Kinaptic — Techniques and Insights for Creating Competitive Accessible 3D Games for Sighted and Visually Impaired Users

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***Abstract*— We present the first accessible game that allows a fair competition between sighted and blind people in a shared virtual 3D environment. We use an asymmetric setup that allows touchless interaction via Kinect, for the sighted player, and haptic, wind, and surround audio feedback, for the blind player. We evaluated our game in an in-the-wild study. The results show that our setup is able to provide a mutually fun game experience while maintaining a fair winning chance for both players. Based on our study, we also suggest guidelines for future developments of games for visually impaired people that could help to further include blind people into society.**

***Index Terms*— Accessibility, Accessible Game, Blind Gamers, Haptic Device, KINECT.**

I. INTRODUCTION

Today, most digital games and applications place the main focus on high-fidelity graphics and visual effects, touchless natural interaction, and multiplayer modes. Currently, there is a trend towards utilizing more VR technologies, like the Oculus Rift and advanced touchless and markerless user tracking methods. When and if these will enter the mass market, probably over the the next few years, this development will, unfortunately, exclude blind and visually impaired people more and more from the digital progress. According to the Federal Statistical Office of Germany, the number of blind or highly visually impaired people was estimated at around 125,000 in 2013 in Germany alone [1]. As the human eyesight decreases over time, the largest amount of blind people can be found in the age group of 50 and over. Currently, about 11% of this generation uses computer games [2], but in the future, this fraction will increase enormously with the next generations of digital natives. Hence, a large amount of people who grew up playing video games will no longer be able to do so, due to their loss of eye sight. This can result in increasing social isolation if, for instance, long-time friendships from multiplayer games run dry, but also in a loss of potential customers for the gaming companies.

For general computer usage, there are several tools on the market to support visually impaired users like Braille line [3], screen reader [4] or screen magnifier. All these tools provide slow interaction mechanics and focus on making 2D content, such as websites, accessible. None of the mentioned tools is suitable for gaining full real-time situation- and self-awareness for 3D immersive virtual environments. Sighted players gain this awareness through visual input by directly computing distances to objects and by people's interactions and mimics, whereas blind players can only rely on simple audio feedback or Braille line.

The goal of our work is the development of a shared virtual real-time 3D environment for both blind and sighted users. The sighted user should not be deprived from familiar features like 3D rendering and natural interaction. The main challenge is to make the 3D environment accessible for the blind user by an appropriate stimulation of the non-visual senses. Unfortunately, simply converting visual feedback to other modalities usually results in an enormous loss of information: For instances, the resolution and detail of visual stimuli is much larger than the feedback that we can perceive through audio or haptic modalities in the same amount of time [5]. Hence, such a simple conversion would lead to a disadvantage for the visual impaired user if both have to solve the same task. Providing further assistance to overcome this problem, e.g. auto-aiming and -movement in a first-person-shooter, significantly alters the task and the experience.

Consequently, we decided to chose an asymmetric setup. Obviously, input and output modalities are asymmetric: The sighted player focuses on the visual rendering and can interact using a Kinect camera. The blind player experiences the environment by using touch input with a haptic device, wind feedback, and 3D sound. Additionally, we chose asymmetric *tasks*. The idea of asymmetric tasks often appears in games like hide-and-seek or Blind man's buff. We decided to develop a digital 3D game version of tag. We chose such a competitive setup with intend: A well-balanced competitive game in the same virtual 3D environment, where both players have equal winning chances, shows a fair accessibility for visual impaired and sighted users. To our knowledge, our novel game is the first game that provides this accessibility for real-time 3D environments. We tested and improved our setup iteratively in cooperation with the local blind association. Finally, we conducted an in-the-wild user study to evaluate our game. The results outline methods and guidelines to help compensate the lack of visual orientation in virtual 3D environments. This can help to optimize accessible games and make existing games accessible.

II. RELATED WORK

Previous projects, which focus on games for blind players, can be divided into two types: designing complete new games or modifying existing games. In both cases visual input is often replaced by audio or haptics [6].

Many modifications of existing games for visual impaired players are exergames like "VI-Tennis" [7], "VI-Bowling" [8] or "Eyes-Free Yoga" [9]. They use the Kinect or Wii motion to track the user movement and audio or vibrotactile mechanics to provide feedback. However, they all focus on single-player modes and have only simple game mechanics. Actually, vibrotactile feedback can compete with visual feedback in such simple one-switch games like Kinect Sports [10]. However, usual 3D games have fast and complex game mechanics and the modalities cannot be easily changed in every game [5].

