PushToSki - An Indoor Ski Training System Using Haptic Feedback

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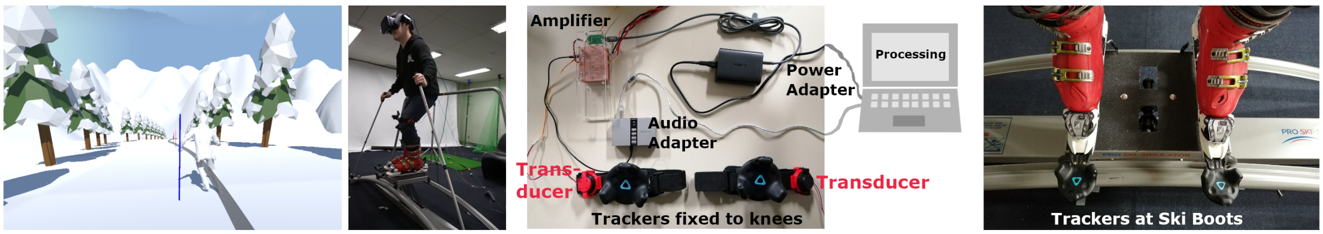

Figure 1: Overview of our haptic feedback system.

ABSTRACT

Haptic feedback is an intuitive way of improving required postures in sports without having the trainee change their head-pose towards visual cues and therefore possibly worsening their overall body-pose. However, this feedback is not possible in a dynamic sport like alpine skiing which is why we propose a virtual reality ski training system that uses vibration as a haptic feedback method. Our system uses a commercially available indoor ski simulator and several trackers to capture the user's motion together with a set of vibration motors which will provide direct, haptic feedback to the user. Our system therefore allows giving haptic feedback even while the trainee is moving on the simulator.

CCS CONCEPTS

• **Human-centered computing** → **Haptic Feedback**.

KEYWORDS

Ski training, virtual reality, haptic feedback

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1 INTRODUCTION AND MOTIVATION

Plenty of sports require a specific posture and head-pose for a healthy execution which is why a coach will often apply haptic feedback to a trainee to correct a false pose. This intuitive feedback allows improving the body posture without having to change the head-pose to look at visual cues (such as a video) which could lead to an undesired change in the overall posture. However, in alpine skiing, this is not possible while the trainee is executing the skiing movement.

Therefore, we propose a VR-based system for alpine ski training which is based on the former work of Nozawa and Wu [Nozawa et al. 2019; Wu et al. 2019]. It uses a commercially available indoor ski simulator combined with a head mounted display (HMD) and a set of motion trackers as well as a set of transducer which provide haptic feedback in form of vibrations. The user can see a virtual ski slope through the HMD and follow a human-avatar on it which displays the prerecorded motion of an expert skier. To provide suitable haptic feedback for the trainee and a better understanding of how to mimic the expert's motions, we propose a haptic feedback method using the aforementioned transducers to indicate the direction and strength of change in pose.

As former studies suggest, haptic feedback can be very beneficial if applied at the correct position and with the right timing (see [Spelmezan 2012; Van Der Linden et al. 2011]). To the best of our knowledge, this is the only work that provides direct haptic feedback for ski-training in VR as former works concentrate on visualization.

2 SYSTEM DESIGN

Our system uses a ski simulator (Pro Ski®-Simulator Power Ski Simulator [1]) together with the HTC Vive's head mounted display and four Vive trackers which are attached to the skis and the knees. Additionally, two transducers (voice coil vibration motors) are attached to the outside of the knees, one for each knee. Hereby, the audio signal of the PC is sent to an Audio Adapter (Starcom 7.1 USB

[1]https://www.ski-simulator.com/power-ski-simulator-en

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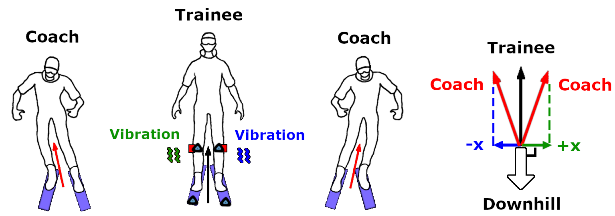

Figure 2: Feedback and desired movement of trainee.

