Virtual Skiing as an Art Installation

Franc Solina, Borut Batagelj, Slavko Glamočanin
Computer Vision Laboratory, University of Ljubljana, Faculty of Computer and Information Science,
Tržaška 25, SI-1000 Ljubljana, Slovenia
E-mail: *{franc.solina, borut.batagelj}@fri.uni-lj.si*

Abstract - *The Virtual Skiing game allows the user to immerse himself into the skiing sensation without using any obvious hardware interfaces. To achieve the movement down the virtual skiing slope the skier who stands on a pair of skis attached to the floor performs the same movements as on real skis, in particular this is the case on carving skis: tilting the body to the left initiates a left turn, tilting the body to the right initiates a right turn, by lowering the body, the speed is increased. The skier observes his progress down the virtual slope projected on the wall in front of him. The skier's movements are recorded using a video camera placed in front of him and processed on a PC in real time to drive the projected animation of the virtual slope.*

Keywords - *Skiing, Virtual Reality, Computer Vision, Game, Art*

1. INTRODUCTION

Real-time interaction of people with virtual environments is a well established concept but finding the right interface to do it is still a challenging task. Wearing different kinds of sensors attached to the body of the participants is often cumbersome. Computer vision offers the exiting possibility to get rid of such sensors and to record the body movements of participants using a camera [1]. People, their appearance (i.e. face), their emotions and the movements of their bodies are becoming on the other hand an important object of study in computer vision research [2].

The number of application areas for virtual environments is growing since the cost of technology for making virtual environments is in general going down. Sporting games in general are an attractive area for using virtual technology. Many training machines for cycling, running, rowing are enhanced with a virtual world to make the training more interesting. Instead of a static scene in a fitness room one can get the feeling of moving along a real scene or even to race against other real or virtual competitors. Virtual exercisers are sophisticated simulations that deliver the demands, stresses, and sensations of a sport or exercise with unprecedented verisimilitude and precision.

Artists on the other hand experiment freely with new technology and they try to invent better and new ways of interfacing with virtual worlds [3, 4]. We initiated our project of virtual skiing as an interactive art installation, which gave us more freedom to experiment and to show our results to a wider public in an art gallery setting. The Computer Vision Laboratory and the Video and New Media Department of the Academy of Fine Arts, both at the University of Ljubljana, Slovenia, have collaborated in bringing together modern arts and information technologies since 1995. Projects involving the Internet, teleoperation, mobile robots and web cameras have been successfully exhibited [5, 6].

Our first successful art installation involving computer vision methods was "15 seconds of fame" [7]. This installation used face detection to single out a random face in the crowd of spectators in front of the installation. The objects of images being analyzed by computer vision methods are to an increasing degree people, and the goals of these systems are to find people in images, identify them or determine their activity, which opens the door to a multitude of possible applications [2]. This people-centered computer vision objective, which is an increasingly important goal in video surveillance, is in turn becoming a major focus of cultural production. A video camera in combination with various types of displays has been used in numerous art installations, often as a sort of electronic mirror or as a simple interaction device [4].

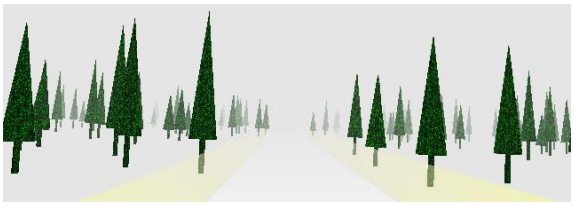

Fig. 1. The virtual slope is covered with sparsely populated trees among which the skier must find his way

The installation for virtual skiing consists of a room with big white wall in front of the skier and a floor covered with artificial snow. The skier stands on a pair of skis which are attached to the floor. The virtual slope is projected on the entire wall in front of the skier (Fig. 1). By using the same movements as on real snow the skier can negotiate also the virtual slope (Fig. 2). The movements of the skier

are captured by a video camera in front of the skier which in turn controls the animation of the virtual slope.