Audio feedback is also used in games that are especially designed for blind people, since this output device is widespread and inexpensive. An example therefore is ”AuditoryPong” [11]. The educational game “Audiopolis“ [12] simulates a city and its environmental sounds to teach blind children how to navigate in urban scenes. They also have utilized haptic devices to act as virtual canes and have proven that haptic devices can be appropriate and intuitive for navigating in virtual 3D environments. The concept of a virtual cane is also used in the orientation experiment of Maidenbaum et al. [13], where the cane is simulated by audio feedback only. Instead of a haptic device, a normal keyboard was used in this experiment and the cane was controlled by the space bar.

Another approach is to add audio features for orientation that are not available in non-digital environments. For instance, the adventure game “Terraformers“ [14] presents a technique that uses sound propagation (sonar) to describe the proximity of obstacles. Also, audio feedback is an essential feature to grant blind people a sense of silent activities. In the majority of cases, these sounds are exaggerated and abstract versions of real environmental tones, e.g. menu navigation acoustics as well as success and failure feedback for actions [15], [16]. The voice over is frequently used for explanations in games. For instance, voice over gives feedback in an extensive way for every action as demonstrated in “Terraformers“ and “AudioBattleship“ [15], an audio-based version of the classic battleship.

Considering the lack of appropriate hardware for end users, haptic output is not as commonly used as audio output. “TiM games“ [17] and “Digital Clock Carpet“ [16] introduce methods of a 2D navigation in environments by simulating different tactile surfaces with various materials. Another example is “Braille Play“ [18] which teaches how to write and read Braille letters using the vibration feedback and the touch interface of smartphones. For non-visual navigation in 3D gaming environments haptic devices are usually used. The project “Blind Hero“ [6] shows a way to play a virtual guitar using a haptic glove without any visual input. For a larger spatial awareness, “Audiopolis“ [12] presents a method to experience the structure of environmental surfaces using a Novint Falcon. Nikolakis et al. [19] conceive a way to provide haptic and tactile feedback by combining a Cyber-Grasp and a Geomagic Phantom for object manipulation and recognition in virtual environments.

To validate the setups, the presented projects carried out user tests with blind and sighted players under the same conditions, thus, without any visual input. “Blind Hero“ and “Finger Dance“ [20] show that under these conditions blind players have better orientation and as a result better odds.

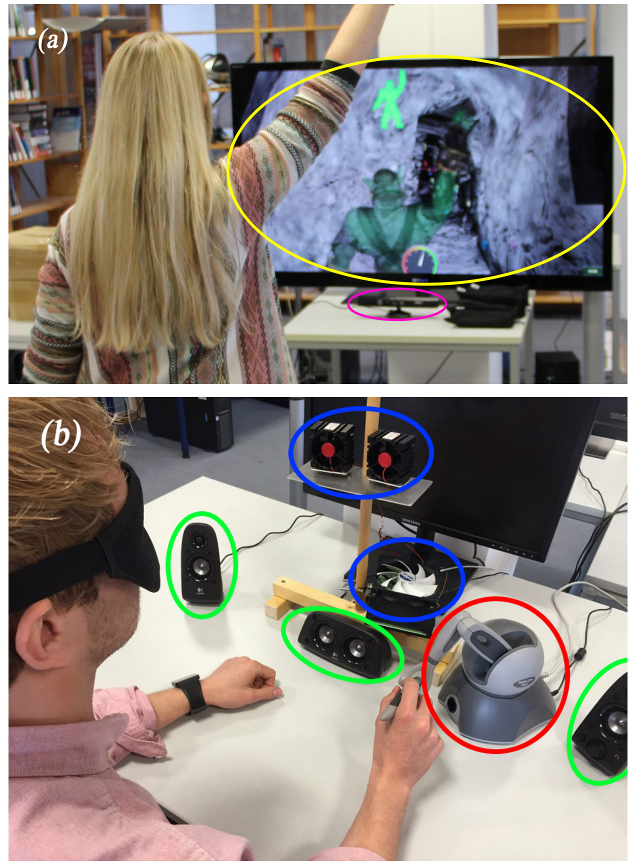

Fig. 1. Setup for (a) the sighted and (b) the blind player

However, none of these works present a competitive asymmetric multiplayer approach for both, sighted and unsighted players. Actually, there exist only very few projects with this focus, like e.g. “AudioBattleship“ [15] that supports a round-based gameplay. Beyond games, Sallnäs et al. [21] implement a collaborative asymmetric 3D environment. However, a balanced access was not the focus of this work.

