles required the users to rotate their full body while keeping the hands in their field of view. For this reason we have switched the hand tracking mechanic from hand recognition using LeapMotion to position tracking using an HTC Tracker. This change, at the cost of realistic hand visualization, allowed the users to move in a more intuitive way which resulted in having a better experience overall.

5 HeatSense Prototype

The prototype consists of an array of thermoelectric Peltier elements grouped into 4 to 8 individually controlled channels (Fig.3). In order to avoid overheating of the elements and enable the provision of cold sensation for extended duration of time we used a water cooling system with custom made heat exchangers designed to minimize the size of the setup. During the stress tests we were able to continuously cool the cold side of the elements to temperatures below zero degrees Celsius, which is more than sufficient for this setup. The elements are mounted on the internal side of a soft fabric glove worn by the user as well as the flexible straps that help fix the elements around their arm. Peltier elements are driven using an array of switched mode power supplies (SMPS) capable of providing controlled and steady voltages and currents (Fig.4), as the Peltier elements drastically lose their efficiency if even small ripple is present on the power lines. SMPS, batteries, wireless and controll hardware is placed in the backpack to allow for easier movement and player mobility. The backpack also acts as a mount for the secured water container containing the pump that circulates water through the cooling system. Vibrotactile sensations on hand are provided by Linear Resonant Actuators. The virtual reality setup is built using Unity3D engine and is provided to the user through the HTC Vive headset.

In order to overcome the delay of the thermal feedback onset we used a linear extrapolation of the hand position to predict the timing when the user is about to perform the action requiring thermal feedback. This allows us to start heating or cooling the thermal elements moments before the feedback is necessary, which results in decrease of the perceived thermal onset delay and enables much better user experience. Basically users perceive the change of temperature exactly when the interation occurs.

6 Conclusions

After presenting this setup to multiple participants at Virtual Reality themed venues and events we can conclude that the general performance of the feedback system is much higher than the user expectations. The negative feedback was registered only regarding the tracking with LeapMotion, which was addressed in the present setup together with minor ergonomic improvements. We believe that presentation of this system at the workshop could spark many interesting ideas for future work and make one more step towards completley novel sports based on novel, augmented or supplimented senses.

Acknowledgments

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