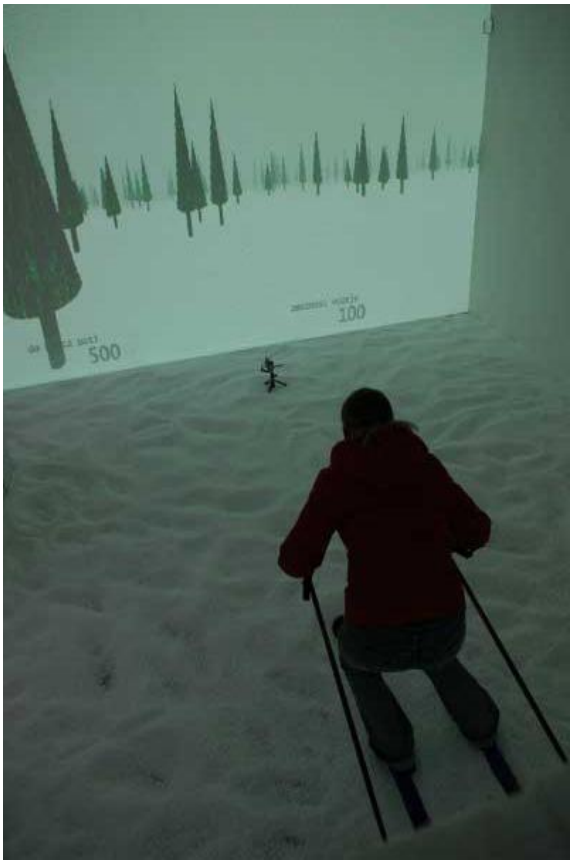

Fig. 2. The skier performs the same movements as on real skis to turn on the virtual ski slope. The position of the video camera can be seen at the bottom of the projection

The Virtual Skiing installation was on display in an art gallery in Ljubljana for two weeks and received a very good response from the audience. In the next sections we outline some related work on virtual skiing. In section 3 we present our installation of virtual skiing in detail. In section 4 we discuss how the installation can be used for different games. We conclude with a summary and suggestions for future work.

2. RELATED WORK

Skiing is a popular sport, which is unfortunately restricted to appropriate climactic and terrain conditions. Therefore various attempts have been made to bring this sport closer to anyone using modern technology. A very costly and direct method is to build an artificial slope with artificial snow or some other surface that enables sliding. Much more cost effective is now virtual technology although the whole ensemble of sensations experienced in the virtual world is not as realistic.

There have been quite a number of skiing games and skiing simulators played on a regular computer interface or on dedicated platforms such as the video game "Alpine Racer" by Namco. In the mid 1990's a special robotic platform was built by Jim Rodnunsky for the Vail ski center. The Ski and Snowboard Simulator is a surging, rolling, swaying, pitching, heaving, and yawing hydraulic recreation which took $4 million to develop. More recently, complete 3D models of existing ski centers have been build for promotional goals. They enable the user to freely move around and attain additional information or to follow a predefined path for the user to experience a virtual downhill race [8, 9].

An immersive virtual reality cross-country skiing track was built for rehabilitation purposes at University of Colorado [10]. On the other hand, biomechanical research of skiing has also been affected by modern technology. Specialized or general tools for video analysis of various sport disciplines exist, skiing included.

3. IMPLEMENTATION OF THE VIRTUAL SKIING SYSTEM

3.1. Structure of the system

The Virtual Skiing installation consists of the following elements:

- a room with artificial snow on the floor and a pair of skies attached to the floor,
- a video camera in front of the skier which records the skier's movements,
- a computer with a 3D graphics card,
- a sound system to convey the basic sound events (i.e. colliding with a tree) and
- a video projector to project the virtual slope.

3.1. Processing of the video images

The video is grabbed by a digital video camera at 20 frames per second. The camera is placed in front of the skier (Fig. 2). In first version of the software the background of the skier from the point of the camera had to be uniform white. In this way it was fairly easy to binarize the images and separated the figure of the skier from the background. On the other hand, we had problems with transportability because we couldn't provide everywhere the white background. In new version we subtract the background from every image frame. The background image is taken at the beginning and periodicity when there is no moving in front of the camera. In such a way we also get rid of the problems with changing illumination during the exhibition. Additionally we binarize the images to final separate the figure of the skier from the

background (Fig. 3). The threshold for binarization is determined dynamically using a histogram method each time a new participant steps into the scene. The image subarea, where binarization takes place, can be adjusted interactively to suit different setups of the installation.

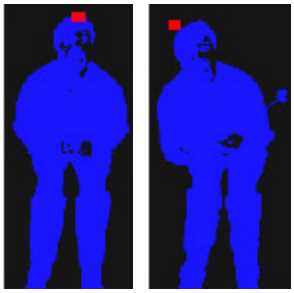

Fig. 3. The silhouette of the skier as result of the background subtraction and binarization of the input video image

Each time a user enters the scene as seen from the camera, the height of his silhouette is recorded and the center of his silhouette is determined by finding a pixel balance between his left and right side (marked as red square in Fig. 3). As the skier shifts his body to the left or right side this initiates on modern carving skis a turn in the same direction. Turning can be therefore controlled just by shifting the center of the body/silhouette. When the user flexes his knees and lowers his body to achieve a lower air resistance the height of his silhouette is decreased and this is interpreted as an increase of the skier's speed (Fig. 4). The information of the body's position relative to the upright position is given to the skiing polygon rendering engine, which displays the virtual slope. In reality, the biomechanics of skiing is much more complicated but for the interaction with a virtual environment such actions are quite realistic.

