VR Ski Coach: Indoor Ski Training System Visualizing Difference from Leading Skier

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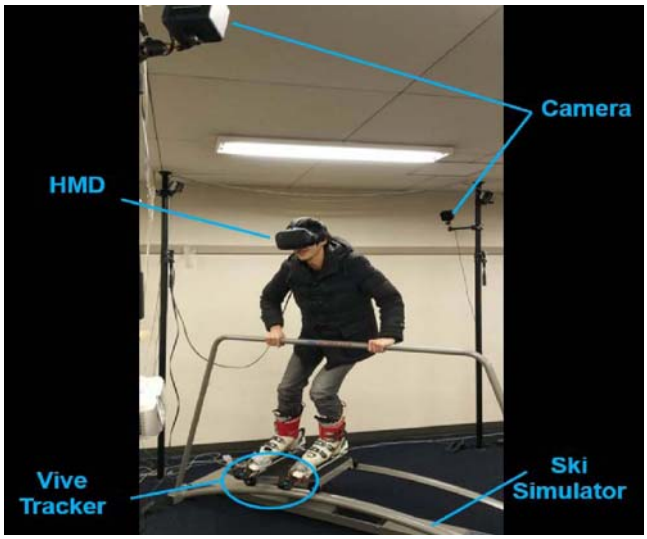

Figure 1: System overview

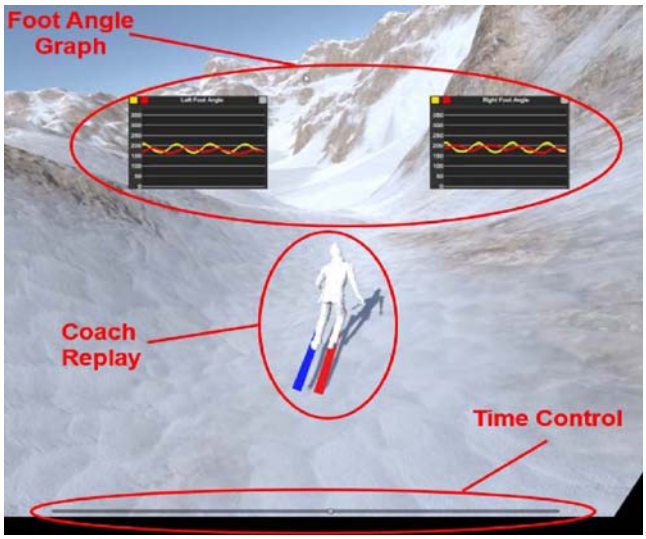

Figure 2: Virtual functions

Abstract

The training of skiing is difficult because of environmental requirements and teaching methods. Therefore, we propose a virtual reality ski training system using an indoor ski simulator. The system is based on a simple indoor ski simulator with two trackers to capture the motion of skis. Users can control the skis in the virtual ski slope we provided and train their skills with a replay of a professional skier. The training system consists of three modules: a coach replay system for reviewing pro-skiers's motion; a time control system that can be used to watch the detailed motion of both the coach and the user; and a visualization of the angle of the skis to compare the difference of motions between the users and the coach.

Index Terms: Human-centered computing—Visualization—Visualization techniques—Treemaps; Human-centered computing—Visualization—Visualization design and evaluation methods

1 Introduction

Skiing is a famous sport with long history and many studies about ski training are conducted. However, there are still many restrictions in training skiing. First, environment dependencies: skiing requires snow and sloping environments, which means the sports in limited to seasons and places. With the development of virtual reality and ski simulator [2], it is possible to provide an immersive virtual ski environment to the user. Another problem is that skiing cannot be taught like other sports, in which there is a method of viewing and mimicking expert's motion directly, since it is not possible to follow a expert for a beginner and also difficult to learn the motion from recorded video. Furthermore, it is difficult for beginners to notice the difference between the expert motion and theirs. The coach have to tell them directly to correct their forms and center of gravity, which makes the training of skiing to be man-to-man.

Therefore, we propose an VR-based ski training system which replay the motion of a coach skier in a virtual slope. The user can ski on an indoor ski simulator and can see the virtual ski slope through the HMD, a recorded expert skier who is skiing the same course will always be shown before the user. The user can also manipulate the time scale to change the speed, it is possible to observe the details of the experts by slowing the speed; and challenge a faster level by adding the speed. In addition, the difference of both feet angles between the user and the expert will be visualized on two graphs, which only use the data of the tracker on the skis so the user do not require to wear any additional equipment except the ski boots. Also, the system can be use remotely while the coach can use a motion capture system to stream the motion to the student's HMD, which mean a coach can teach mutiple student at the same time.

To the best of our knowledge, exist studies cannot deal with real-time ski coaching while our work is the first VR ski training system that can provide real-time feedback, our studies also show that our method is effective in helping beginners understand expert's motion.