III. SYSTEM OVERVIEW

Simply limiting the input and output devices for the sighted player reduces his chances [5]. Consequently, we decided to use an asymmetric setup in order to guarantee equality of opportunities for both groups. The basic idea was a virtual variation of the classic trap game. The sighted player tries to escape, while the blind player tries to catch him.

Basically, the sighted player digs a tunnel to escape by using his whole body as a controller to move the ground. His movements are tracked by a Kinect (see Figure 1a, pink ellipse) and he receives visual feedback on a large stereoscopic screen. Obviously, crouching on the ground would reduce the tunnel size. In order to avoid this simple strategy, we introduced another challenge: We periodically display full body poses on the screen that have to be struck by the player or his speed is reduced.

The blind player controls an avatar in ego-perspective. He flies through the tunnel which is created by the escaping opponent and tries to catch him. The avatar is controlled

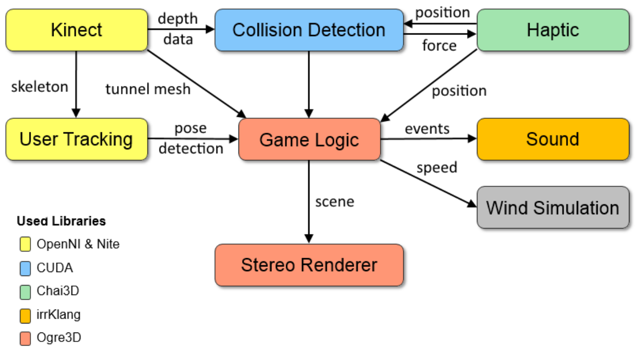

Fig. 2. System Overview

by a haptic device that gives feedback on collisions with the tunnel walls (see Figure 1b, red sphere). Furthermore, a common 5.1. surround system (Figure 1b, green ellipses) provides audible feedback: The player can hear the noises produced by the sighted player during his digging and he can trigger a sonar signal that indicates the middle of the tunnel. Our in-house developed speed-controlled wind simulator (Figure 1b, blue ellipses) provides additional feedback on the acceleration to the blind player.

Additionally, the blind player is equipped with the opportunity to increase his speed. One button on the haptic device triggers a boost which only lasts for a few seconds. Obviously, the game is over when the blind player touches the sighted player or if the sighted player escaped, i.e. the distance between the two players is too large.

A. System Components

The general challenge is to combine multiple in- and output methods, such as 3D rendering, 3D sound, haptics and user tracking. Figure 2 shows the general structure of the system with its several components. The graphics are rendered by Ogre3D graphics engine. The irrKlang library is used to render 3D sound. The sighted player tracking is done via OpenNI and Nite.

The system is running on four parallel threads with different workloads and demands for performance. The most demanding thread is the haptic thread which needs to be updated in a frequency of 1000 Hz to provide a sensible feedback. This thread is reliant on the collision detection which should be as fast as possible. Stereoscopic 3D rendering has a demand of 120 Hz to provide a smooth motion flow for each eye. However, the Kinect can only capture 30 frames per second when operating in the highest possible resolution setting, so its thread can run at 30 Hz.

Kinect and Tunnel Creation

Based on the depth camera input, a mesh is created to represent the tunnel. First, we perform a background subtraction on the Kinect depth image to identify the player (Figure 3a). Second, we extract the player's silhouette (Figure 3b), which includes single fingers and extremities. To create a tunnel mesh for our purpose, these details are not required.

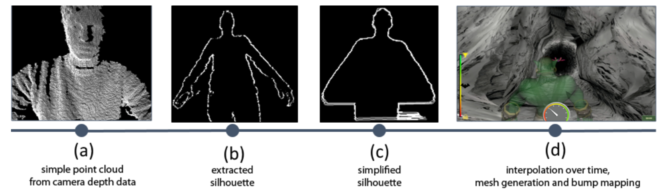

Fig. 3. Steps of the generation of the tunnel out of the Kinect stream

Therefore, in the next step, all points that do not belong to the outer contour are filtered out. By smoothing each silhouette, most of the noise of the captured point cloud is eliminated (Figure 3c). The main challenge with the creation of the mesh for the 3D tunnel is correspondence between the points from different silhouette frames because the number of points can vary between 400-900 points. It is not clear which points have to be connected to triangulate a mesh. In addition, many of the points are redundant for the appearance of the tunnel surface. To solve this problem, the set of original silhouette points $A = (a_1, a_2, \ldots, a_m)$ with size m is reduced to a set of points $B = (b_1, b_2, \ldots, b_n)$ with fixed size n.