The software is written in C++ and uses the DirectShow interface to capture video data. For displaying the terrain the cross-platform SDL library and a custom rendering engine based on OpenGL is used [12].

3.2. Rendering

The rendering of the virtual terrain is done in OpenGL using the cross-platform SDL library. The trees have been modeled in 3D Studio and imported into the rendering engine. At startup this engine computes random positions and heights for 400 trees, which make up all of the trees seen. Additionally, 7% of the trees are flagged as "hearts". This information is used when the user is skiing in the survival mode of the game to draw hearts. Different modes of the game are explained in Sec. 4.

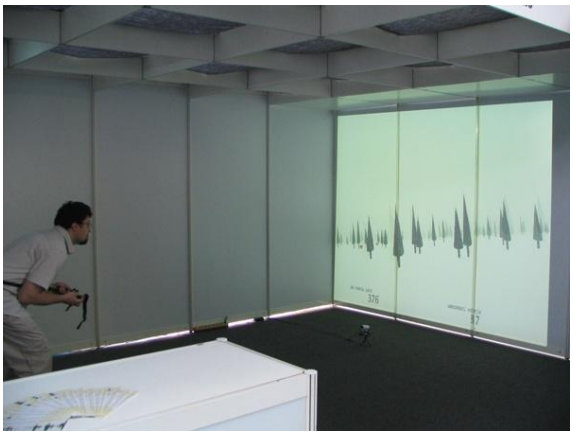

Fig. 4. Lowering the body reduces air resistance and increases the speed of the skier in the virtual world

3.2. Collision detection

When the user comes in the virtual world too close to a tree, a collision is triggered. The collision algorithm is quite simple and written to suit the dedicated terrain rendering engine. It first checks if any of the trees are close along the direction of the movement of the skier (z axis). Then it checks if any of these trees are also in the x axis range (x axis of the projected image) with the following simple formula:

$$(skier\_x\_location - tree\_x\_location)^2 \qquad (1)$$

When the skier collides, three parameters are taken into consideration: the skiers speed, tree height and the side from which the skier hits the tree (left, right, or direct middle). The life points are decreased according to the skier's speed and tree height. The side of the tree is used to "bounce" the skier off the tree to the side that the skier came from. Hitting the tree on its left side, would bounce him back to the left.

4. GAME PLAY

There are two modes of how the Virtual Skiing installation can be used: plain skiing and survival mode.

4.1. Plain skiing

The user skis the virtual slopes with no obvious objective other than to enjoy the experience.

4.2. Survival mode

The object of this mode is to travel a certain distance, which is depicted on the lower left on the screen (it starts with 500 and counts down to 0 at the finish). If you hit any tree you lose "life" points. The exact number of lost points depends on how close

was the encounter with a tree, the speed of the skier and the height of the tree. If the skier looses all of his/hers "life" points the game is over. But the skier can also regain life points. By skiing through the "hearts" on the terrain the number of his/hers "life" points increase (Fig. 5).

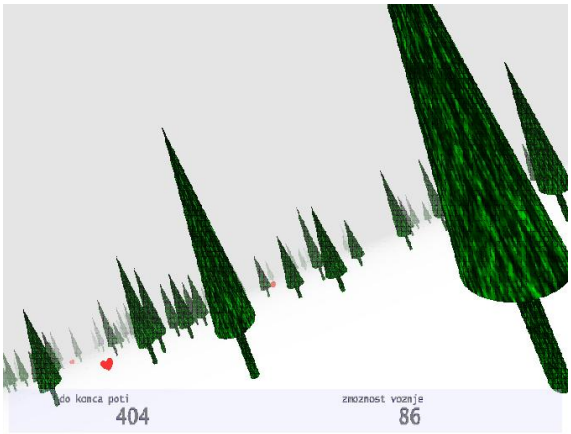

Fig. 5. Crashing into the trees decreases the number of "life" points, but skiing through "hearts" on the slope increases the number of "life" points

5. CONCLUSIONS

The installation Virtual Skiing provides a user with the opportunity to interact with a virtual space. The virtual skier can navigate down the virtual slope just by changing the posture of his body. The possible actions are turn right/left and change of the speed of descent. In the process of navigating down the slope the skier must avoid the sparsely arranged trees. The interface is very intuitive since the skier just repeats the actions that he knows from real skiing and learns to control his movement in the virtual world in less than a minute. The system works in real time and is very robust to any influences from the environment, such as change of illumination. Other games for the same virtual skiing setup could be introduced. A race course with gates could be implemented so that the skiers could compete and try to finish the course in the shortest time. A virtual model of an existing slope could be used as a promotional means for that ski resort. Virtual Skiing is just one possible application of such computer vision based interface and other applications are under development.

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