2 Related Works

Several studies on skiing has been performed, Kobeissi et al. [5] put a motion sensing add-on on a balance board and apply it to ski training, while Hasegawa et al. [3] developed a device to provide real-time sonification feedback of the center of gravity of the skier, which can guide the skier and overcome the recation of leaning back. However, most of the exist studies of ski training do not focus on the visibility factors of skiing which have been proved to be important by previous research from Aleshin et al. [1]

Aleshin et al. [2] are the first to bring ski training to virtual environment using a ski simulator, they use projection screen to create the visualization system and a SkyTec interactive trainer as the simulator. Although their system cannot fully replace actual alpine skiing, their simulator was proved to be effectively in alpine skiing training. Nevertheless, simply showing the slope and some flags is more like a game or exercises instead of formal training, and the sense of immersion is not high enough in case of using a

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projection screen, which is also quite important in ski training.

Except skiing, many other sports are trained using VR, Ikeda et al. [4] proposed a method of replaying the motion of sports in mixed reality for golf training. They recorded the motion of an expert and replay the whole action on a MR HMD, which also use a special DP matching to tell the difference between the user and the experts. Their method is proved to be useful in training golf, however, golf swing is a simple action which does not contains large movement like skiing, the user can view the motion gradually to understand the difference which is not possible for skiing.

3 System Design

3.1 Hardware Design

The training system consists of a indoor ski simulator, a VR head mounted display, two cameras and a pair of VR trackers. Head mounted display will not greatly disturb the experience since real skiing also require goggle and therefore has a narrow field of view. The set-up of the system can be known from Figure 1, in which we set the two VR trackers on the skis to get the position and rotation. The skis are able to move lateral and a counterforce will be caused by the rubber band in the simulator to return the skis to the original positions, which can be adjust by changing the number of the bands.

3.2 Software Design

We create a virtual ski slope for training and use a type of curvy splines to simulate gravity to force the users to move according to the designed course. Since the users can move laterally to a certain extend. For ski training methods, three functions are implemented: a coach replay function, a time control function and a graph visualization of foot angle.

4 Methodology

Our training system consists of three functions:

Coach replay function: We invited two former alpine ski world cup racers for taking the data of expert skiers, a Xsens motion capture system was used to capture the full body motion of them for replaying. The replay of the 1s later motion of the coach will be always shown in front of the user. We also calibrate the motion according to the course to make sure the user can see the specific motion in the corresponding place, just as the white model shown in Figure 2. This function allows the user to observe the motion close behind an expert skier, which is almost not possible in real skiing. Since the user's position is always fixed behind the expert's, we can also do a remote coaching by connecting the system with a remote one and stream the motion of coach, which means a coach can teach multiple student at the same time.

Time control function: We designed a time control function to change the time scale of the game, which has two modes: the auto mode and the manual mode. In the auto mode, the time could be gradually speed up from a slow motion to adjust the level dynamically for the user until the user can hardly catch up with the expert. We compare the similarity of foot angle (which will be explained in the next section) to judge whether the user is following the experts. While in the manual mode, there is a slide bar for user to control. The scale of the bar is from -1x to 3x, in which the negative means a roll back of time and the number means the magnitude of speed. For example, the user can slow down the motion to 0.5x to understand and imitate the motion of the replayed coach easier, or even use -1x to rollback the time to have another try. The user can also simply accelerate the motion to challenge a higher level.

Foot angle visualization: To let the user understand the difference between the expert and himself/herself, we visualize two graph on the HMD to show the foot angle of the user and the expert. The data are taken from the VR tracker's rotation, and plot on 2D coordinate, of which the horizontal axis is the place of the course. The two graphs on top of Figure 2 are showing the right and left foot angle of the user (the red line) and the expert (the yellow line), respectively. Since the angles are position-related, the user can know how the expert move his/her feet in the same position and notice the difference. From our pilot tests, a professional skiers can always output beautiful sine curve while a beginner's graph is always aperiodic.

5 Demo

In our demo, we prepare several ski boots of different sizes for users to put on, and they will stand on the ski simulator wearing a HTC Vive Pro. The demo will take about 3 minutes (except the dressing time) for the users to ski with our coach system. Inside the virtual environment, users will find themselves in a snow mountain with the skies under their feet. They can experience all three types of functions and enjoy skiing in the slope we provided.

6 Conclusion & Discussion

Our system is able to provide a few types of visualization to the user to get a better understanding of skiing. We also practiced some pilot tests by having some beginner skiers to follow the expert skiers. According to the short interviews after the tests, all subjects provided a positive respond of the visualization and most of the subjects find that it is helpful in ski training. However, quite a lot future improvements should be done to our research:

· First, quantitative evaluation is not performed by now, while it is difficult to study whether a user is learning faster using our system since the learning rate will be different. That is why we only asked user whether they could understand the expert's skiing better. However, we will try to evaluate the time of user can catch up with the expert with/without the support of our system, which might tell the effect of the system.

· Since we do not want to add sensors or trackers on user's body that can limit the action of user, the system is now only dealing with foot angle for comparison. We took an interview on top racers and got the information that the most important factor in alpine skiing is the angle of skis. That's why the system only use the binding angle taken by Vive tracker, however, we are planning to import center of gravity as another factor for evaluation.

· Last but not least, cyber sickness is a problem to solve for VR contents especially for high speed sports such as skiing. In our pilot tests, we found that a sudden vertical movement like climbing a small mound will make the user fill sick. We are trying to fix this problem by predicting the route of the skier to reduce the latency in our future work.

Acknowledgments

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