$$b_j = \frac{\sum_{(j-1)*p+1}^{j*p} a_i}{n} \text{ with } p := \frac{m}{n} \quad (1)$$

In the examples shown here, each silhouette is reduced to 50 points, resulting in a smoothed silhouette with a fixed number of points. Each silhouette is then coarsely analyzed by calculating the mean distance of the points to the middle point and potentially scaled to provide a minimum of space, preventing impassable parts in the tunnel. Afterwards, we compute a mesh over all the processed silhouettes each frame of the graphics engine and texture it using bump mapping (Figure 3d).

Haptic Feedback and Collision Detection

The main challenge in haptics is fast collision detection. Actually, the collision detection component connects the haptic component to the game logic. It collects the tunnel mesh data and calculates the collision points with the haptic point data to return the forces.

The collision detection is performed on the GPU by using Nvidia's CUDA API. The range of motion of the haptic device is restricted. We use this limits to pre-compute a set of points which possibly have a collision. To do that, we reduce the amount of points which we need to copy and consider for collision. In the next step, we adaptively interpolate over all vertices of the tunnel mesh until a minimum coverage of points per area is reached to achieve a more exact detection. Then we compute the intersection of each point with the bounding sphere of the haptic handle. In case of an intersection, the penetration depth is calculated for each colliding point by calculating the penetrated spherical cap of the bounding sphere.

To calculate the penetrated volume for one point, we construct a ray equation from the point and its normal, which we plug into the sphere's equation and solve the resulting quadratic equation. In case of an intersection, we get two scalar $t_{1,2}$ at which the ray intersects the sphere. We then simply determine the smaller t and calculate the spherical cap volume that is defined by the plane of the current point's normal and the sphere.

$$v_i = \frac{\pi t^2}{3} * (r^3 - t) \quad (2)$$

where r is the radius of the bounding sphere. Finally, we multiply the point's normal vector n_i with the resulting volume v_i and average over all intersecting points. This guarantees a continuous haptic feedback. Additionally, we apply a constant force into the z-direction to keep the device constantly in its workspace.

This methods provides information to compute only 3 DOF feedback forces but does not support torques. In our setup, we used a Phantom that provides 6 DOF for input but only 3 DOF for the output. Hence, a 3 DOF haptic rendering is sufficient.

User Tracking

The user tracking component from the libraries OpenNI and Nite receives information from the depth camera and extracts the sighted player's skeleton. From this skeleton, we extract the position of all available joints. Then the pose detection is performed by comparing the positions of these joints with pre-defined poses.

Sound

For ingame sounds and audio feedback, the irrKlang sound engine is used. irrKlang supports the playback of audio sources in a 3D space. Similar to geometric objects in Ogre3D, a sound source can be defined by its three coordinates. This enables us to create audible feedback for collision detection and navigation.

Wind Simulation

In our pre-tests, we recognized that the limited workspace of the haptic device prevents a feeling of the current speed for the blind player. Consequently, we decided to develop an additional feedback method: the wind simulation. We connect three common computer fans to an Arduino. Two fans are mounted at face height, the third one is targeted at the hand controlling the haptic device (see Figure 1b, blue ellipses).

IV. USER STUDY

The focus of the user study is to evaluate the system with respect to the given hypothesis. Thus, we aim to answer the question, if the additional in- and output devices are an equivalent replacement for visual output and touchless input. In the following, an overview of the user study including the pre-studies, participants, setup and the procedure of the test runs is given.

A. Pre-Studies

The final user study is based on the results of user-centered development process. As soon as our game reached testable conditions, we performed iteratively three qualitative pre-studies with blind users. In respect of the agile development process the early integration of users of the target group helps to reduce the risk of missing the needs of the potential target group [22, p. 303]. All three participants tested the game for about an hour and were asked to use the Thinking-Aloud-method while playing. A detailed and structured interview based on a questionnaire followed right after playing. The focus of the interview was to determine which features help to navigate and orientate within the virtual environment.