Audio Adapter [2]) and then amplified before reaching the transducers. We use a frequency of 50Hz for the vibration. The latency of the system is less than 100ms.

The trainee will ride down a slope in a virtual ski environment created in Unity3D. An avatar will be displayed in front of them, moving with the prerecorded data of an expert skier. Our goal is to improve the parallel stance of the trainee, specifically to decrease the angle between the lower leg and the ground. To compare the expert and the trainee, we calculate the center of the feet and the center of knees via the trackers and the position data of the expert's animation. Since both lower legs during parallel skiing should be parallel to each other, the location of the centers is sufficient for the error calculation. We then take the vector from the feet-center to the knee-center of both expert and trainee, normalize them to a length of 0.5 meters and get the difference vector between them. From this difference vector we take the axis perpendicular to the moving direction (down-hill direction) to decide which vibration motor should be vibrating and with what strength. The vibration hereby mimics a push feedback event to the knee, meaning that the trainee should move their knees in the opposite direction of the vibration.

3 PILOT STUDY

Our original system design included four vibration motors, two attached to each side of each knee. Our goal thereby was to give the trainees feedback for each individual leg. In a pilot study we invited two participants (Aged 30 and 59, two male, one with almost no experience, one with several years of skiing experience) to test our system. In particular, we asked them how intuitive the system is. Their feedback suggested that four motors is excessive. In detail, both participants explained that they only concentrated on either one knee or one pair of motors (for example the outside pair). They also stated that whenever there were vibrations on different sides of the knees, they did not know which side to move to. We therefore reduced the number of motors to two and placed them on the outside of both knees.

4 DISCUSSION AND CONCLUSION

Our system is currently comparing the angles of the lower legs, however, it was designed to compare any angle between two joints. Thus, we would like to extend it to other important body parts like the upper body. Also, we would like to reduce the number of trackers needed and use a visual tracking system (like the Microsoft Kinect) instead. This way it would be possible to track all joint's positions and give feedback for any body part. Though, due to our pilot study, we are concerned that too much feedback might lead to confusion which is why further studies are needed to evaluate a suitable amount of vibration feedback.

Also, we are currently using an HMD to increase immersion. However, we are concerned about the trainee not being able to see themselves and the equipment. This might lead to safety risks when a user practices on their own. Also, long exposure to a VR environment can lead to cyber-sickness which would be unfavorable for long training sessions.

Furthermore, we are currently conducting a user study to evaluate the efficiency of our system. We therefore compare our system to a modified version of [Wu et al. 2019] where a colored trail is displayed behind the expert's avatar. The color indicates which direction the trainee should move their knee while the shade shows how much they should change their angle. Initial qualitative feedback from this study indicates that our system is helpful for the trainees to improve their movement and is easily understandable. Even though the latency of the system was just less than 100ms, none of the participants commented about the latency. Nonetheless, for future experiments we would like to reduce the latency by using multi-threading and change the audio generation to the audio adapter. Despite still needing to evaluate the quantitative results, we believe that our system has the potential to help ski trainees in refining their parallel stance.

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REFERENCES

Takayuki Nozawa, Erwin Wu, and Hideki Koike. 2019. Vr ski coach: Indoor ski training system visualizing difference from leading skier. In *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*. IEEE, 1341–1342.

Daniel Spelmezan. 2012. An investigation into the use of tactile instructions in snowboarding. In *Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services*. 417–426.

Janet Van Der Linden, Rose Johnson, Jon Bird, Yvonne Rogers, and Erwin Schoonderwaldt. 2011. Buzzing to play: lessons learned from an in the wild study of real-time vibrotactile feedback. In *Proceedings of the SIGCHI Conference on Human factors in Computing Systems*. 533–542.

Erwin Wu, Florian Perteneder, Hideki Koike, and Takayuki Nozawa. 2019. How to vizski: Visualizing captured skier motion in a vr ski training simulator. In *The 17th International Conference on Virtual-Reality Continuum and its Applications in Industry*. 1–9.

[2]https://www.startech.com/en-us/cards-adapters/icusbaudio7d