After the first pre-study, we improved the game features based on the feedback of the participants and tested the game again with another subject. The pre-study has shown that extensive feedback is essential. Especially regarding the wind simulation, which was developed after one of the participants noted a lack of sense of his speed. However, it is important to keep the amount of feedback balanced. In addition, the sound must correlate with all other output devices. Even finest inconsistencies were perceived as disturbing.

Before our final study with blind users on the bat side, we performed a lab study with only sighted players in order to fine-tune the game parameters and test our questionnaire. We included only sighted players, because the number of visually impaired users is limited. In this pre-study, we performed 30 tests in total with two participants each. This gave us not only important feedback, but also pointed out that the flying/moving speed of both players still doesn't enable a balanced winning chance for both of them. Those improvements were made before the final study.

B. Participants

For the final study we had 14 test subjects in total and 7 of them were visually impaired. All subjects were aged between 10 and 54, with an average age of 27. 79% of the test subjects were male and 21% female. All visually impaired participants were blind or had a very low eyesight of approximately 5%. They have this either since they were born or were in the age of 1 to 3 and was caused by a ocular disorder like the cone dystrophy.

C. Setup and Procedure

The user study took place as a laboratory study. In the context of computer games, a field study might be more significant since this guarantees a more relaxing atmosphere, but due to the amount of different devices this was not practicable. We used two rooms: one room to introduce the participants to the study and interview them afterwards and another room with the game setup (see SYSTEM OVERVIEW). Both, the sighted and blind player where recorded via cameras as well as observed by evaluators for qualitative data analysis such as reactions and emotions. Likewise the screen was recorded for further analysis. A log file collected different events of the game like collisions or the usage of the boost, the actual position of both players and other data.

All test runs followed a pre-defined schedule to ensure comparable and applicable results. We prepared an audio introduction that explained the most important points of our game. Since our test subjects were from a different city only for the study and had to return the same day, we could only run two rounds with each pair of players. Each run was divided into two phases, the training and the test phase. During the training phase we gave detailed verbal instructions to both participants and ensured that they understood their individual controls. This phase was finished when both players said that they felt comfortable with all the controls. Once the game was over the subjects were interviewed to answer our questionnaire. After all participants had one test run done, each of them played a second round but this time without the training phase. Instead they had a warm-up phase to get the feeling for the game and their character back. After the second round, each test subject answered another questionnaire to compare the differences of both rounds and to analyze the learning process of the players. Additionally, we recorded anonymous data from the game, including all occurred game events.

V. RESULTS

In this section we present the analysis of both data source, the objective data recorded during the game and the subjective ratings from the questionnaire. The results draw conclusions for the development of accessible games for visually impaired players and additionally show various behaviors of players in the game. In our questionnaire we asked the participants to give answers on a 5-point Likert scale ranging from 1="never" to 5="always" for every feature with respect of certain parts of their perception. We compared the usefulness of each feature by using one-way between subjects analysis of variance (ANOVA) tests.

After first round, the blind player rated acoustic feedback (Mean=4.71, Standard Deviation=0.487) and haptic feedback (M=4.14, SD=1.573) as significantly more useful for orientation in virtual environment. The other features (wind, sonar, and ambient sound) are regarded as being less useful (F(4, 89)=34.85, p=0.000, see Figure 4).

During the game, the blind players were able to feel their actual positions in the virtual environment (M=4.14, SD=1.214, F(6, 41)=1.671, p=0.153). However, they found it difficult to estimate the virtual speed of their opponent (M=2.71, SD=1.704) and their distance either to their opponent (M=2.57, SD=1.618) and to the lateral walls (M=2.57, SD=0.786). The estimation of their own speed was rated slightly better (M=3.16, SD=1.602), see Figure 5.

After finishing first round, the blind players played a second round. During this round, they became more comfortable and paid more attention to other feedback sources. They rated acoustic (M=4.33, SD=1.211, F(4, 24)=3.564, p=0.020, see Figure 4) as the most useful feedback, followed by haptic (M=3.83, SD=1.602), sonar (M=3.83, SD=1.169), and ambient sound (M=3.00, SD=2.345).

During the second round, their awareness of orientation has been increased, they became more aware of surrounding sound (M=4.5, SD=0.836, F(6, 33)=0.954, p=0.471), own speed (M=3.50, SD=1.643), tunnel structure (M=3.16, SD=2.041), and also were able to estimate their distance to the opponent (M=3.16, SD=1.602), lateral walls (M=3.00,

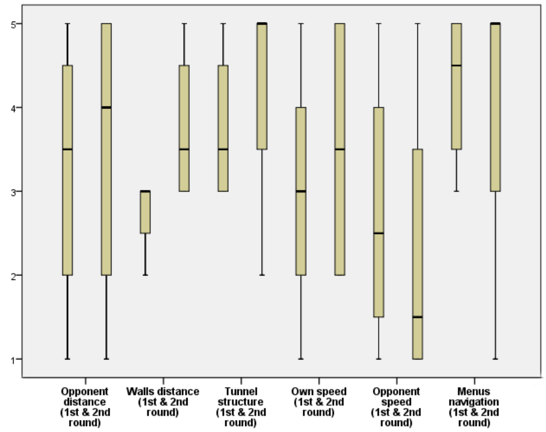

Fig. 4. Orientation elements for blind player after first and second round

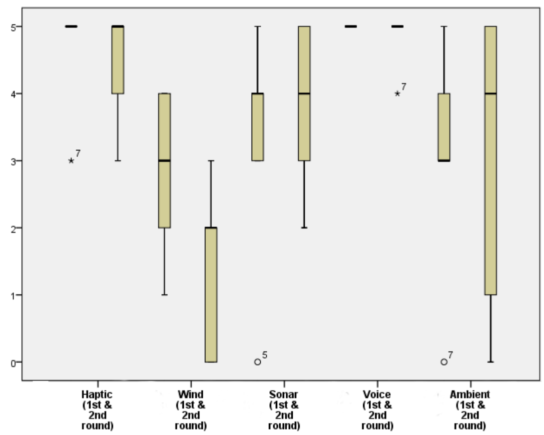

Fig. 5. Gameplay orientations for blind player after first and second round

SD=1.414). However, their awareness of the opponents virtual speed was slightly reduced (M=2.2, SD=1.643), see Figure 5.

We evaluated fun factor after each round. As for the first round, both blind players (M=4.57, SD=0.786, F(1, 12)=0.000, p=1.000) and sighted players (M=4.57, SD=0.534) felt they have fun playing the game. This remains same after the second round. Both blind (M=4.66, SD=0.816, F(1, 10)=0.571, p=0.467) and sighted players (M=4.00, SD=2.000) still rated the games as fun to play.

We also anticipated the use of asymmetric input and output devices for both players as challenging. We evaluated the fairness of our game by a χ^2-test of goodness-of-fit [23] test in order to determine whether the game fairness is well balanced between both players. The results show that the winning / losing chances were equally distributed in the population, $\chi^2(2, N = 14) = 1, p < .05$.. In other words, both players, the blind as well as the sighted player, have the opportunity to win with a probability of 50% in all cases, hence the game is well balanced.

Finally, we analyzed the strategic behavior of our participants acting as the bat. We recognized four main behavior patterns:

1) Orientation along walls

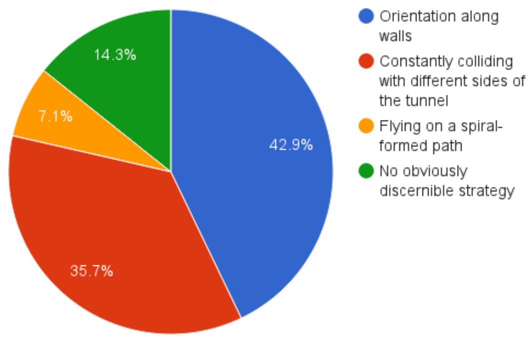

Fig. 6. Frequencies of the behavior patterns

2) Spinning between different sides of the tunnel
3) Flying on a spiral-formed path
4) No obviously discernible strategy

Blind players applying the first pattern always touch along one side of the tunnel wall using the haptic device.

Players applying the second pattern also use the wall for orientation, but they constantly jump between all available walls - left, right, up and down. In most situations the reason for the change is a strong collision with the wall.

One test subject even tried a different tactic after he failed in the first test run. He used his second hand as support for the playing hand to create small spiral movements to fly through the tunnel. This movement pattern allows the player to decrease the amount of strong collisions while maintaining a rather small distance to the middle of the tunnel.

In two of the matches, we were not able to identify a discernible behavior pattern: The players lost both rounds after a very short period of time.

We assigned a behavior pattern to each test run with respect to the recorded data if we found a strong resemblance in the behavior. Figure 6 shows the distribution of the patterns. Additionally, we analyzed the logs to identify specific characteristics of each pattern like differences in the amount of collisions through time. Please note, a collision does not necessarily mean heavy collisions with the wall but also slightly sliding on the surface of the wall.

Participants who used the wall for orientation had an average amount of 154 collisions per second while test subjects with the second behavior pattern only had 85 collisions per second. The only test run with the spiral movement had even 234 collisions per second. Even with this high amount of collisions the subject won the game because of the prevention of strong collisions and the right timing with the boost function. The subject with the spiral pattern even had the highest average speed of 287.5 units/s (284 units/s for the second, 225 units/s and 106 units/s for the fourth pattern).

VI. DISCUSSION

Our results show that it is possible to develop a mutually funny real-time competitive game for both sighted and visually impaired users sharing the same virtual 3D environment. Our asymmetric setup was able to balance a fair winning chance for both players. As expected, haptics was rated as most important modality for orientation in the virtual 3D environment by the visually impaired users. This matches with previous results from user studies. For instance Sallnäs et al. [21] reported similar results for cooperative tasks for sighted and visually impaired.

In case of sound we differentiated speech, sonification (the environment sounds, like the sound of the collapsing tunnel and the sound of the digging Ogre) and audio cues (the sonar feature). Surprisingly, the ambient sound and the sonar was rated lowest with respect to the usefulness for orientation. Talks with the blind users during the breaks but also during the pre-studies showed, that in the real world, these are the most important orientation features, even more important than the sense of touch (by using a white cane for instance) for some of them. This also corresponds to the literature [24]. There may be several reasons to explain this: First, the novelty when using haptic devices for the first time may lead to a preferred concentration on this sense. Actually, none of our subjects ever tested a Phantom device before. The better rating of the acoustic cues in the second test runs may emphasize this hypothesis. However, audio was still rated lower even in the second round. A second explanation may be the poor sound simulation. Recent audio engines for games support only a very basic simulation of the complex reverbations that appear in the real world. Moreover, the sighted and the blind players interacted in the same room and consequently, there was some communication between the players, some of the competitive kind but also both players motivated each other. This may disturb the audio feedback provided by the game. Further investigations on this topic would be very interesting.

Even if we did not switch off specific modalities (for instance audio only and haptics only vs audio and haptics) the high rating of both modalities seem to indicate the importance of multimodal cues, especially in highly challenging environments, which also corresponds to the literature [7].

A second interesting result is the use of the different strategies for the orientation with the haptic device. There was no significant difference in the winning chance between the strategies, hence, they all seem to be successful. Unfortunately, we did not expect this results before the test run, so we did not include questions about that in our questionnaire. It would be interesting to detect whether the different strategies correspond to different haptic orientation strategies in the real world. However, the two unsuccessful runs without any strategy indicate that it might be helpful to provide some guidance to new users who use haptic devices for the first time. Even if those users without any strategy passed the learning phase and agreed that they totally understood the game and told they are comfortable with the control, they failed during the game. Actually, such a guidance should be selected with respect to the user preferred strategy.

VII. CONCLUSIONS AND FUTURE WORK

We presented, to our knowledge, the first accessible game for visually impaired people with an asymmetric approach that allows blind and sighted players to interact competitively in the same complex 3D virtual environment. Our game uses an asymmetric approach with different VR input and output devices, while guaranteeing a fair winning chance for all players.

We conducted a user study that shows that the haptic device and the acoustic feedback have a positive effect on the players' environmental awareness. But also tactile feedback like the usage of wind to simulate the speed can help blind users by the orientation in virtual 3D environments. An interesting result of our experiments is the usage of different orientation and navigation patterns which all lead to a similar success in playing the game and in a similar rating of the game experience. It would be interesting to further investigate whether or not the blind people also use different behavior patterns in real life. Moreover, it is an interesting question if there is a reason for these different patterns.

However, the most important sensory input for blind players to determine their orientation within the environment remains the sound. We showed that 3D sound in combination with abstract sound features, such as sonar or voice-overs, have a significantly positive effect on self-orientation. More sophisticated audio, e.g. using the image source method or ray tracing, might increase the positive effect on self-orientation. Thus, realistic audio feedback should have a higher priority in the game development processes. Finally, it would be interesting to check if more sophisticated 6-DOF haptic devices or bi-manual setups would help to improve game experience.

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